DEPERTMENT OF TRANSPORTATION AND COMMUICATIONS (DOTC)
THE REPUBLIC OF THE PHILIPPINES

INFORMATION COLLECTION SURVEY FOR THE MEGA MANILA SUBWAY PROJECT IN THE REPUBLIC OF THE PHILIPPINES

FINAL REPORT

SEPTEMBER 2015

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS GLOBAL CO., LTD.
ALMEC CORPORATION
JAPAN INTERNATIONAL CONSULTANTS FOR TRANSPORTATION CO., LTD.
TOKYO METRO CO., LTD.

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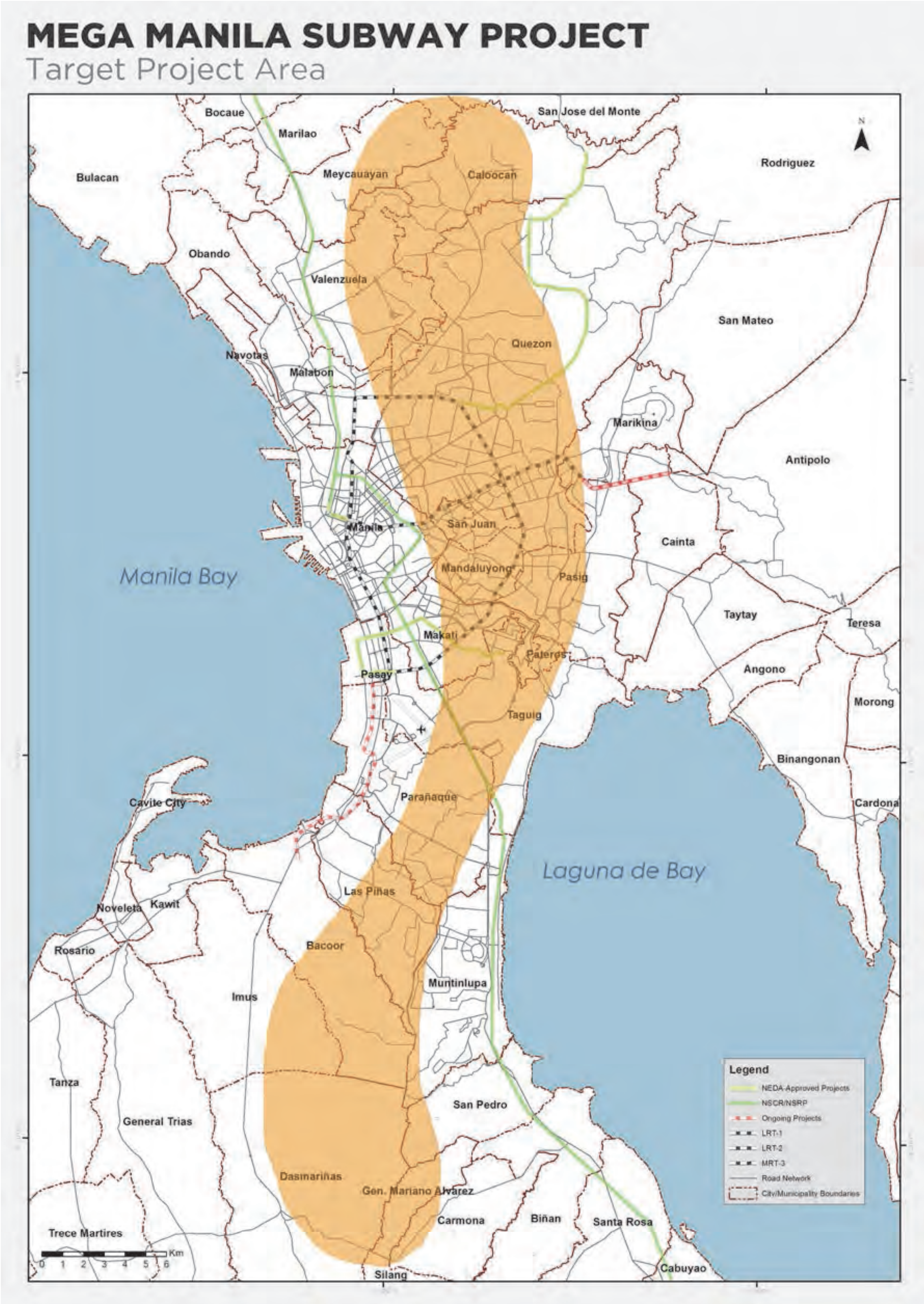
Exchange Rate (March 2015)

1 Philippines Peso (PhP) = 2.7088 Japanese Yen (JPY)

1 US dollar (US$) = 119.03 JPY

1 US dollar (US$) = 43.95 PhP



Source: *JICA Study Team*

LOCATION MAP OF TARGET PROJECT AREA

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INFORMATION COLLECTION SURVEY FOR THE MEGA MANILA SUBWAY PROJECT IN THE REPUBLIC OF THE PHILIPPINES

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Abbreviations

Abbreviation	Full Name
AC	Alternating Current
ACELP	Algebraic Code Excited Linear Prediction
ADB	Asian Development Bank
AFC	Automatic Fare Collection
AG	Automatic Gate
AGT	Automated Guideway Transit
ALI	Ayala land Inc.
ASEAN	Association of South‐East Asian Nations
ATACS	Advanced Train Administration and Communications System
ATC	Automatic Train Control
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATS	Automatic Train Stop
BCDA	Bases Conversion and Development Authority
BGC	Bonifacio Global City
BLDC	Bonifacio Land Development Corporation
BLT	Build-Lease-Transfer
BMCL	Bangkok Metro Public Company Ltd.
BOO	Build-Own-Operate
BOT	Build-Operate-Transfer
BPO	Business Process Outsourcing
BRLC	Bulacan, Rizal, Laguna and Cavite
B/C	Benefit / Cost
CA	Concession Agreement
CAMANAVA	Caloocan, Malabon, Navotas and Valenzuela
CAVITEX	Manila-Cavite Expressway
CBD	Central Business District
CBTC	Communications Based Train Control
COA	Commission of Audit
CTC	Centralized Train Control
DBM	Department of Budget and Management (of the Republic of the Philippines)
DC	Direct Current
DMU	Diesel Multiple Unit
DOF	Department of Finance (of the Republic of the Philippines)
DOTC	Department of Transportation and Communication (of the Republic of the Philippines)
DPWH	Department of Public Works and Highways (of the Republic of the Philippines)
E&M	Electrical and Mechanical
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMU	Electric Multiple Unit
ENPV	Economic Net Present Value
ETCS	European Train Control System
ETSI	European Telecommunications Standards Institute
EWR	East West Railway
FBDC	Fort Bonifacio Development Corporation

Abbreviation	Full Name
FC	Foreign Currency
FIRR	Financial Internal Rate of Return
FMD	Ferrocarril de Manila-Dagupan
FY	Fiscal Year
F/S	Feasibility Study
GAA	General Appropriations Act
GCMT	Global Cities Mass Transit
GCR	Greater Capital Region
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GOJ	Government of Japan
GOP	Government of Philippines
GRDP	Gross Regional Domestic Product
HQ	Headquarters
HSR	High Speed Railway
ICAO	International Civil Aviation Organization
IEEE	Institute of Electrical and Electronics Engineers
IGBT	Insulated Gate Bipolar Transistor
IMO	International Maritime Organization
ISO	International Organization for Standardization
ITS	Intelligent Transportation System
ITU-R	International Telecommunication Union Radiocommunication (Sector)
JBIC	Japan Bank For International Cooperation
JICA	Japan International Cooperation Agency
JPY	Japanese Yen
LC	Local Currency
LCD	Liquid Crystal Display
IEC	International Electrotechnical Commission
LED	Light Emitting Diode
LGU	Local Government Unit
LRT	Light Rail Transit
LRTA	Light Rail Transit Authority
LRV	Light Rail Vehicle
LTFRB	Land Transportation Franchising and Regulatory Board
METI	Ministry of Economy, Trade and Industry (of Japan)
MICT	Manila International Container Terminal
MLIT	Ministry of Land, Infrastructure, Transport and Tourism (of Japan)
MMDA	Metropolitan Manila Development Authority
MMS	Mega Manila Subway
MMSP	Mega Manila Subway Project
MMUTIS	Metro Manila Urban Transportation Integration Study
MOA	Memoranda of Agreement / (SM) Mall of Asia
MRR	Manila Railroad Company
MRT	Mass Rapid Transit / Metro Rail Transit
MRTA	Mass Rapid Transit Authority of Thailand
MRTC	Metro Rail Transit Corporation Limited

Abbreviation	Full Name
MTSL	Mass Transit System Loop
MVA	Mega Volt Ampere
NAIA	Ninoy Aquino International Airport
NCR	National Capital Region
NEDA	National Economic Development Authority
NEDA ICC	NEDA Investment Coordination Committee
NHA	National Housing Authority
NLRC	North Luzon Railways Corporation
NPV	Net Present Value
NR	North Rail
NSCB	National Statistical Coordination Board (of the Republic of the Philippines)
NSCR	North-South Commuter Railway
NSO	National Statistics Office (of the Republic of the Philippines)
NSRP	North-South Railway Project
O&M	Operation & Maintenance
OCC	Operation Control Center
OCS	Overhead Catenary System
OD	Origin-Destination
ODA	Official Development Assistance
OTS	Office for Transportation Security
PAHs	Project Affected Houses
PAPs	Project Affected Persons
PC	Pre-stressed Concrete
PHBOR	Philippine Inter Bank Offered Rate
PHIVOLCS	Philippine Institute of Volcanology and Seismology
PhP, PHP	Philippine Pesos
PHPDT	Peak Hour Peak Direction Traffic
PMO	Project Management Office
PMSM	Permanent Magnet Synchronous Motor
PNR	Philippine National Railways
PPP	Public Private Partnership
PRA	Philippine Railway Agency
PRC	Programmable Route Control
PSD	Platform Screen Door
PUJ	Public Utility Jeepney
PWM	Pulse Width Modulation
RATP	Régie Autonome des Transports Parisiens
RL-CELP	RaiL system Code Excited Liner Prediction
ROW	Right-of-Way
SCADA	Supervisory Control And Data Acquisition
SLEX	South Luzon Expressway
TETRA	TErrestrial Trunked RAdio
TIMS	Train Information Management System
TIS	Train Information System
TOD	Transit Oriented Development
TRO	Temporary Restriction Order

Abbreviation	Full Name
TTC	Travel Time Cost
TVM	Ticket Vending Machine
USD	United States Dollar
VAT	Value Added Tax
VOC	Vehicle Operation Costs
VVVF	Variable Voltage Variable Frequency

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Chapter 1

INTRODUCTION

Chapter 1 INTRODUCTION

1.1 Background of the Study

The population of Metro Manila, the National Capital Region (NCR), has increased at the rate of 1.8% per annum and has reached 12 million in 2010 from 7.9 million in 1990 although the Metro Manila is a relatively small urban area with approx. 620 km^2. In fact, the population density of the Metro Manila (191 persons/ha) is comparably higher than other mega cities in Asia, where persons per ha of Tokyo is 131 and that for Shanghai is 124. Rapid growth of population in the urban area is a significant threat to the sustainable development of the area. Despite the fact that the transportation network in Manila Metro Manila, such as highways and LRT/MRTs, have been constructed gradually, the infrastructure development has not caught up with the increasing transportation demand with even worth traffic jam in the central business district, resulting in the decrease of the country's competitiveness against others.

Japan International Cooperation Agency (JICA) has implemented a study called "Roadmap for Transport Infrastructure Development for Metro Manila and its Surrounding Areas" (hereinafter called as "Roadmap Study") in 2013, where the transport development investment plan was established and prioritized projects were selected. Recommendations and proposals in the Roadmap Study was approved at the board of directors meeting of National Economic and Development Authority (NEDA) in June 2014. Main objective of the Roadmap Study was to realize the ideal transport network by 2030 and the Roadmap Study recommended the implementation of various projects, such as the construction of approx. 300 km railways and approx. 500 km highways, rationalization of public transport system and network, and transportation control system.

In the Roadmap Study, 2 railway lines in north-south direction were proposed as the sustainable development means in the Manila Greater Capital Region (GCR: 3 regions of the NCR, Region III and IV-A), one of which was planned as the subway connecting San Jose del Monte at north and Dasmariñas at south via EDSA (Circumferential Road No.4: C4), which is the main objective of this Study. A very preliminary study without consideration of detailed alignment and technical requirements was carried out in the Roadmap Study for the realization of the subway project.

1.2 Objective of the Study

This study, Information Collection Survey for the Mega Manila Subway Project (hereinafter called as the "Study" or also as the "MMSP"), aims to collect and confirm basic information regarding the proposed subway project in the Roadmap Study (hereinafter called as the "Project", not necessarily limited to the particular route proposed in the Roadmap Study, but the planned subway in north-south corridor through the GCR in general), which will be a beneficial and valuable input to the realization of the Project, in particular application to the NEDA ICC (Investment Coordination Committee) by the Department of Transportation and Communications (DOTC) of the Republic of the Philippines. The main outcome of the Study will be the several options of the implementation of the north-south corridor subway project, without definitive suggestion or recommendation on particular option among several options to be proposed, but with rough cost estimate, construction schedule, results of rough economic and financial analysis. Other important aspects related to the project implementation, i.e. disaster and risk prevention, potential project implementation scheme, non-railway business opportunities, etc., will be also presented in the deliverables of the Study.

1.3 Area of the Study

The area of this study includes the NCR, Region III and Region IV-A

1.4 Scope of the Study

Scope of the Study and the items being studied is as shown in the table below:

Table 1.4-1 Items to be Studied

Classification		Substance
1	Review of Existing Laws and Regulations regarding Subterranean Rights	• Confirmation of laws and regulations regarding the property right and usage/development right of underground space • Confirmation of laws and regulations regarding construction of underground structures, e.g. underground corridor, subway, etc. • Confirmation of the necessity procedure for the revision or renewal of the existing laws and/or regulations
2	Confirmation of situation and issues in GCR transportation sector	• Implementable Scheme from technical and technological aspects • Construction cost and period • Environmental and Social Consideration • Connectivity with public transport network, including planned lines • Benefit to residents and potential of commercial development along railway corridor • Current situation of Right of Way (ROW) as well as issues and concerns • Existing structures buried underground (water pipes and drainage, cables, natural conditions, etc.)
3	Review of Existing Plan for Development of Manila GCR Transport Network and Urban Planning as well as Establishment of Development Scheme under Transit Oriented Development	• Confirmation and identification of information that requires updating through the review of existing documents and interviews with concerned persons • Establishment of development scheme under Transit Oriented Development (TOD)
4	Improvement of Transport Demand Forecast	• Demand forecast model will be updated • The number of passengers boarding and alighting at each station as well as the number of passengers on board between stations will be calculated for the design year.
5	Route Alignment and Systems Planning	• Route Alignment • Railway Systems
6	Review of Natural Conditions	• For each alternative route plan, existing geographical and geotechnical data and information will be collected and analyzed to study the suitability and implementability of each alternative route as the subway and also to find out issues to be taken into consideration.
7	Consideration on Risk Evaluation and Measures of Natural Disaster	• Flood risk • High tide and earthquake

8	Rough Project Cost Estimation	• Rough Estimate of Project Cost • Preliminary Economic and Financial Analysis (EIRR/FIRR)
9	Consideration of Project Implementation Organization and Operation and Maintenance Organization	• Based on the existing project implementation organization and operation and maintenance organization in railways of Manila GCR, those most applicable to the implementation of Mega Manila Subway will be considered and proposed, incorporating opinions and suggestions from those concerned in the Philippines.
10	Consideration of Project Implementation Scheme and Financing Plan	• Applicability of PPP scheme (e.g. subsidy, separation of infrastructure and operation, outsourcing of operation) and options of financial plan will be roughly considered.
11	Consideration on Environmental and Social Impact	• Review of natural and social environment impact • Political measure of land acquisition and resident resettlement plan and confirmation of existing situation
12	Utilization of Japanese Technology	• Introduction of Japanese technology that can be utilized in the MMSP, e.g. measures to mitigate impacts to existing structures, advanced construction methods, state of the art railway systems, etc.
13	Creation of 3D CAD Images	• Creation of 3D CAD images for underground sections with complicated condition where there are existing substructures and thus neighboring construction would be required
14	Creation of Project Video	• Creation of approx. 3 minute video with narration to propagate the MMSP to people and those concerned in the Philippines
15	Issues and Concerns for Next Step	• Items to be considered for the project implementation and construction body and system • Items to be considered for the operation and maintenance organization
16	Implementation of Training in Japan	• The training will be implemented after discussion with JICA to decide the dates and contents of the training. • The training program and its budget will be prepared by following JICA Guideline of Implementation of Training in Contract for Consultants, etc. (April in 2014).

This report, Final Report, covers Items Nos. 1 to 13 and 15.

1.5 Basic Concept for Selection of Route Alignment Options

The Mega Manila Subway Project (MMSP) was initially envisaged and proposed in a study called “Roadmap for Transport Infrastructure Development for Metro Manila and its Surrounding Areas (Region III & Region IV-A), March 2014” (Roadmap Study) financed by JICA. Therefore, the Study Team has first studied the rough route, including some options, proposed in the Roadmap Study, where the preliminary consideration was made to propose the routes for the MMSP.

Based on the Roadmap Study as the staring point, the JICA Study Team has collected various information necessary to select (more precisely “nominate”) several route alignment options that will be the basis for carrying out the Feasibility Study for MMSP, in which the route for the MMSP will be selected. It is a fundamental concept and policy of the JICA and the JICA Study Team that any particular option will not be selected as the selected route for the MMSP in this Study since the Study is an information collection survey carried out prior to the Feasibility Study and the information available and the consideration made are too little to determine the most feasible and suitable route option for the MMSP, which is one of the largest infrastructure projects in the Philippines, from various viewpoints and aspects for the determination. Therefore, the Study is being made towards the selection (nomination) of several route alignment options based on major criteria in selecting route options, with results of various factors for each option, e.g. demand forecast, social impact, rough cost estimate, preliminary economic and financial analysis, etc. Although the results will be presented, no particular option will be determined to be the "selected option". The most feasible and suitable route shall be determined not only by one of the factors, e.g. demand, cost, EIRR, etc., but shall be done through comprehensive consideration of all factors. It shall be also noted that the results of each factor have been made based on the data and information currently available as well as the railway network plan already approved or acknowledged at this moment. If the railway network plan is changed, e.g. the route of other new railway is changed, a new railway route is proposed, etc., or if new major roads (trunk road, expressway, etc.) are added in the plan, then the results of each factor for each option vary from those presented in this Study. Such consideration shall be made in the Feasibility Study stage.

Following is the major items used as the basis for presenting the results of each factor for each selected option:

- Functioning as North-South transport backbone, with separation in station territories with North-South Railway Project being carried out by JICA and PPP Center to maximize the benefit of both projects
- Design year for Demand Forecast study at 2025, 2035 and 2045
- Design year for Economic and Financial study up to 40 years from the commencement of Phase 1 revenue operation
- Implementation of project in 2 phases, with assumption of the revenue operation of Phase 1 staring in 2025 and that of Phase in 2035
- Rough cost estimate for Phase 1 and Phase 2 project costs, including construction cost, utility relocation cost, tax, consultants cost, physical contingency, land acquisition and compensation, and ancillary road construction (necessary for construction of railways along existing roads or on areas currently without roads)
- No consideration of branch lines to other directions, e.g. to existing or new airports, etc.

Chapter 4 describes the detailed criteria in the selection of route alignment options and the options selected based on such criteria, and Chapter 15 shows the summary of route selection against various studies conducted.

Chapter 2

CURRENT SITUATION AND ISSUES OF TRANSPORT SECTOR IN THE TARGET AREA

Chapter 2 CURRENT SITUATION AND ISSUES OF TRANSPORT SECTOR IN THE TARGET AREA

2.1 Current Situation and Issues on Urban Development

2.1.1 Greater Capital Region (GCR)

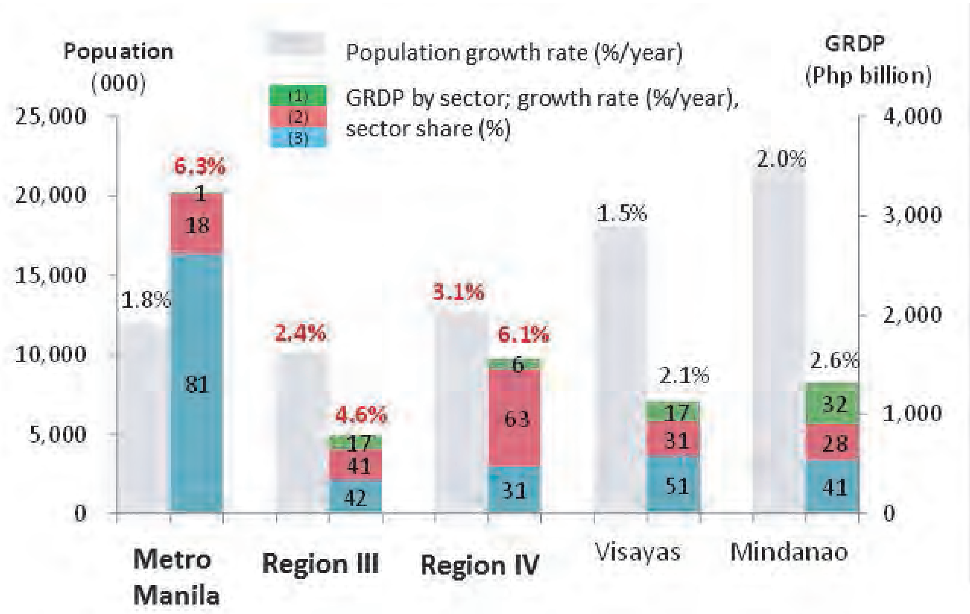
Greater Capital Region or GCR is an economic powerhouse driving the country's global competitiveness, and home to more than one third of the country's population. On the GCR land area of 39.5 thousand km^2 (11.5% of the Philippines), population grew faster than the rest of the country, from 15.4 million in 1980, 20.6 million in 1990, and 34.6 million in 2010 - suggestive of in-migration attracted by perceived higher economic opportunities. (Table 2.1.1-1 and Figure 2.1.1-1)

Table 2.1.1-1 Socio-Economic Characteristics of GCR

Geographical Area	Area (km^2)	Population (1,000)		GRDP (Php billion)	
		2000	2010	2000	2010
Philippines	343,448	76,507	92,338	3,916	5,702
Metro Manila (NCR)	620	9,933	11,858	1,113	2,043
Central Luzon (Region III)	22,015	8,205	10,138	327	514
CALABARZON (Region IV-A)	16,873	9,321	12,610	557	1,004
Total (3 regions)	39,508	27,458	34,604	1,997	3,562
Study Area/Philippines	11.5%	35.9%	37.5%	51.0%	62.5%

Note: NCR (National Capital Region)

Source: *NSO (National Statistics Office)*



Source: *NSO (National Statistics Office)*

Notes: GRDP in 2000 prices.

Figure 2.1.1-1 GRDP and Population Growth of GCR

2.1.2 Expansion from Metro Manila (NCR) to Mega Manila (NCR + 4 Adjacent Provinces)

Manila's population continued to swell: from 1.6 million in 1948, to 2.5 million in 1960, then nearly doubling to 4 million just a decade later. 1980 sees another increase to 6 million, and 7.9 million in

1990. Today, Metro Manila is a city of approximately 12 million people which still continues to grow at 1.8% per year within a relatively small urban land area of 620km^2 (see Table 2.1.2-1).

Densification accelerates the expansion of the existing urban areas unto outer areas beyond the boundary of Metro Manila forming a city-region. Today, the actual metropolitan area extends to 4 adjacent provinces, i.e. Bulacan, Rizal, Laguna and Cavite (BRLC). Many people reside in these peri-urban areas and commute to Metro Manila. By 2030, the population in such 4 adjacent provinces will exceed that of Metro Manila (NCR), and accordingly Mega Manila (NCR and 4 adjacent provinces) will become one of the largest urban areas in the world with total population of 30 million (see Figure 2.1.2-1 and Figure 2.1.2-2).

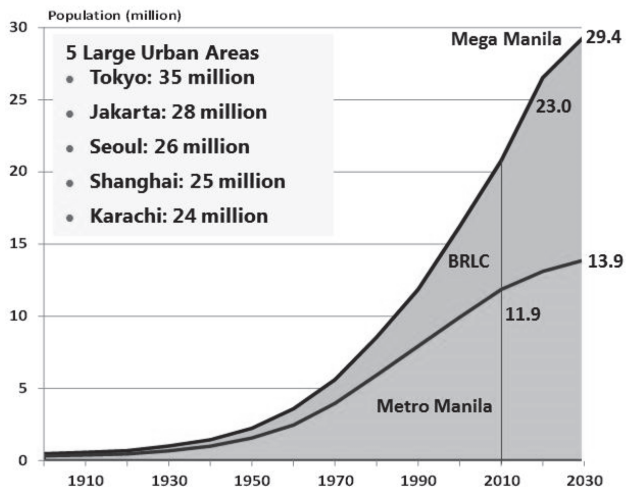
The unabated urbanization of the metropolitan region has been and is associated with economic growth as well as with increase in motorization. A growth that brings about enormous diversified impacts on land use, transport and environment, threatening sustainable development. The high population density of Metro Manila (191 persons/ha), which is quite high compared to other Asian cities, aggravate the situation (see Table 2.1.2-1).

Table 2.1.2-1 Population Growth from 1980 to 2010 in Mega Manila

Province/ City/ Municipality		Area (km^2)	Population (1,000)					Annual Population Growth Rate (%)		Population Density (person/ha)	
			Actual			Estimated 1)					
			1990	2000	2010	2020	2030	‘90-‘00	‘00-‘10	2010	2030
Metro Manila (NCR)		620	7,929	9,933	11,858	13,109	13,904	2.3	1.8	191	224
Adjacent Provinces	Bulacan	2,796	1,505	2,234	2,924	3,472	3,958	4.0	2.7	11.3	14.2
	Rizal	1,192	977	1,707	2,485	2,999	3,474	5.7	3.8	20.8	29.1
	Laguna	1,918	1,370	1,966	2,670	3,223	3,733	3.7	3.1	13.9	19.5
	Cavite	1,574	1,153	2,063	3,091	3,731	4,321	6.0	4.1	19.6	27.5
	Sub-total	7,479	5,005	7,970	11,170	13,425	15,486	4.8	3.4	14.9	20.7
Total Mega Manila		15,059	12,934	17,903	23,027	26,534	29,390	3.3	2.5	15.3	19.5

Source: *National Statistics Office (NSO)*

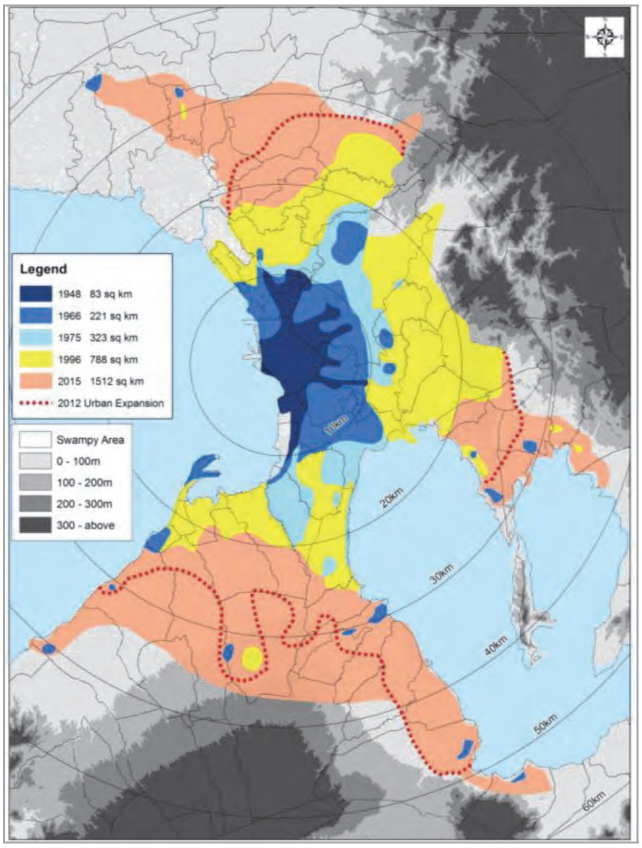
Note: Estimated in the Roadmap Study (JICA, 2014) based on the population forecast of National Statistical Coordination Board (NSCB)



Source: *National Statistics Office (NSO), 2010*

Note: Estimated in the Roadmap Study (JICA, 2014) based on the population forecast of National Statistical Coordination Board (NSCB)

Figure 2.1.2-1 Population Growth in Mega Manila



Source: *Roadmap Study (JICA, 2014)*

Figure 2.1.2-2 Trend in Urban Area Expansion of Metro Manila

2.2 Current Situation and Issues on Transportation Sector

2.2.1 Overall

As discussed in the previous section, the population density of Metro Manila (191 persons/ha) is comparably higher than other mega cities in Asia, where persons per ha of Tokyo is 131 and that for Shanghai is 124. Rapid growth of population in the urban area is a significant threat to the sustainable development of the area. Despite the fact that the transportation network and services in Metro Manila, such as circumferential/radial highways, expressways and LRT/MRT, have been constructed gradually, the infrastructure development has not caught up with the increasing transportation demand with even worth traffic jam in the central business district.

As for the international and domestic long-distance transportation to/from Manila, the Ninoy Aquino International Airport (NAIA) located in Pasay is the only airport in Metro Manila, but has four terminals to provide both international and domestic flight services. The Port of Manila consists of three main port groups (Manila North Harbor, Manila South Harbor and Manila International Container Terminal (MICT)).

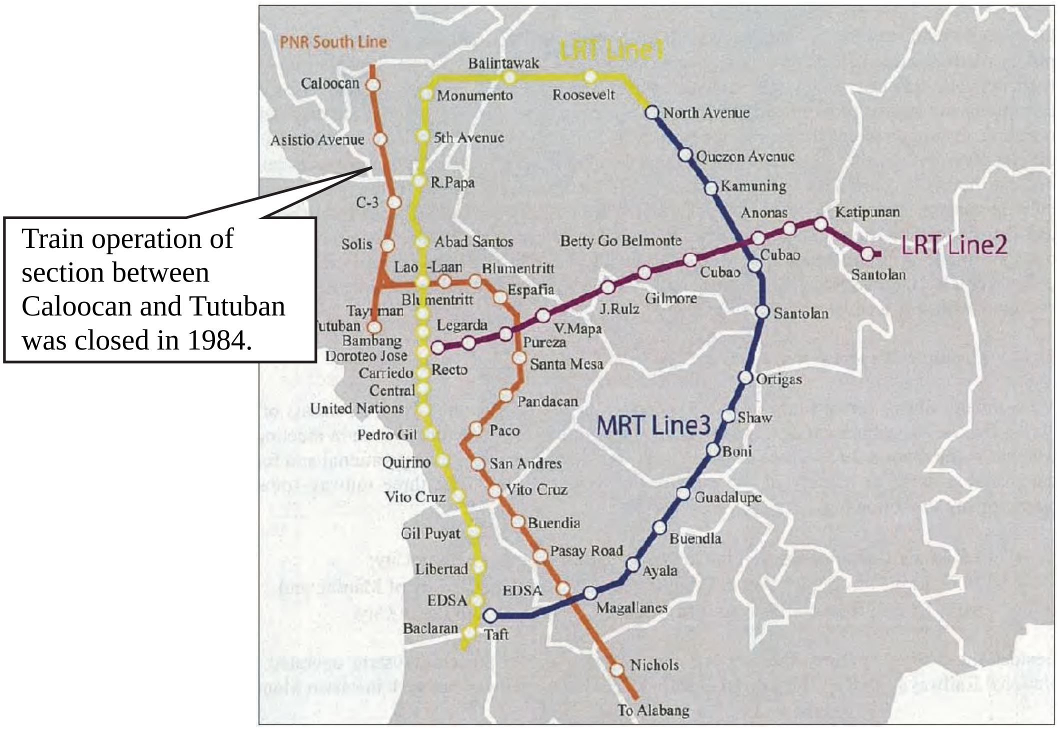
2.2.2 Road Network

Metro Manila has a well-articulated radial (R-1 to R-10) and circumferential (C-1 to C-5) roads, which provide the principal trunk roads within the metropolis. Interchanges provide grade separations at several intersections of these roads. However, there are still some missing sections aside from non-compliance to desired standards in many segments due to right-of-way constraints and porous zoning controls.

Metro Manila is linked by expressways to CALABARZON region on the south by the SLEX (about 60 km long) and atop it is the Skyway (16 km from Makati to Alabang); to Central Luzon on the north by the NLEX (84 km long) which T-connects to Subic-Clark-Tarlac Expressway (94 km from Tarlac City in the East, to the Subic Freeport and its international container port in the West). On the southwest is the Manila-Cavite Expressway (or CAVITEX), which is a 14-km toll road that forms part of R-1 skirting the coastline of Manila Bay to Naic of Cavite.

2.2.3 Railway Network

Railway is still sparsely developed, although Metro Manila was first among the ASEAN capitals to build one. Three LRT/MRTs (elevated for the most part) with a total length of 50 km serve Metro Manila. These are: the 20-km LRT 1 along R-2 in the southern section and R-9 in the northern section, the 13-km LRT-2 along the R-6 corridor, and the 17-km MRT-3 on C-4. A 4th railway line is the PNR South Commuter Line – stretching 28 km, double-track for the most part, from Tutuban in Manila to Alabang in Muntinlupa and a farther 12 km on a single track to Biñan in Laguna. The PNR North Commuter Line (about 32 km to Malolos) was closed in 1984. Attempts to rebuild the line through the decade-old North Rail Project have not succeeded.



Source: *LRTA*

Figure 2.2.3-1 Existing Railway Network

2.2.4 Road Traffic

Road transport includes private vehicles and public transport vehicles such as buses, jeepneys, UV express service (FX), taxis, tricycles and pedicabs. In the Transport Roadmap Study, a comparison of the estimated 2012 travel demand with the observed person trip data by MMUTIS in 1996 within and to/from Metro Manila showed an increase of 15% by car, while trips by public transport (bus and jeepney) declined by about 7%. In terms of vehicle trips, the car trips grew by an average of 3.3% per year while the public vehicle trips increased by 2.2% per year in the period of 1996-2012. While the vehicle ownership increased 112 vehicles per 1,000 people in 1995 to 161 vehicles per 1,000 people in 2010, the vehicle occupancy rate in the period of 1996-2012 decreased from 2.5 persons/vehicle to 1.7 persons/vehicle for passenger cars, from 15.1 persons/vehicle to 10.0 persons/vehicle for jeepneys and from 46.5 persons/vehicle to 35.3 persons/vehicle for buses, respectively. Thus, car traffic has increased because of the growth in car ownership and decline of car occupancy rate.

2.2.5 Urban Transport Issues

The significant increase in traffic volume resulted in congestion level much worse than that in the late 1960's, in some cases leading to total grid-locks on key arterial and circumferential roads. An assessment of the current traffic situation shows that most of the road links in the network are either operating at or exceed their capacity (see Figure 2.2.5-1). 55% to 76% of traffic (in road km) in Metro Manila travels at speed below 10 km/h, and 75% to 92% travels below 20 km/h (Table 2.2.5-1).

Source: *Roadmap Study (JICA, 2014)*

Figure 2.2.5-1 Traffic Demand/Capacity Gap in Metro Manila Roads in 2012

Table 2.2.5-1 Road Section by Vehicle Travel Speed in Metro Manila in 2012

Area	Ratio of Road Traffic by Speed	
	< 10km/h	< 20km/h
City of Manila	76%	92%
North Metro Manila	58%	80%
Central Metro Manila	63%	80%
South Metro Manila	55%	75%

Source: *Roadmap Study (JICA, 2014)*

Traffic congestions occur not only on road traffic but also on railway traffic, especially along LRT1 and MRT3. The cheap fare of LRTs compared to other public transport modes and the lack of railway network attract the passengers to the LRT1 an MRT3 more than their capacity. (Figure 2.2.5-2) This resulted in overcrowding on the platforms with the queue of passengers reaching all the way down to the stairs and streets below, especially during the morning and evening hours. This causes a dangerous situation for passengers on the platforms and in the concourse areas. The passengers also suffer unnecessary delays and discomfort due to delayed trains. In addition, the overloaded railway infrastructure has been facing mechanical problems, causing accidents and operation suspensions.

Source: *JICA Study Team*

Figure 2.2.5-2 Congested Platform on MRT3 Station

The problems of the railway system in Metro Manila are caused by not only the capacity-demand gap but also lack of the following integrations:

(1) <u>Physical Integration</u>

This is important to attain network efficiency and economics of scale and scope. An integrated network can provide convenience and shorter travel time for passengers. In the case of Metro Manila, four railways are operated but there is no common station for transfer. In addition, intermodal facilities should also be reconsidered at the station area. In general, the bus stops are a little bit far from the railway stations. This results in the passengers loading/unloading at not designated areas and ignoring the bus stops.

(2) <u>Service Integration</u>

This includes integration of fare collection, operation and maintenance (O&M), procurement, provision of feeder services, etc. Such integration also provides benefit for both passengers and operators. Regarding the provision of feeder service by service integration, the railway lines currently in operation are in competition with buses and jeepneys plying the same route. Some of these buses and jeepneys can be relegated to providing feeder services for the rail line. This setup can result in reduction of O&M costs for the buses and jeepneys, and to an increase in ridership for the three rail lines.

(3) <u>Institutional Integration</u>

The Philippine setting for urban transport management is highly fragmented. There is a lack of clarity on the mandate of different government entities in charge of O&M functions and regulations. This lack of organizational clarity results in overlapping of functions, which in turn can result in management conflicts that hinder the government's decision-making process. Having different agencies separately conducting their own procurement, and without product standardization, integration of similar transport system/subsystems into a network can be problematic.

2.3 Development Polices and Plans of Urban and Transport Sectors

2.3.1 Overall

In 2013 JICA has implemented Roadmap Study, where the transport development investment plan was established and prioritized projects were selected. Recommendations and proposals in the Roadmap

Study was approved at the board of directors meeting of National Economic and Development Authority (NEDA) in June 2014. Main objective of the Roadmap Study was to realize the ideal transport network by 2030 and the Roadmap Study recommended the implementation of various projects, such as the construction of approx. 300 km railways and approx. 500 km highways, rationalization of public transport system and network, and transportation control system.

2.3.2 Spatial Development Concept

Today, spatial structure in GCR is highly mono-centric with the prominent feature of Metro Manila. Although developments are taking place in Clark, Subic, Tarlac and other areas in the north and in Batangas, Cavite and Laguna on the south, they are still initial stages and implemented in a rather uncoordinated manner.

In the Roadmap Study, the precedent plans such as Philippine Development Plan 2011–2016 and the development plans of 2011-2016 for Metro Manila (NCR) and two adjoining regions (Central Luzon and CALABARZON) were referred and proposed the development concepts and strategies for GCR.

With the introduction of proposed development concept and strategies, the future will be different. Growth centers will be developed in a hierarchical manner and in a way that they are connected and form clusters and the north-south transport corridors can minimize negative impacts on the environment and avoid hazard risks.

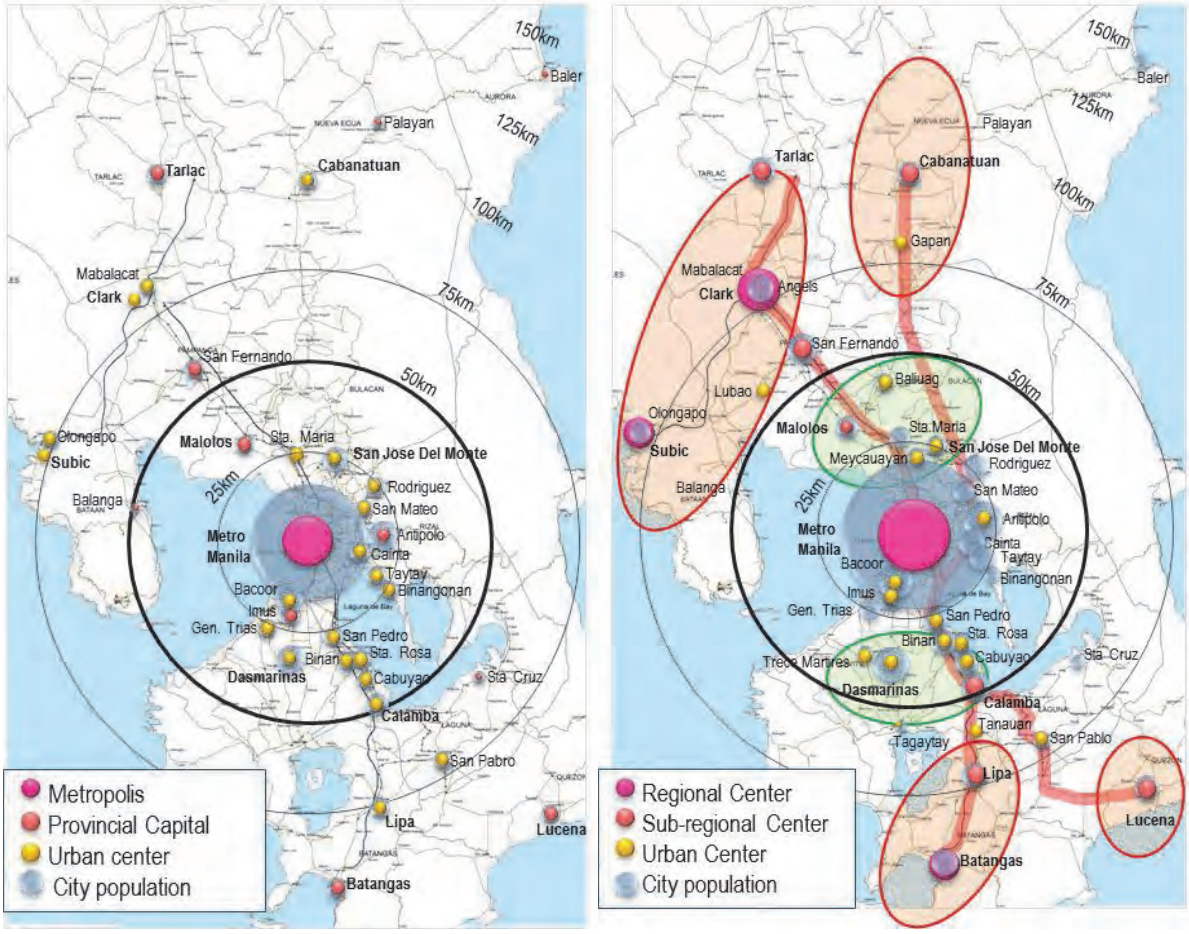
The urban centers and clusters should be developed hierarchically to decentralize and complement the functions of each urban center and cluster. The proposed urban center and their functions are described in the table below.

Table 2.3.2-1 Hierarchy and Functions of Urban Centers in GCR

<table>
<tr><th colspan="2">Hierarchy</th><th>Functions</th></tr>
<tr><td colspan="2">Regional Centers</td><td>・ Core cities of metropolitan regions which shall serve as a leading center of various activities in the region
・ Self-sustained by developing diverse activities
・ Regional hub of transport network</td></tr>
<tr><td rowspan="3">Sub-Regional Centers</td><td>Provincial Capitals 1)</td><td rowspan="3">・ Expected to be the center at the sub-region or provincial level, by providing a wide range of services and facilities
・ Existing urban centers located approximately 50km away from a regional center and connected to regional centers or Metro Manila
・ A balanced development and sustainability would be pursued in these centers</td></tr>
<tr><td>City Centers 2)</td></tr>
<tr><td>Municipal Centers 3)</td></tr>
<tr><td colspan="2">Potential New Urban Centers</td><td>・ Residential towns equipped with employment opportunities
・ Connected to commuter railway or expressway to Metro Manila with emphasis on access to public transport</td></tr>
</table>

Source: *Roadmap Study (JICA, 2014)*

- Provincial Capitals: The capital of the government, economy, and services of a province
- City Centers: The center of the government, economy, and services of a city
- Municipal Centers: The center of the government, economy, and services of a municipality



Source: *Roadmap Study (JICA, 2014)*

Figure 2.3.2-1 Spatial Development Concept for GCR

While integrated and coordinated infrastructure development at the regional level is required for the sustainable development of Metro Manila, the roles of Central Business Districts (CBDs) in the metropolis have been affecting its socio-economic performance both positively and negatively. While CBDs attract investments and create employment opportunities, they are becoming bottlenecks in the urban transport system. Serious traffic congestions are observed in and around the CBDs. It is expected that improvement of public transport access may contribute to reduced road congestions, improved mobility and comfort of public transport users, and enhanced CBD activities.

Rapid urbanization created several CBDs where commercial and business activities are concentrated in Metro Manila. The main CBDs are as follows.

(1) Monumento Area (Caloocan City): This is located in South Caloocan with about 558ha of total area. This area functions as a gateway CAMANAVA (Caloocan, Malabon, Navotas and Valenzuela) area.

(2) Quezon Circle Area (Quezon City): This area includes North Triangle and East Triangle and has been developed as a mixed-use development, led by the National Housing Authority (NHA) and Ayala land Inc. (ALI), called Triangle Park.

(3) Cubao Area (Quezon City): This is an old commercial center developed by the Araneta Family with a total area of 35ha. This area is also known as a transport hub, with numerous bus terminals and stations of LRT2 and MRT3.

(4) Eastwood City (Quezon City): This is a commercial and residential development area

covering a total of 17ha. This area accommodates the Eastwood City Cyber Park, which was an early leader in the business process outsourcing (BPO) industry in the Philippines.

(5) Ortigas Center (Pasig City): This is the second most important business district in the Philippines. It is home to many shopping malls, offices and building complexes in more than 100ha of total land.

(6) Bonifacio Global City (Taguig City): This is home to upscale residential condominiums and corporate office buildings. The total area of 260ha was converted from the US Army Camp.

(7) Makati CBD (Makati City): This is the leading financial and central business district in the Philippines. Much of the area is owned by ALI. Numerous corporate headquarters and regional headquarters locate in this CBD.

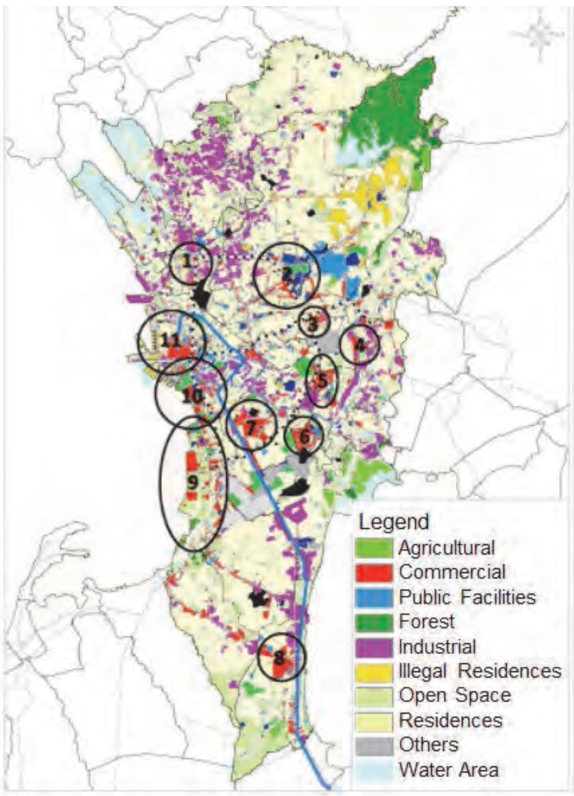
(8) Alabang Center (Muntinlupa City): This is the commercial center of Muntinlupa, composed of Alabang Town Center, Northgate Business District, and others.

(9) Manila Bay Area (Pasay City): This area is mainly composed of Bay City and Entertainment City in the reclamation area. The area is still under development, but many shopping and entertainment facilities have already been built and operational, including SM Mall of Asia (MOA) and casinos and hotels.

(10) Port Area (Manila City): This area facilitates inter-island commerce and trade as well as between the Philippines and its neighboring countries. Ermita, which is home to government offices and tourist attractions, is located in this area.

(11) Central Manila (Manila City): This is one of the oldest CBDs in the Philippines, which is composed of Binondo (oldest Chinatown in the world), Tutuban and Divisoria areas. This area functions as a center of commerce, finance and trade.

The uncontrolled rapid urbanization causes the urban sprawl and the traffic congestions within Metro Manila. CBDs have been developed without considering connectivity among them.



Source: *Preparatory Survey on Metro Manila CBD Transit System Project (JICA, 2015)*

Figure 2.3.2-2 CBDs in Metro Manila

2.3.3 Urban Transport Development Plans

In the Roadmap Study, various plans for comprehensive urban transport development projects in the GCR comprising roads, railways, airports and ports towards 2030, named as the "Dream Plan", were proposed and it was approved by NEDA Board in 2014.

There are five main components of the transport interventions for a better Mega Manila. The first component is comprised of urban roads. The second component is the construction of expressways both intercity and urban. The third component is comprised of urban and suburban rails. The fourth component is the improvement of bus and jeepney services. The last, but the most important component, is traffic management. These components are made up of the following (see Figure 2.3.3-1):

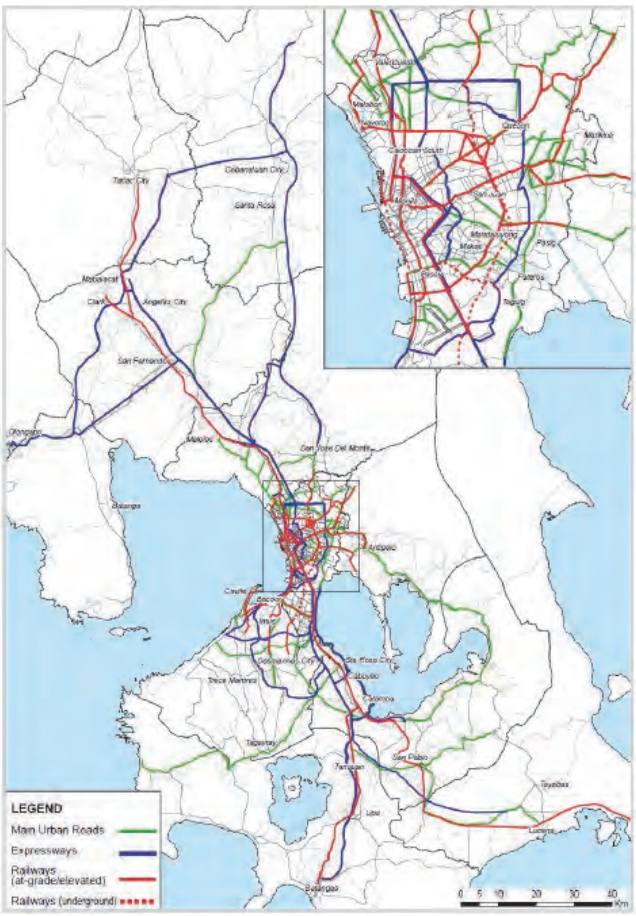
(1) At-grade Roads: includes missing links on C3, C5, bridges and others; 137 km of new roads; flyovers; sidewalks and pedestrian facilities.

(2) Expressways: compose of intercity expressway of 426 km and urban expressway network of 78 km.

(3) Urban/Suburban Rail: comprising 6 main lines with combined length of 246 km; 5 secondary lines measuring 72 km, and integration of lines for improved accessibility.

(4) Bus/jeepneys: includes modernized fleet and operation; rationalized route structure; and improved terminals and interchange facilities.

(5) Traffic Management: includes Intelligent Transportation System (ITS) for different modes of transport, traffic signals, traffic safety, and traffic environment and education.



Source: *Roadmap Study (JICA, 2014)*

Figure 2.3.3-1 Overall Transport Network Concept of Dream Plan for Mega Manila 2030

2.3.4 Mass Transit Network

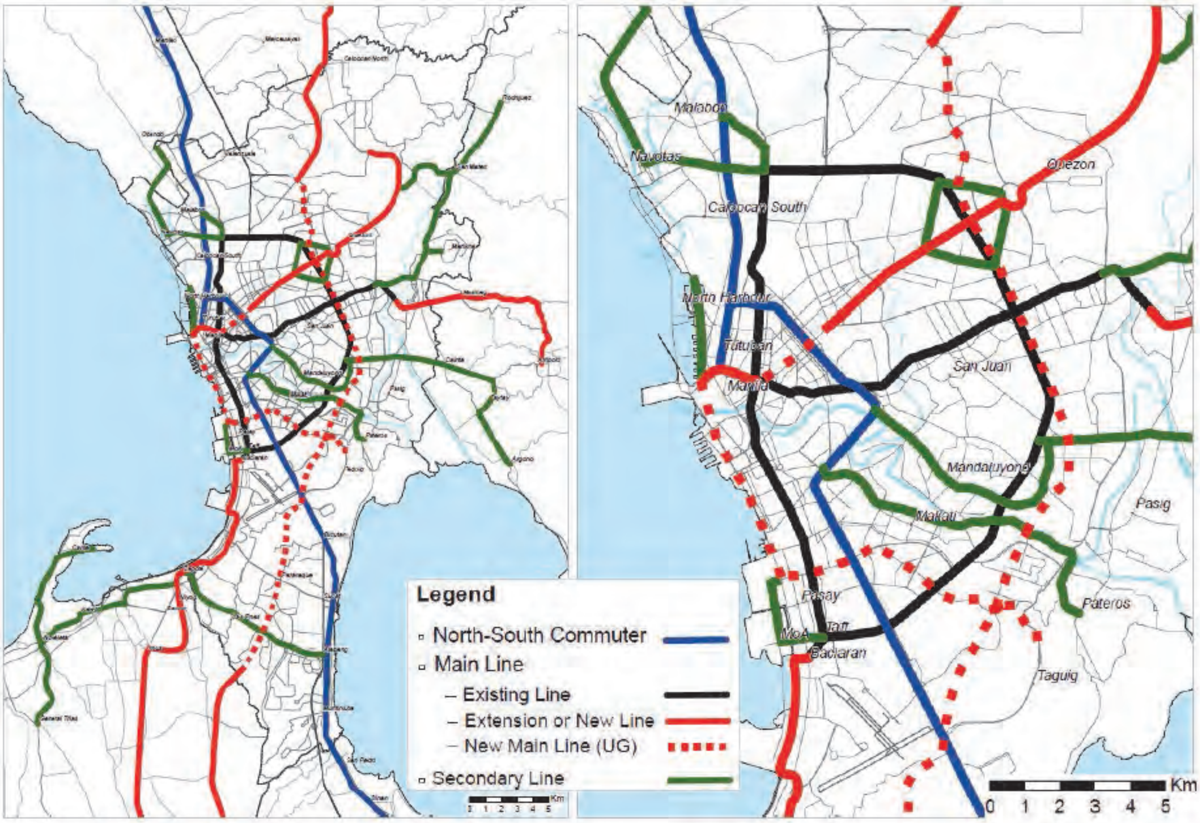
The proposed mass transit network comprises the following (see Figure 2.3.4-1):

(1) North-South backbone: Two north-south rail lines can form the backbone of the future metropolitan area. One is the suburban commuter service using the PNR right-of-way between Malolos (Bulacan) and Calamba (Laguna) and the other is a subway line; the first ever for the country, connecting San Jose Del Monte in the north and Dasmariñas in the south on or around EDSA and connecting CBDs of Cubao, Ortigas and Bonifacio Global City along the way.

(2) Expansion and extension of existing lines: LRT Lines 1 and 2 and MRT Line 3 should be extended and their capacities expanded to serve the growing peri-urban areas in the BRLC provinces.

(3) Other lines: In addition to these, other main and secondary corridors should be provided with adequate urban rail transit systems such as MRT, LRT, monorail, BRT, depending on their local conditions.

With this envisioned system, Mega Manila will be covered with a total of 318 km of modern mass-transit system. This will dramatically improve accessibility of the people. Moreover, because of the shift away from the use of road-based transport (i.e., bus/jeepney and cars), at grade roads will also be decongested.



Source: *Roadmap Study (JICA, 2014)*

Figure 2.3.4-1 Overall Transport Network Concept of Dream Plan for Mega Manila 2030

2.4 Current Status of Relevant Projects and Plans by Other Donors and/or Private Sector

Mass urban railway services are operated currently in Metro Manila only. It consists of a network of electrified, rail-based mass transit systems that augment the road network system in trying to meet the transport demand in the metropolis. Three urban railway transit systems plus the Philippines National Railways (PNR) commuter line are now operational and four more are in the planning stage or already in the pipeline for construction. In addition, 3 extension projects of existing lines are currently on-going or about to start bidding process. The four railway transit systems in operation are the following:

- PNR Commuter service between Tutuban in Metro Manila and Alabang; and PNR long distance services to southern locations in Luzon Island, which is currently not in operation;
- LRT Line 1, a north-south line from Roosevelt (Quezon City) to Baclaran (Pasay City);
- LRT Line 2 an east-west line from Santolan (Pasig City) to Recto in Manila City, and
- MRT Line 3 a semi-circle north-south line from North Avenue in Quezon City to EDSA station in Pasay City.

The operational lines and future planned/proposed lines are shown in Figure 2.4-1. This chapter describes the key features of these lines, services provided, and the future roles of these lines in serving the urban and sub-urban transportation needs of the Metro Manila and the Greater Capital Region (GCR) population.

Source: *JICA Study Team*

Figure 2.4-1 Existing and Planned Railways in Metro Manila & GCR Areas

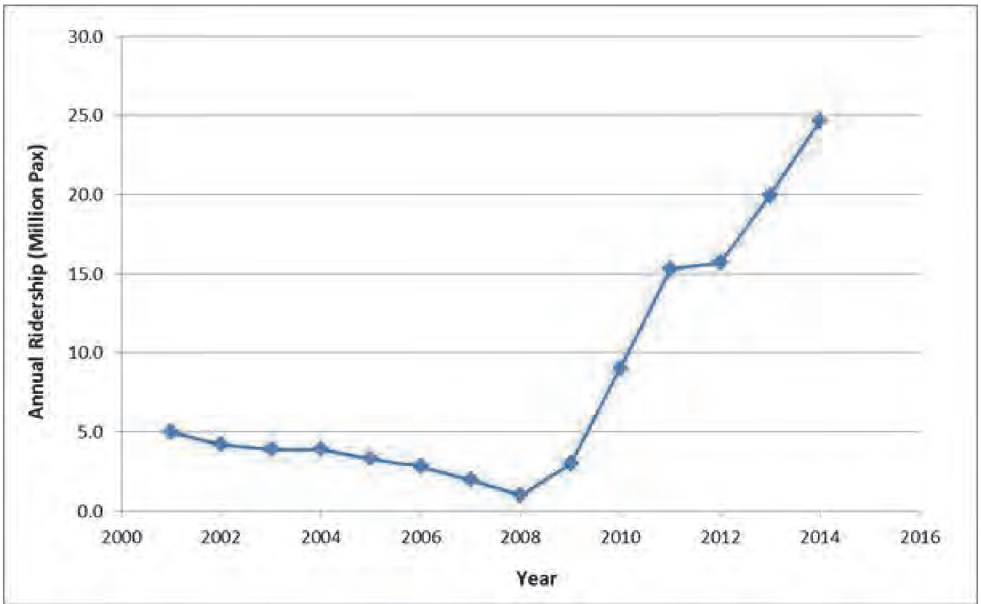
2.4.1 Existing Systems

2.4.1.1 Philippines National Railways (PNR)

The PNR network on Luzon Island mainly consists of a north-south line operating out of Metro Manila main railway station of Tutuban. Services to the north out of Metro Manila have been suspended almost since the conception of the North Rail (NR) Project, and the long distance services to the south of Metro Manila to Bicol were suspended after the severe typhoon in September 2006. The only remaining on-going service since 2006 has been between Metro Manila and Alabang.

Analysis of the patronage over the last decade paints a bleak picture. However, in 2009 PNR introduced new (mostly refurbished) rolling stock for services between Metro Manila and Alabang and some limited service to Binan, and beyond to Bicol. As a result, the patronage has increased considerably on the Metro Manila – Alabang section of the line. Figure 2.4.1.1-1 below shows the annual ridership on the PNR network for Metro Manila -Alabang and Other-services.

The PNR network in the GCR extends from Tutuban in Metro Manila to Alabang, which is a narrow gauge double track (except Sucat – Alabang section) over a length of about 28km. PNR operates this section from 5:00AM to 19:00 daily, with ½ hourly service during the AM & PM peak periods (06:00-11:00 & 15:00-19:00) from Monday through Saturday and hourly service during the inter-peak times and on Sundays.



Source: *PNR*

Figure 2.4.1.1-1 Annual Patronage of PNR Line (2001-2014)

In addition, the PNR network in the south of Luzon Island is shown in Figure 2.4.1.1-2. It is a single track from Metro Manila to Bicol/ Mayon 415 km long. PNR runs 3-trains a week to Bicol and three trains back to Metro Manila. In addition, PNR also runs limited commuter services in Bicol area with patronage less than 2,000 Pax per day. This is of little interest here. As per time-table the journey should take about 13 hours from Metro Manila to Bicol, but it is common knowledge that more often it takes up to 20~24 hours. This is mostly due to very poor track condition, numerous at-grade level crossings, and old rolling stock. Therefore, for obvious reasons the patronage is very low on the long haul section. This service is run for social reasons at a very low fare rather than to provide rail travel between Metro Manila and Bicol.

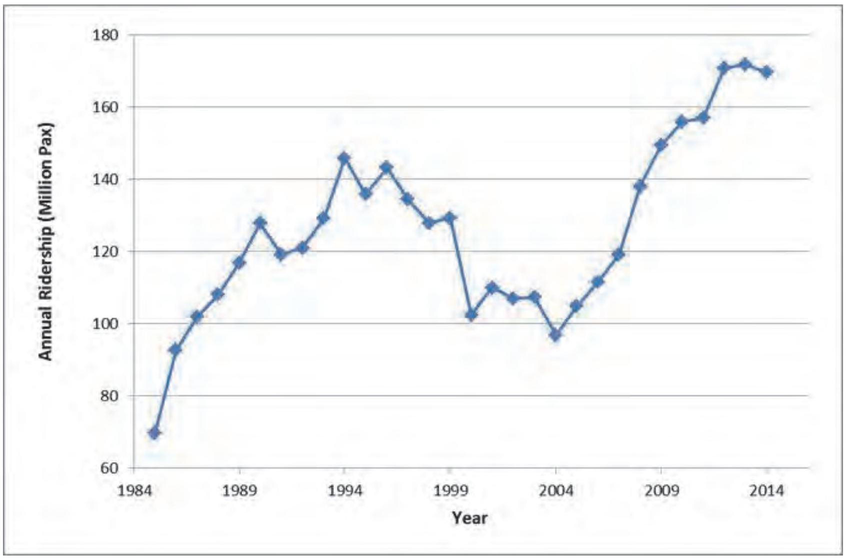
Source: *PNR Website*

Figure 2.4.1.1-2 PNR Network in Luzon Island Philippines

2.4.1.2 LRTA Line 1 (LRT-1)

LRT Line 1 is operating along a 20.35 km elevated railway system servicing the Taft Avenue - Rizal Avenue and North EDSA corridors. It currently handles about 457,000 passengers per weekday, with peak traffic reaching 525,000 passengers during special festive dates of the year. Due to the increased ridership of LRT 1, a train acquisition project was conceptualized with the primary objective of expanding the LRT Line 1 capacity by 50% from a nominal carrying capacity of 18,000 passengers per peak-hour per direction to 27,000 or 235,000 additional commuters to be carried by the system daily. This objective was achieved in 2000 through the procurement of seven new, air-conditioned 4-car trains and the transformation of the existing 2-car trains to 3-car trains with corresponding modifications to the existing vehicles, systems, facilities, and structures to support the operation of the expanded system. Later, in 2007, the Light Rail Transit Authority (LRTA) completed the Phase II of the LRT 1 Capacity Expansion Project, which effectively increased the capacity of LRT Line 1 to 40,000 passengers per hour per direction from the previous capacity (Phase I) of 27,000 hourly passengers.

The LRT Line 1 North Extension is a 5.7 km elevated viaduct that was completed in 2009, adding two more stations (Balintawak and Roosevelt) to the revenue operation of Line 1. The last phase of this project is to build a Common Station that will connect the Line 1 and MRT Line 3, and in the future with Line 7 as well. The construction of this station has been stopped by a Supreme Court Temporary Restriction Order (TRO) due to commercial disputes between a major retail shopping mall conglomerate and the DOTC/LRTA over the location of the said station. The historical annual ridership is shown in Figure 2.4.1.2-1 below.



Source: *LRTA*

Figure 2.4.1.2-1 Annual Patronage of LRT Line 1

Source: *LRTA*

Figure 2.4.1.2-2 LRTA Line 1

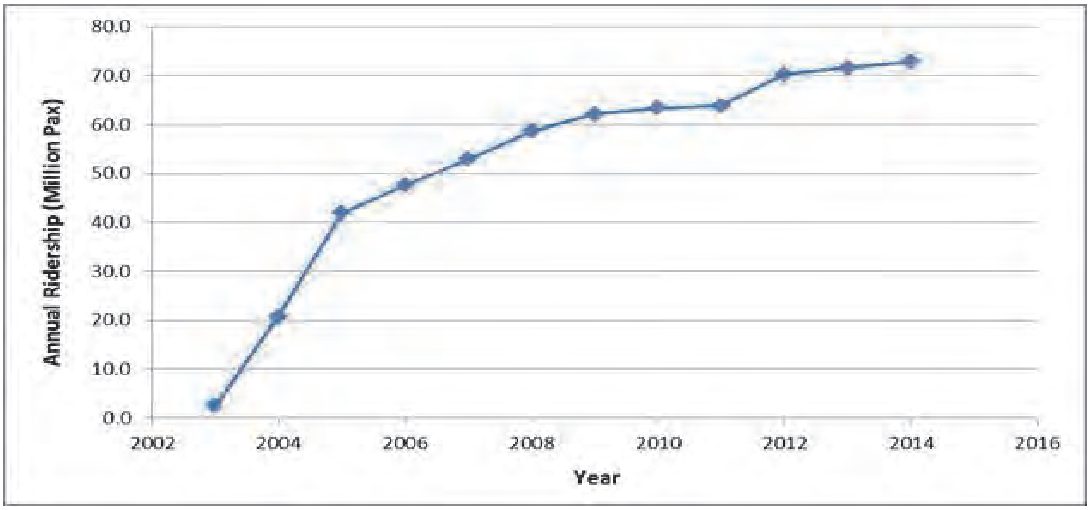
Source: *CMX Consortium*

Figure 2.4.1.2-3 Three Different Types of Rolling Stock for LRTA Line 1

2.4.1.3 LRTA Line 2 (LRT-2)

The Megatren, more popularly known by its generic name LRT Line 2, is a 13.8 km mass transit line that traverses four cities in Metro Manila namely Pasig, Quezon, San Juan and Manila along the major thoroughfares of Marcos Highway, Aurora Boulevard, Ramon Magsaysay Boulevard, Legarda and Recto Avenue. The Megatren, which started initial commercial operation in April 2003, is the latest of its kind in the world today. It is an Automatic Train Operation system which is at par in terms of facilities and technology with those in other parts of the world. It is equipped with a CCTV system that enables the railway operator to monitor activities of passengers and employees at the stations and inside the trains. Moreover, the LRT 2 is commuter friendly and has facilities especially designed for the elderly and persons with disabilities. The Megatren system has 18 four (4) - car trains. Each train is 92.6 meters long and consists of four motorized cars. One train can seat 232 passengers. It can accommodate 1,396 more standing passengers along its spacious coaches.

Data from LRTA showed average daily ridership growing rapidly from opening (year 2004) and then tapering off after 5 years, reaching 213 thousand in 2013. These ridership were way below (by as much as 2/3) the original traffic forecast when the feasibility study was made in the late 1990s.



Source: *LRTA*

Figure 2.4.1.3-1 Annual Patronage of LRT Line 2

Source: *LRTA*

Figure 2.4.1.3-2 LRTA Line 2 Train

2.4.1.4 MRT Line 3 (MRT-3)

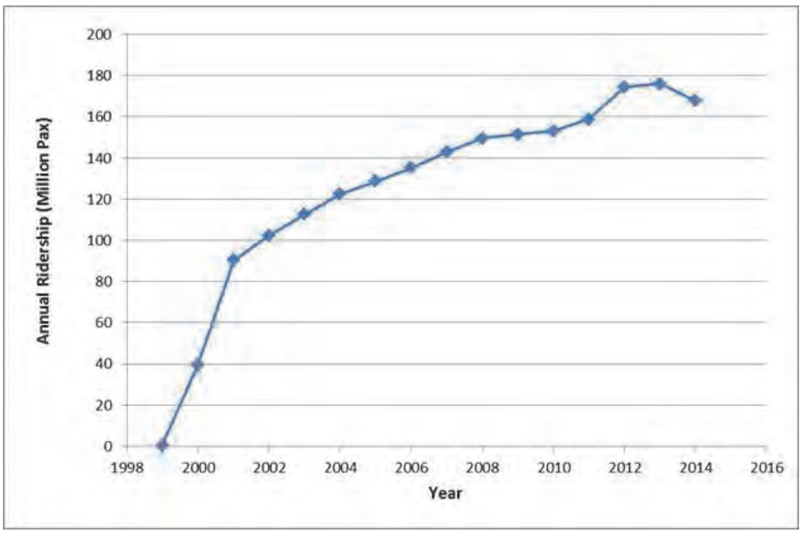
Under a BLT contract to Metro Rail Transit Corporation (MRTC), the EDSA MRT or MRT Line 3, a 16.9-kilometer modern rail system stretching along EDSA from North Ave. in Quezon City to Taft Ave. in Pasay City was constructed from 1998 to 2001. This Metro Rail system is designed to carry traffic in excess of 23,000 passengers per hour per direction initially, and is expandable to accommodate 48,000 passengers per hour, per direction. The rail system has a total fleet of 73 Czech-made modern air-conditioned rail cars, of which up to 60 cars in three-car trains are operated daily during the peak hours. Each train can seat 216 passengers and carry under crush capacity 1,182 passengers.

This line has been losing its carrying capacity in the recent years due to unavailability of rolling stock, reaching critical levels in 2015, and also providing a lower-than-standard level of service due to often power interruptions, signaling problems, and even derailments.

It is expected that in the coming month this situation will improve with the introduction of new rolling stock from China, the implementation of the common ticketing system, and some systems enhancements.

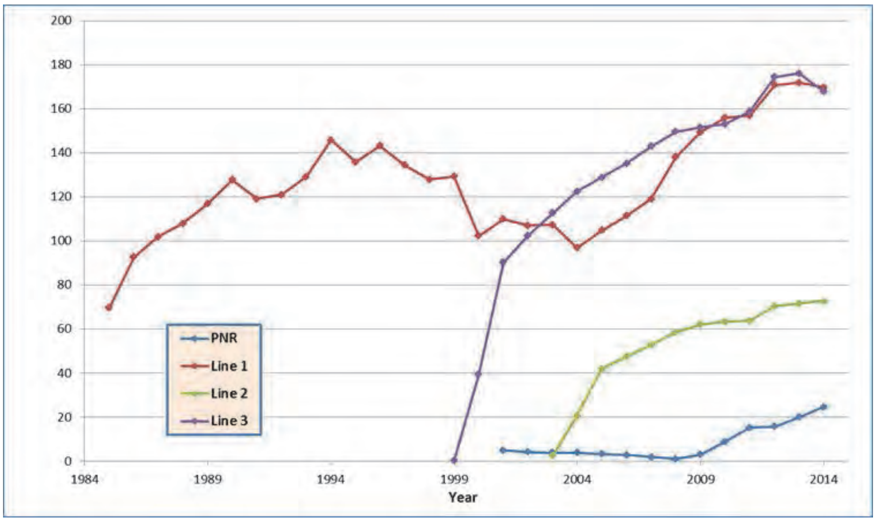
Source: *http://www.mb.com.ph*

Figure 2.4.1.4-1 MRT Line 3 on EDSA



Source: *MRTC/DOTC*

Figure 2.4.1.4-2 Annual Patronage of MRT Line 3



Source: *PNR/LRT/MRTC/DOTC*

Figure 2.4.1.4-3 Annual Patronage of PNR, LRT Lines 1/2 and MRT Line 3

Table 2.4.1.4-1 shows a summary of the main parameters of the three existing railway lines.

Table 2.4.1.4-1 Main Parameters of Railway Lines in Manila

Item /Description	LRT Line 1	LRT Line 2	MRT Line 3
Structure Type	Elevated track with PC-I beams	Elevated PC concrete box girder	Elevated & underground track with PC-I beams
Route Length	20.35km	13.52 km	16.9 km
No. Stations	20	11	13
Track Gauge	1435 mm	1435 mm	1435 mm
Min. curve radius	170 m main line, 28 m in yard	175m main line, 100m depot	370m main line, 25m depot
Maximum gradient	4.0%	5.0%	5.0%
Car-body length	26,000 mm (G2,G3) 29,280 (G1	22,500 mm	31,720 mm
Height	3,320 mm (G2) 3,272 (G1) 3,350 (G3)	3,700 mm	3,250 mm
Car-body width	2,590 mm (G2, G3) 2,485 (G1)	3,200 mm	2,500 mm
Axle load	10.7 tons (G2) 8.7t (G1) 10.3t (G3)	16.6 ton	8.8 ton
Train make-up	4 cars/train (G2, G3); 3 (G1)	4 cars/train	3 cars/train
Capacity	1,358 pax/train (G3 formation)	1,628 pax/train	1,182 pax/train
Max, Speed	60 km/h	80 km/h	65 km/h
Rolling Stock Maker	G1 Original: Bombardier G2 Capex I: Adtranz G3 Capex II: Kinki Sharyo	ROTEM Toshiba	CKD Tatra Mitsubishi Heavy Industry (MHI)
Scheduled Speed	38 km/h	32.8 km/h	30 km/h
Signalling	ATP, ATS	ATP, ATO, ATS	ATP, CTC
Fare	Distance-wise. Min P12, max P20	Distance-wise. Min P12, max P15	Distance-wise. Min P9.5, max P15
Voltage	750 kV DC	1500 V DC	750 kV DC
Feeder system	Over Head Contact	Over Head Contact	Over Head Contact
Travel Time	53 minutes	30 minutes	30 minutes
Headway	112 sec. (after Capex 2 Project)	Min. 1.5 minutes	Min .3 minutes
Cost (US$ Millions)	$500, or $35 per km (₱ 3.5 billions of 1982)	$850, or $61.6 per km	$698, or $41.3 per km

Source: *JICA Study Team*

2.4.2 Railway Sector Future Projects

In addition to the Metro Manila Subway Project (MMSP), the following projects are being proposed, either by Government agencies or private investors, for future implementation.

2.4.2.1 Line 1 South (Cavite) Extension Project

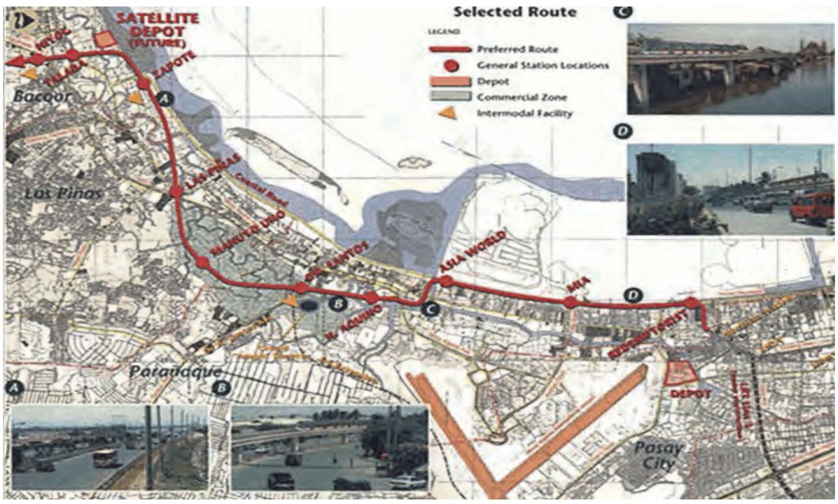
The project aims to extend the existing 20.35 km LRT Line 1 System southward by an additional 11.7km, of which approximately 10.5km will be elevated and 1.2km will be at-grade. The South Extension will start from the existing line's last station at Baclaran and will traverse the cities of Parañaque and Las Piñas in Metro Manila and reach the municipality of Bacoor, Province of Cavite. The extension will initially include 8 new passenger stations with a provision for 2 additional passenger stations. A satellite depot for light rail vehicle (LRV) storage and light maintenance will be located at Zapote, near the southern end of the proposed line. Intermodal facilities will also be installed at high-demand stations.

The key features of the Line 1 Cavite Extension Project, based on the project study conducted by JICA, are as follows.

- Interconnectivity to the existing Line 1 at Baclaran Terminal to form a continuous line and transport more people
- Compatible technology with the existing Line 1 to permit through running of trains
- Integrated fare collection system, with ticket commonality for seamless travel
- Intermodal facilities at three high demand stations
- Common maintenance facility for the extension and the existing Line 1 in Pasay City

The project seeks to (a) immediately provide safe, reliable and environment-friendly transportation services in Metro Manila and the suburbs; (b) immediately alleviate the worsening traffic condition in the Paranaque-Las Pinas-Cavite area and (c) catalyze commercial development around the rail stations. Figure 2.4.2.1-1 shows proposed alignment for this project. The current status of the project, as of May 2015 is as follows:

- The concessionaire has been selected and awarded, and Concession Agreement (CA) was signed on 2nd October 2014. The contract was awarded to the Light Manila Rail Corporation (LRMC)
- The contract for Consulting Services for the Grantors' portion (Japanese ODA Loan) was awarded to the CMX Consortium. The mobilization started on 2nd February 2015.



Source: *LRTA Data*

Figure 2.4.2.1-1 Line 1 South (Cavite) Extension Project Proposed Alignment

2.4.2.2 Line 2 East Extension Project

The Line 2 East Extension Project consists of extending the elevated tracks of Line 2 by approximately 4.1 km from its current terminus in Santolan to the Masinag market in Antipolo along the center-line of Marcos Highway and provision of 2 new stations. Two stations will be constructed: (a) the Emerald Station straddling Imelda Avenue and adjoining Robinson’s East Mall and the Sta. Lucia East Mall in Cainta, and (b) the Masinag Station near the Masinag market at the crossroad of Marcos and Sumulong Highways. The works for Line 2 extension does not require right-of-way acquisition, no procurement of rolling stock, and no depot expansion.

These works are again to be executed by two mechanisms. In this case, (a) the Government of the Philippines (GOP) shall fund the engineering consultants to prepare the detailed design, assist the client with the procurement and supervise construction of the civil and structural works; and (b) the Japanese ODA Loan through JICA will be used to procure the E&M systems and trackworks of the extended section, including integration with the existing system.

The current status of the project, as of May 2015 is as follows:

- The Detailed Design Consultant for the Civil works was selected, mobilized and already completed the detailed design of the viaduct works, and concept design for the Design and Build contract for the two stations. The Consultant is the Consortium formed by FDSC, KRNA, and Soosung from Korea.
- The contract for the viaduct civil works was awarded to D.M. Consunji Inc., and they were mobilized by the end of April 2015.
- The contract for Consulting Services for the E&M works’ portion (ODA Loan) was awarded to the CMX Consortium. The mobilization started on 2nd February 2015.

2.4.2.3 Metro Rail Transit Line 7 Project

The Metro Rail Transit Line 7 (MRT-7) will be the fourth rapid transit line to be built in Metro Manila. When completed, the line will be 23 km long with 14 stations, and will be operated by the Universal LRT Corporation (ULC). The line will run in a northeast direction, traversing Quezon City and a part of Caloocan City in Metro Manila before ending at the City of San Jose del Monte in Bulacan province. Passengers will be able to transfer to the Yellow Line and Blue Line through the Metro Manila Integrated Rail Terminal (a.k.a Common Station) that will link the three lines at North Avenue in Quezon City.

Under the proposal, the project will have a combined 45-km of road and rail transportation running from the Bocaue exit of the North Luzon Expressway (NLEX) to the intersection of North Avenue and EDSA. The 22-km, 6-lane asphalt road will connect the NLEX to the major transportation hub development in San Jose del Monte. The 23-km mostly elevated MRT starts from there and ends at the integrated station beside SM City North EDSA.

The construction period is expected to last 3-1/2 years. ULC will operate and manage the system on behalf of the government over 25 years while gradually transferring ownership of the system to the government in proportion to payments of annual capacity fees. Figure 2.4.2.3-1 shows proposed alignment for this project.

Currently, the project is in the final stage of financial closing.

Source: *LRTA*

Figure 2.4.2.3-1 MRT-7 Project Proposed Alignment

2.4.2.4 North-South Railway Project (NSRP)

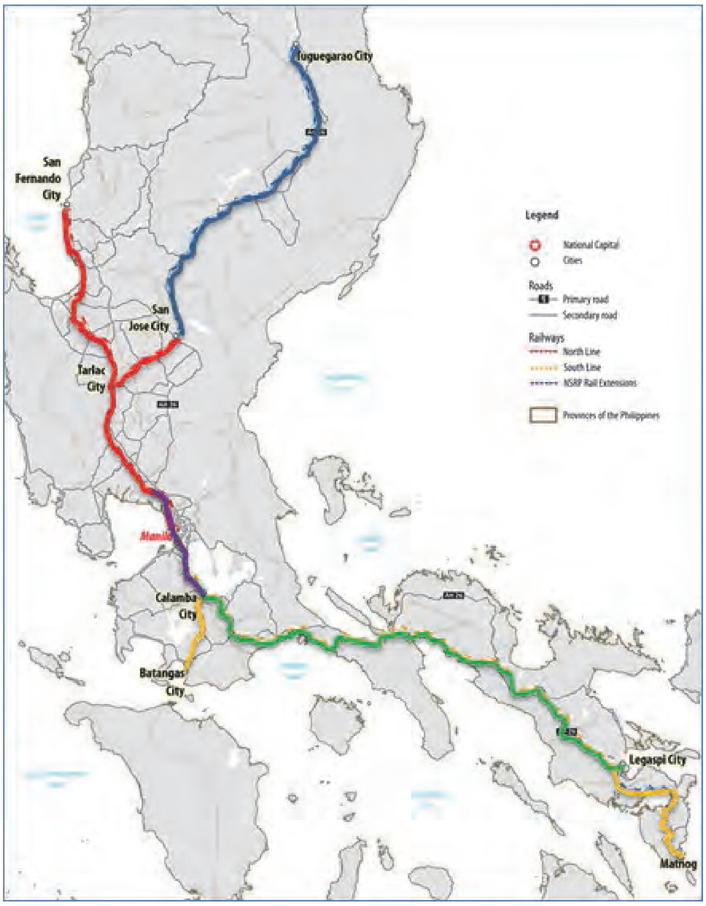
The north part of North-South Railway Project, formerly known as North-South Commuter Railway Project, was envisioned at the beginning of the Pre-Feasibility Study of 2012 as a commuter line that will eventually link Clark to NAIA with the intention of combining an Airport Rail Express Service with the Commuter Service within the same infrastructure. Later, changes were made regarding the alignment based on study findings, coordination with relevant agencies, and deliberations and decisions within DOTC. Alignment changes such as Clark to FTI in Manila, then shortening the north terminal to Malolos and extending the service to the south (i.e., Calamba), and dropping the Airport Rail Express Service were considered. Since middle 2012, two studies have been carried out where the horizontal and vertical alignments have been investigated, together with other parameters such a demand, environmental and social impacts, E&M systems, and operation plan, among others.

Among the conclusions from the mentioned studies is the decision to follow the PNR Right of Way (ROW) as the basic horizontal alignment for the entire length of system. However, as the selected alignment is also shared with three different highway projects by DPWH, the vertical and horizontal alignments between the Caloocan – FTI Section have been challenging due to its huge cost and severe environmental/social implications for all projects involved. Despite this, as a result of coordination with GOP, the NSRP has been envisioned as follows:

- North South Commuter Railway Project (Phase 1): North part of the NSRP, i.e. Malolos Station to Tutuban Station, requested by GOP to GOJ to be funded by Japanese ODA Loan. The Tutuban Station is planned to be built adjacent to Recto Avenue, where Tutuban

Shopping Mall is currently located. GOJ/JICA and GOP are currently under discussion on the request.

- Phase 2: South part of the NSRP to branch off from Solis Station toward the South until Calamba, providing a commuter services that will operate seamlessly with the NCR in the north. This project would be implemented under PPP Scheme. Asian Development Bank (ADB) has been nominated a Financial Transaction Advisor for this project, and bidding is expected by early 2016. This section will also offer long distance services towards the southern cities of Luzon Island.



Source: *DOTC and JICA Study Team for NSCR*

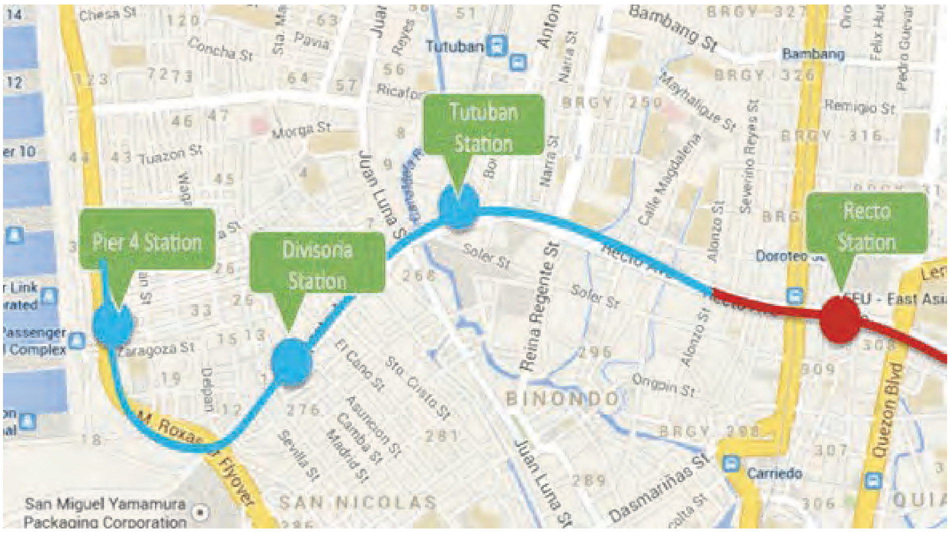
Figure 2.4.2.4-1 North-South Railway Project Master Plan

2.4.2.5 LRTA Line 2 West Extension Project

This newly effort for implementing this project was initiated by the Department of Transportation and Communications (DOTC) and the Light Rail Transit Authority (LRTA) in the light of the impending implementation of phase 2 of LRT-2 (extension to the East). Thus, the project can be classified as phase 3 of LRT-2 System.

There is very little to add (or subtract) on the technical aspects of the Line 2 west extension project – as the subject has been addressed and rehashed in the aforementioned two earlier studies. Besides, logic dictates that any extension should follow the technology of the existing Line 2 system. The focus of this effort is therefore on the re-planning of the extension in the light of a firm decision to include the effect of the North South Railway (NSRP) Project – with Tutuban/Divisoria as its terminal hub.

This project, the LRT-2 Phase 3, focuses on the western extension of LRT Line 2, from the existing Recto Station in the east to Tutuban PNR Station near the Divisoria market and further to Pier 4 along Road R10 for about 3 km. It would have three (3) additional stations. Figure 2.4.2.5-1 shows the proposed three stations and alignment.



Source: *DOTC Line 2 West Extension Study*

Figure 2.4.2.5-1 Proposed Alignment and Stations for Line 2 West Extension

The objective of the Line 2 Phase 3 project is to extend the existing Line 2 westward, in accordance with the MMUTIS Plan (1999) as well as the more recent Transport Roadmap Study for the Greater Capital Region (2014). The design parameters will essentially be the same as those of the original line. The Tutuban Station is foreseen to be a major transfer station – or a common station for NSRP Commuter Service and LRT-2, and thus strengthens the interconnectivity of the evolving mega Manila rail network. Figure 2.4.2.5-2 shows a concept design of the future Tutuban Station Hub area.

Source: *JICA TOD Study*

Figure 2.4.2.5-2 Future Tutuban Station Hub Area

This project has been approved by NEDA to be implemented under General Appropriations Act (GAA) funding.

2.4.2.6 East West Railway (EWR) Project

East West Railway Project, originally called MRT-8 East Rail, was based on the concept developed by a private group (ATS), and the first alignment concept was traversing portions of Manila in Sta. Mesa, Mandaluyong, Pasig, Quezon City and Rizal. It was about 17-km long and had 16 stations and a depot on a 13 ha lot owned by Filinvest, 1.75km from San Juan station in Cainta. This unsolicited proposal was put on hold in 2009.

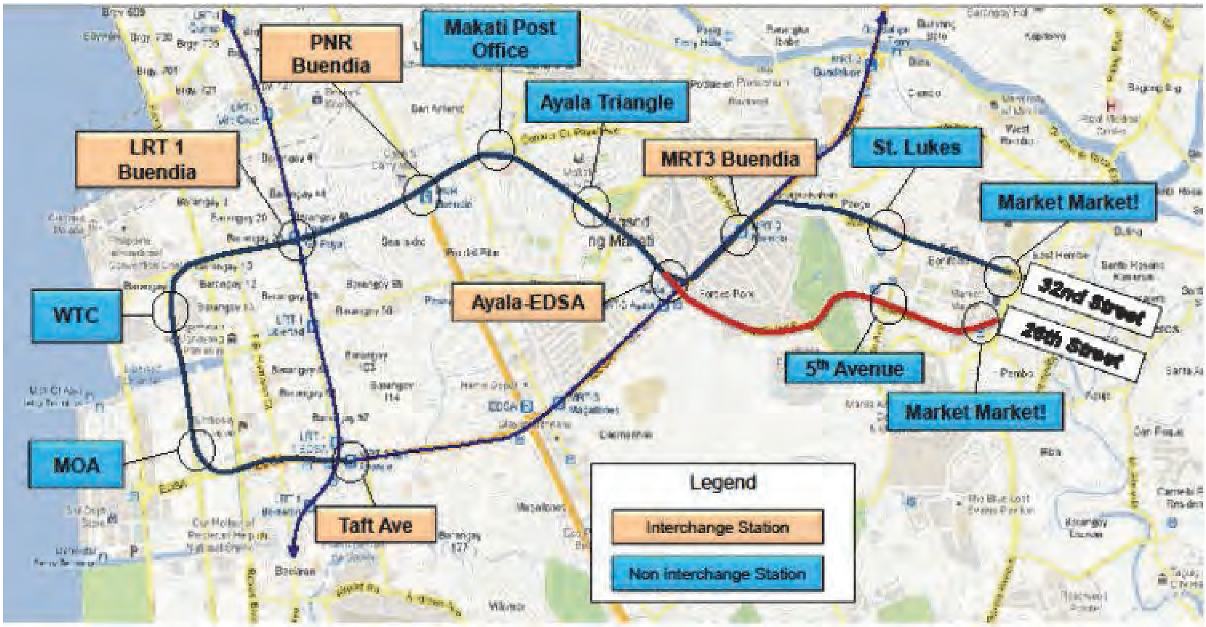
In September 2014, METI has conducted a Pre-Feasibility Study to revive this project called "Study on Medium Capacity Transit System Project in Metro Manila", which proposed a modified alignment from Cainta city, taking Ortigas extension, then turning into ADB Avenue in Ortigas CBD, then Shaw Blvd., crossing EDSA and continue until Aurora Blvd. connecting to Line 2 at V. Mapa station, with a total of 18.8km, 2.2 of them underground, 12 stations, and incorporating an AGT System. The study was completed in March 2015.

Source: *METI Study on Medium Capacity Transit System Project in Metro Manila*

Figure 2.4.2.6-1 Proposed Alignment for EWR

2.4.2.7 Mass Transit System Loop (MTSL)

This project, also known as "Makati Loop", was proposed to construct a subway system between Bonifacio Global City (BGC) and reclamation area, passing by Makati CBD. The estimated project cost indicated in the website of Public-Private Partnership (PPP) Center of the Philippines is 135 billion pesos or USD 3 Billion, as of May 2015.



Source: *DOTC*

Figure 2.4.2.7-1 Proposed Alignment for MTSL

2.4.2.8 Global Cities Mass Transit (GCMT) Project

Pre-FS Study was carried out by Ministry of Economy, Trade and Industry (METI) of Japan in 2012 proposing a monorail system between Makati CBD, and Global cities of BGC, McKinley Hills, McKinley West, Newport, and NAIA Terminals 1, 2 and 3, and finally with Line 1 Cavite Extension. Cost estimated for the project is 70 billion pesos. The Project is currently on-hold.

Source: *BCDA*

Figure 2.4.2.8-1 Proposed Alignment for GCMT

2.5 Existing Railway Network and Transport Capacity

There are three mass transit urban railway lines in Metro Manila, and a commuter mainline railway (PNR) as illustrated in Figure 2.4-1 in the previous section. The key features are:

(1) PNR –28.0 km line with 16 stations, narrow gauge commuter rail, from Tutuban to Alabang

(2) LRT Line-1 18.1 km with 20 stations, standard gauge grade-separated mass transit system, from Baclaran in the south to Roosevelt in the northern section of EDSA;

(3) LRT Line-2 12.6 km with 11 stations, standard gauge mass transit system, from Recto in Manila city to Santolan in the east;

(4) MRT Line-3 16.9 km with 13 stations, standard gauge mass transit system along EDSA (C-4), from Taft to North Avenue.

The three mass transit lines and PNR commuter in Metro Manila carried about 1.35 million passengers on an average week-day in 2012 (the PNR carried a small proportion of about 46,000 passengers). The daily demand and line capacity characteristics of each line are summarized in Table 2.5-1. The three mass transit lines combined carry about 10% of the public transport passenger-km of travel within Metro Manila, compared to 48% by jeepney and 42% by buses on about 850km of roads. This is a fairly good performance compared to traffic with just 51.3km of mass transit railways with 44 stations (excluding PNR), for a city of over 12 million inhabitants.

Table 2.5-1 Characteristics of Railways in Metro Manila

Description		PNR[2)]	LRT Line1	LRT Line2	MRT Line3	Total Railway
Line Length (km)		28.0	18.1	12.6	16.9	75.6
No. of Stations		16	20	11	13	60
2011 Annual Pax (million)		15.4	156.9	63.8	158.8	394.9
2011 Average Weekday Daily Pax (1,000)		46	476	193	481	1,196
2012 Average Weekday Daily Pax (1,000)[1)]		50	519	212	572	1,348
AM-peak Hour Boarding Pax/hr		2,000	43,200	18,000	48,100	111,300
Peak Line Volume (Max: Pax/hr/direction=pphpd)		1,000	20,100	11,500	20,300	20,300
Current Operational Headway (min.)		30	3	5	3	-
Current Rolling Stock Crush Capacity (Pax/train)		max. 500	1,350	1,600	1,180	-
Current Line capacity (Pax/hr/direction=pphpd)		1,000	27,100	19,500	23,600	-
Current Load Factor (Line Volume/Capacity)		max. 100%	74%	59%	86%	-
Maximum Future Capacity[3)] Assuming extended trains to full platform length & rolling stock with modern technology	Train Length (m)	160 - 170	110	110	153	-
	Pax/Train	2,268	1,358	1,628	1,576	-
	Headway	6 min.	112 sec.	1.5 min.	2.5 min.	-
	Pax/hr/dir=pphpd	22,380	40,000	65,000	46,000	-

Source: *PNR/ LRTA/ MRT Data &JICA Study Team Analyses*

Note 1: LRT Lines 1&2 Data is for Mar-12, MRT Line-3 Data for Sep-12, and PNR for Feb-12.
Note 2: PNR Data is for Tutuban to Alabang and peak period data is estimated by the study team.
Note 3: Future Capacities are estimated based on possible capacity expansion program.

2.6 Necessity of Mega Manila Subway Project and Issues in Implementation

There are currently 4 railways in operation in the Philippines, which are PNR, LRT Line 1, LRT Line 2 and MRT Line 3. Except the PNR's railway operation, all other railways are functioning as the mass rapid transit in the central area of the National Capital Region (NCR). Such mass rapid transit systems in the central area are contributing to the social and economic activities as one of the major transportation systems for the transportation of commuters, residents, travelers, etc., inside the central area of the NCR, covering west to north areas by LRT Line 1, east to south areas by MRT Line 3 and east-west direction through cities of Manila, San Juan, Quezon and Pasig by LRT Line 2. Commuters working in the central area of the NCR coming from northern and southern parts of the NCR or even further north/south of the NCR boarders use private cars, buses, UV Express, jeepneys, etc. or combination of them until they reach the central area where there are mass rapid transit systems. Due to the high congestion of railways and the inconvenience of transfer from vehicles to railways, many commuters even continue using vehicle transportations going to their destinations in the central area of the NCR, which accelerates the traffic congestion in the central area as well as other areas of the NCR.

In order to fundamentally alleviate such heavy traffic congestion in the central area of the NCR as well as NCR borders and beyond, it is essential to have a railway network connecting the suburban areas and the central area of the NCR. Due to its geological feature of the area surrounding the NCR, the expansion of populations and commercial areas is toward both north and south direction. Therefore, it is apparent that railways connecting suburban areas and the central area of the NCR shall be provided in north-south direction.

To achieve such objective, there is a master plan to construct north-south railway utilizing the right of way of the PNR, called North-South Railway Project, being studied by JICA for Phase 1 (Malolos – Tutuban, 37km) in the north part and by PPP Center for Phase 2 (Tutuban-Calamba, 56km) in the south part, where the corridor will be northwest to southeast through Tutuban in the central area of the NCR. The construction of the south extension of LRT Line 1 has just started and there is a plan to further extend the line to the south, down to Dasmarinas in the province of Cavite. As to the north part, Universal LRT Corporation (BVI) Limited has been given a concession to construct, operate and maintain a new mass rapid transit system, namely MRT Line 7, connecting between the north part of the central area of the NCR at north part of EDSA and east of Caloocan North, with possible extension to further north up to San Jose Del Monte.

Although various plans have been made to connect the central area of the NCR and suburban areas at north and south as mentioned above, there is a vacant space in both north and south suburban areas, which are the central parts. Considering the existing populations of the central parts of north and south suburban areas and the expected grown in the future in these areas, it is obvious that a railway connecting the central NCR and these areas are of essential and also of importance to alleviate the traffic congestions connecting these suburban areas and the central area of the NCR. Hence, the Mega Manila Subway Project (MMSP) was proposed in the Roadmap Study to function as the 2nd north-south transport backbone in the Greater Capital Region.

2.7 Status of Land Acquisition and Current Usage of Right of Way for MMSP

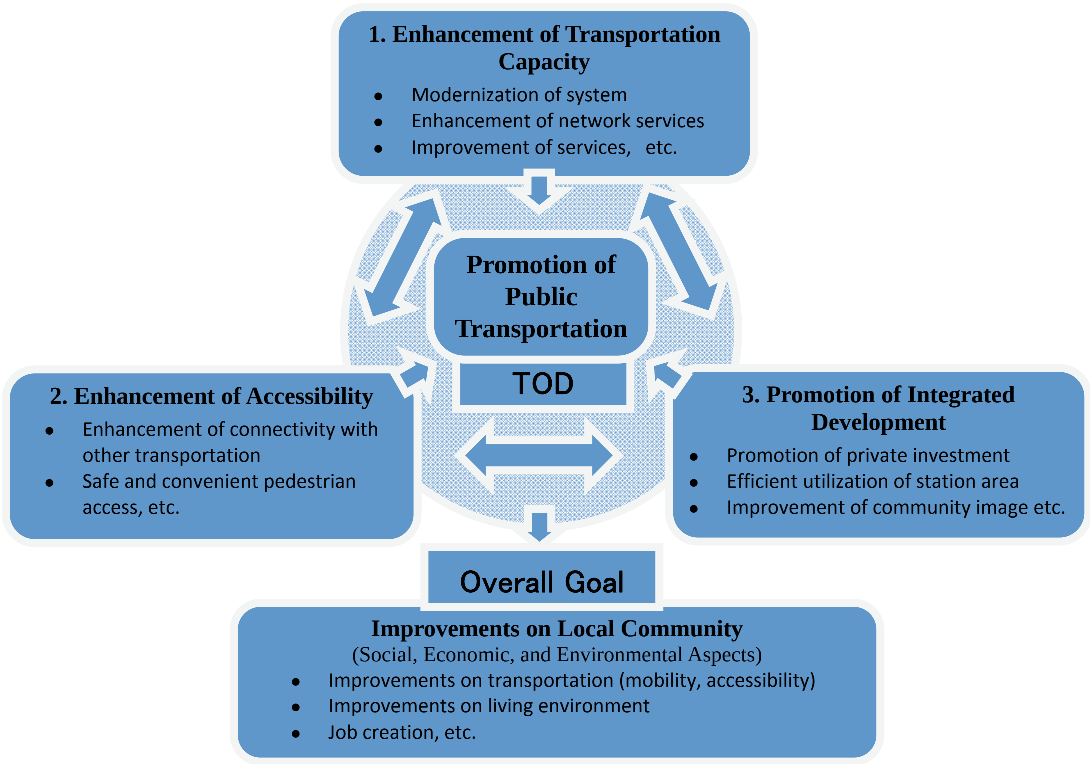
Although the development of the MMSP initiated in the Roadmap Study has been acknowledged in the government of the Philippines as one of the new railway projects required in the Philippines in near future, there has been no action made to date regarding the land acquisition. Land acquisition can be started after the Feasibility Study is completed and the proposed route is approved. The expected Right of Way (ROW) for the MMSP is currently partially used as roads, either trunk roads or local roads, while some portions are occupied and used either by private owners or as public space. Although the alignment of the MMSP has been planned utilizing the existing roads to the maximum extent, land acquisition will be required in areas with no existing roads, with narrow road width and on private properties. Details are described in Chapter 12.

2.8 Transit Oriented Development (TOD)

2.8.1 Concept and Objectives of TOD

TOD is a development approach that promotes public transportation with the multiplier effects through the integration of transportation development and other types of development such as commercial, office, and residential development in the vicinity of mass transit stations.

As Figure 2.8.1-1 shows, the enhancement of transportation capacity and accessibility as well as the promotion of integrated development are essential to implement successful TOD that contributes to promotion of public transportation.



Source: *Preparatory Survey on Promotion of TOD for Urban Railway in the Philippines (JICA, 2015)*

Figure 2.8.1-1 Concept of TOD

2.8.2 Practice and Schemes of TOD

Japan has a long history of railway transportation and many successful TOD cases for access improvement and integrated development along the railway corridor. Through PPP schemes, experience and resources in the private sector have been utilized to implement the integrated development including the development of public transportation facilities. In Japan, schemes of land readjustment and urban redevelopment have been adopted to develop and manage the public transportation facilities. The projects implemented under these schemes also promote the intensification of land use by the construction of the multi-layer facilities such as a pedestrian deck and multistory parking. Regarding the land intensification, Japanese good practices of utilization the space under the viaduct for commercial and public facilities including public transportation facilities also can be referred to the integrated development along the MMSP.

Some major examples of integrated development in Japan and mechanism of the schemes for integrated development in Japan are referred in Appendix A (1) and Appendix A (2), respectively.

2.8.3 Current Situation of TOD in Metro Manila

In Metro Manila there are three LRT/MRT lines and PNR currently used for the urban transportation. However, each railway line is developed independently and there is very limited coordination between lines to physically connect each other for smooth transfer. There is also less consideration in providing transit spaces for bus and jeepney at railway station. This situation causes for the passengers inconvenience in transferring between public transport modes.

TOD is also not realized in Metro Manila. Railway stations and bus/jeepeny terminals are not constructed integrated with the urban development of adjoining area both areas in urban and sub-urban. Urban developments in suburban area are fully depending on the road network.

When new railway project is implemented in Metro Manila, it is indispensable to incorporate the TOD concept In order to promote the use of railway and maximize the benefit and positive impact of railway development.

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Chapter 3

CURRENT STATUS AND REVIEW OF ISSUES OF LEGAL FRAME FOR USAGE OF SUBTERRANEAN SPACE

Chapter 3 CURRENT STATUS AND REVIEW OF ISSUES OF LEGAL FRAME FOR USAGE OF SUBTERRANEAN SPACE

3.1 Present Situation of Laws and Regulations for Ownership and Usage Right of Subterranean Space

The plan for the construction and operation of a Subway in the Philippines is a novel proposition. This is perhaps the first time that the Philippine government is seriously considering this modern method of mass transportation.

It is critical for projects of this scale to operate under a clear legal framework for the compulsory acquisition of land and right of way. More often than not, infrastructure execution is bogged down due to the inability to secure crucial land access and work areas to implement the undertaking. Without a clear inventory of legal and obligatory methods available to project proponents, the endeavor might be at a loss with regard to methods and means to efficiently hurdle problems associated with the purchase of land.

It should be understood, however, that this endeavor is the first of its kind here in the country. The proponent must realize that this is a pioneering project and there may be gaps in law and regulation that will be needed to filled up. Moreover, the Philippines, as a country, has not developed laws that regulate subsurface rights and subterranean space. Hence, existing regulation on the matter simply does not exist, and related legislation which does exist, pertains only to surface and airspace rights.

This section of the study aims to visit the existing laws and regulations to catalog the legal and regulatory tools available that may be used in this new frontier of transportation development.

3.1.1 Right-of-Way Implementing Agencies

The power of eminent domain, as mentioned in the prefatory portion of the study, is the ability of government of compulsory appropriation of private property for public use though the payment of just compensation. For the purposes of the project, we have identified the two main government agencies that will play a curtail role in land acquisition and right of way purchases: The Department of Transportation and Communication and the Department of Public Works and Highways.

Philippine Track projects have always been executed through a collaboration between the Department of Public Works and Highways (DPWH) and Department of Transportation and Communication (DOTC). Between these two government agencies, the government power of compulsory land acquisition is exercised.

The DPWH, as the lead agency for public infrastructure and road projects, is experienced and well-versed with expropriation proceedings. It is mandated to “undertake (a) the planning of infrastructure, such as national roads and bridges, flood control, water resources projects and other public works, and (b) the design, construction, and maintenance of national roads and bridges, and major flood control systems.” The Department’s function necessitates that it is empowered to take real property of private individuals and entities and convert the use of these lands to public use or utilization. The DPWH is the sole entity authorized to build, maintain and operate the national road network. It may, however, devolve and delegate its power and responsibilities to other entities like Local Government Units and other public or private entities with its prior permission.

The DOTC, on the other hand, is the premiere government agency tasked to manage and regulate the development of the Philippines’ in the spheres of mass transport and communications technology. It is responsible for the maintenance and advancement of the critical infrastructure placed under its power of control. According to its official webpage “the Department is at the forefront of crucial projects aimed to improve the lives of Filipinos through the efficient use of available government resources.”

The mandates and functions of the DPWH and DOTC are so entwined that, in most if not all government infrastructure projects, they are surely to be found together in collaboration and in partnership. Together they have caused the construction of:

- LRT Lines 1 and 2
- Manila International Airport
- Expansion of the Philippine National Railways
- MRT Line 3

Both departments, in tandem, have caused private property to be turned over to the government for a public use.

3.1.2 Expropriation: Law and Jurisprudence

Compulsory State property acquisition is governed primarily by the 1987 Constitution of the Republic of the Philippines, which prohibits the taking of private property for public use without payment of just compensation[1]. The State's capacity to administer said "taking" contemplated by this constitutional provision is better known as jura regalia, or the power of eminent domain.

Eminent domain is said to be a power inherent in sovereignty and thus, exists organically without need for inclusion in any particular constitution or law[2]. It is therefore apparent that since the Constitution makes mention of the power of eminent domain only when it seeks to limit said power for the protection of the individual, the Constitution itself recognizes that this power emanates not from its introduction in any written document, but rather from the mere existence of the sovereign entity.[3]

Eminent domain partakes of five (5) essential requisites:

(A) There must be "taking";

(B) Said taking must be done by competent authority;

(C) Said taking must be for public use;

(D) The private owner must be paid just compensation; and

(E) The requirements of due process of law must be observed.

What constitutes "taking" under the power of eminent domain has been generally defined by the Supreme Court as "entering upon private property for more than a momentary period, and, under the warrant or color of legal authority, devoting it to a public use, or otherwise informally appropriating or injuriously affecting it in such a way as substantially to oust the owner and deprive him of all beneficial enjoyment thereof."[4]

It is important to note that, in order to understand the threshold of "taking" in the relevant sense, full use of the entire property in question is not at all required before the constitutional guarantee of recompense under Section 9, Article III thereof becomes applicable. On this note, the Court has opined that "ownership is nothing without the inherent rights of possession, control and enjoyment."[5] Thus,

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[1] 1987 PHILIPPINE CONSTITUTION, Art. III, § 9.
[2] BERNAS, S.J., JOAQUIN G. THE 1987 CONSTITUTION OF THE REPUBLIC OF THE PHILIPPINES: A COMMENTARY. REX BOOK STORE, (2003).
[3] Visayan Refining Co. v. Camus, 40 Phil. 550, 559 (1919).
[4] Republic v. Vda. de Castellvi, et al. G.R. No. L-20620. August 15, 1974.
[5] Municipality of La Carlota v. National Waterworks and Sewerage Authority. G.R. No. L-20232. September 30, 1964.

as soon as the private owner is deprived of the "ordinary and beneficial use" of his property, or of the value thereof, there is already "taking" in the constitutional sense[6].

Categorically, the Court has also ruled that "taking" under the power of eminent domain can partake of the nature of an easement or right-of-way[7]. In another case, the Court found occasion to declare:

> *"Nominally, the power of eminent domain results in the taking or appropriation of title to, and possession of, the expropriated property; but no cogent reason appears why the said power may not be availed of to impose only a burden upon the owner of condemned property, without loss of title and possession.*
>
> *It is unquestionable that real property may, through expropriation, be subjected to an easement of right of way."*[8]

On this particular score, however, the Court has also decided that even where the State acquires only an easement of right of way over private property, the private landowner is still entitled to just compensation based on the full value of his property, if he/she is deprived of full enjoyment of his/her property.[9]

Another requisite for the exercise of the power of eminent domain is that the taking must be done by competent authority. Broadly speaking, the taking must be done by the State, through the executive branch of the government clothed with authority from the legislature.[10]

Jurisprudence has also held that the legislature may, within its mandate, delegate the power to expropriate to other entities within the State, such as (but not limited to) municipal corporations, other government entities, and public service corporations.[11]

The third requisite for a valid expropriation is that the taking must be for public use, which has been identified or likened with "public benefit," "public utility" or "public advantage.[12]" Consequently, the "necessity" of the expropriation is also appreciated as a natural component of public use. It has been ruled, however, that only a reasonable necessity, rather than an absolute necessity, is required.[13]

It is not necessary, however, that the entire public actually benefits from the expropriation. Indeed, the Supreme Court has opted to look at "public use" in a much broader sense, liberally assigning "indirect benefit" to the general public even if the actual use of the expropriated property is limited only to a select few.[14]

The fourth requisite for a valid expropriation is the payment of just compensation to the private owner of the expropriated property. Just compensation has been defined as "the just and complete equivalent of the loss which the owner of the thing expropriated has to suffer by reason of the expropriation,[15]"

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6 Id.
7 National Power Corporation v. Gutierrez, et al. G.R. No. L-60077. January 18, 1991.
8 Republic of the Philippines v. Philippine Long Distance Telephone Company. G.R. No. L-18841. January 27, 1969.
9 National Power Corporation v. Manubay Agro-Industrial Development Corporation. G.R. No. 150936. August 18, 2004.
10 Visayan Refining Co. v. Camus, 40 Phil. 550, 559 (1919).
11 City of Manila v. Chinese Community of Manila. 40 Phil 349 (1919); Teneria v. Manila Railroad Co. 22 Phil. 111 (1912).
12 Guido v. Rural Progress Administration. 84 Phil. 847 (1949).
13 Manila Railroad Co. v. Mitchell. 50 Phil. 382 (1927).
14 Phil. Columbian Assn. v. Panis, 229 SCRA 668 (1993).
15 Province of Tayabas v. Perez. 66 Phil. 467, 469 (1938); City of Manila v. Estrada. 25 Phil. 208, 234 (1913).

"which should be neither more nor less, whenever it is possible to make the assessment, than the money equivalent of said property.[16]" This is considered the true measure of the indemnity, as opposed to whatever gain would accrue to the expropriating entity[17]. The State's obligation to pay just compensation, being a constitutional guarantee in favor of the private individual, is never extinguished by statutory prescriptive periods.[18]

Quantitatively, just compensation is based on the property's actual "market value," which has been defined as "the price fixed by the buyer and seller in the open market in the usual and ordinary course of legal trade and competition; the price and value of the article established or shown by sale, public or private, in the ordinary way of business; the fair value of property as between one who desires to purchase and one who desires to sell; the current price; the general or ordinary price for which property may be sold in that locality."[19]

The Court has also held that, along with the actual value of the property to be taken, just compensation must also account for "consequential damages," or damages to other interests of the private owner that may be attributed to the expropriation.[20] Just compensation may also be owed to persons other than the private owner, who possess lawful interest in the property to be expropriated, such as mortgagors, lessees and vendees in possession under an executory contract.[21]

It is also important to consider the actual time as to when just compensation is to be reckoned. The general rule, as declared by the Court, is that "Just compensation is computed at either the time of taking or the institution of the expropriation proceedings, whichever is earlier."[22] This hornbook principle was reinforced by the Court when it made the following pronouncement in the case of Republic v. Lara:[23]

> *"Where property is taken ahead of the filing of the condemnation proceedings, the value thereof may be enhanced by the public purpose for which it is taken; the entry by the plaintiff upon the property may have depreciated its value thereby; or, there may have been a natural increase in the value of the property from the time the complaint is filed, due to general economic conditions.*
>
> *The owner of private property should be compensated only for what he actually loses; it is not intended that his compensation shall extend beyond his loss or injury. And what he loses is only the actual value of his property at the time it is taken."*

However, the Court also effectively introduced an exception to this rule in the case of National Power Corporation v. Court of Appeals[24], when it opined that in situations where the property value increases between the time of taking and filing, <u>independently of the expropriator's participation or influence</u>, then just compensation is to be computed as of the time of the later event.
Moreover, in cases where the State does not indemnify the private landowner for the use of his property from the time of taking, the latter is entitled to legal interest on the price of the land from the

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[16] National Power Corporation v. Gutierrez, et al. G.R. No. L-60077. January 18, 1991.
[17] J.M. Tuason and Co., Inc. v. The Land Tenure Administration, et al. G.R. No. L-21064. February 18, 1970.
[18] National Power Corporation v. Heirs of Macabangkit Sangkay. G.R. No. 165828. August 24, 2011.
[19] Manila Railroad Co. v. Fabie. 17 Phil 206,208 (1910); City of Manila v. Corrales. 32 Phil. 85, 92, 98 (1915).
[20] BERNAS, S.J., JOAQUIN G. THE 1987 CONSTITUTION OF THE REPUBLIC OF THE PHILIPPINES: A COMMENTARY. REX BOOK STORE, (2003).
[21] Id.
[22] Ansaldo v. Tantuico. G.R. No. L-50147. August 3, 1990.
[23] 50 O.G. 5778 (1954).
[24] G.R. No. 113194. March 11, 1996.

time it was taken up to the time that payment is made by the State.[25] In a separate case, the Court also ordered the State to pay the attorney's fees of the private owner upon the conclusion of eminent domain proceedings.[26]

3.1.3 Procedure

The procedure for the exercise of the power of eminent domain is mainly governed by Rule 67 of the Revised Rules of Court of the Philippines. Summarily, said procedure may be outlined with the following steps:

(1) The expropriating authority files a verified complaint with the Regional Trial Court possessing jurisdiction over the location of the property in question[27], and deposits, either simultaneous with or subsequent to said filing, an amount equivalent to the assessed value of the property with an authorized government depositary.[28]

(2) If the court finds the expropriation claim meritorious, it issues an order of expropriation which authorizes the taking of the property upon the payment of just compensation to be determined as of the date of the taking of the property or the filing of the complaint, whichever comes first.[29]

(3) Upon the rendition of the expropriation order, the court appoints not more than three (3) competent and disinterested persons as commissioners to recommend to the court the just compensation for the property sought to be taken.[30]

(4) Within a period prescribed by the court, the commissioners submit their report as regards the proper compensation due the private owner[31], and the court, once all parties have had the opportunity to comment, accepts the report and renders judgment thereon.[32]

Effectively, the procedure under the Rules of Court is applied for the purpose of guaranteeing due process of law for the benefit of the private owner, which is the fifth and final requisite for a valid expropriation as enumerated above. This procedure ensures that the private owner is given a full opportunity to present his side on such questions as the existence of public use, the necessity of the taking, and the adequacy of the just compensation recommended by the commissioners and approved by the court.

Recent laws have also streamlined and authorized the taking of property under specific rules. In the acquisition of property and property rights, Section 5 of the Limited Access Highway Act[33] also provides that "the Department of Public Works and Communications may in pursuance of existing law recommend the acquisition of public property and property rights for limited access facilities and service roads, including the rights of access, view and light by gift, devise, purchase or condemnation."[34]

As far as the right-of-way acquisition for national infrastructure and other purposes, Section 4 of the Act to Facilitate the Acquisition of Right-of-way, Site or Location for National Government

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25 Alfonso v. Pasay City. G.R. No. L-12754. January 30, 1960.
26 Amigable v. Cuenca. G.R. No. L-26400. February 29, 1972.
27 1997 RULES OF CIVIL PROCEDURE, rule 67, § 1.
28 1997 RULES OF CIVIL PROCEDURE, rule 67, § 2.
29 1997 RULES OF CIVIL PROCEDURE, rule 67, § 4.
30 1997 RULES OF CIVIL PROCEDURE, rule 67, § 5.
31 1997 RULES OF CIVIL PROCEDURE, rule 67, § 7.
32 1997 RULES OF CIVIL PROCEDURE, rule 67, § 8
33 RA 2000
34 Ibid

Infrastructure Projects and for Other Purposes[35] provides the rules for expropriation proceedings:

B. *Upon the filing of the complaint, and after due notice to the defendant, the implementing agency shall immediately pay the owner of the property the amount equivalent to the sum of (1) one hundred percent (100%) of the value of the property based on the current relevant zonal valuation of the BIR; and (2) the value of the improvements and/or structures as determined under Section 7 hereof;*

C. *In provinces, cities, municipalities and other areas where there is no zonal valuation, the BIR is hereby mandated within the period of sixty (60) days from the date of the expropriation case, to come up with a zonal valuation for said area; and*

D. *In case the completion of a government infrastructure project is of utmost urgency and importance, and there is no existing valuation of the area concerned, the implementing agency shall immediately pay the owner of the property its proffered value taking into consideration the standards prescribed in Section 5 hereof. In the event that the owner of the property contests the implementing agency's proffered value, the court shall determine the just compensation to be paid the owner within sixty (60) days from the date of filing of the expropriation case. When the decision of the court becomes final and executory, the implementing agency shall pay the owner the difference between the amount already paid and the just compensation as determined by the court.*

Moreover, the same law also provides for the following additional methods of acquisition:

1. Quitclaim;
2. Exchange or barter;
3. Donation;
4. Negotiated sale;
5. Expropriation; and
6. Any other mode as provided by law.

Section 5 of RA 8974 sets the standards for the assessment of the value of the land subject to expropriation proceedings or negotiated sale. In order to facilitate the determination of just compensation, the court will consider among other well-established factors such as:

1. The classification and use for which the property is suited;
2. The developmental costs for improving land;
3. The value declared by the owners;
4. The current selling price of similar lands in the vicinity;
5. The reasonable disturbance compensation for the removal and/ or demolition of certain improvements on the land and for the value of improvements thereon;
6. The size, shape or location, tax declaration and zonal valuation of the land;
7. The price of the land as manifested in the ocular findings, oral as well as documentary evidence presented; and
8. Such facts and events as to enable the affected property to have sufficient funds to acquire similarly-situated lands of approximate areas as those required from them by the government, and thereby rehabilitate themselves as early as possible.

[35] RA 8974

3.1.4 LRT and MRT Track Projects

Light Rail Transport Authority/LRT2

In 1966, the government of the Philippines tapped the Japan International Cooperation Agency (JICA) to conduct and draw studies for the modernization of the Philippine traffic and transport system. JICA's study suggested the construction of a series of five (5) circumferential roads and a track-based mass transport system that ran along one of the major highways in the metropolis. Most of the highway recommendations were adopted, which led to development of the C1 to C5 system of roads. However, due to the costs involved in putting up an electric train, mass transport project was shelved.

The mass transport project was again revived a decade later. This time, under a grant coming from the World Bank, Freeman Fox and Associates was asked to improve on the JICA recommendations. The updated study called for an elevated train system to bypass the many intersections that mar Philippine highway. It also increased the projected costs from One Billion Five Hundred Million Pesos (P 1,500,000.00) to Two Billion Pesos in 1977.

On July 1982, The Light Rail Transit Authority was created via executive fiat of President Marcos and two years later, on December 1, 1984, the first line of the LRT was commissioned. The LRTA still manages and maintains the different existing commuter routes, mainly based on Taft Avenue and its intersections.

Metro Rail Transport Corporation/MRT3

The Metro Rail Transit Corporation is a conglomeration of Ayala Land, Inc., Fil Estate Management Inc., Anglo-Phil, Inc., Ramcar Inc., Greenfield Development Corporation, Antel Land Holdings Inc., and DBH Inc, in partnership with the DOTC. It was incorporated not via special charter or law but through the Philippine Corporation Code, similar to local corporations. Under a Build-Lease-and-Transfer scheme, it was envisioned that the different owners the train system would secure the funding to complete and execute the project and lease it to the government. In turn, the Department of Transportation and Communications would hold the franchise and actually operate the public transport system.

Formally inaugurated on July 15, 2000, the MRT opened its lines to serve all of the planned thirteen (13) stations. Since then, it has continually served the riding public, especially those who commute via the expanse of the Epifanio Delos Santos Avenue (EDSA).

ROW Experience

In both mass transport projects, the need was for DOTC or its partners to construct elevated trains, tracks and ancillary structures more or less on existing national thoroughfares that the DPWH operates and maintains. In the case of LRT, it was on Taft Avenue, Manila. For MRT3, it was on Epifanio de los Santos Avenue (EDSA) that stretches from Caloocan to Makati.

It should be taken into consideration that not all structures, buildings and provisions needed for LRT2 and MRT3 are located on government property or national highways. Some facilities like stations and ticketing outlets are on property outside of the thoroughfare boundaries. It was on those locations that DOTC used the expropriation process to garner entry and possession of needed land for the project.

Apart from traversing privately owned properties, many infrastructure projects undertaken by the national government often require passage either through or under national roads, highways, and/or other publicly owned properties. In this regard, it is instructive to note that all such national roads and highways are legally under the management and supervision of the Department of Public Works and Highways. Specifically, Executive Order No. 124 (s. 1987), which reorganizes and redefines the powers and functions of the DPWH, contains the following relevant provisions:

> *Section 3. Declaration of Policy. The State shall maintain an engineering and construction arm and continuously develop its technology, for the purpose of ensuring the safety of all infrastructure facilities and securing for all public works and highways the highest efficiency and the most appropriate quality in construction. The planning, design, construction and maintenance of infrastructure facilities, especially national highways, flood control and water resource development systems, and other public works in accordance with national development objectives, shall be the responsibility of such an engineering and construction arm. However, the exercise of this responsibility shall be decentralized to the fullest extent feasible.*
>
> *Section 5. Powers and Functions. The Ministry, in order to carry out its mandate, shall have the following powers and functions:*
>
> *a) Provide technical services for the planning, design, construction, maintenance, and/or operation of infrastructure facilities;*
>
> *b) Develop and implement effective codes, standards, and reasonable guidelines to ensure the safety of all public and private structures in the country and assure efficiency and proper quality in the construction of public works;*
>
> *XXX*
>
> *e) Ascertain that all public works plans and project implementation designs are consistent with current standards and guidelines;*

It is beyond dispute, therefore, that all public works administered on any and all national roads and highways would require the coordination and consent of the DPWH. This would seem even more applicable in cases of projects proposed and/or undertaken by the DOTC. The Executive Order No. 124-A (s. 1987), amended from Executive Order No. 124 (s. 1987) by adding the below sentences to the previous e) as shown above, which reorganizes and defines the powers and functions of the DOTC, provides in part:

> *e) Coordinate with the Department of Public Works and Highways in the design, location, development, rehabilitation, improvement, construction, maintenance and repair of all infrastructure projects and facilities of the Department. However, government corporate entities attached to the Department shall be authorized to undertake specialized telecommunications, ports, airports and railways projects and facilities as directed by the President of the Philippines or as provided by law;*

For the most part of the two projects, the actual infrastructure and facilities were built right on top of the highways that it needed to service. Hence, the right of way purchases were kept to a minimum. Since Government already owned the land through previous expropriation exercises that caused the highway to be constructed, it was only a matter of formal permission for another government instrumentality to make use of the property.

Pursuant to the clear legal mandate of the DPWH over national roads and highways, and in compliance with the express statutory requirement of direct coordination between the DOTC and DPWH in the development, construction and maintenance of all infrastructure projects undertaken by the former, previous railway projects such as LRT Line 2 and the MRT Line 3 have been attended by the mentioned Memoranda of Agreement executed under the express authority of the DOTC and DPWH Secretaries.[36] Presumably, these Memoranda provide for the following terms and conditions,

[36] Interview with Former DOTC Undersecretary for Planning Dr. Primitivo Cal, March 15, 2015, Mactan, Cebu

among others:

A. The specific area, within DPWH jurisdiction, covered by the provisions of the MOA;

B. The particular DOTC project covered by the provisions of the MOA;

C. An exclusive recital of all permitted works permitted to be undertaken per the agreement of both parties; and

D. The power of the DPWH to supervise all works undertaken on the covered properties, and perform any and all actions reasonably necessary for the purpose.

It is highly reasonable to infer, based on this previous coordination between the DOTC and DPWH that any future project involving the use of public roads and highways shall be made subject to a written Memorandum of Agreement between the two agencies prior to the commencement of any works upon said areas.

The current rules of expropriation, moreover, do not stratify or classify different types of privately owned real property that the state can acquire. The government has plenary and general powers to take, within the rules promulgated, any kind or type of real property from private individuals or entities. Hence, it does not matter whether the property is low-rise, high-rise, underground, aboveground, commercial, residential or otherwise. Once the government has initiated expropriation proceedings by filing the appropriate case and paying the mandated deposit, it can already take possession and enter the property. In fact, in a matter of months, the Government can secure a court ruling giving possession and ownership in its favor. However, in most instances, a long protracted suit with regard to the just compensation due to the previous owners is filed and left to the courts to decide. This may cause a problem with the government and its project proponents because the court may award higher values for land compensation then what was budgeted for the project.

Verily, if the established Philippine expropriation standards are applied to the LRT and MRT Projects, the following conclusions regarding just compensation can be derived:

A. for at least for the portions that ply or are located on top of or on government-owned property such as roads or highways, it need not pay for just compensation for the use of the property,

B. for private property, of any kind or form, needed for the completion of the project, the proponent may rely on the existing rules to appropriate the land, subject to the payment of just compensation as discussed.

3.2 Legal Framework for Compensation to Land Owners and Construction Implementation in relation to Underground Construction

Currently, the primary law on property as regards subterranean areas may be found in Article 437 of the Civil Code of the Philippines, which provides:

> *Art. 437. The owner of a parcel of land is the owner of its surface and of everything under it,*[37] *and he can construct thereon any works or make any plantations and excavations which he may deem proper, without detriment to servitudes and subject to special laws and ordinances. He cannot complain of the reasonable requirements of aerial navigation.*

It has been opined that the term "special laws," as read in the above provision, is all-embracing. Thus, it includes the 1987 Constitution which specifically declares that all minerals and other natural resources found underground are owned by the State.[38] In the 1988 case of Republic of the Philippines v. Court of Appeals,[39] the Supreme Court reinforced this doctrine, while also declaring that since rights over public land are indivisible, there exists no "dividing line" between surface rights and subsurface rights. Thus, under the current state of the law, he who owns the surface ipso jure owns the subsurface, except for any natural resources located therein which are owned by the State.

On the matter of private ownership rights over subterranean portions of land, the 2007 case of National Power Corporation v. Ibrahim, et al.[40] is particularly instructive. In that case, Ibrahim and his co-heirs belatedly discovered underground tunnels constructed by NPC, traversing their property and rendering them unable to commence the construction of a motorized deep well, which they had originally intended. Apparently, NPC had constructed the tunnels in order to siphon water flowing from Lake Lanao and facilitate the operation of several hydroelectric power plants in the area.

In the end, the Supreme Court rejected NPC's contention that its construction of the tunnels did not prevent Ibrahim et al. from utilizing and enjoying the same, particularly with respect to the surface area thereof. It particularly cited Article 437 of the Civil Code as above-quoted, and concluded that notwithstanding the fact that the State only occupied the sub-terrain portion, it was liable to pay not merely an easement fee but rather the full compensation for land since, in this case, the nature of the easement practically deprived the owners of its normal beneficial use.[41]

The Supreme Court later promulgated a final decision in the 2011 case of National Power Corporation v. Heirs of Macabangkit Sangkay[42] which essentially mirrored its disposition of the Ibrahim case. There, it reiterated that NPC was liable for just compensation based on the value of the entire property involved.

As it stands, the current state of Philippine jurisprudence on this matter can be summarised by the following overview below:

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37 Emphasis supplied.
38 PHILIPPINE CONSTITUTION, Art. XII, § 2
39 G.R. No. L-43938. April 15, 1988.
40 G.R. No. 168732. June 28, 2007.
41 Id.
42 G.R. No. 165828. August 24, 2011.

Table 3.2-1 Summary of Current State of Philippine Jurisprudence

CASE NAME AND DETAILS	PURPOSE FOR TAKING	RELEVANT DOCTRINE/S
Republic v. Lara 50 O.G. 5778 1954	Undetermined	Where property is taken ahead of the filing of the condemnation proceedings, the value thereof may be enhanced by the public purpose for which it is taken; the entry by the plaintiff upon the property may have depreciated its value thereby; or, there may have been a natural increase in the value of the property from the time the complaint is filed, due to general economic conditions. The owner of private property should be compensated only for what he actually loses; it is not intended that his compensation shall extend beyond his loss or injury. And what he loses is only the actual value of his property at the time it is taken.
Alfonso v. Pasay City G.R. No. L-12754 30 January 1960	Extension of Existing Public Street	In cases where the government does not indemnify the private landowner for the use of his property from the time of taking, the latter is entitled to legal interest on the price of the land from the time it was taken up to the time that payment is made by the government.
Municipality of La Carlota v. National Waterworks and Sewerage Authority G.R. No. L-20232 30 September 1964	Supervision, Administration and Control Over an Existing Waterworks System	Ownership is nothing without the inherent rights of possession, control and enjoyment. Where the owner is deprived of the ordinary and beneficial use of his property or of its value by its being diverted to public use, there is taking within the constitutional sense.

Republic of the Philippines v. Philippine Long Distance Telephone Company G.R. No. L-18841 27 January 1969	Interconnection of Telephone Lines	Nominally, the power of eminent domain results in the taking or appropriation of title to, and possession of, the expropriated property; but no cogent reason appears why the said power may not be availed of to impose only a burden upon the owner of condemned property, without loss of title and possession. It is unquestionable that real property may, through expropriation, be subjected to an easement of right of way.
J.M. Tuason and Co., Inc. v. The Land Tenure Administration, et al. G.R. No. L-21064 18 February 1970	Subdivision of Property and Sale to Various Occupants	It is well-settled that just compensation means the equivalent for the value of the property at the time of its taking. It means a fair and full equivalent for the loss sustained, which is the measure of the indemnity, not whatever gain would accrue to the expropriating entity.
Amigable v. Cuenca G.R. No. L-26400 29 February 1972	Road Widening Project	At the conclusion of eminent domain proceedings, the private landowner is entitled to the recovery of attorney's fees from the government.
Republic v. Vda. de Castellvi, et al. G.R. No. L-20620 15 August 1974	Official Use by the Philippine Air Force	"Taking" under the power of eminent domain may be defined generally as entering upon private property for more than a momentary period, and, under the warrant or color of legal authority, devoting it to a public use, or otherwise informally appropriating or injuriously affecting it in such a way as substantially to oust the owner and deprive him of all beneficial enjoyment thereof.
Republic v. Court of Appeals G.R. No. L-43938 15 April 1988	Mining Claims	Rights over public land are indivisible. Hence, there is no "dividing line"between surface rights and subsurface rights.

Ansaldo v. Tantuico G.R. No. L-50147 03 August 1990	Road Widening Project	Private landowners who do not seasonably raise any objections while knowing of the government's use of their property for public purposes, are effectively entitled only to proper damages for the loss of said property. Just compensation is computed at either the time of taking or the institution of the expropriation proceedings, whichever is earlier.
National Power Corporation v. Gutierrez, et al. G.R. No. L-60077 18 January 1991	Construction, Operation and Maintenance of Power Transmission Lines	"Taking"under the power of eminent domain can partake of the nature of an easement or right-of-way. For this reason, the owner of the property expropriated is entitled to just compensation, which should be neither more nor less, whenever it is possible to make the assessment, than the money equivalent of said property.
National Power Corporation v. Manubay Agro-Industrial Development Corporation G.R. No. 150936 18 August 2004	Installation of High-Powered Transmission Lines	Even where the government acquires only an easement of right of way over private property, the private landowner is still entitled to just compensation based on the full value of his property.
National Power Corporation v. Ibrahim, et al. G.R. No. 168732 29 June 2007	Construction of Underground Tunnels to Siphon Water from Lake Lanao	Notwithstanding the fact that the government only occupies the sub-terrain portion, it is liable to pay not merely an easement fee but rather the full compensation for land. This is so because in this case, the nature of the easement practically deprives the owners of its normal beneficial use.
National Power Corporation v. Heirs of Macabangkit Sangkay G.R. No. 165828 24 August 2011	Construction of Underground Tunnels to Divert Agus River Flow to Hydroelectric Power Plants	Statutory prescriptive periods do not apply with regard to payment of just compensation, as the latter is a constitutional guarantee.

A survey of pertinent cases regarding surface and subsurface rights reveals that Philippine law does not distinguish. Consequently, there is no differentiation whether land rights to be acquired are surface or subterranean. Hence, as long as there is a deprivation of full use or enjoyment regarding the property rights of property owner, full value of the property taken shall have to be paid in compensation.

In order to clearly distinguish and reconcile the concepts of just compensation and "full value," it must be emphasized that the jurisprudential definition of just compensation (i.e. market value of the property expropriated) mostly contemplates cases where the private owner's entire property is taken for public purposes. This is harmonious with the idea that compensation is meant to return to the private owner the exact value, more or less, of what he had "lost" by reason of the expropriation. In these cases, just compensation is synonymous with "full value."

However, when affected property is merely subject to an easement or right-of-way, it stands to reason that just compensation should not be equal to "full value," since what the private owner loses is not the entire and total use of the property, but only a specific portion thereof. However, the Supreme Court in the aforementioned Ibrahim and Sangkay cases fixed just compensation based on the full value of the affected properties because it observed, given the relevant facts, that the nature of State intrusion into the properties involved effectively deprived the private owners of their full enjoyment of said properties.

Among the most instructive dissections of the concept of just compensation was enunciated by the Supreme Court in the case of Association of Small Landowners in the Philippines, Inc., et al. v. Honorable Secretary of Agrarian Reform,[43] to wit:

> "*Just compensation is defined as the full and fair equivalent of the property taken from its owner by the expropriator. It has been repeatedly stressed by this Court that the measure is not the taker's gain but the owner's loss.* ***The word 'just' is used to intensify the meaning of the word 'compensation' to convey the idea that the equivalent to be rendered for the property to be taken shall be real, substantial, full, ample.***"[44]

To be clear, it would not be entirely accurate to opine that just compensation is, as an absolute rule, equivalent to "full value" in any case. Rather, what we may observe from a cursory reading of jurisprudence and law is that, just compensation is equivalent to a property's full market value <u>whenever it is judicially established that the taking has deprived the private landowner of full enjoyment over the expropriated property</u>.

Our findings in this regard are bolstered by a recent DOJ Opinion[45] signed by no less than current Secretary, Leila M. De Lima. The document, addressed to Undersecretary Jose Perpetuo M. Lotilla, sought to answer questions regarding the propriety of the payment of just compensation to property owners should transportation infrastructure or facilities be built under the latter's property. The legal query was drafted in the hopes to quiet budgetary issues pertaining to the Makati-Taguig Subway Line Project. In the correspondence, the good Secretary is of the belief that the property owners can claim just compensation for the full value of their property. Citing existing rules and current case law, the Secretary concludes that any impairment to the enjoyment of the property whether surface or subsurface shall cause the property owner have rights to just compensation to the actual value of the property subject to rules and regulations and as determined by a competent court.

Furthermore, our study is also mirrored by the private Legal Opinion issued by the Puyat Jacinto Santos Law Office for the DOTC[46]. In the memorandum, private counsel had the opportunity to advise that subterranean right of way acquisition is similar to surface right of way as the payment for compensation is the same: full value of the property taken.

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[43] G.R. No. 78742. July 14, 1989.
[44] Emphasis supplied.
[45] Department of Justice Opinion No. 43, Series of 2014, July 17, 2014
[46] Puyat Jacinto Santos Law Office Memorandum addressed to the Department of Transportation and Communication and The Public-Private Partnership Center dated May 30, 2014

It is quite pertinent to consider, therefore, that as of yet, there are no Laws, Rules and Regulations for the use of Subsurface territory or property. As of the moment, this study, as supported by current jurisprudence, private legal memoranda, and an official Department of Justice Opinion on the matter of subsurface rights and use, indicates that full value must be paid of owners deprived of full enjoyment of their property.

Therefore, if the current Philippine expropriation standards are applied to the Mega Manila Subway Project, the proponent can expect:

A. for at least for the portions that are directly under government-owned property such as roads or highways, it need not pay for just compensation for the use of the property,

B. for private property, of any kind or form, needed for the completion of the project, the proponent may rely on the existing rules to appropriate the land, subject to the payment of just compensation as discussed.

C. the subsurface entrance to private property whether clandestine or overt shall entitle the land owner to the full value of his property as compensation.

3.3 Recommendations for Necessary Legal Framework and Process

It becomes readily apparent, from a cursory reading of the available legislation and jurisprudence on the matter that the Civil Code allows for the enactment of special laws and ordinances in order to modify private ownership over subterranean areas, but that the legislature has so far declined to act affirmatively. In this regard, the esteemed Justice J.B.L. Reyes himself commented:

> *"The rights to the subsurface should equally be limited to the depth reasonably required to the exploitation and utilization of the soil. Just as the Code denies to the surface owner the right to limit aerial navigation over his land, it should also refuse him any right to impede subterranean travel or mining, or the digging of underground shelters and depots (remember the atom bomb) with proper authority, so long as the enjoyment of the surface or the structures thereon is not substantially disturbed. If the ownership does not extend ad caelum neither should it go down usque ad inferos."*[47]

Clearly, what exists is not so much a vacuum, but rather a deficiency of legislation as regards the limitation of private ownership over subsurface areas. Unless and until this is adequately supplied, the prevailing jurisprudential doctrine espoused most recently in the Ibrahim and Sangkay cases shall almost certainly continue to be upheld and reinforced by the Supreme Court.

Under the current doctrinal regime, the payment of full value is obligatory when the expropriation process is forced upon a property owner. Payment of market or of a similar price will also be the result if the project proponent or government resorts to other means allowed by RA 8974. Hence, there can be no question that more often than not right-of-way acquisitions will be an extremely expensive endeavor. The taking of property for subterranean use whether shallow or deep will not not have an effect on the compensation to be paid to the owner. If existing jurisprudence and laws are applied, it shall be of full value of the property.

This begs the question why is there a lack of law regarding subterranean use? The state of law is perhaps the result of a lack of development with regard to the special land use. In the span of over a hundred years of mass transportation projects, this is perhaps the first time that an actual subway for the Philippines is proposed. Thus, due to the pioneering status of the project, no law specific to the nature of the use of the land is readily available. What is used therefore to determine the taking of property and the payment thereof are the laws relevant only for overland use.

[47] Observations on the New Civil Code. 15 Lawyer's Journal 499. October 31, 1950.

In contrast, specific laws and regulations have already been enacted with regard to the use of property rights over airspace. In fact, the Philippine government regulates the height of buildings and airspace through many government agencies like the Civil Aviation Authority of the Philippines, the Housing and Land Use Regulatory Board, and even through the local government units by their imposition of zoning and building height restrictions. Unfortunately, there are no such governing and regulating agencies that monitor and regulate the use of subsurface property rights in the Philippine setting.

The lack of law is even more emphasized when the Philippine Civil Code, the main law applied to the numerous Supreme Court cases mentioned above, is compared to other progressive jurisdictions. For example, German Civil Code states:

> *"The right of the owner of a plot of land extends to the space above the surface and to the subsoil under the surface. However, the owner may not prohibit influences that are exercised at such a height or depth that he has no interest in excluding them."*[48]

Similarly, the Japanese Civil Code also recognizes the need of special law that should regulate property rights by saying:

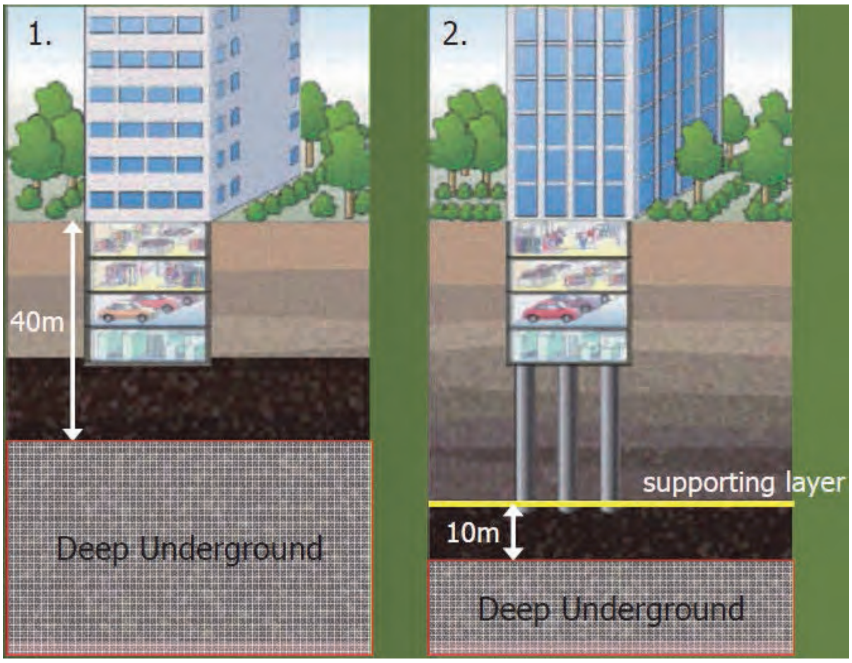
> *"Ownership in land shall extend to above and below the surface of the land, subject to the restrictions prescribed by laws and regulations."*[49]

Clearly, the rights of a property owner under cannot be absolute as to claim all that is above and below his or her property. There must be imposed limits to the interests of the property owners with regard their land. Several countries have passed laws regulating subsurface or subterranean property rights. For example in Finland, the government only gives the property owner six (6) meters of underground use, below which shall be reserved only for the government to develop.[50] Also, the Japanese authorities restricts land ownership of private individuals located in identified mega cities to a limit of forty (40) meters underground.[51] In both the Finnish and Japanese models, there will be no compensation payout to private owners should government develop the subsurface space in the specified depths. These specific limitations of subsurface property ownership lessens the costs of any government infrastructure or mass transit project that needs to implemented.

The Japanese Model is especially interesting to dissect. In 2001, the Japanese Parliament passed the "Special Measures for Public Measures for Utilization of Deep Underground". The act was envisioned to maximize all underground space for the infrastructure development. Although the use of subsurface territory for parking, basements and storage areas was already prevalent in Japan, it was concluded that the government can still use areas even deeper in depth for official and public projects.

The mentioned law defines "deep underground" as forty (40) meters below the surface of the property if no subterranean structures have been built under the property or ten (10) meters below the deepest depth or supporting layer of the existing subterranean structures. The law clearly allows government to build under private property classified as "deep underground". Moreover, the law exempts the authorities from paying compensation to land owners. In effect, the law has limited or regulated the ownership and rights of property owners with regard to subsurface usage.

[48] Bürgerliches Gesetzbuch, section 905
[49] Civil Code of Japan, Article 207
[50] Helsinki Underground Master Plan
[51] Japanese Deep Underground Utilization Act of 2001



Source: *MLIT of Japan*

Figure 3.3-1 Definition of Deep Underground in Japanese Deep Underground Utilization Act of 2001

The foregoing considered, it is proposed that the DOTC initiate high level discussions with the leaders of both Houses of Congress to lobby for the introduction of special regulation statutes peculiar to subterranean or subsurface property rights. It is further suggested the agencies and organizations concerned study the different laws and methods of regulations discussed. This is to ensure the project envisioned will be had for a reasonable cost and budget.

However, all is not lost for speedy expropriation proceedings, with a concerted view towards the hastening of the property acquisition process for government infrastructure projects, without sacrificing transparency and accountability[52].

Senate Bill No. 2447 was introduced by Sen. Teofisto Guingona III in November 2014. It intends to amend relevant provisions of Republic Act No. 8974 in order to meet the stated purpose:

52 Explanatory Note, Senate Bill No. 2447.

Table 3.3-1 Proposed Amendment to Senate Bill No. 2447

FORMER RA NO. 8974 PROVISION	AMENDED RA NO. 8974 PROVISION
Section 1. *Declaration of Policy*. –Article III, Section 9 of the Constitution states that private property shall not be taken for public use without just compensation. Towards this end, the State shall ensure that owners of real property acquired for national government infrastructure projects are promptly paid just compensation.	**Section 1.** *Declaration of Policy*. –Article III, Section 9 of the Constitution states that private property shall not be taken for public use without just compensation. Towards this end, the State shall ensure that owners of real property acquired for national government infrastructure projects are promptly paid just compensation<u>, while providing for the expeditious acquisition of the required right-of-way for the projects.</u>

Clearly, the intention here is to include time-efficiency as an express part of the law's overall intent. This is material since the courts usually resort to an examination of a law's declaration of policy when construing its provisions in judicial proceedings. In the body of the law, it is apparent that the Bill intends to encourage resort to expropriation proceedings since these, being compulsory in nature, contribute to a quicker resolution of acquisition processes in accordance with the specific thrust of the proposed amendments. The bill is awaiting its first reading at the Senate.

Compulsory land acquisition is further streamlined by the introduction of a specified formula for the determination of just compensation. Section 9 of Senate Bill 2447 effectively rewrites and amends the current law RA 8974 to effects two (2) substantial changes. First, it modifies and offers a more comprehensive computation of the proper amount to be deposited to the court, which again facilitates a faster resolution of any issues as to this. Second, it gives the implementing agency even more ways to compel the court to issue the Writ of Possession once the proper amount has been deposited. This is crucial because once the Writ of Possession has been issued to the implementing agency, project implementation may immediately follow thereafter. Overall, the proposed amendments remove much of the discretion on the part of the court, and enables a smoother and quicker end to expropriation proceedings for covered projects.

Perhaps the most important provision in this Senate Bill is Section which reads:

> *"Section 10. Entry into Private Lands for Subsurface or Subterranean Works. –Whenever necessary for a government infrastructure and development project to construct or install underground works like railroads or tunnels in the subsurface or subterranean portion of lands owned, occupied or leased by other persons,* ***the government or any of its authorized representatives may not be prevented from entering into the subsurface or subterranean portions of such private lands by the surface owners or occupants if such entry is made more than fifteen (15) meters from the surface****."*[53]

Evidently, this is a totally new provision which makes a distinction between surface entry and subsurface entry. At the outset, it would appear that this new provision exempts any government works more than fifteen (15) meters underground from the payment of just compensation to the owners of the surface property. However, seeing as the provision merely prohibits the "prevention" of the government from entering into subsurface portions of private property in order to implement said

[53] Emphasis ours

works, it is still not clear whether compensation will still be available to land owners if entry is done below the prescribed depth. The hearings on the proposed Bill shall likely shed further light on this issue once they have commenced. This provision is perhaps a form of recognition that subsurface rights, just like aerial rights, are not absolute and should be regulated in some degree or measure.

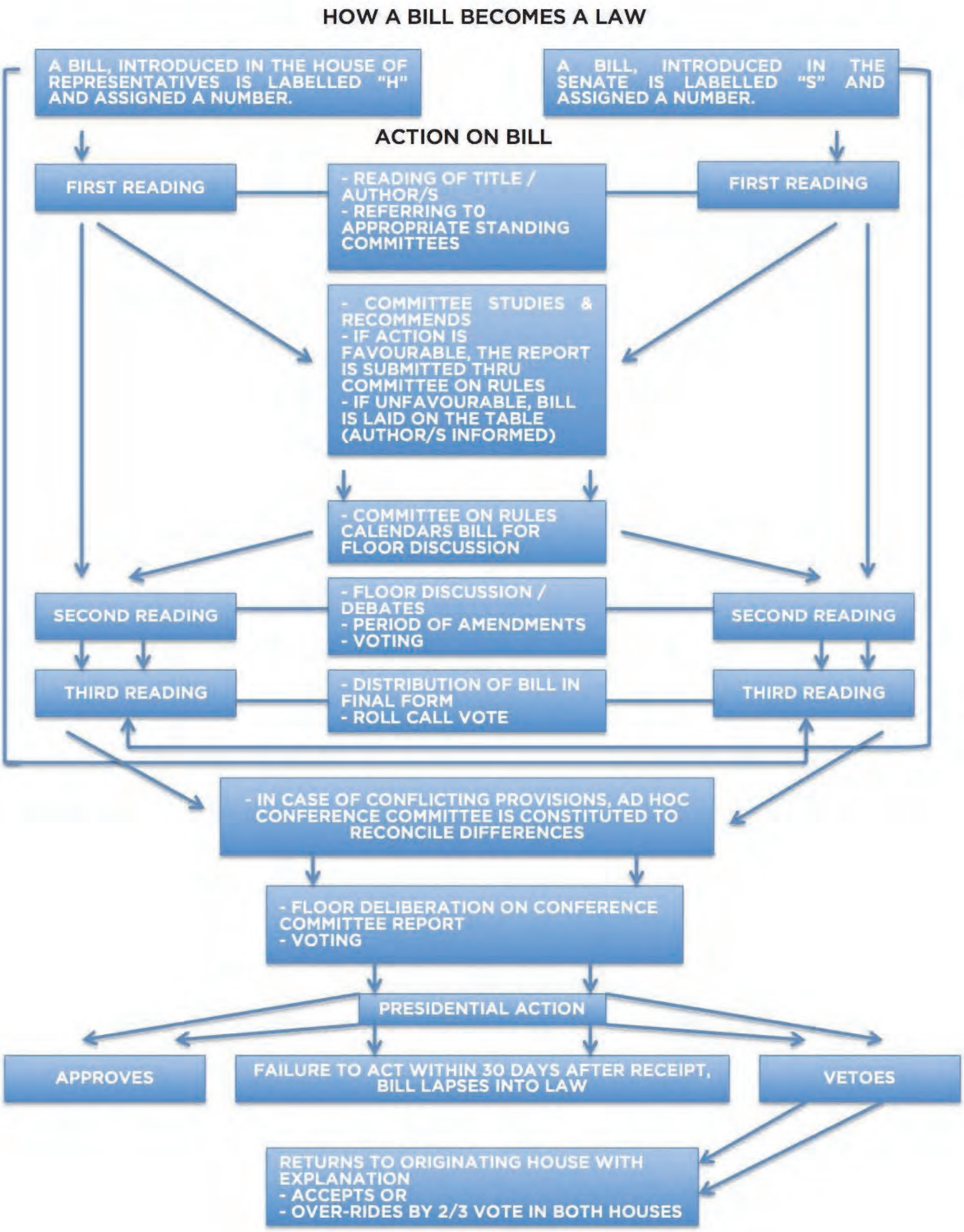
Currently, the proposed Bill is being made subject to review before both Houses of Congress, its provisions under scrutiny and review. Under the Constitution, legislative proposals may originate from either House of Congress – the Senate or the Lower House – but need to be approved by each House via simple majority upon the third and last reading thereof.

Upon approval of the proposed Bill by both Houses, the same is presented to the President for approval. If he approves it, or does not communicate his veto to the House of origin within thirty (30) days from receipt of the Bill, the same becomes a law as if he had signed it. If he vetoes the Bill within the aforementioned time, the House of origin is bound to reconsider the Bill in light of the President's comments. If, upon such reconsideration, two-thirds of said House agrees to pass the Bill, it shall be sent to the other House for its own reconsideration. A vote of two-thirds from the second House will again be necessary to pass the Bill into law.

This constitutional process of passing all laws in the Philippines, whether original or amendatory in nature, partakes of a uniform and mandatory nature. It involves the active participation of both Houses of Congress, as well as that of the President. The proposed amendment to RA 8974 would therefore need to complete this process in order to be passed into law. It is currently being studied by the appropriate Senate committees for their recommended action.

As a whole, the process can be understood by referring to the following diagram[54].

[54] Congressional Library; House Printing Division, Administrative Support Bureau, July 1996



Source: *Congressional Library; House Printing Division, Administrative Support Bureau, July 1996*

Figure 3.3-2 Procedure of Bill to be Law

Should the proposed legislation hurdle all congressional hearings and make it into law, the complexion of current infrastructure projects will change. A new tool can now be used to bypass the usual bottlenecks associated with implementation and execution. Our study has liaised with the proponents of the Bill and they have assured us that they will welcome our inputs and suggestions for the future studies and hearings.

This study also recommends the adopting of provisions like that of the Japanese Deep Underground Utilization law that allows entry into private property for depths forty (40) meters below the surface, without payment of just compensation, for as long as the use is of public use and convenience. The enactment of laws with similar intent as give government with immediate access to subterranean areas without the hindrance of lengthy judicial entanglement regarding property compensation will greatly improve the speed projects like the Mega Manila Subway to be built.

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Chapter 4

CRITERIA IN CONSIDERATION OF ROUTE ALIGNMENT OPTIONS

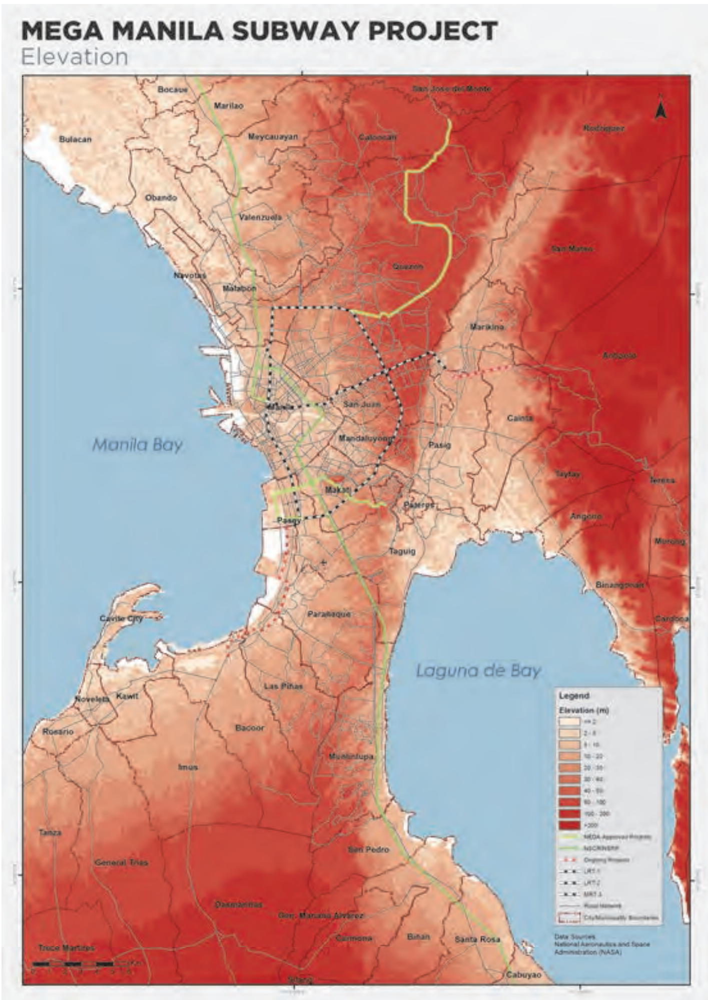
CHAPTER 4 CRITERIA IN CONSIDERATION OF ROUTE ALIGNMENT OPTIONS

4.1 Geological Condition and Natural Disaster Risk

4.1.1 Geological Condition

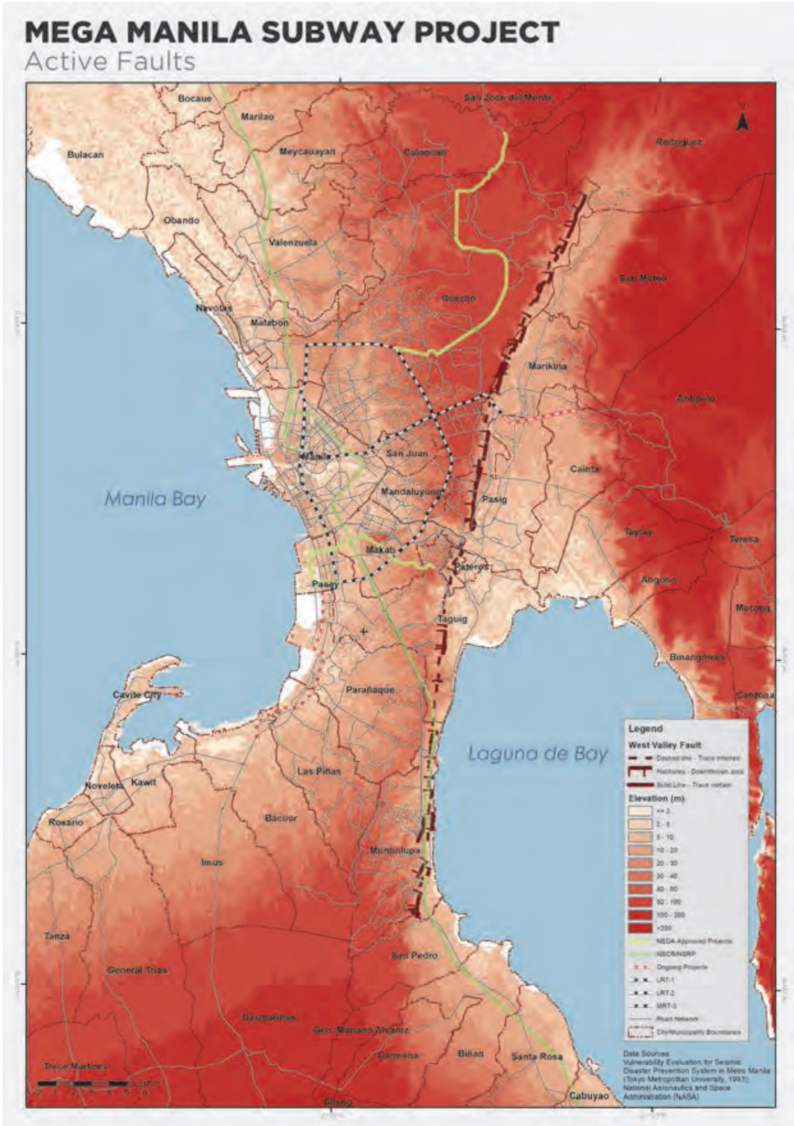
Although it is not an absolute or a decisive factor, geological condition is one of the important factors to select a suitable railway alignment. However, except extraordinary cases, there are also always measures to mitigate or overcome negative impacts of such geological condition to the railway structures by advanced technologies adopted in various developed countries, e.g. Japan, where there is a long history in railway development and many railway lines have been constructed with various kinds of construction methods at locations with various kinds of geological conditions. Geological condition itself is not hazardous to the railway construction and/or operation, but is the fundamental factor of potential natural disaster risks.

Since boring survey is not included as a scope of works of this Study, basic data of geological condition was obtained from the existing documents, i.e. reports of studies carried out in the past as well as data received from institutions in the Republic of the Philippines. Data related to geological condition received are elevation and location of faults, which are shown with the target project area of the Mega Manila Subway Project (MMSP) as follows:



Source: *PHIVOLCS*

Figure 4.1.1-1 Elevation in Target Project Area

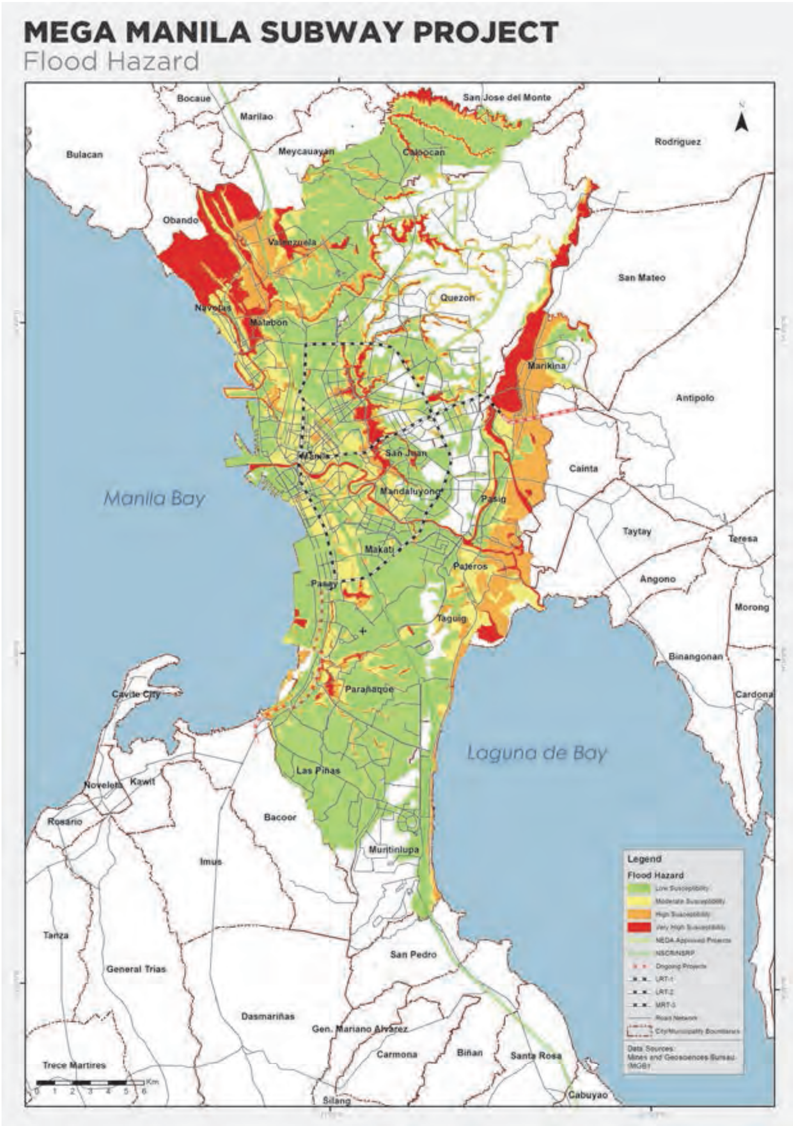


Source: *PHIVOLCS*

Figure 4.1.1-2 Location of Faults in Target Project Area

4.1.2 Natural Disaster Risk

Railway structures and facilities are vulnerable to severe natural disasters, which is one of the highest risk factors in the operation of the railway. As the natural disaster cannot be avoided and cannot be estimated when it would happen, necessary precautions shall be taken during the design stage. One of the potential natural disaster in the Philippines affecting the railway facilities and its operation is the flooding. Following shows the potential flood area in the target project area of the MMSP based on the flood hazard map prepared by Mines and Geosciences Bureau, Department of Environment and Natural Resources, of the Philippines. The map was prepared in the course of their own research, in which Guidebook for the Conduct of landslide and Flood Susceptibility Assessment and Mapping, making assumption of the worst case scenario. Measure measures that should be taken against flooding are described in detail in Chapter 11, referring also to the past studies conducted by JICA.



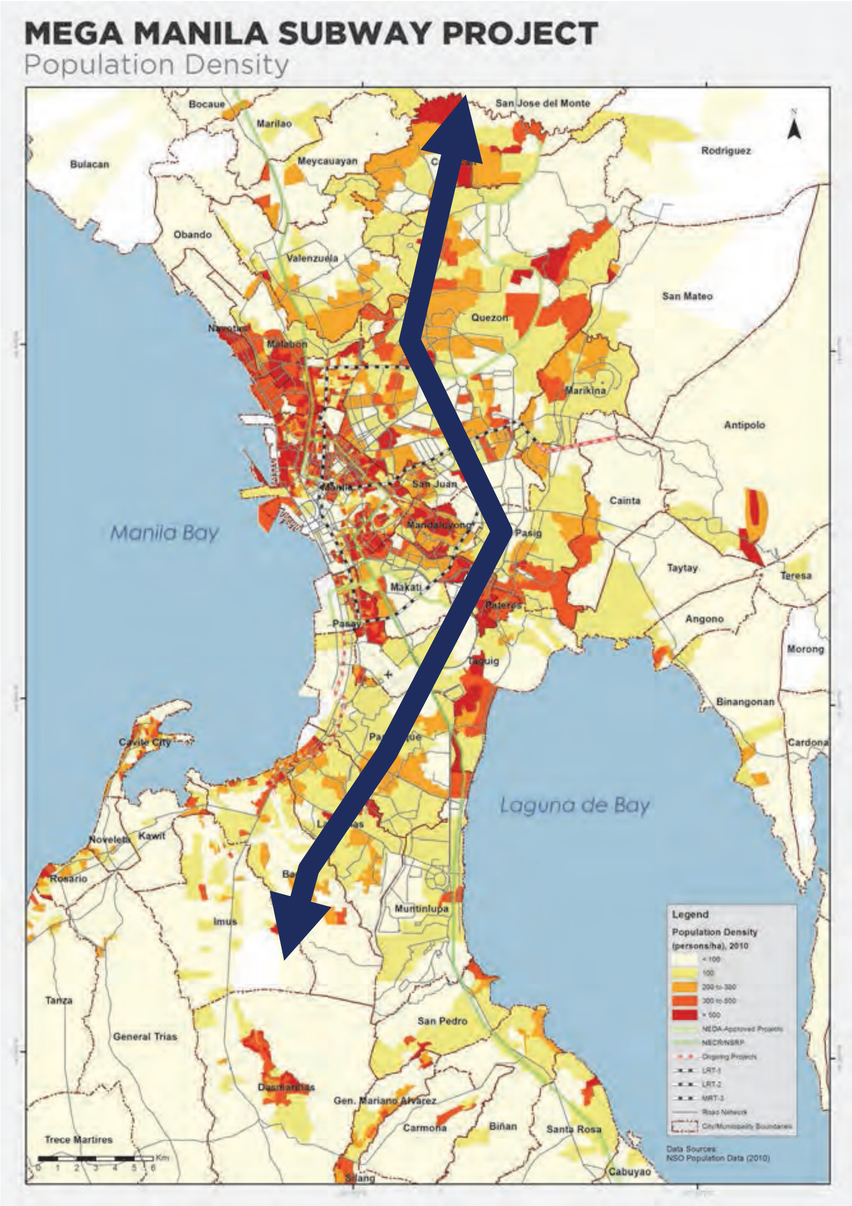
Source: *Mines and Geosciences Bureau with modification by JICA Study Team*

Figure 4.1.2-1 Flood Hazard Map in MMSP Target Project Area

4.2 Socio-Economic Aspects

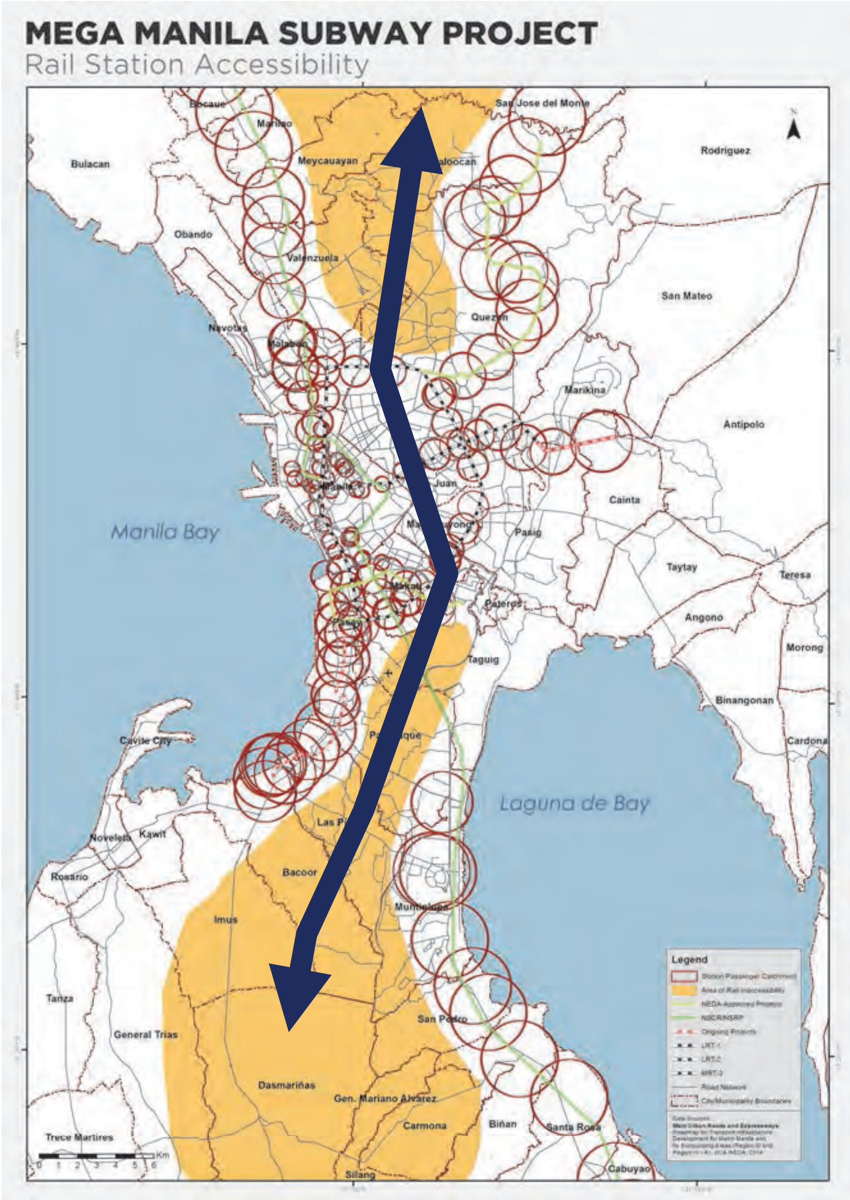
4.2.1 Population Density and Railway Service Coverage

Population accumulation is one of the important criteria for route consideration for maximizing the number of railway ridership. The railway should serve for the areas where large potential demand is expected. Figure 4.2.1-1 shows the distribution of current population density and railway network both existing and committed in Metro Manila and its surrounding area. The MMSP alignment should connect the area with medium to high population density in avoiding the duplication of the service coverage of other railway lines, particularly in the sub-urban areas in both south and north Metro Manila as shown in Figure 4.2.1-2. As a result, railway coverage area in Metro Manila will be expanded.



Source: *NSO (National Statistic Office)*
with modification by JICA Study Team

Figure 4.2.1-1 Population Density in Target Project Area and Expected Corridor of MMSP

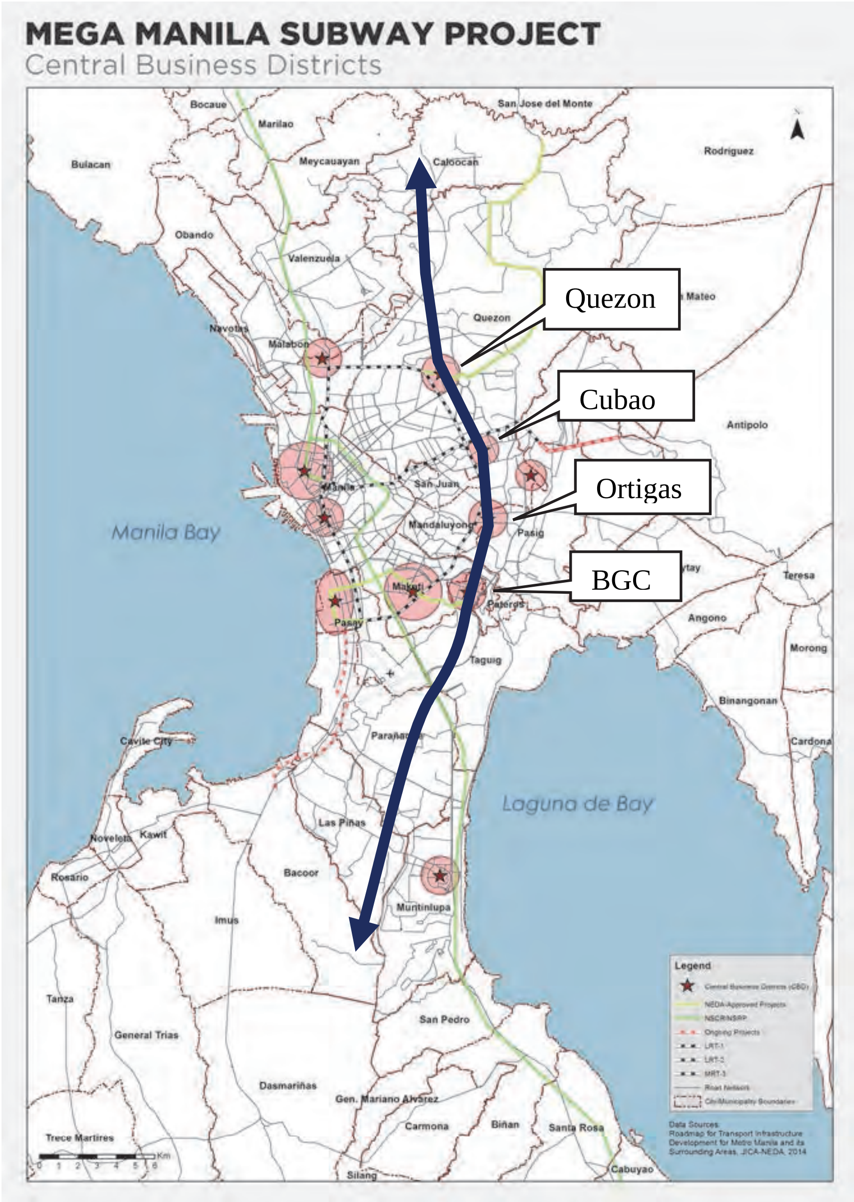


Source: *JICA Study Team*

Figure 4.2.1-2 Stations' Direct Catchment Areas of Existing and Planned Railways and Expected Corridor of MMSP

4.2.2 CBD

In general, CBD in Metro Manila has large residential population as well as significant activities such as business, commerce, institution and entertainment. A lot of people are gathering to and from CBD and making huge trips generated and attracted. Therefore, major CBDs such as Quezon, Cubao, Ortigas and BGC are to be connected by MMSP as a mass transit transport system.



Source: *Preparatory Survey on Metro Manila Central Business Districts Transit System Project in the Republic of the Philippines (JICA Study, Interim report, June 2014) with modification by JICA Study Team*

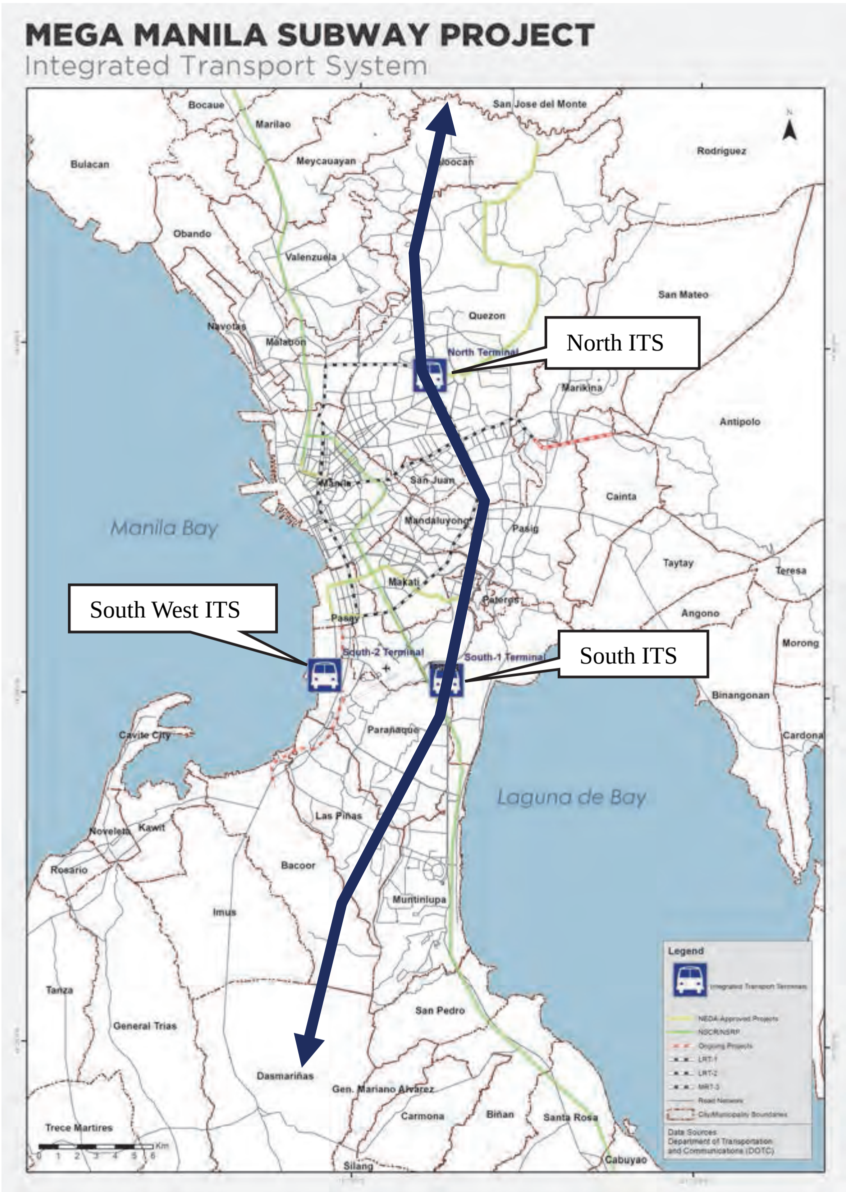
Figure 4.2.2-1 Existing CBDs and Expected Corridor of MMSP

4.3 Connectivity with Public Transport Network

In general, it is more effective to develop public transport system as network than single line of railway and bus, since the most of trips in metropolis can't be completed by single mode of public transport. It is very essential to provide good and convenient connection between stations of railways and other public transport modes such as bus and jeepney for smooth and efficient transfer. Along the route of MMSP, there will be a number of crossing railways such as LRT1, LRT2, MRT3, MRT7 MTSL and NSCR.

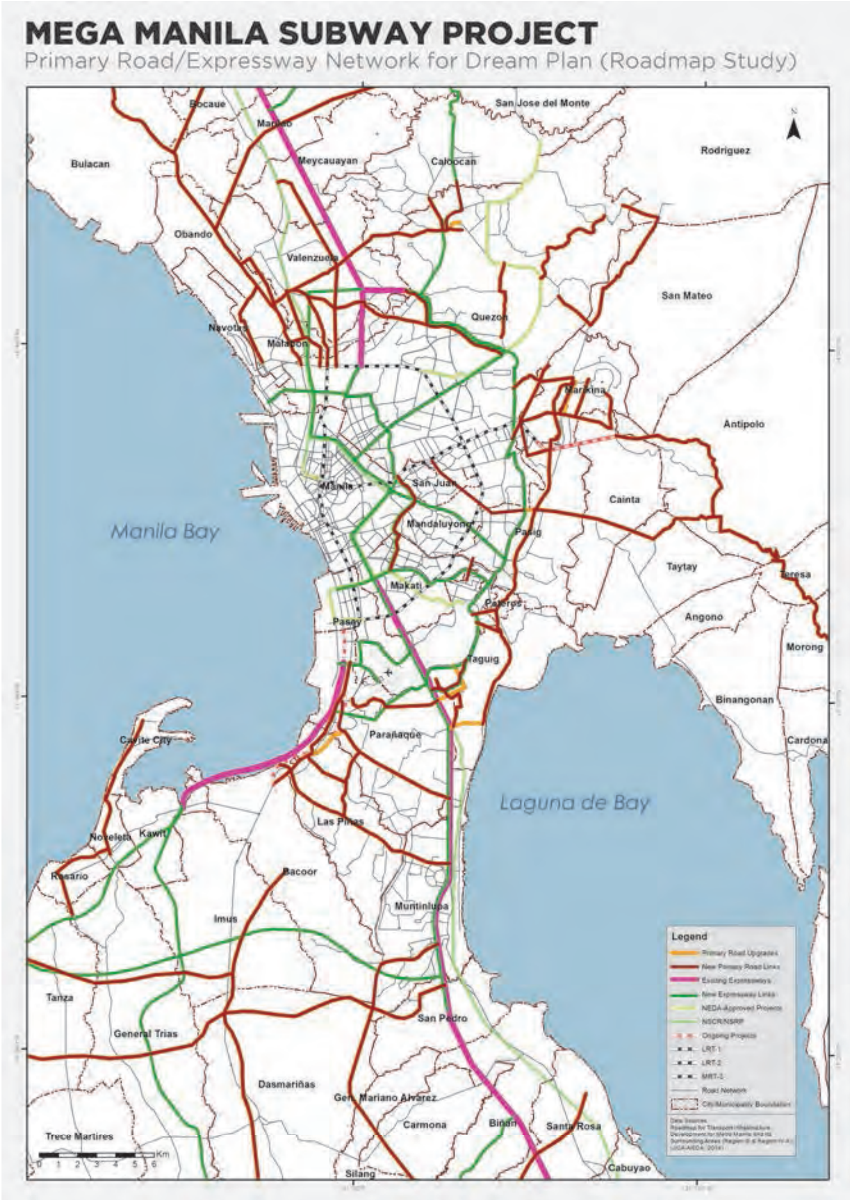
ITS (Integrated Transport System) is planned to be developed in Metro Manila to construct multimodal transport terminal for road-based public transport services such as provincial buses, city buses and jeepneys. Three ITS terminals are proposed in the north, south and south-west of Metro Manila. Among three ITS, the MMSP is to be connected with the south and north ITSs properly.

Road network is also to be considered for the consideration of the MMSP route. In case the right-of-way (ROW) of arterial roads can be utilized for railway development, it is basically easy to construct the railway structures of both underground and elevated.



Source: *DOTC with modification by JICA Study Team*

Figure 4.3-1 ITS Development Plan and Expected Corridor of MMSP



Source: *Roadmap Study (JICA, 2014)*

Figure 4.3-2 Road Network Development in Target Project Area

4.4 Technical and Engineering Aspects

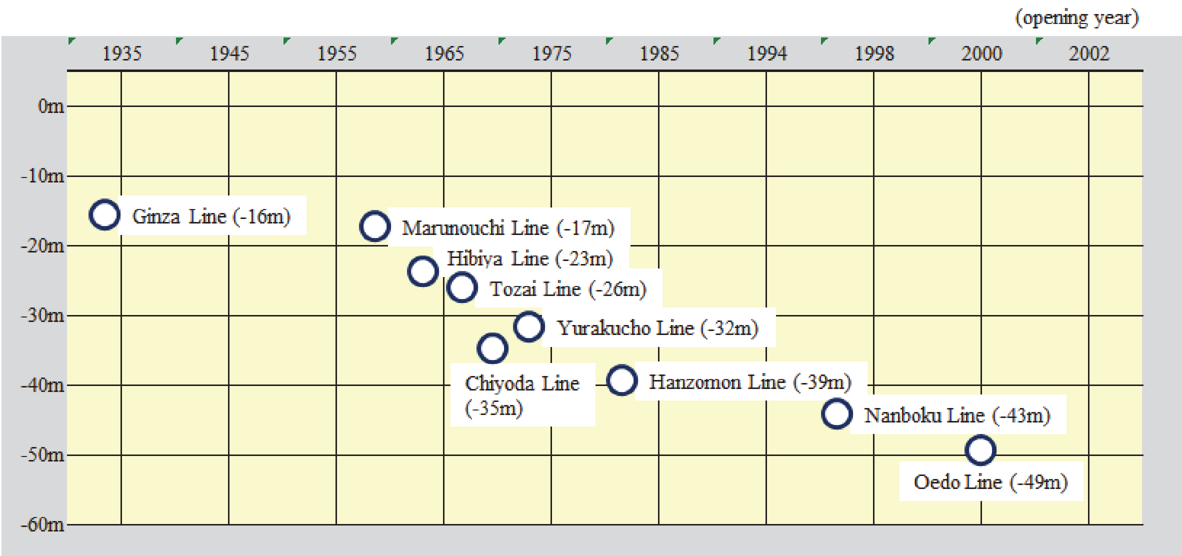
Although the government of the Philippines has been keen on the development of subways, including the Mega Manila Subway Project (MMSP), there is no specific law or regulation regarding the usage of subterranean spaces, as described in Chapter 3.

There are elevated railways, flyover and underpass roads, large-scale buildings, etc. at the surface in the central area of Manila, while water pipes, sewage pipes, electric power distribution lines, signal cables, etc. are buried shallow underground in the area as well. Therefore, designing and constructing a subway utilizing those areas, i.e. aerial space and shallow underground, would require longer time and higher cost due to difficulty in confirming the existing structures and facilities that may interfere or conflict with the planned subway structures.

Accordingly, utilization of the deep underground space where there would be no interference or conflict with existing structures, in the MMSP would be one of the practical and desirable options. Utilization of the underground at approx. 20m from the ground level would be also possible with careful consideration on the conflict with the existing structures.

4.4.1 Utilization of Deep Underground Space

In Japan, the first subway system was established 90 years ago and several subways were constructed since then, especially in Tokyo. Since the subway routes needed to cross each other in the underground space, there were many cases that the new subway was constructed below the existing subway. The recent subway tends to be constructed deeper than the older subways.



Source: *Ministry of Land, Infrastructure, Transport and Tourism of Japan*

Figure 4.4.1-1 Transition of Maximum Depth of Subways Constructed in Tokyo

A new law was established in Japan regarding the usage of deep underground, i.e. below 40 meters from the ground level or below 10 meters from the supporting layer, where the influence of existing structures could be eliminated. Such law enabled the government agency to utilize the deep underground without compensation to the land owners of the space above. This makes the route alignment planning more flexible as the spaces below areas with existing structures, or areas of private property could be also utilized in addition to the areas below the existing roads.

As there are some experiences of constructing structures at deep underground space, it is possible to build a subway at deep underground space in the Philippines.

4.4.2 Use of Underground Space with Considerations to Existing Structures

The construction of subway in the deep underground space is technically possible, but the construction cost would be higher as the construction cost of an underground station becomes proportionally higher by the depth of the station due to an increase of the excavation volume. In addition, the convenience to passengers would be worsened due to longer distance and time to access to the platform level. Therefore, unless it is the only option, the construction of subways in the deep underground space should be avoided. It is always the best to plan underground structures as shallow as possible to minimize the construction cost.

Following factors should be carefully considered in the planning of subway to determine the extent of proximity between the planned subway and the existing structure nearby.

- Ground condition (soil type, etc.)
- Safety level of the existing building
- Importance of the existing building
- Difficulty of the construction

Moreover, it is significant to consider the most appropriate method of construction to be applied, considering the conditions in the construction. It would be technically possible to build a subway as shallow as possible by considering the impact of the subway structures to the existing structures.

4.5 Existing Right of Way

As described in Chapter 3, there is no law or regulation regarding the use of deep underground space for the construction of public facilities by the government. Beside of that, at this moment, there is no lands reserved or acquired for the implementation of the MMSP, although the space below the existing roads could be fully utilized with the coordination with the relevant authority as well as those who are currently using the space above the ground, i.e. MRT Line 3 on EDSA, etc.

As the Right of Way (ROW) for the MMSP has not been secured yet as described above, coordination with authorities of roads and existing structures on roads would be required. In addition, coordination with the owners of lands at the ground level, either public or private, would be also required in case the proposed subway goes through the underground below such lands, which would probably take a long time. Therefore, it is desirable to design spaces required for the construction of facilities for the MMSP as minimum as possible.

Following consideration will be required in the planning of the subway structures as well as the detailed route alignment itself in the next step, i.e. the Feasibility Study.

- Determination of the extent of proximity with existing structures as explained in Chapter 4.4
- Study on the construction method
- High-precision displacement prediction of structures based on the selected construction method

Regarding the ROW of existing structures/facilities on roads along the MMSP corridor, coordination with the relevant authorities/agencies will be required in the Feasibility Study, taking into account the latest applicable laws and/or regulations.

4.6 Existing Underground Structures

In the planning, designing and constructing the underground structures, considerations shall be made to the existing structures, structures buried underground, etc., that are:

- Substructures (pile cap, pile, foundation, etc.) of elevated railway and road structures
- Substructures (pile cap, pile, basement, etc.) of buildings
- Water distribution pipes and drainage facilities
- Power distribution and communication cables
- Natural conditions, such as fault, etc.

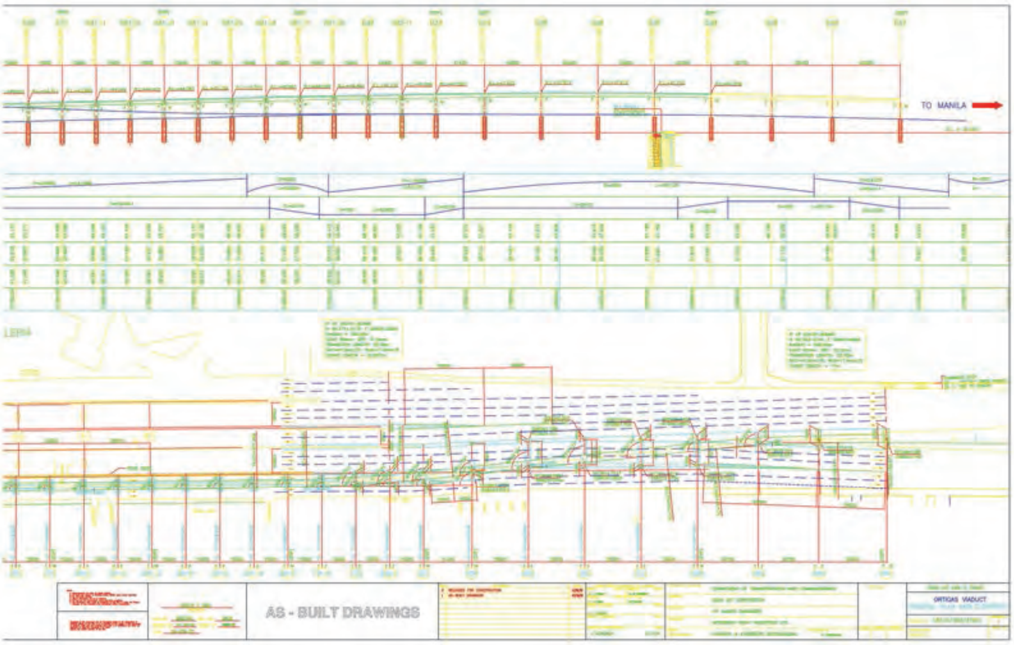
Data and information of the existing conditions related to the above in the target project area have been obtained from various agencies, e.g. DPWH, LRTA, MRTC, PHIVOLCS, Maynilad, etc., and have been carefully reviewed for the consideration of route alignment options.

4.6.1 Substructures (pile cap, pile, foundation, etc.) of Elevated Railway and Road Structures

There is an option in the selected route alignment options that runs the underground of EDSA, where elevated structures and stations of MRT Line 3 are located in the middle of the road, thus many substructures for those structures exist above and below the road. Following was confirmed by reviewing the data and information obtained from LRTA and MRTC.

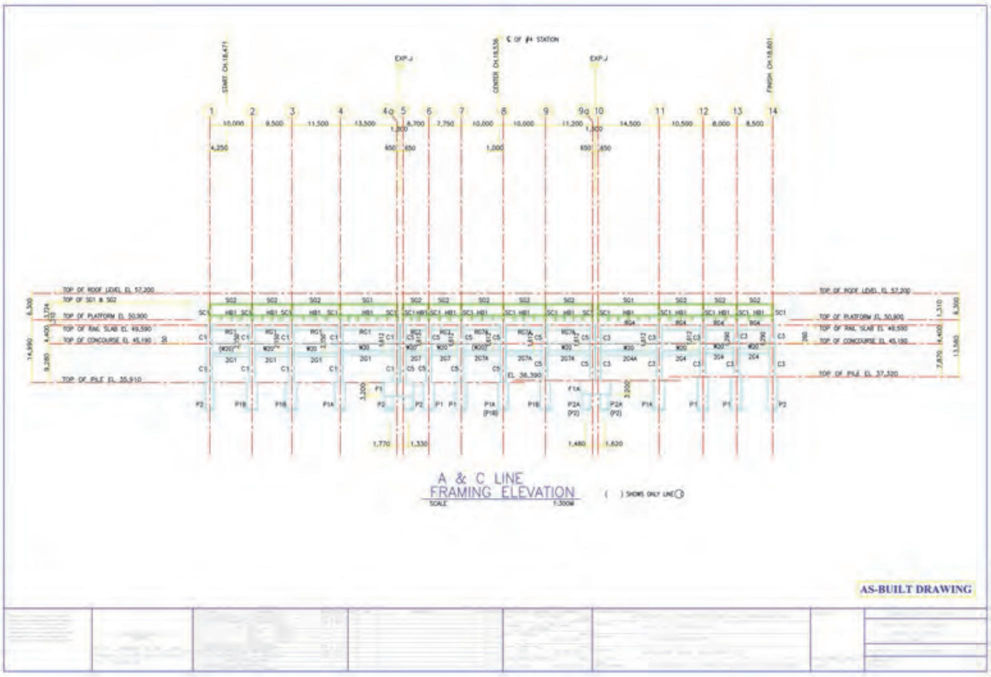
(1) MRT Line 3

The average length of the piles of the mainline elevated structures is approximately 10 m, and the longest one is 15 m. Most of the substructures for the elevated stations of MRT Line 3 are spread foundation without piles, but there are 20 m long piles as the substructures for Cubao Station. Therefore, if the route option along EDSA is selected and the construction below EDSA will be required, underground structures (tunnels) and stations shall be designed with due consideration in such existing substructures of MRT Line 3 along EDSA.



Source: *MRTC*

Figure 4.6.1-1 Plan and Profile of MRT Line 3

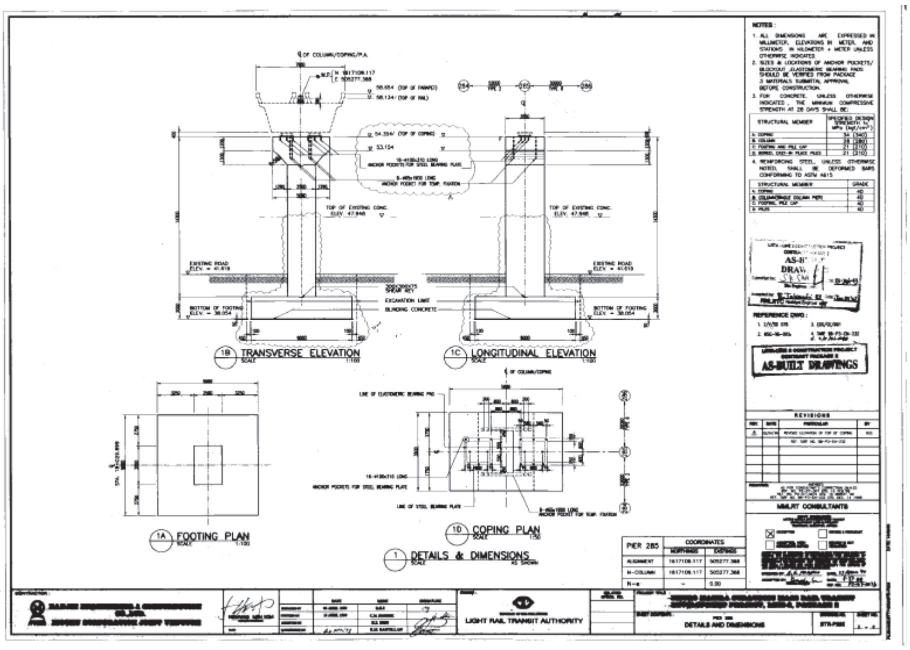


Source: *MRTC*

Figure 4.6.1-2 Station Foundation of MRT Line 3

(2) LRT Line 2

LRT Line 2 crosses MRT Line 3 at the corner of EDSA and Aurora Boulevard at Cubao, and thus there are piers of LRT Line 2 around the corner. Based on the data obtained from LRTA, it was found that the piers have only spread foundation without piles as shown in Figure 4.6.1-3. Therefore, the underground structure of the subway along EDSA has no direct impact on the piers of LRT Line 2. However, the position of the underground structure of the subway shall be carefully considered, taking into account the impact on the spread foundation of LRT Line 2 piers in shallow underground.



Source: *LRTA*

Figure 4.6.1-3 Spread Foundation of Piers of LRT Line 2

(3) Road Structures

There are flyovers and underpass at some locations along the major roads, where substructures of such road structures exist, thus these structures shall be considered in the design of understructures of the subway. In addition, detailed data and information for the flyovers and expressways (Skyway) currently planned and to be constructed in near future shall be obtained from the relevant agency and shall be investigated if those structures have any conflict with the understructures of the subway.

Source: *DPWH*

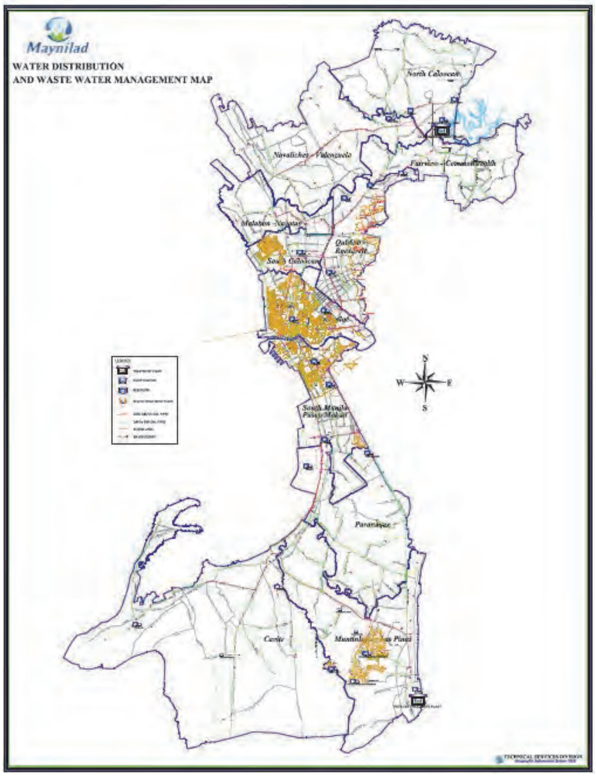
Figure 4.6.1-4 Example of Flyover (Interchange) Plan

4.6.2 Substructures (pile cap, pile, basement, etc.) of Buildings

The proposed subway route alignment, regardless of the options, run though only the areas below the existing roads, but also the areas below the public or private properties. In such a case, underground conditions of buildings near the subway route shall be carefully investigated and the consideration shall be made about the impact of the subway structures against the substructures of buildings. In addition, appropriate construction methods for each case shall be also studied. There are often cases that the basement is used as the parking space, which shall be also taken into account.

4.6.3 Water Distribution Pipes and Drainage Facilities

Typically, water distribution pipes are buried along roads in residential areas, and accordingly there are water distribution pipes along the subway route, regardless of the options. In addition, drainages for houses and rainwater also exist along or below roads along the subway route. (Figures 4.6.3-1 and 4.6.3-2) Therefore, necessary coordination with the relevant agencies how the existing pipes and drainages can be protected or diverted in the design and the construction of foundation for elevated structures and stations, entrances of underground stations, etc., that will be built in shallow underground. Appropriate construction methods for each case shall be studied and proposed.



Source: *Maynilad*

Figure 4.6.3-1 Water Distribution Pipe Network

Source: *PHIVOLCS*

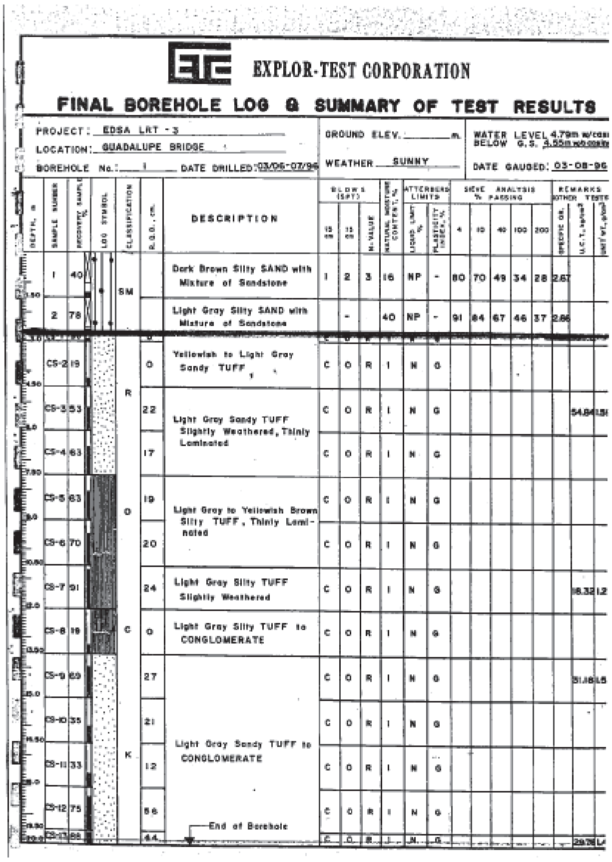
Figure 4.6.3-2 Sewage Pipe Network

4.6.4 Power Distribution and Communication Cables

Similar to water distribution pipes and drainage facilities, cables, such as power distribution, communication, etc., buried underground shall be also investigated and necessary actions, such as protection, diversion, etc., shall be considered in consultation with necessary agencies. In the suburban areas, there are aerial high voltage transmission lines with towers or poles. In case the height of such high voltage transmission line is relatively low, necessary consideration, such as Electronic-Magnetic Compatibility, etc., shall be made not to affect the E&M systems of the railway. Thus, investigations shall be carried out at early stage during the design phase to identify the locations, positions and routes of underground cables as well as aerial high voltage transmission lines in consideration with relevant agencies, such as power distribution company.

4.6.5 Natural Conditions, such as Fault, etc.

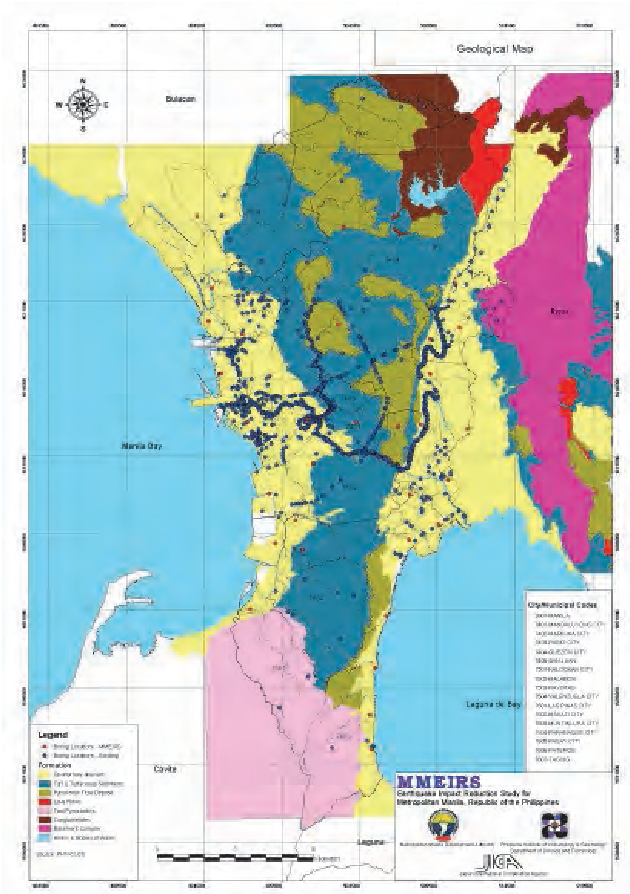
The Philippines is a volcanic county and there are tuff and/or pyroclastic material in the Metro Manila. Based on the result of the soil investigation previously made, it was found out that stiff layer with tuff exist at around 10 m below the ground level. (Figure 4.6.5-1)



Source: *MRTC*

Figure 4.6.5-1 Result of Soil Investigation near Guadalupe

There is an area with quaternary alluvium at low land near Manila Bay and Markina River. There are weathered sandstones at 5 m below the ground near FTI, which is close to coastal area. (Figure 4.6.5-2)



Source: *PHIVOLCS*

Figure 4.6.5-2 Soil Conditions of Mega Manila

It was found out that there are two faults along Markina River in the Metro Manila. Some of the proposed alignment route options for the MMSP crosses or runs near the faults. According to the information obtained from PHIVOLCS, the estimated damage of an earthquake originated from the fault near Marikina River was studied, thus data of the study shall be reviewed and considered in the planning and designing of the subway route and structures. (Refer to Figure 4.1.1-2 for locations of faults in the target project area and Figures 11.1.2.1-1 to 11.1.2.1-3 and Figures 11.1.2.1-9 to 11.1.2.1-10 for intensity distribution due to an estimated earthquake.)

4.7 Benefit to Residents along Railway and Potential for Development along Railway

4.7.1 Benefit to Residents along Railway

Following benefits to residents along the railway are considered.

(1) Enhancement of convenience in life: Reduction of travel time by development of MMSP enables the residents along railway to access to the more facilities of daily necessities.

(2) Improvement of traffic convenience: Development of MMSP brings about the improvement of traffic convenience of community resident.

(3) Reduction of road traffic accident: Motorist is expected to use the MMSP by developing of MMSP, and as result, reduction of road traffic accident is anticipated.

(4) Improvement of the environment: Motorist is expected to use the MMSP by development of MMSP, and accordingly, reduction of CO_2 in community is anticipated.

4.7.2 Potential for Development along Railway

Following potentials for development along the railway is expected to be enhanced by development of MMSP.

(1) Promotion of firm location: Possibility of invitation of firm is expected by productivity increase brought about the improvement of traffic convenience.

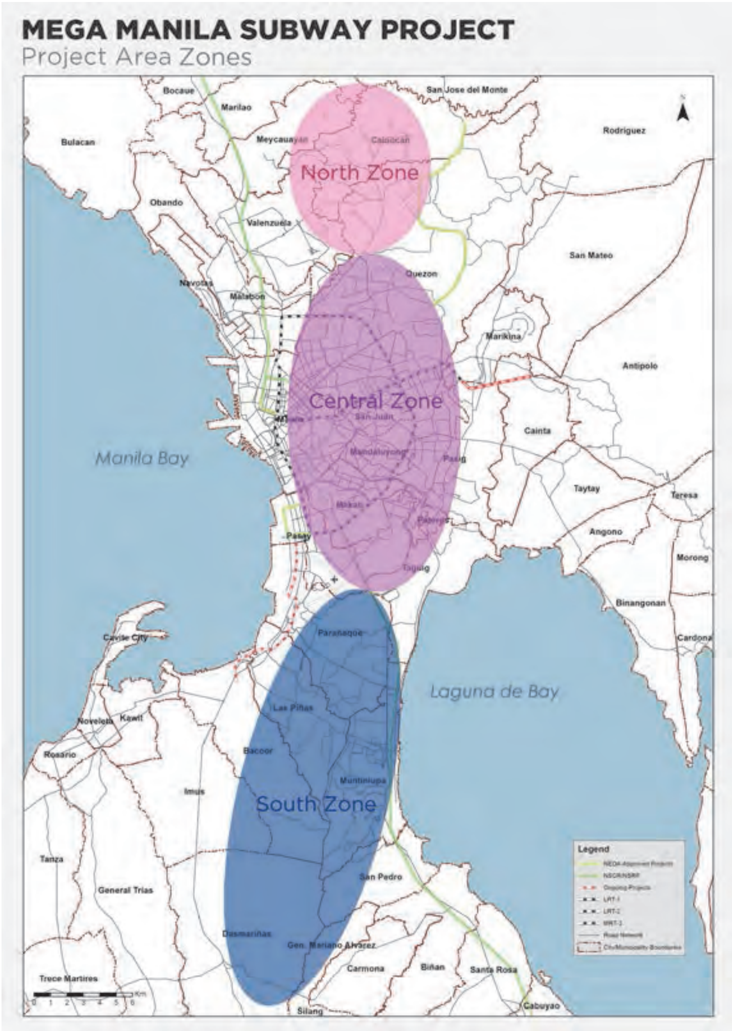
(2) Increase of residential population: Population inflow is expected by enhancement of attractiveness of residence through the improvement of traffic convenience for business districts.

(3) Activation for community renovation: Activation of community along railway is expected through accumulation of residence, commerce, and business unit at the periphery of station.

4.8 Consideration of Route Alignment Options

4.8.1 Zoning

Since the target project area of the MMSP is quite long, route alignment options have been considered separating the area into 3 zones, i.e. North Zone, Central Zone and South Zone, as shown in the figure below.



Source: JICA Study Team

Figure 4.8.1-1 Zoning of MMSP Route Alignment Consideration

The connecting area between the North Zone and the Central Zone was determined as the area to connect the suburban area in the north and the center of the NCR. As a result of consideration, the section along Mindanao Avenue between Quirino Highway and EDSA was selected as such connecting area. This section was also along the proposed subway route in the Roadmap Study.

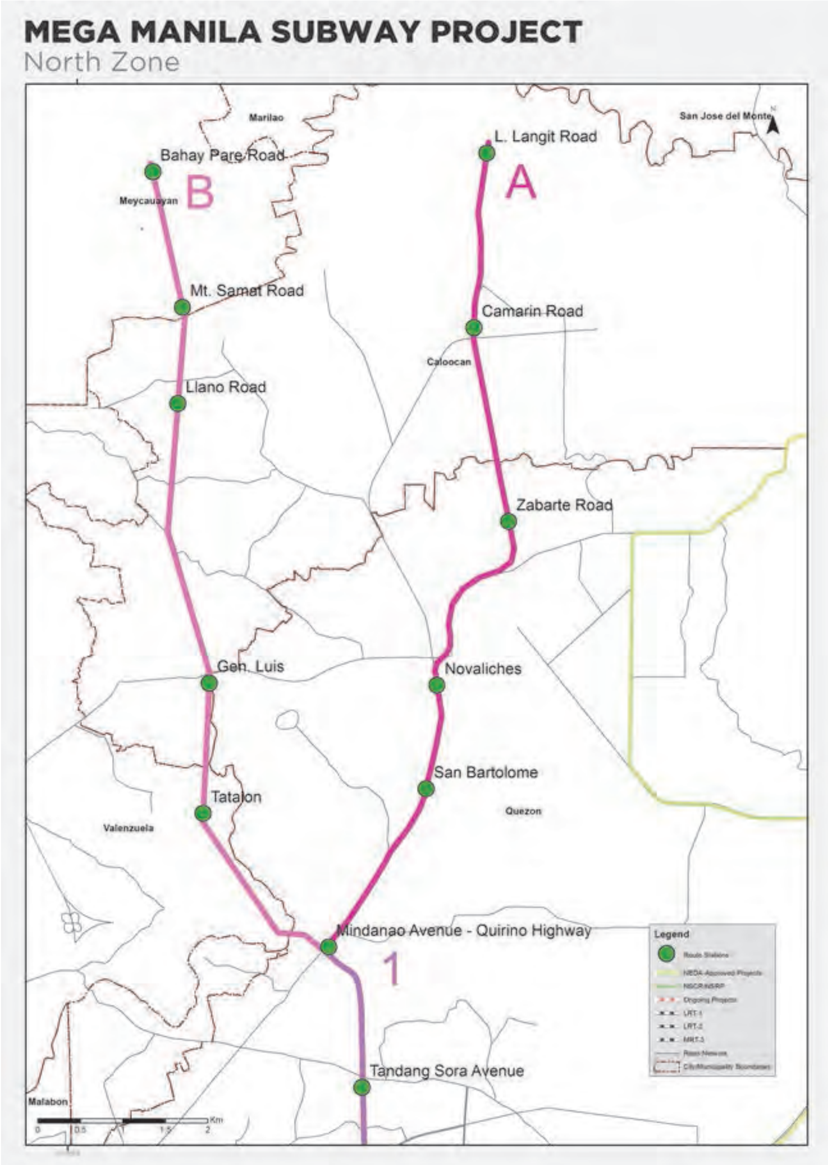
As to the connecting area between the Central Zone and the South Zone was selected at the FTI since the FTI is planned to be developed as the major transportation hub, connecting suburban areas in the south and the center of the NCR. A station of the North-South Railway Project (NSRP) is also planned at this area, thus the station in this area can also function as the transfer station between the NSRP and the MMSP.

Options in the North Zone are named either Option “A” and Option “B”, those in the Central Zone are Option “1”, Option “2” and Option “3”, and those in the South Zone are Option “a” and Option “b”. There are 12 combined options, which are described as Option “A1a”, Option “B2b”, and so on.

4.8.2 Route Options in North Zone

The proposed route alignment in the Roadmap Study as well as some options also proposed were studied first in terms of their feasibility and practicality against the major criteria explained above. As selected as the proposed subway route in the Roadmap Study, a route through Quirino Highway and Zabarte Road seemed to be highly potential due to the availability of existing roads, heavy traffic on the route and the social and commercial activities already in place along the route. Minor adjustment has been made to the proposed route in the Roadmap Study, considering the width of the road at one section. In addition, the north end has been changed from the city center of San Jose Del Monte as proposed in the Roadmap Study to the end of Zabarte Road crossing L. Langit Road in the MMSP since there is no road going to further north beyond L. Langit Road. In addition, the corner of Zabarte Road and L. Langit Road is currently functioning as the local transport center and is considered suitable to be the terminal station of the MMSP. This route, going through Quirino Highway and Zabarte Road, is selected as Option A.

As an alternative route in the North Zone, a route going along Mindanao Avenue crossing Quirino Highway and turn to the north at Que Balag Road, then further to the north at the north of Bahay Pare Road is proposed. Although there is no existing roads in most of the sections of this route, there are many existing residents and also areas being developed as the residential complex along this proposed route. This route is selected as Option B.



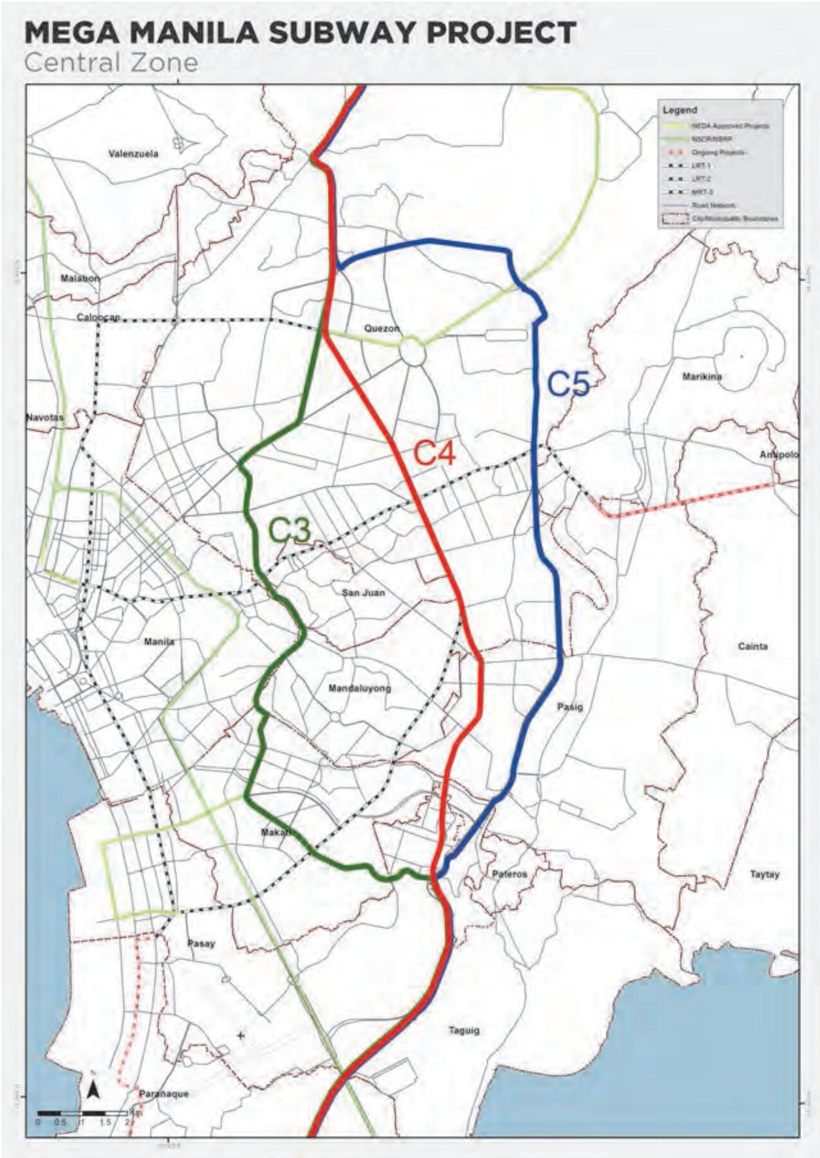
Source: JICA Study Team

Figure 4.8.2-1 Route Alignment Options in North Zone

4.8.3 Route Options in Central Zone

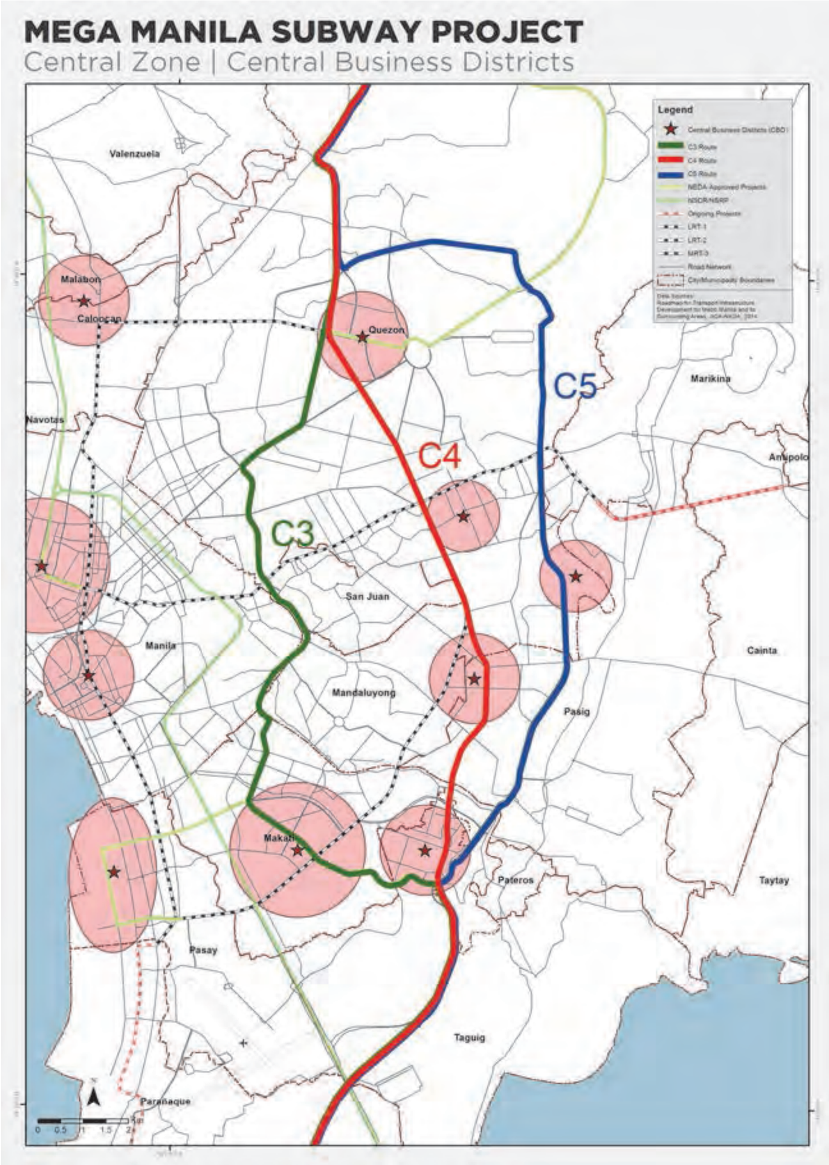
4.8.3.1 Consideration of Main Corridor

Since there are several potential routes in the Central Zone, where a new railway is required inside the area, a direct connection with suburban areas is demanded, etc., because the social and commercial activities are spread in various areas in the Central Zone, which is the center of the NCR. Before narrowing down the corridor to be selected as the route for the Central Zone, a comparison was made among equally highly potential corridors at a glance, which are along the Circumferential Roads 3, 4 and 5, also known as C3, C4 (EDSA) and C5 respectively, since these circumferential roads are the major trunk roads in the center of the NCR having various social and commercial facilities, such as malls, business offices, educational facilities, etc., along the corridor and thus heady traffic at all times. The comparison was made based on the major criteria as well as preliminary consideration on technical issues in order to describe the characteristics and potentiality as the route for the MMSP and also the necessity of having a new railway in the corridor. Routes of each corridor in the Central Zone and the relation between the corridors and some major criteria are as shown in figures below:



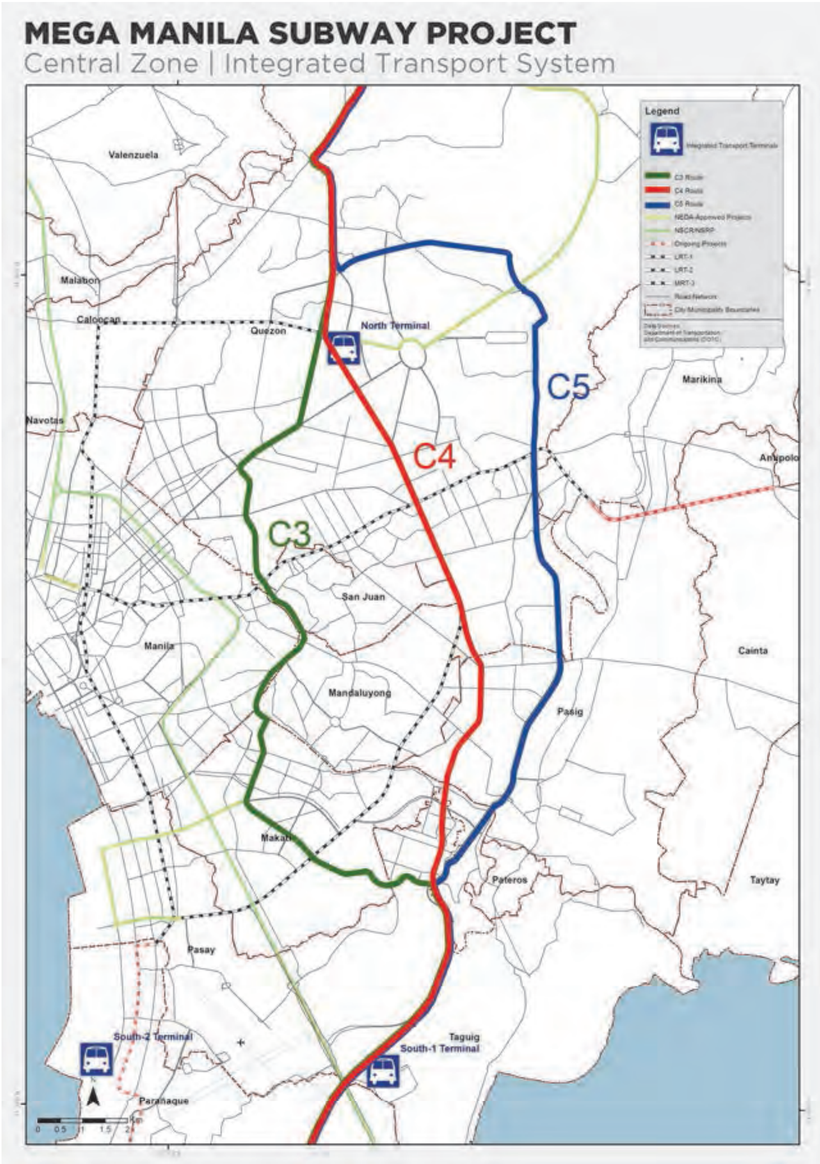
Source: JICA Study Team

Figure 4.8.3.1-1 Potential Route Alignment of C3/C4/C5 in Central Zone



Source: JICA Study Team

Figure 4.8.3.1-2 Major Criteria (CBD) and C3/C4/C5 Routes



Source: JICA Study Team

Figure 4.8.3.1-3 Major Criteria (ITS) and C3/C4/C5 Routes

The result of the comparison of each potential corridor in the Central Zone is shown in the table below:

Table 4.8.3.1-1 Preliminary Comparison of Potential Corridors in Central Zone

Criteria	C3 Route		C4 (EDSA) Route		C5 Route	
Geological Condition and Disaster Prevention	○		◎		△	
Elevation	△	C3 route mainly runs relatively low elevation areas.	◎	C4 route entirely runs through the high elevation areas.	○	C5 route mainly runs through the high elevation areas except north of Pasig.
Fault	◎	C3 route is away from faults.	○	C4 route is partly near but mostly away from faults.	△	C5 route crosses faults several times.
Flood and inundation	○	C3 route runs partly through areas with flood impact, but with relatively low impact.	◎	C4 route runs through areas free from potential flood.	○	C5 route runs partly through areas with flood impact, but with relatively low impact.
Social and Economic Condition	○		◎		○	
Population Density	◎	C3 route runs through several medium to highly dense areas.	○	C4 route runs through some medium to highly dense areas.	○	C5 route runs through some medium to highly dense areas.
Population Growth	◎	C3 route runs through several areas where population growth is medium to high.	○	C4 route runs through some areas where population growth is medium to high.	○	C5 route runs through some areas where population growth is medium to high.
Central Business District (CBD)	△	C3 route runs through Makati CBD only.	◎	C4 route runs through 4 CBDs (Quezon City, Araneta Center Cubao, Ortigas and BGC).	○	C5 route runs through near 2 CBDs (Ortigas and BGC).
Urban and Transport Planning and Development	△		◎		○	
Station Territories	◎	C3 route runs through areas without station territories of other lines, except interchanging stations.	○	C4 route partly runs through along MRT3, although the station territories sharing with MRT3 are limited.	◎	C5 route runs through areas without station territories of other lines, except interchanging stations.
Integrated Transport System (ITS)	△	C3 route only runs through 1 ITS facility (South Terminal 1).	◎	C4 route runs through 2 ITS facilities (North Terminal and South Terminal 1).	△	C5 route only runs through 1 ITS facility (South Terminal 1).

Criteria	C3 Route		C4 (EDSA) Route		C5 Route	
Railway Network	○	C3 route crosses LRT1, LRT2 and MRT3 as well as planned Makati Transit System Loop (MTSL) and North South Railway Project (NSRP).	◎	C4 route partly go through with MRT in parallel, and crosses LRT2 as well as planned MRT7, MTSL and NSRP.	△	C5 route crosses LRT2 as well as planned MRT7, MTSL and NSRP. DOTC has a plan to implement BRT project along C5, which is exactly the same alignment as C5 route.
Highways/Trunk Roads Network	△	C3 route partly shares roads with planned (partly under construction) highway and runs through areas with no trunk roads.	◎	C4 route runs through areas where there is no planned highway.	△	C5 route mainly shares roads with highway planned in Roadmap Study.
Traffic Volume	○	C3 route mainly runs through medium traffic volume roads.	◎	C4 route mostly runs through medium to high traffic volume roads.	◎	C5 route mostly runs through medium to high traffic volume roads.
Construction and Cost	△		◎		○	
Constructability of tunnel sections	△	C3 route may run through wide roads on C3 but with elevated highway above roads, if implemented, and also runs through areas (not on C3) where there is no wide roads along the route, where tunnels may need to be great deep underground.	○	C4 route partly runs through below EDSA where there are many existing substructures for elevated railway (MRT3) and flyovers, and also runs through areas without roads (except station areas). If construction in great deep underground, where there is no interference of other substructures, is allowed, tunnel construction would become easier	○	C5 route mainly runs through below relatively wide roads (C5), except the area with 2 tight corners. There are some flyovers (even some places with 2 flyovers in parallel) along the route where there are substructures below the roads.

Criteria	C3 Route		C4 (EDSA) Route		C5 Route	
Constructability of stations and station entrances	△	Stations on C3 route could be constructed below wide road on C3, but not on roads not on C3 (south part of central zone) where there have been problem in land acquisition. Construction of station entrances may be difficult in some areas.	○	Stations on C4 route could be constructed on or beside C4 road, and also on relatively wide roads in south part of central zone. Construction of station entrances would be relatively easy in most areas.	○	Stations on C5 route could be constructed on C5 roads, which is relatively wide throughout the route. However, the length of station access corridor would be longer due to wide roads. Construction of station entrances would be relatively easy in most areas.
Estimated Construction Cost	○	Unit construction cost of C3 route would be relatively high due to construction of some sections under areas without roads, thus would need to be constructed in great deep area. Consideration to protect from flooding, e.g. high station entrance, installation of water shut panels, etc., would be required. Total length of C3 route is longer than C4 route and thus total construction cost would be relatively high.	◎	Unit construction cost of C4 route would be relatively high due to construction of some sections under areas without roads, thus would need to be constructed in great deep area. Total length of C4 route is the shortest among 3 options, thus total construction cost would be the lowest.	○	Unit construction cost of C5 route would be moderate due to construction mainly under roads where construction in great deep area would not be required. Consideration to protect from flooding, e.g. high station entrance, installation of water shut panels, etc., would be required. Total length of C5 route is much longer than C4 route and thus total construction cost would be higher.

Note: ◎ as very good, ○ as good and △ as fair

In short, the comparison of 3 potential corridors in the Central Zone can be summarized as follows:

Geological Condition and Disaster Prevention

Among 3 options above, C4 route is the most suitable option since it is situated in high elevation, away from faults and also away from potential flooding area. Part of both C3 and C5 routes is inside potential flooding area, thus measures for flood protection will be required at some station entrances. C5 route crosses faults at several locations.

Social and Economic Condition

Although C3 route runs through more areas with high population density and high population growth than others, locations of potential stations for both C4 and C5 routes are located in areas with high density and more importantly economically growing areas. Therefore, there is actually no difference among 3 options regarding this category.

Urban and Transport Planning and Development

C4 route is the most suitable option since it runs through 4 CBDs and 2 ITS facilities, where railway connection is significantly required. C4 route is also good in terms of demarcation between railway and highway as there is no highway plan on C4 route, whereas there are highway plans on C3 and C5 routes. C4 route is also desirable due to many interchange stations with other railway lines.

Construction and Cost

Each route indeed has pros and cons in terms of constructability, e.g. interference with existing substructures, station entrance locations, etc. However, C4 route is estimated to be more viable due to its route length connecting north and south zones, resulting in the lowest total construction cost among 3 options.

Conclusion and Recommendation

From various aspects mentioned above, C4 (EDSA) route is considered to be the most viable and the desirable option for the corridor for MMSP in the Central Zone.

4.8.3.2 Consideration of Route Options on and near Selected Corridor (C4)

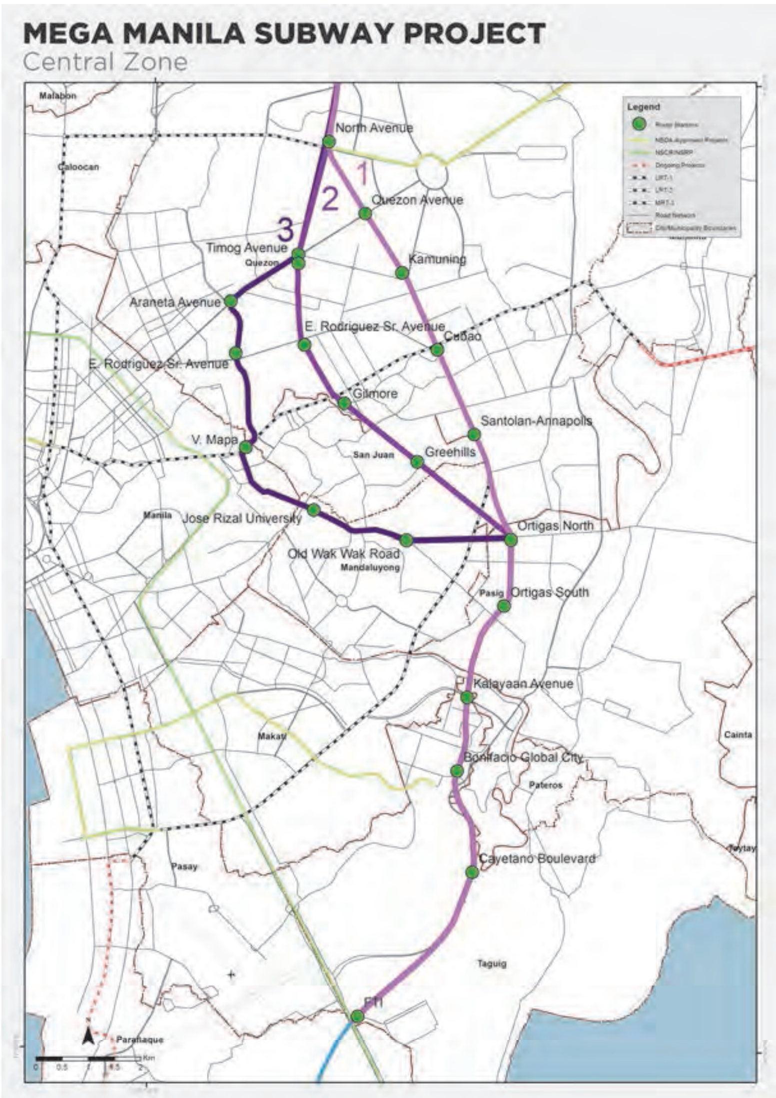
Upon elaboration of the main corridor in the Central Zone, a consideration was made for possible options on and near the identified corridor, i.e. C4 (EDSA).

Since there is a plan to construct a common station at the north of EDSA to become the interchange station for LRT Line 1 and MRT Line 3 as well as MRT Line 7 in the future, it is appropriate to plan the MMSP going through the common station as well. It seems that the exact location of the common station has not been fixed yet, thus the station in this area for MMSP has been tentatively set as North Avenue Station. The exact location of this station on MMSP shall be fixed after the exact location of the common station is fixed. North Avenue Station is selected as the starting point of each route option in the Central Zone.

A new railway, especially that requires huge investment cost, shall be constructed on a route where many people and business activities will receive benefit from the railway operation. Therefore, going through as many Central Business District (CBD) as possible is one of the key element in the consideration of the route for a new railway. Thus, it is considered desirable that all route options in the Central Zone go through Ortigas North Station, so that MMSP runs through at least 3 major CBDs in the center of the NCR, that are the Quezon City CBD, Ortigas Center and Bonifacio Global City. Accordingly, route options in the Central Zone were considered in the area between North Avenue station and Ortigas North Station.

A route along C4 (EDSA), which was proposed as the route for the subway in the Roadmap Study, is definitely one of the route options in the Central Zone as Option 1, which also goes through a CBD, namely Araneta Center Cubao, between Quezon City CBD and Ortigas Center. Since there is MRT Line 3, an existing railway in operation, running along the same corridor for approx. 6 km sharing 6 stations with one of the route option for MMSP, a concern was raised in the meetings held during the Study with concerned parties whether there will be a possibility that the ridership of the MRT Line 3 even after the capacity expansion is implemented will be reduced due to the operation of the MMSP on the same corridor. This will be justified in the Demand Forecast section.

Two alternative routes are proposed in the Study, that are the one, as Option 2, going down south the West Avenue after North Avenue Station and going into Ortigas Avenue via Gilmore Station of LRT Line 2 towards Ortigas North Station, and another, as Option 3, going down south the West Avenue and turns west on Quezon Avenue, then going south along G. Araneta Avenue, which is a corridor of the planned Metro Manila Skyway, entering Victrino Mapa Street / P. Sanchez Street / Shaw Boulevard via V. Mapa Station of LRT Line 2 up to the area near the entrance to Wack-Wack Golf & Country Club, then crossing the areas without roads until entering into Ortigas Avenue to reach Ortigas North Station. Both alternative routes run through areas with many commercial facilities as well as educational facilities, and also interchange with LRT Line 2 stations. Route alignment as well as the proposed stations of each option in the Central Zone are as shown below:

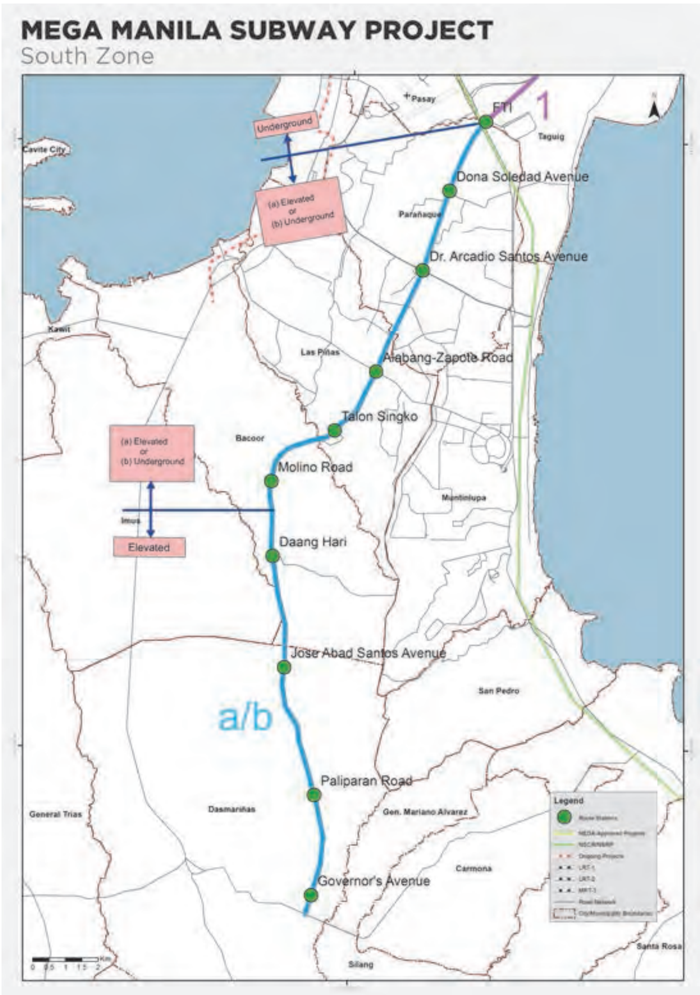


Source: JICA Study Team

Figure 4.8.3.2-1 Route Alignment Options in Central Zone

4.8.4 Route Options in South Zone

As proposed in the Roadmap Study, there is no existing north-south trunk road in the potential areas for the subway in the South Zone, i.e. from FTI to Dasmarinas in the Province of Cavite, except the section along Molino-Paliparan Road, and thus the proposed route alignment in the South Zone needs to go through areas without existing roads. Therefore, 2 options are considered in the South Zone, which are Option “a” with the elevated structures after passing the FTI station and the SLEX (South Luzon Expressway) all the way down to the Governor’s Drive station as the south end station for the MMSP, and Option “b” where underground structures continues until the alignment reaches and enters into Molino-Paliparan Road and thereafter the alignment becomes elevated up to the Governor’s Drive station. In order to achieve Option “a”, road construction along the MMSP alignment will be required together or in advance of the construction of MMSP. Locations of stations in the South Zones are selected at locations along major roads and where there are commercial facilities and/or gates to residential areas. The interval between stations in the south part of the South Zone is long compared to other sections since the area has not been fully developed yet. If this area will be developed and more demand is expected, the positions and the number of stations in this area can be re-considered before the commencement of Phase 2 construction. In addition, in case Option “a”, i.e. elevated structure throughout the South Zone section, is selected, it would be possible to add new station(s) in the future in the South Zone section even after the commencement of the revenue operation of Phase 2. Route alignment as well as the proposed stations in the South Zone, which are exactly the same for Option “a” and Option “b” except structural type between FTI station and Daang Hari station, are as shown below:

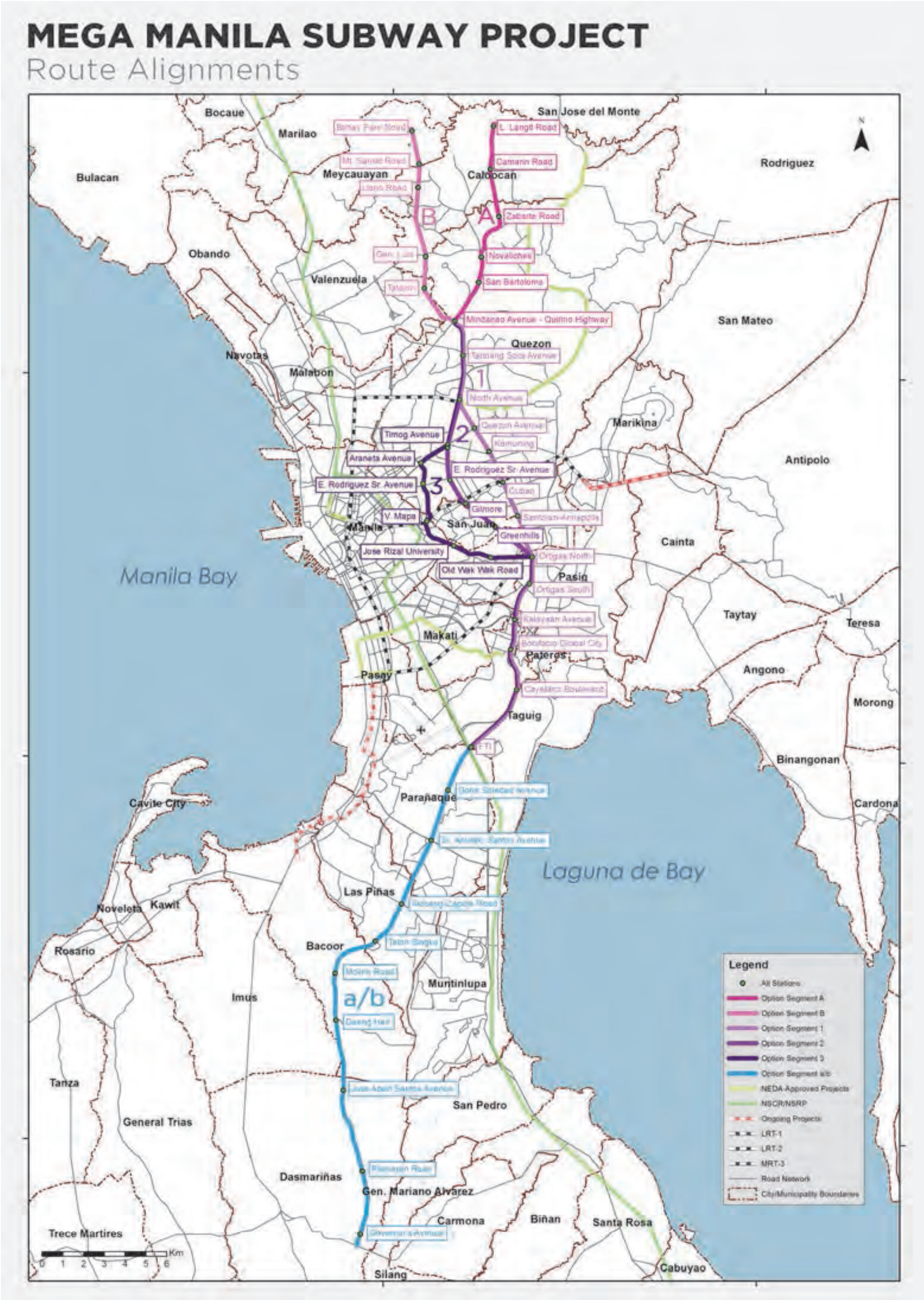


Source: JICA Study Team

Figure 4.8.4-1 Route Alignment Options in South Zone

4.8.5 Summary of Route Options

As described above, 2 options are proposed in the North Zone, 3 options in the Central Zone, and 2 options in the South Zone. In combination, there are 12 route options for the MMSP, for which considerations of demand forecast, preliminary project cost estimate and economic and financial analysis are made to confirm the characteristics of each option. In addition, social and environmental considerations including areas that need to be acquired, rough number of households to be affected, and rough cost required as compensation. Since this Study is an information collection survey, no particular route option will be recommended or proposed as the selected route for the MMSP as stated in the previous chapter.



Source: JICA Study Team

Figure 4.8.5-1 Route Alignment Options of MMSP

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Chapter 5

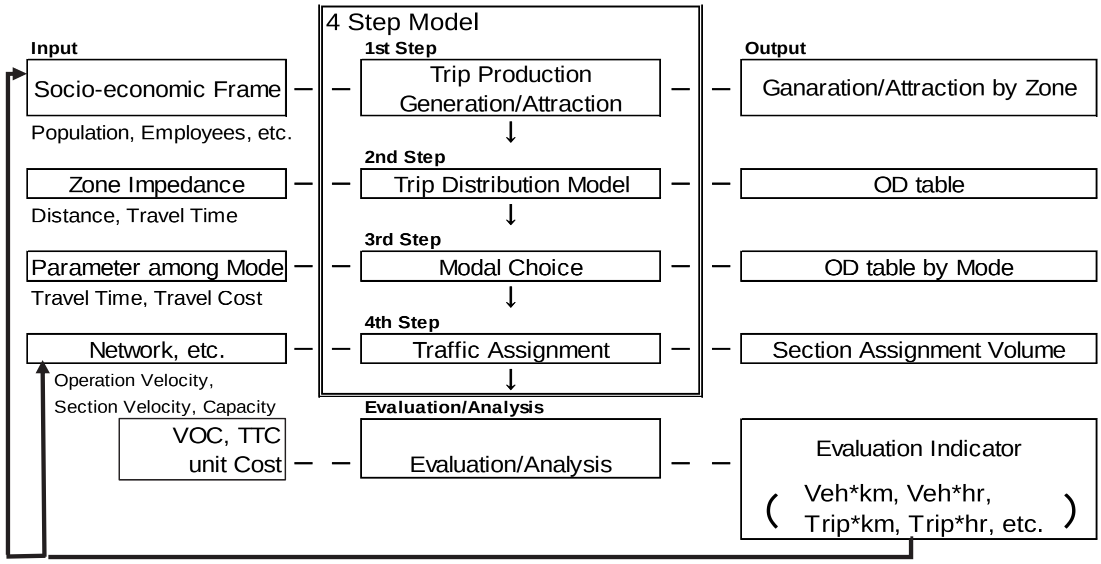
DEMAND FORECAST

Chapter 5 DEMAND FORECAST

5.1 Method of Demand Forecast Updating

5.1.1 Orthodox 4 Step Model

Demand forecast was done by orthodox 4 step model as shown in Figure 5.1.1-1. Database used in the demand forecast for the Study was based on "Metro Manila Urban Transportation Integration Study" (1996; JICA; hereinafter referred as MMUTIS) to keep consistency with the previous studies[1].



Source: *JICA Study Team*

Figure 5.1.1-1 Orthodox 4 Step Model

5.1.2 Demand Forecast Precondition

(1) Operating Frequency

Operating frequency for the Mega Manila Subway (MMS) was set as indicated below. Average waiting time of passengers was assumed as the half of operating frequency.

Table 5.1.2-1 Subway Operating Frequency

Unit: min.

Year	2025	2035	2045
Headway	5	4	4

Source: *JICA Study Team*

(2) Number of Cars of MMS per Train

Number of cars of MMS per train was set as indicated below.

Table 5.1.2-2 Number of Cars of Subway per Train

Unit: Cars/Train

Year	2025	2035	2045
No. of Cars	6	8	10

Source: *JICA Study Team*

(3) Average Operation Speed

Average operation speed of MMS was set at 45.0 km/hr.

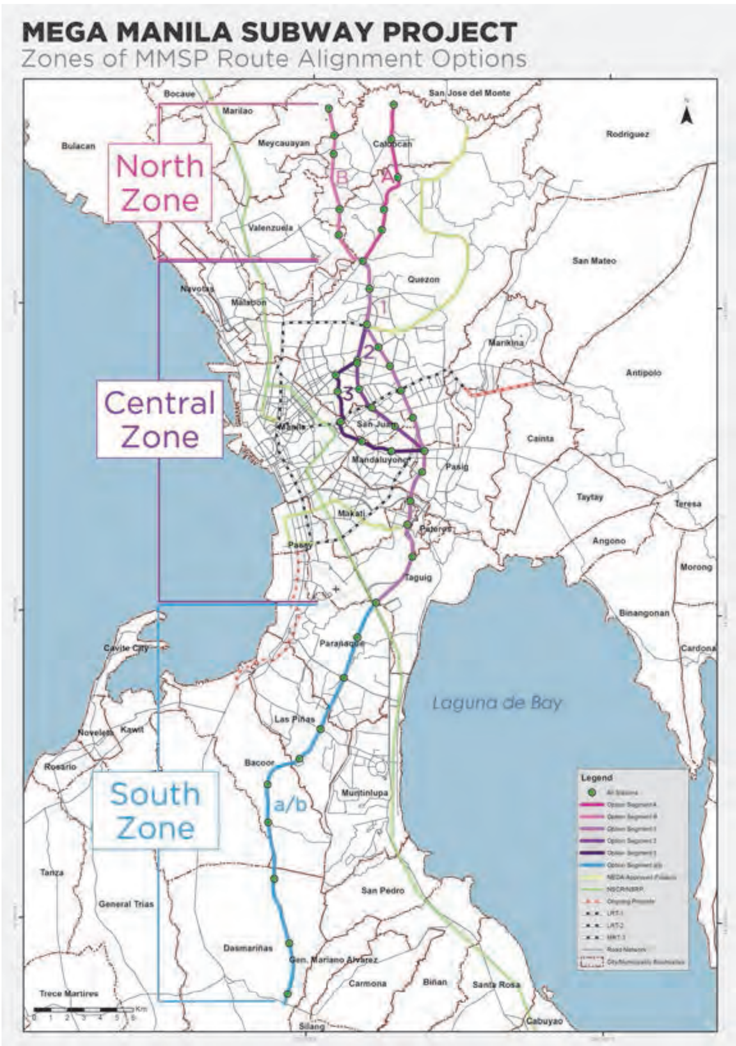
5.1.3 Method of Demand Forecast Updating

Updating of the demand forecast for the Study was done by updating following information.

(1) Route and Station Options for Mega Manila Subway Project (MMSP)
(2) Fare Setting for MMSP
(3) Implementation Schedule and Years of MMSP

(1) Route and Station Options for MMSP

There are 2 route options (A, B) in the North Zone, 3 options (1, 2, and 3) in the Central Zone in the MMSP. Although there are also 2 options in the South Zone, no consideration was made between the options since the options are along the same route with only difference in structural type, i.e. elevated or underground. Section lengths and station locations are exactly the same for both options. The number of stations of the overall project was 29 stations in Options A3 and B3, whereas those in other options were 27 stations. The route combination in this chapter is indexed as 2 digits such as A1, where "A" stands for Option A in the North Zone and "1" for Option 1 in the Central Zone.



Source: *JICA Study Team*

Figure 5.1.3-1 Subway Route Options

(2) Fare Setting for MMSP

Fare setting applied in the Feasibility Study for the north section of the North-South Railway Project (NSRP), being currently carried out by JICA, is 2 times higher than those of existing LRT Lines 1/2 and MRT Line3 due to the difference of the nature of NSRP compared to those of LRT Lines 1/2 and MRT Line 3. Although the fare setting for the subway initiated in the past study, i.e. Roadmap Study, was the same as those of LRT Lines 1/2 and MRT Line 3, the fare setting for the MMSP in this Study was set to be the same as that of the NSRP as shown in table below, considering the similarity of nature of the railway between NSRP and MMSP, i.e. longer distance, longer stations interval, faster operation speed, etc.. Fare upward tendency was made by the increase of GDP/Capita.

Table 5.1.3-1 Railway Fare Setting

Past Study Unit: PhP

Mode	2025		2035		2045	
	Fix	/km	Fix	/km	Fix	/km
LRT 1/2	18.75	1.40	28.10	2.13	36.70	2.78
MRT 3	18.75	1.40	28.10	2.13	36.70	2.78
PNR	-	-	-	-	-	-
NSRP	37.50	2.80	56.20	4.25	73.40	5.55
Subway	18.75	1.40	28.10	2.13	36.70	2.78
Others	18.75	1.40	28.10	2.13	36.70	2.78

This Study Unit: PhP

路線	2025		2035		2045	
	Fix	/km	Fix	Fix	/km	Fix
LRT 1/2	18.75	1.40	28.10	2.13	36.70	2.78
MRT 3	18.75	1.40	28.10	2.13	36.70	2.78
PNR	-	-	-	-	-	-
NSRP	37.50	2.80	56.20	4.25	73.40	5.55
Subway	37.50	2.80	56.20	4.25	73.40	5.55
Others	18.75	1.40	28.10	2.13	36.70	2.78

Source: *JICA Study Team*

(3) Implementation Schedule and Years of MMSP

Implementation of the MMSP is divided into 2 phases. Phase 1 is planned to be opened in 2025 with the implementation of one of Options 1, 2 and 3 in the Central Zone only. Phase 2 will be full route implementation of the MMSP, including North Zone section and South Zone section, which is planned to commence its revenue operation in 2035. There are 6 route options used in the demand forecast, that are A1, A2, A3, B1, B2 and B3, and estimated years were 3 years, i.e. 2025, 2035 and 2045.

5.2 Results of Updated Demand Forecast

Following indicators were estimated as the results of updating the demand forecast.

(1) Number of Subway Passenger and Station OD Volume
(2) Subway Section Volume
(3) Subway Fare Revenue

Following item was also estimated in order to verify the fare setting for the MMSP used in the Study.

(4) Sensitivity of Fare Setting

(1) Number of Subway Passenger and Station OD Volume

Table 5.2-1 shows the number of MMS passengers on each option route. Station OD volumes of each option are shown in Appendix C.

Table 5.2-1 Number of MMS Passengers

Unit: 1,000 Passengers/day

Option	2025	2035	2045
A1	421	1,470	2,049
A2	386	1,476	2,059
A3	478	1,568	2,205
B1	421	1,652	2,185
B2	386	1,666	2,257
B3	478	1,776	2,385

Source: *JICA Study Team*

Note: The above figures in 2035 and 2045 include the entire section of the MMS, covering north, central and south zones.

Although Option 1 in the Central Zone (i.e. Options A1 and B1) runs through some section along EDSA in parallel with the existing MRT Line 3, it was verified by the analysis of demand forecast for the MRT Line 3, including the future capacity expansion of the MRT Line 3 and the MMSP that there will be little impact to the demand of MRT Line 3 arising from the parallel operation of the MMSP with MRT Line 3 in some section. This is mainly because the target passengers are different between the MRT Line 3 and the MMSP, where the MRT Line 3 passengers are for travel among the central areas at lower fare, but the MMSP passengers are for travel between suburban areas and the central areas at higher fare with higher average running speed. Therefore, it can be assumed that the co-existence of the MRT Line 3 and the MMSP in some section along EDSA would be possible and reasonable. The detailed justification shall be made during the Feasibility Study with the updated database for the demand forecast, incorporating the latest available road and railway networks.

(2) Section Volume

Tables 5.2-2 (1) to 5.2-2 (6) show the section volumes between stations for each option.

Table 5.2-2 (1) Section Volume (Option: A1)

Option: A1

(Unit: 1,000 Passengers/day)

Direction: North to South

Station	Section	2025	2035	2045
L._Langit_Road				
	1	-	88	126
Camarin_Road				
	2	-	134	194
Zabarte_Road				
	3	-	141	226
Novaliches				
	4	-	134	214
San_Bartolome				
	5	-	132	214
Mindanao_Avenue-Quirino_Highway				
	6	82	124	196
Tandang_Sora_Avenue				
	7	122	135	218
North_Avenue				
	8	98	110	166
Quezon_Avenue				
	9	101	114	170
Kamuning				
	10	114	123	185
Cubao				
	11	119	135	198
Santolan-Annapolis				
	12	120	141	216
Ortigas_North				
	13	109	135	201
Ortigas_South				
	14	93	130	192
Kalayaan_Avenue				
	15	88	129	189
Bonifacio_Global_City				
	16	67	145	202
Cayetano_Biylevard				
	17	57	140	196
FTI				
	18	-	130	184
Dona_Soledad_Avenue				
	19	-	139	191
Dr._Arcadio_Santos_Avenue				
	20	-	151	204
Alabang-Zapote_Road				
	21	-	102	136
Talon_Singko				
	22	-	99	117
Molino_Road				
	23	-	78	119
Daang_Hari				
	24	-	86	127
Jose_Abad_Santos_Avenue				
	25	-	104	157
Paliparan_Road				
	26	-	153	199
Governor's_Drive				

Direction: South to North

Station	Section	2025	2035	2045
Governor's_Drive				
	26	-	154	202
Paliparan_Road				
	25	-	106	160
Jose_Abad_Santos_Avenue				
	24	-	88	130
Daang_Hari				
	23	-	78	120
Molino_Road				
	22	-	95	114
Talon_Singko				
	21	-	97	134
Alabang-Zapote_Road				
	20	-	148	199
Dr._Arcadio_Santos_Avenue				
	19	-	136	188
Dona_Soledad_Avenue				
	18	-	126	182
FTI				
	17	55	139	196
Cayetano_Biylevard				
	16	65	144	202
Bonifacio_Global_City				
	15	85	129	191
Kalayaan_Avenue				
	14	90	129	190
Ortigas_South				
	13	108	135	195
Ortigas_North				
	12	119	143	210
Santolan-Annapolis				
	11	116	137	199
Cubao				
	10	115	125	183
Kamuning				
	9	97	109	172
Quezon_Avenue				
	8	96	104	172
North_Avenue				
	7	119	136	227
Tandang_Sora_Avenue				
	6	77	125	206
Mindanao_Avenue-Quirino_Highway				
	5	-	133	222
San_Bartolome				
	4	-	134	227
Novaliches				
	3	-	146	237
Zabarte_Road				
	2	-	129	211
Camarin_Road				
	1	-	84	134
L._Langit_Road				

Source: *JICA Study Team*

Table 5.2-2 (2) Section Volume (Option: A2)

Option: A2

(Unit: 1,000 Passengers/day)

Direction: North to South

Station	Section	2025	2035	2045
L._Langit_Road				
	1	-	86	132
Camarin_Road				
	2	-	128	206
Zabarte_Road				
	3	-	136	242
Novaliches				
	4	-	127	228
San_Bartolome				
	5	-	131	228
Mindanao_Avenue-Quirino_Highway				
	6	75	123	208
Tandang_Sora_Avenue				
	7	122	137	230
North_Avenue				
	8	98	111	185
Timog_Avenue				
	9	100	115	187
E._Rodrigues_Sr._Avenue				
	10	109	125	196
Gilmore				
	11	116	132	208
Greenhills				
	12	108	126	201
Ortigas_North				
	13	98	121	188
Ortigas_South				
	14	82	118	185
Kalayaan_Avenue				
	15	76	117	180
Bonifacio_Global_City				
	16	54	135	196
Cayetano_Biylevard				
	17	44	131	191
FTI				
	18	-	130	183
Dona_Soledad_Avenue				
	19	-	138	189
Dr._Arcadio_Santos_Avenue				
	20	-	150	205
Alabang-Zapote_Road				
	21	-	101	135
Talon_Singko				
	22	-	99	115
Molino_Road				
	23	-	78	118
Daang_Hari				
	24	-	86	126
Jose_Abad_Santos_Avenue				
	25	-	104	156
Paliparan_Road				
	26	-	153	202
Governor's_Drive				

Direction: South to North

Station	Section	2025	2035	2045
Governor's_Drive				
	26	-	155	203
Paliparan_Road				
	25	-	105	157
Jose_Abad_Santos_Avenue				
	24	-	88	128
Daang_Hari				
	23	-	78	118
Molino_Road				
	22	-	94	111
Talon_Singko				
	21	-	98	131
Alabang-Zapote_Road				
	20	-	148	200
Dr._Arcadio_Santos_Avenue				
	19	-	135	186
Dona_Soledad_Avenue				
	18	-	127	182
FTI				
	17	38	130	199
Cayetano_Biylevard				
	16	47	133	205
Bonifacio_Global_City				
	15	68	115	189
Kalayaan_Avenue				
	14	74	115	185
Ortigas_South				
	13	93	116	188
Ortigas_North				
	12	103	123	200
Greenhills				
	11	111	129	206
Gilmore				
	10	107	125	190
E._Rodrigues_Sr._Avenue				
	9	94	112	180
Timog_Avenue				
	8	94	109	177
North_Avenue				
	7	120	139	219
Tandang_Sora_Avenue				
	6	75	123	200
Mindanao_Avenue-Quirino_Highway				
	5	-	133	218
San_Bartolome				
	4	-	132	217
Novaliches				
	3	-	140	234
Zabarte_Road				
	2	-	129	207
Camarin_Road				
	1	-	86	130
L._Langit_Road				

Source: *JICA Study Team*

Table 5.2-2 (3) Section Volume (Option: A3)

Option: A3

(Unit: 1,000 Passengers/day)

Direction: North to South

Station	Section	2025	2035	2045
L._Langit_Road				
	1	-	81	135
Camarin_Road				
	2	-	128	203
Zabarte_Road				
	3	-	137	236
Novaliches				
	4	-	125	224
San_Bartolome				
	5	-	125	223
Mindanao_Avenue-Quirino_Highway				
	6	86	122	205
Tandang_Sora_Avenue				
	7	119	137	234
North_Avenue				
	8	82	105	188
Timog_Avenue				
	9	81	105	187
Araneta_Avenue				
	10	88	114	186
E._Rodrigues_Sr._Avenue				
	11	100	129	212
V._Mapa				
	12	106	140	225
Jose_Rizal_University				
	13	106	140	227
Old_Wak_Wak_Road				
	14	106	141	229
Ortigas_North				
	15	78	126	205
Ortigas_South				
	16	59	124	194
Kalayaan_Avenue				
	17	52	122	189
Bonifacio_Global_City				
	18	41	137	206
Cayetano_Biylevard				
	19	31	132	197
FTI				
	20	-	129	186
Dona_Soledad_Avenue				
	21	-	136	191
Dr._Arcadio_Santos_Avenue				
	22	-	151	204
Alabang-Zapote_Road				
	23	-	100	136
Talon_Singko				
	24	-	97	115
Molino_Road				
	25	-	78	118
Daang_Hari				
	26	-	85	126
Jose_Abad_Santos_Avenue				
	27	-	103	155
Paliparan_Road				
	28	-	150	201
Governor's_Drive				

Direction: South to North

Station	Section	2025	2035	2045
Governor's_Drive				
	28	-	153	203
Paliparan_Road				
	27	-	107	157
Jose_Abad_Santos_Avenue				
	26	-	89	128
Daang_Hari				
	25	-	79	117
Molino_Road				
	24	-	95	111
Talon_Singko				
	23	-	98	131
Alabang-Zapote_Road				
	22	-	149	200
Dr._Arcadio_Santos_Avenue				
	21	-	135	189
Dona_Soledad_Avenue				
	20	-	127	185
FTI				
	19	27	132	198
Cayetano_Biylevard				
	18	37	137	208
Bonifacio_Global_City				
	17	49	118	190
Kalayaan_Avenue				
	16	56	119	191
Ortigas_South				
	15	76	121	200
Ortigas_North				
	14	104	135	217
Old_Wak_Wak_Road				
	13	105	136	218
Jose_Rizal_University				
	12	104	136	214
V._Mapa				
	11	99	129	202
E._Rodrigues_Sr._Avenue				
	10	86	114	174
Araneta_Avenue				
	9	81	106	174
Timog_Avenue				
	8	82	106	175
North_Avenue				
	7	119	147	224
Tandang_Sora_Avenue				
	6	85	133	204
Mindanao_Avenue-Quirino_Highway				
	5	-	139	220
San_Bartolome				
	4	-	138	220
Novaliches				
	3	-	146	243
Zabarte_Road				
	2	-	136	202
Camarin_Road				
	1	-	84	122
L._Langit_Road				

Source: *JICA Study Team*

Table 5.2-2 (4) Section Volume (Option: B1)

Option: B1

(Unit: 1,000 Passengers/day)

Direction: North to South

Station	Section	2025	2035	2045
Bahay_Pare_Road				
	1	-	86	95
Mt._Samat_Road				
	2	-	77	106
Llana_Road				
	3	-	118	176
Gen._Luis				
	4	-	147	219
Tatalon				
	5	-	145	224
Mindanao_Avenue-Quirino_Highway				
	6	82	143	225
Tandang_Sora_Avenue				
	7	122	152	241
North_Avenue				
	8	98	117	171
Quezon_Avenue				
	9	101	125	178
Kamuning				
	10	114	134	192
Cubao				
	11	119	139	195
Santolan-Annapolis				
	12	120	143	207
Ortigas_North				
	13	109	133	191
Ortigas_South				
	14	93	127	183
Kalayaan_Avenue				
	15	88	124	184
Bonifacio_Global_City				
	16	67	141	196
Cayetano_Biylevard				
	17	57	135	189
FTI				
	18	-	130	180
Dona_Soledad_Avenue				
	19	-	138	191
Dr._Arcadio_Santos_Avenue				
	20	-	150	203
Alabang-Zapote_Road				
	21	-	100	143
Talon_Singko				
	22	-	98	131
Molino_Road				
	23	-	78	125
Daang_Hari				
	24	-	87	124
Jose_Abad_Santos_Avenue				
	25	-	105	153
Paliparan_Road				
	26	-	153	199
Governor's_Drive				

Direction: South to North

Station	Section	2025	2035	2045
Governor's_Drive				
	26	-	155	200
Paliparan_Road				
	25	-	106	155
Jose_Abad_Santos_Avenue				
	24	-	89	125
Daang_Hari				
	23	-	78	125
Molino_Road				
	22	-	94	123
Talon_Singko				
	21	-	96	139
Alabang-Zapote_Road				
	20	-	147	201
Dr._Arcadio_Santos_Avenue				
	19	-	135	187
Dona_Soledad_Avenue				
	18	-	125	178
FTI				
	17	55	132	189
Cayetano_Biylevard				
	16	65	138	198
Bonifacio_Global_City				
	15	85	125	185
Kalayaan_Avenue				
	14	90	125	181
Ortigas_South				
	13	108	129	186
Ortigas_North				
	12	119	141	202
Santolan-Annapolis				
	11	116	136	194
Cubao				
	10	115	137	191
Kamuning				
	9	97	125	171
Quezon_Avenue				
	8	96	118	162
North_Avenue				
	7	119	159	153
Tandang_Sora_Avenue				
	6	77	153	237
Mindanao_Avenue-Quirino_Highway				
	5	-	153	231
Tatalon				
	4	-	142	222
Gen._Luis				
	3	-	113	179
Llana_Road				
	2	-	74	105
Mt._Samat_Road				
	1	-	86	95
Bahay_Pare_Road				

Source: *JICA Study Team*

Table 5.2-2 (5) Section Volume (Option: B2)

Option: B2

(Unit: 100 Passengers/day)

Direction: North to South

Station	Section	2025	2035	2045
Bahay_Pare_Road				
	1	-	86	94
Mt._Samat_Road				
	2	-	76	98
Llana_Road				
	3	-	115	164
Gen._Luis				
	4	-	139	215
Tatalon				
	5	-	145	221
Mindanao_Avenue-Quirino_Highway				
	6	75	144	221
Tandang_Sora_Avenue				
	7	122	151	239
North_Avenue				
	8	98	117	183
Timog_Avenue				
	9	100	124	189
E._Rodrigues_Sr._Avenue				
	10	109	134	196
Gilmore				
	11	116	140	211
Greenhills				
	12	108	135	204
Ortigas_North				
	13	98	127	189
Ortigas_South				
	14	82	123	185
Kalayaan_Avenue				
	15	76	123	183
Bonifacio_Global_City				
	16	54	139	199
Cayetano_Biylevard				
	17	44	135	193
FTI				
	18	-	128	182
Dona_Soledad_Avenue				
	19	-	136	192
Dr._Arcadio_Santos_Avenue				
	20	-	149	207
Alabang-Zapote_Road				
	21	-	102	142
Talon_Singko				
	22	-	99	125
Molino_Road				
	23	-	78	123
Daang_Hari				
	24	-	86	128
Jose_Abad_Santos_Avenue				
	25	-	105	157
Paliparan_Road				
	26	-	152	197
Governor's_Drive				

Direction: South to North

Station	Section	2025	2035	2045
Governor's_Drive				
	26	-	152	196
Paliparan_Road				
	25	-	105	156
Jose_Abad_Santos_Avenue				
	24	-	86	127
Daang_Hari				
	23	-	79	122
Molino_Road				
	22	-	95	119
Talon_Singko				
	21	-	97	136
Alabang-Zapote_Road				
	20	-	146	201
Dr._Arcadio_Santos_Avenue				
	19	-	133	189
Dona_Soledad_Avenue				
	18	-	126	182
FTI				
	17	38	133	198
Cayetano_Biylevard				
	16	47	138	207
Bonifacio_Global_City				
	15	68	121	192
Kalayaan_Avenue				
	14	74	120	189
Ortigas_South				
	13	93	125	194
Ortigas_North				
	12	103	133	203
Greenhills				
	11	111	139	211
Gilmore				
	10	107	135	193
E._Rodrigues_Sr._Avenue				
	9	94	121	188
Timog_Avenue				
	8	94	116	181
North_Avenue				
	7	120	156	246
Tandang_Sora_Avenue				
	6	75	148	233
Mindanao_Avenue-Quirino_Highway				
	5	-	151	233
Tatalon				
	4	-	143	208
Gen._Luis				
	3	-	119	163
Llana_Road				
	2	-	71	96
Mt._Samat_Road				
	1	-	85	90
Bahay_Pare_Road				

Source: *JICA Study Team*

Table 5.2-2 (6) Section Volume (Option: B3)

Option: B3

(Unit: 1,000 Passengers/day)

Direction: North to South

Station	Section	2025	2035	2045
Bahay_Pare_Road				
	1	-	85	93
Mt._Samat_Road				
	2	-	72	99
Llana_Road				
	3	-	107	162
Gen._Luis				
	4	-	139	215
Tatalon				
	5	-	149	221
Mindanao_Avenue-Quirino_Highway				
	6	86	151	227
Tandang_Sora_Avenue				
	7	119	158	252
North_Avenue				
	8	82	107	188
Timog_Avenue				
	9	81	107	188
Araneta_Avenue				
	10	88	118	193
E._Rodrigues_Sr._Avenue				
	11	100	131	216
V._Mapa				
	12	106	144	223
Jose_Rizal_University				
	13	106	142	223
Old_Wak_Wak_Road				
	14	106	143	225
Ortigas_North				
	15	78	127	206
Ortigas_South				
	16	59	125	195
Kalayaan_Avenue				
	17	52	123	193
Bonifacio_Global_City				
	18	41	139	207
Cayetano_Biylevard				
	19	31	133	198
FTI				
	20	-	128	184
Dona_Soledad_Avenue				
	21	-	135	190
Dr._Arcadio_Santos_Avenue				
	22	-	148	203
Alabang-Zapote_Road				
	23	-	98	140
Talon_Singko				
	24	-	96	118
Molino_Road				
	25	-	78	120
Daang_Hari				
	26	-	85	126
Jose_Abad_Santos_Avenue				
	27	-	103	154
Paliparan_Road				
	28	-	152	195
Governor's_Drive				

Direction: South to North

Station	Section	2025	2035	2045
Governor's_Drive				
	28	-	153	198
Paliparan_Road				
	27	-	104	157
Jose_Abad_Santos_Avenue				
	26	-	86	129
Daang_Hari				
	25	-	79	121
Molino_Road				
	24	-	92	110
Talon_Singko				
	23	-	94	134
Alabang-Zapote_Road				
	22	-	146	199
Dr._Arcadio_Santos_Avenue				
	21	-	133	186
Dona_Soledad_Avenue				
	20	-	125	181
FTI				
	19	27	130	198
Cayetano_Biylevard				
	18	37	136	208
Bonifacio_Global_City				
	17	49	119	189
Kalayaan_Avenue				
	16	56	121	191
Ortigas_South				
	15	76	123	197
Ortigas_North				
	14	104	136	217
Old_Wak_Wak_Road				
	13	105	138	217
Jose_Rizal_University				
	12	104	139	216
V._Mapa				
	11	99	128	211
E._Rodrigues_Sr._Avenue				
	10	86	113	189
Araneta_Avenue				
	9	81	102	184
Timog_Avenue				
	8	82	101	184
North_Avenue				
	7	119	160	255
Tandang_Sora_Avenue				
	6	86	152	240
Mindanao_Avenue-Quirino_Highway				
	5	-	151	231
Tatalon				
	4	-	148	220
Gen._Luis				
	3	-	118	168
Llana_Road				
	2	-	77	99
Mt._Samat_Road				
	1	-	88	92
Bahay_Pare_Road				

Source: *JICA Study Team*

(3) Subway Fare Revenue

Subway fare revenue by each options are shown in Table 5.2-3.

Table 5.2-3 Subway Fare Revenue

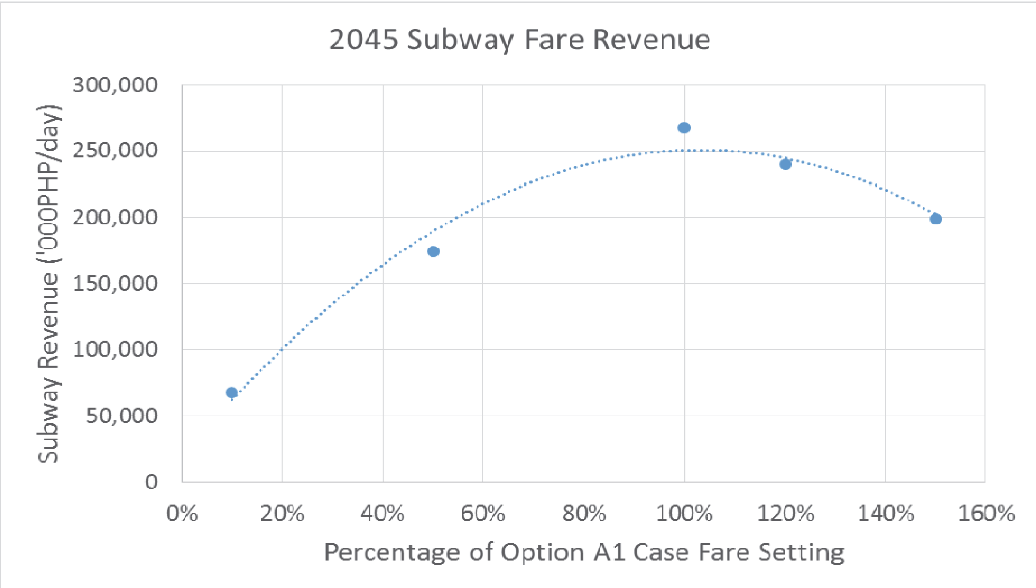
	Unit	Option	2025	2035	2045
Fare Revenue	1,000 PHP/day	A1	27,277	143,666	267,421
		A2	25,411	143,366	270,344
		A3	29,464	155,694	294,724
		B1	27,277	155,112	276,865
		B3	25,411	156,469	284,738
		B3	29,464	168,527	307,441

Source: *JICA Study Team*

Note: The above figures in 2035 and 2045 include the entire section of the MMS, covering north, central and south zones.

(4) Sensitivity of Fare Setting

Figure 5.2-1 shows the result of sensitivity analysis for the fare setting for the MMSP in case of Option A1 in 2045. The result shows that the fare setting assumed for the MMSP is justifiable since the expected revenue is expected to be the highest in case of 100% of the assumed fare setting. However, in order to justify the feasibility of the Project as well as to prepare the most feasible implementation scheme, fare setting for the MMSP should be considered more in detail in the next step of this Study, i.e. Feasibility Study.



Source: *JICA Study Team*

Figure 5.2-1 Sensitivity of Fare Setting for MMSP (Option A1 in 2045 case)

1: "Roadmap for Transport Infrastructure Development for Metro Manila and Its Surrounding Areas (Region III & Region IV-A); 2014, JICA" and "Preparatory Survey on the Clark Airport Expressway Railway (Commuter Section) in the Republic of the Philippines; 2014, JICA"

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Chapter 6

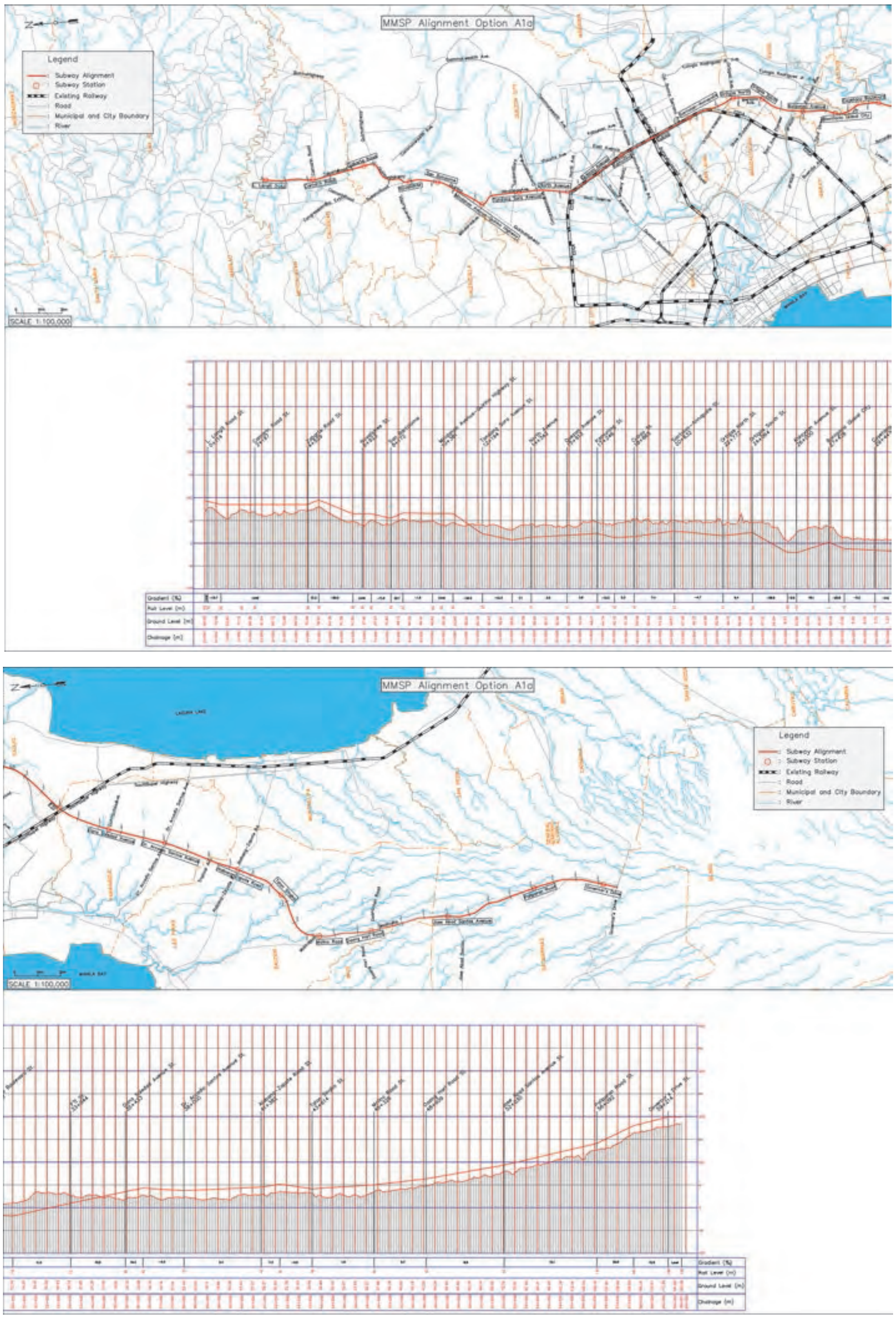
PRELIMINARY ROUTE ALIGNMENT PLAN

Chapter 6 PRELIMINARY ROUTE ALIGNMENT PLAN

6.1 Route Alignment Plan

The preliminary horizontal and vertical route alignment drawings of all route options (12 options) have been prepared in accordance with the criteria described in Chapter 4 as well as the selected route options in Chapter 4.8.

As an example, the preliminary horizontal and vertical route alignment drawings for Option A1a are shown in Figure 6.1-1. Inclusive the drawings shown below, the preliminary horizontal and vertical route alignment drawings of all route options (12 options) are provided in Appendix D.



Source: *JICA Study Team*

Figure 6.1-1 Horizontal and Vertical Route Alignment (Option A1a)

6.2 Civil Structures

6.2.1 General

In the selection of the types of civil structures in planning a new railway, the rate of urbanization in the target project area of the railway, the road width and traffic conditions on the existing road, harmonization with the land use plan and characteristics of railway system are all essential criteria that must be carefully taken into consideration in the selection process.

In urban centers with narrow roads and where road traffic congestion is already a serious problem, construction and installation of urban railway system is expected to worsen the road congestion. Additionally, this condition is further complicated by the high density of buildings and residences located near these roads. Considering the cost and time for necessary land acquisition as well as separation from the road traffic, elevated structures using the space above the road or underground structures below the road are recommended.

Even in suburban areas where land acquisition is relatively easy and resettlement is less required, it is recommended that (i) the required Right of Way (ROW) for the railway and the ancillary road be secured in advance, and (ii) the design of the new development adapt to the essential densification features of urban areas in planning of transport system integrated with the development in suburban areas, such as new town developments.

In Metro Manila, the construction activities at the road level would worsen the road traffic congestion. Therefore, based on the various requirements for the subway and its expected characteristics, either underground or elevated structures should be applied. In addition, during the design stage, consideration on passenger convenient should be carefully taken into account as the access to railway stations is one of the important factors for people using railways.

6.2.2 Types of Civil Structures

In the construction of the subway, railway systems composed of rolling stock, signaling system, power supply system, communication systems, other facilities required for railway operation, space required for system maintenance, and emergency and safety facilities should all be considered in the determining the type of civil structures.

The conformity of structure type with the general traffic system in a track-type is shown in Table 6.2.2-1.

Table 6.2.2-1 Conformity of Structure Types and Typical Trackwork Type

Mode/System	At-Grade		Elevated	Underground
	Exclusive Track	Compatible Track		
MRT	A	B	A	A
LRT	A	B	A	A
Monorail (Straddle Type)	N/A	C	A	B
Monorail (Suspended Type)	N/A	C	A	N/A
AGT	N/A	C	A	A

Note 1: Symbols denote as follows: A= desirable; B=possible; C=not possible; N/A=not applicable

Source: *JICA Study Team*

(1) Elevated Structures

The setting standards and basis of installation space for MRT (overhead catenary type), LRT (overhead catenary type), straddle type monorail, suspended type monorail and AGT (third rail type) are shown in the following tables. Installation space consists of the width required for system operation, lateral space occupancy, upper space occupancy, and lower space occupancy which secure the road space. Table 6.2.2-2 shows the setting standards for the width required for system operation, and Table 6.2.2-3 shows the standards for the width of space occupancy.

Table 6.2.2-2 Setting Standards for Width Required for System Operation

System	Required Width for System Operation (m)	Description
MRT	10.9	Distance between tracks (min. 3.8m, typical 4.0m), width of formation level, (2.75 m), pole section (0.7 m)
LRT	9.7	Distance distance between tracks (typical 3.2m), width of formation level (2.55 m), pole section (0.7 m)
Straddle Type Monorail	7.6	Distance between tracks (typical 3.7m), e.g. Tama Monorail, Tokyo Monorail, Okinawa Monorail in Japan
Suspended Type Monorail	8.8	Distance between tracks (typical 5.1m), e.g. Chiba Monorail in Japan
AGT	7.5	Distance between tracks (typical 3.75m), e.g. Yurikamome in Japan

Source: *JICA Study Team*

Table 6.2.2-3 Setting Standards for Space Occupancy

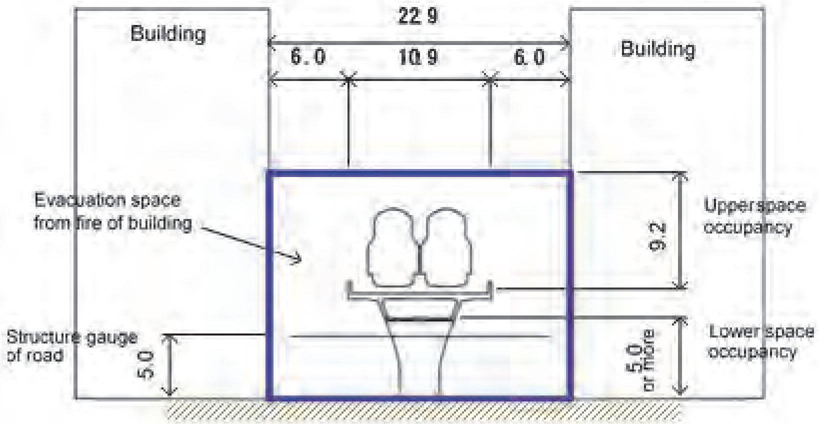
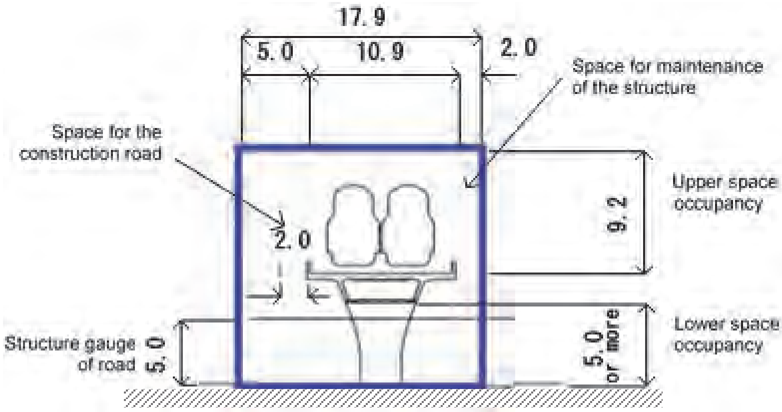
Category		Width of Space Occupancy	Basis of Setting Standard
Lateral Space Occupancy	Construction of Road	Set 5.0 m width space at one side of elevated structure for construction of road.	Major experiences in Japan
	Maintenance of Structure	Set 2.0 m width space at both sides for maintenance work space of elevated structure	Footing space for construction
	Rescue from Building Fire	Set 6.0 m width space at both sides for rescue space of building fire along the route.	Standard in Japan
	Rescue of Monorail Passenger	Set 3.0 m width space at both sides of monorail construction gauge for rescue of monorail passenger.	Standard in Japan
Upper Space Occupancy	MRT/LRT	Considering the space of power pole construction and dangerous range of high voltage (direct current).	Standard in Japan
	Straddle Type Monorail	Set 2.0 m allowance space above the construction gauge.	Securing the allowance for safety operation
	Suspended Type Monorail	Set 2.0 m work space above from the upper edge of elevated structure.	Maintenance work space
	AGT	Set 2.0 m allowance space above the construction gauge.	Securing the allowance for safety operation

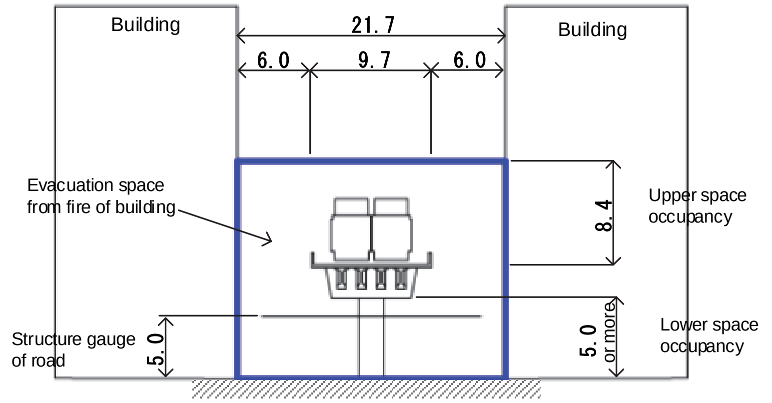
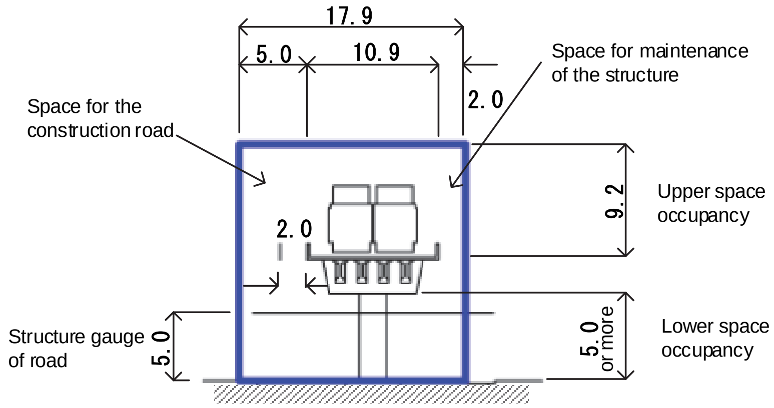
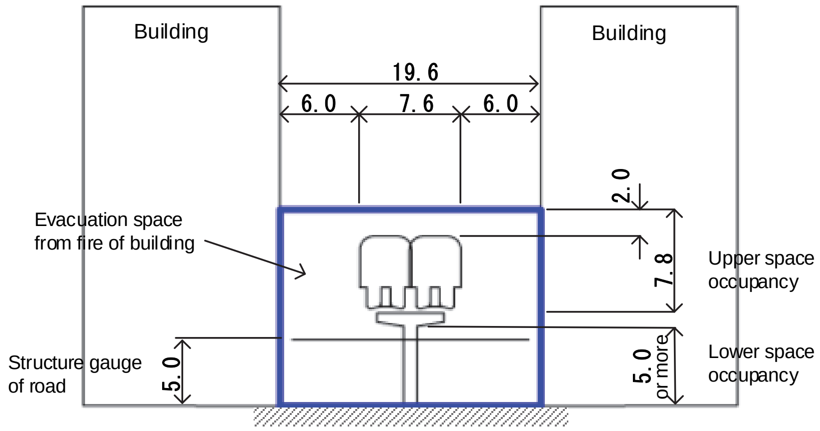
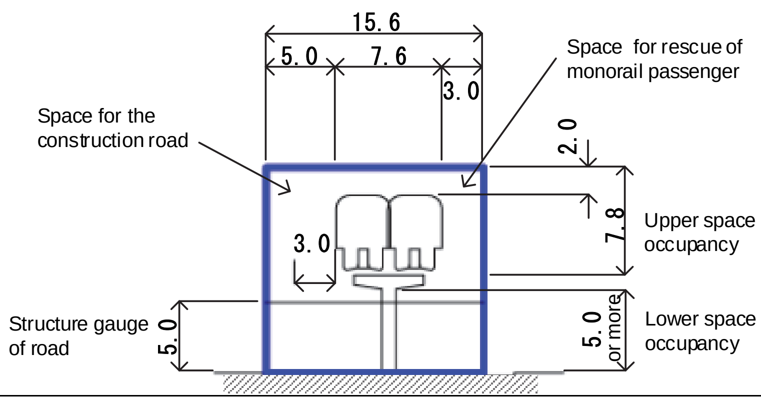
Category		Width of Space Occupancy	Basis of Setting Standard
Lower Space Occupancy	MRT/LRT/AGT, Straddle Type Monorail	Securing more than 5.0 m height between the space from bottom end of bridge cross beam to road construction gauge.	Standard in Philippines
	Suspended Type Monorail	Securing the height more than 5.0 m between the space from the bottom of construction gauge of suspended type monorail and road construction gauge, and added 2.0 m allowance space.	Standard in Philippines, and securing the allowance for safety operation

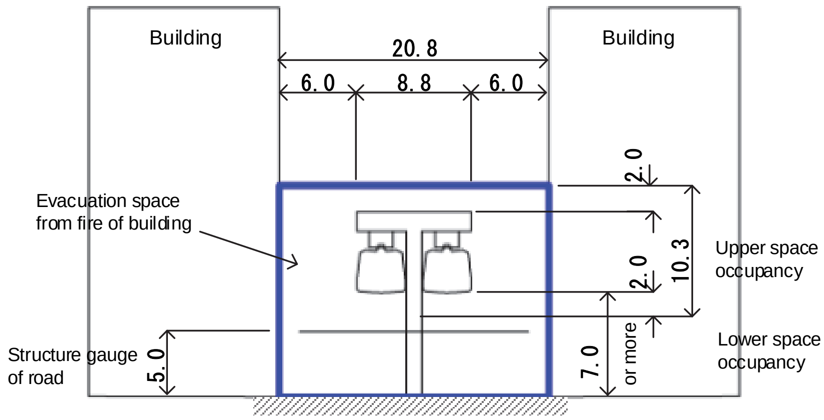
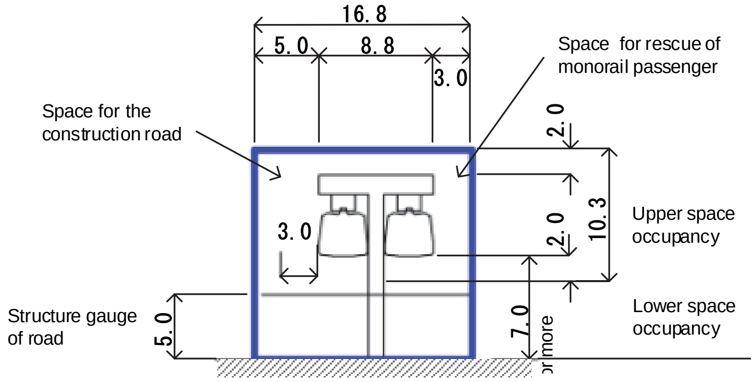
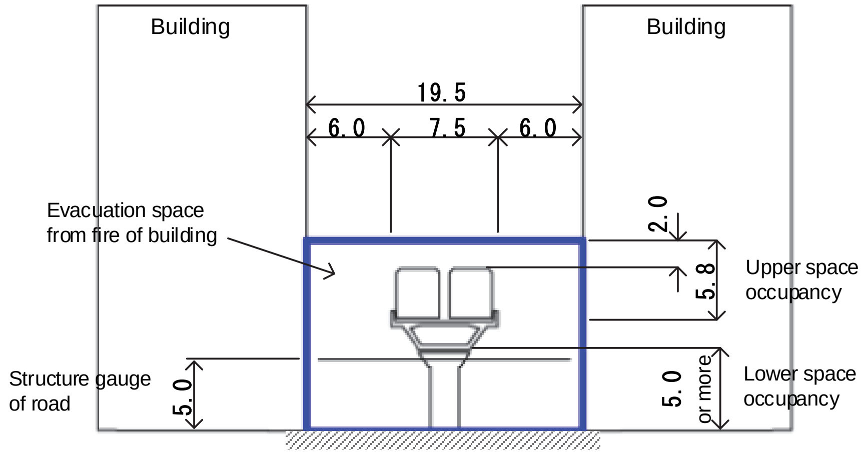
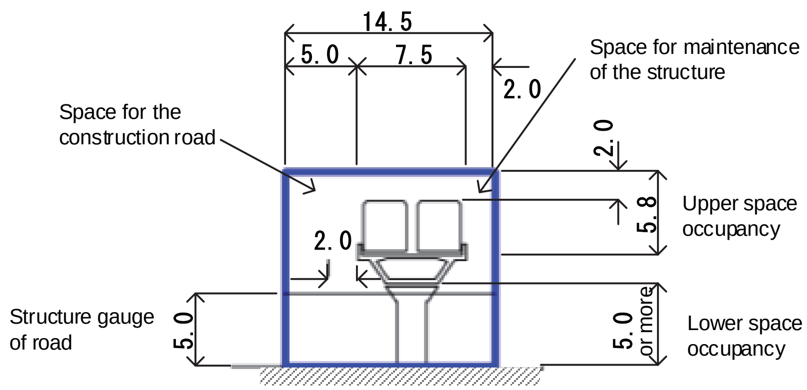
Source: *JICA Study Team*

The typical installation space of elevated structures for each transport system is shown in Table 6.2.2-4. The two cross-sections of installation space are the section where the required width is the widest (section adjacent to the building), and the minimum section (other section).

Table 6.2.2-4 Typical Installation Space by Mode Types

Mode	Section	Typical Installation Space (unit: meters)
MRT (overhead catenary type)	Adjacent to building	
	Other	

Mode	Section	Typical Installation Space (unit: meters)
LRT (overhead catenary type)	Adjacent to building	
	Other	
Straddle Type Monorail	Adjacent to building	
	Other	

Mode	Section	Typical Installation Space (unit: meters)
Suspended Type Monorail	Adjacent to building	
	Other	
AGT (third rail type)	Adjacent to building	
	Other	

Source: *JICA Study Team*

(2) Underground Structures

A shield tunnel, cut-and-cover tunnel, and U-shaped walls are used as the underground structures of an urban railway. The underground structures are applicable to majority of the railway systems such as MRT, LRT and AGT. Based on design standards for underground structures, the structure and space around the structure are required to satisfy clearance requirements. The installation space of different underground structure types are described as follows:

(a) Shield Tunnel

1) Minimum Earth Covering

Generally, the minimum earth covering is of similar range as the outside diameter of the shield tunnel. Especially in the type of soil, size of cross-sectional excavation, condition of surface, and workability of construction, sufficient consideration is required to secure the necessary earth covering.

2) Minimum Earth Covering in Case of Passing through the Bottom of River

Considering the uplift prevention of the tunnel, the minimum earth covering in case of passing through the bottom of a river is set at more than 1.5 times the outside diameter of the shield tunnel.

3) Offset Distance between Shield Tunnels

In case of installation of single track shield tunnel with horizontal or vertical configuration, the offset distance between shield tunnels is generally set to be more than the outside diameter of the shield tunnel to reduce the influence of installation.

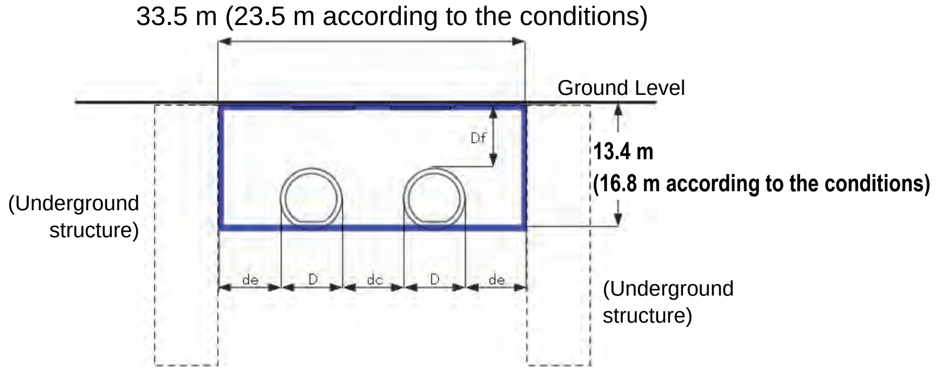
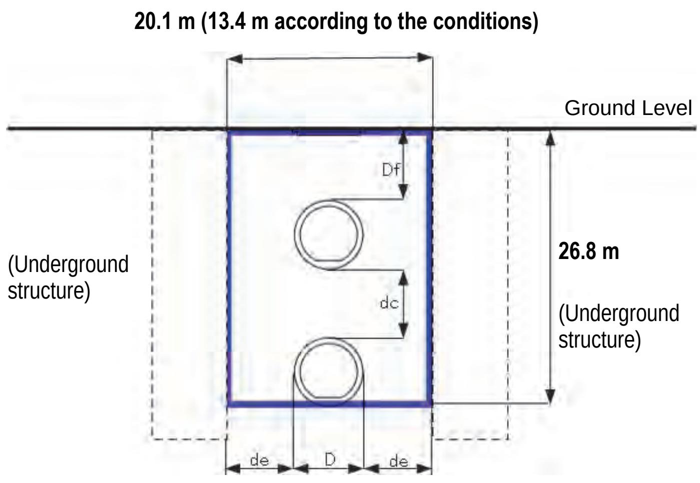
4) Others

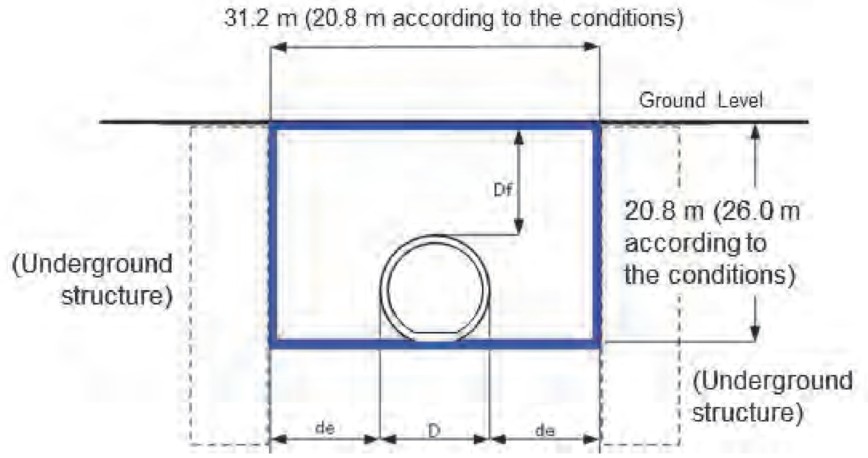
In case of passing under private land or railway, earth covering is set slightly larger to reduce the construction impact on the existing buildings and tracks located above. In case of planning a smaller offset distance than that mentioned above, an impact consideration shall be conducted to secure safety during construction. There are some experiences of adopting half of the outside diameter of the shield tunnel with special treatment such as soil treatment.

In case securing the safety of the required offset distance is not possible, auxiliary construction method can be adopted. As for the offset distance of neighboring underground structures and between the pile and shield tunnel, the same condition of offset distance between the shield tunnels is adopted.

The typical installation space of single track and double tracks shield tunnels are shown in Table 6.2.2-5.

Table 6.2.2-5 Typical Installation Space for Underground Structures

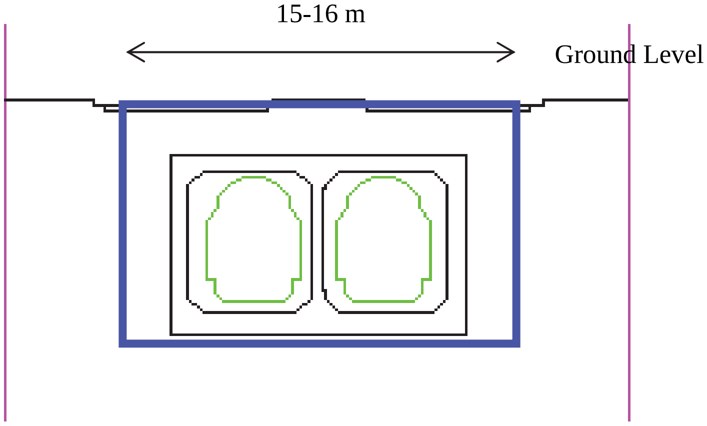
Configuration	Typical Installation Space		
Single Track Shield Tunnel (Horizontal Configuration)			
	Standard outside diameter		D = 6.7 m
	Minimum earth covering	Standard	Df =1D = 6.7 m
		Under private land and railway	Df > 1D = more than 6.7 m
		Bottom of a river	Df =1.5D = more than10 m
	Minimum offset distance between shield tunnels		dc = 1D = 6.7 m (according to the conditions, 0.5D = 3.4 m) Note: absolute minimum at 0.4m with special treatment, e.g. soil improvement
	Minimum offset distance with underground structure		de = 1D = 6.7 m (according to the conditions, 0.5D = 3.4 m)
Single Track Shield Tunnel (Vertical Configuration)			
	Standard outside diameter		D = 6.7 m
	Minimum earth covering	Standard	Df =1D = 6.7 m
		Under private land and railway	Df > 1D = more than 6.7 m
	Minimum offset distance with underground structure		de = 1D = 6.7 m (according to the conditions, 0.5D = 3.4 m)

<table>
<tr><th>Configuration</th><th colspan="3">Typical Installation Space</th></tr>
<tr><td rowspan="7">Double Track Shield Tunnel</td><td colspan="3">
</td></tr>
<tr><td colspan="2">Standard outside diameter</td><td>D = 10.4 m</td></tr>
<tr><td rowspan="3">Minimum earth covering</td><td>Standard</td><td>Df =1D = 10.4 m</td></tr>
<tr><td>Under private land and railway</td><td>Df > 1D = 10.4 m and more</td></tr>
<tr><td>Bottom of a river</td><td>Df =1.5D = 15.6 m and more</td></tr>
<tr><td colspan="2">Minimum offset distance with underground structure</td><td>de = 1D = 10.4 m (according to the conditions, 0.5D = 5.2 m)
Note: absolute minimum at 0.4m with special treatment, e.g. soil improvement</td></tr>
</table>

Source: *JICA Study Team*

(b) Cut-and-Cover Tunnel

The cut-and-cover tunnel shown in Figure 6.2.2-1 has depth of more than 10 meters and width of 15-16 meters. The depth of soil cover on top of this tunnel shall satisfy requirements of structural design standards and technical specification for railway system.

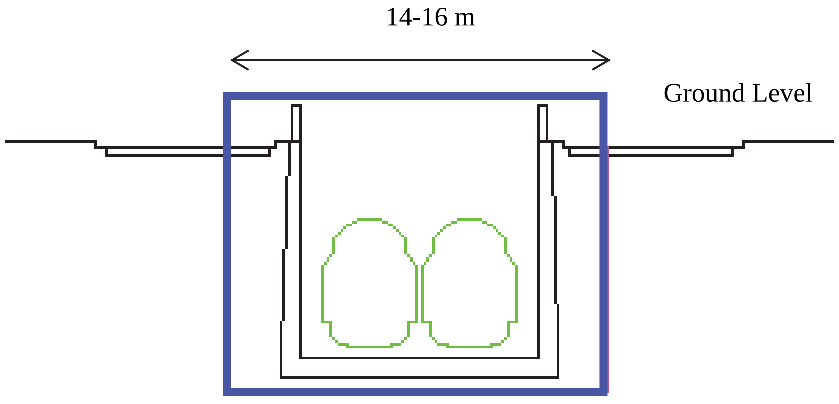


Source: *JICA Study Team*

Figure 6.2.2-1 Installation Space of Typical Cut-and-Cover Tunnel

(c) U-shaped Wall

The typical installation space for a U-shaped wall has maximum depth of 10 meters and width ranging between 14-16 meters. This width is already inclusive of the space required for maintenance works and rescue and evacuation operations. The required safe distance from the roadway of the open top section must be checked with local authorities as well as requirements of structural design standards and technical specification for railway system design (Figure 6.2.2-2).

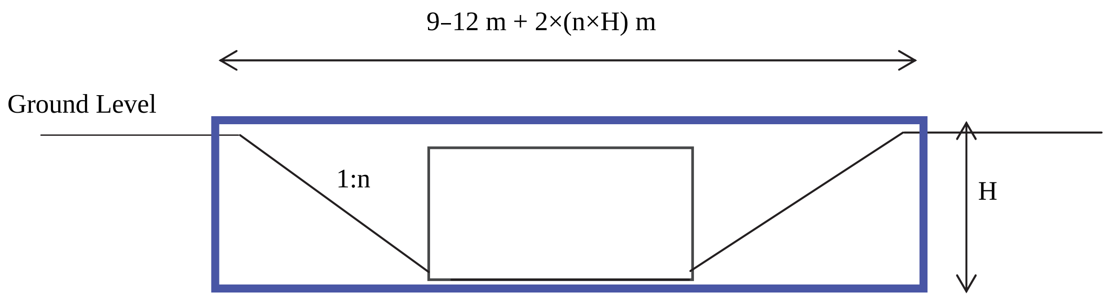


Source: *JICA Study Team*

Figure 6.2.2-2 Typical Installation Space of U-Shaped Wall

(d) Cut Earth

The typical installation space for cut earth is shown in Figure 6.2.2-3. The installation space that includes space for maintenance works and other operational tasks has width that is calculated based on the embankment height and slope, with the minimum width set at 9-12 meters. Similarly, the horizontal clearance requirements shall be consulted with local authorities as well as requirements of structural design standards and technical specifications for railway system design.



Source: *JICA Study Team*

Figure 6.2.2-3 Typical System Envelope of Cut Earth

6.3 Station Structures

6.3.1 Required Space

There are three typical types of station structures, namely over track, elevated and underground.

(1) Over Track Station

The required space and major dimensions for an over track station are as follows (Figures 6.3.1-1 and 6.3.1-2):

(a) Total required width for station: 25-30 meters;

(b) Width of over track station: width of 17-22 meters;

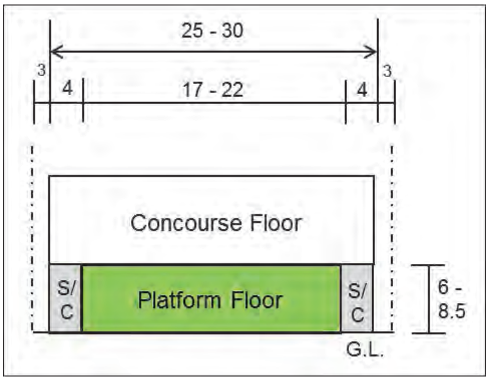
(c) Escalator/Staircase: 4 meters for parallel installation of escalator and staircase;

(d) Sidewalk: 3 meters for wheelchairs passing at the narrowest spot;

(e) Typical width of passageway in the concourse floor: 5-10 meters, depending on the number of passengers;

(f) Lengths of escalator/staircase: ranging from 15-20 meters for 6-8.5 meters gap; and

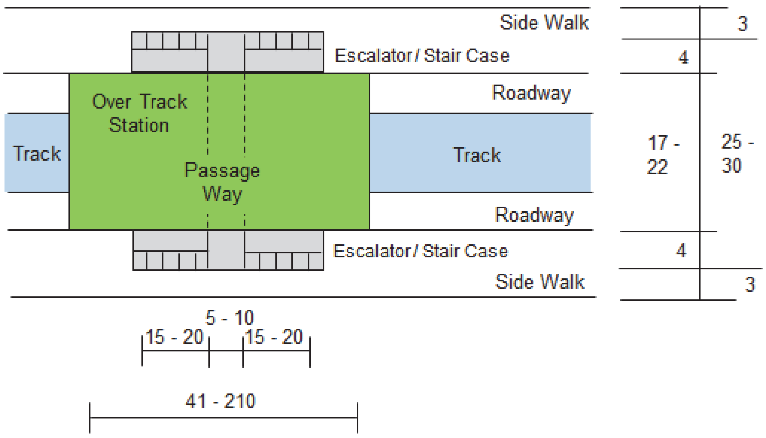
(g) Platform length: 41-210 meters, depending on passenger volume and train length.



(Unit: meter)

Source: *JICA Study Team*

Figure 6.3.1-1 Required Width of Over Track Station



(unit: meter)

Source: *JICA Study Team*

Figure 6.3.1-2 Required Space of Typical Over Track Station

(2) Elevated Station

The required space and major dimensions for an elevated station are as follows (Figures 6.3.1-3 and 6.3.1-4):

(a) Total required width for station: 25-30 meters;

(b) Width of elevated station: 17-22 meters;

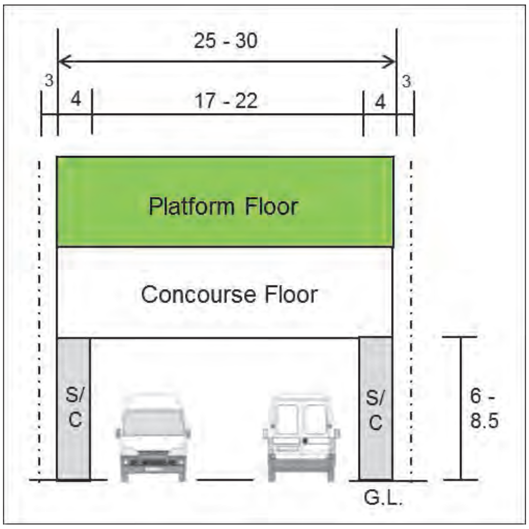
(c) Escalator/Staircase: 4 meters for parallel installation of escalator and staircase;

(d) Sidewalk: 3 meters for wheelchairs passing at the narrowest spot;

(e) Typical width of passageway in the concourse floor: 5-10 meters, depending on the number of passengers;

(f) Length of escalator/staircase: 15-20 meters for 6 - 8.5 meters gap; and

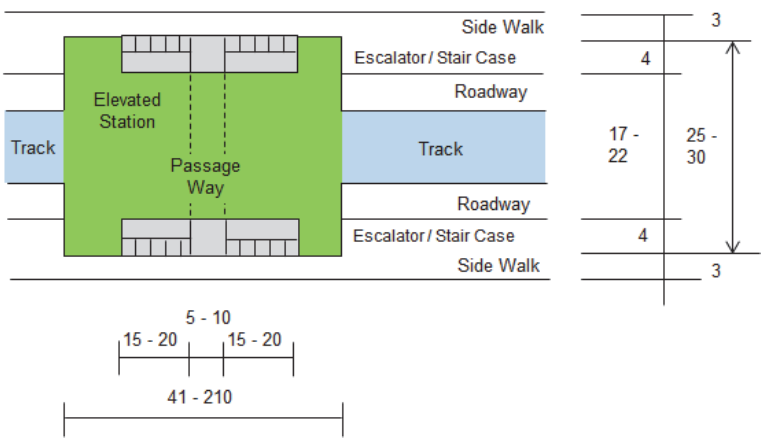
(g) Platform length: 41-210 meters, defined by passenger volume and train length.



(unit: meter)

Source: *JICA Study Team*

Figure 6.3.1-3 Required Width of Elevated Station



(unit: meter)

Source: *JICA Study Team*

Figure 6.3.1-4 Required Space for Typical Elevated Station

(3) Underground Station

The required space and major dimensions for an underground station are as follows (Figures 6.3.1-5 and 6.3.1-6):

(a) Total required width for station: 27-32 meters;

(b) Width of underground station: 17–22 meters;

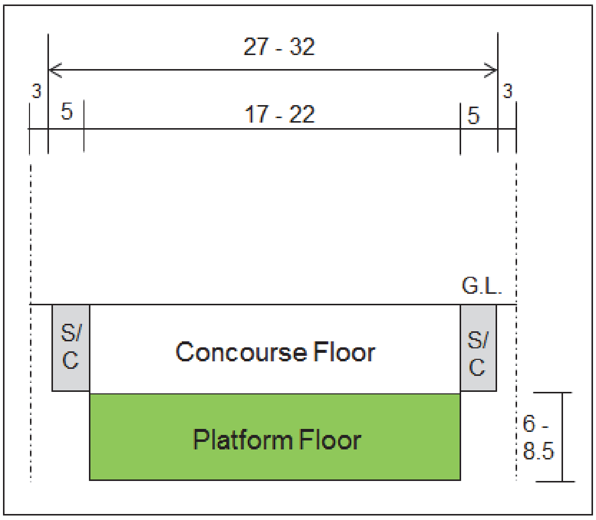
(c) Escalator/Staircase: 5 meters for parallel installation of escalator and staircase with wall structure;

(d) Sidewalk: 3 meters for wheelchairs passing at the narrowest spot;

(e) Typical width of underpass: 5-10 meters, depending on the number of passengers;

(f) Length of escalator/staircase: 13-18 meters for 5-7.5 meters gap; and

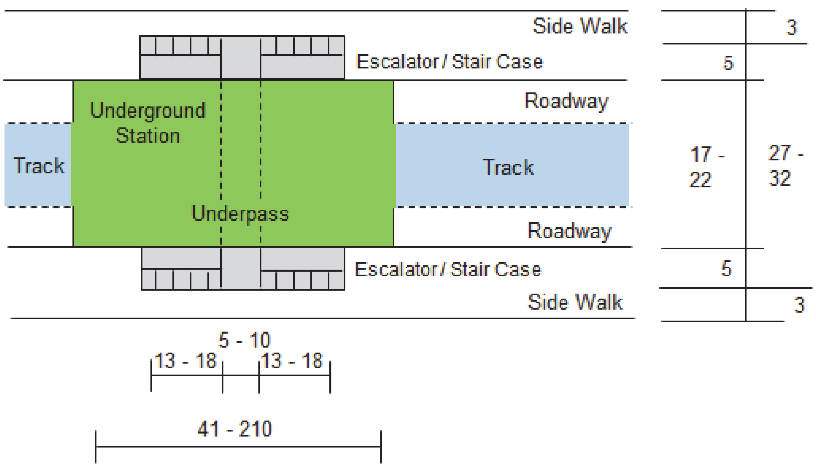
(g) Platform length: 41-210 meters, defined by passenger volume and train length.



(unit: meter)

Source: *JICA Study Team*

Figure 6.3.1-5 Required Width of Underground Station



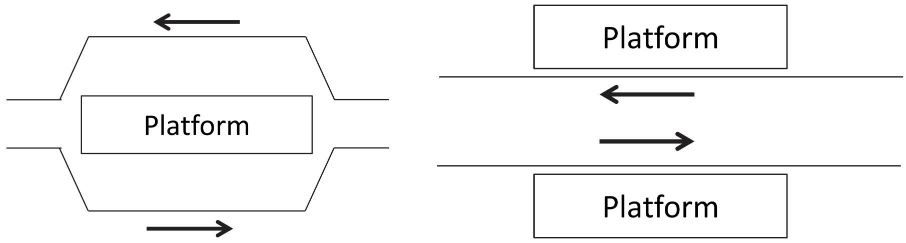
(unit: meter)

Source: *JICA Study Team*

Figure 6.3.1-6 Required Space of Typical Underground Station

6.3.2 Platform Type

There are two platform types with different dimension requirements. Figure 6.3.2-1 shows the schematic diagrams for the (1) island platform and (2) separate (or side) platform. The required installation width is different for each type. The structure width in case of station with island platform is narrower than that of separate platform.



Island Platform Separate Platform

Source: *JICA Study Team*

Figure 6.3.2-1 Platform Types

Both platform(s) types have different features (pros and cons) as described below:

(1) Island Platform

- Narrow platform width compared to the total width of 2 separate platforms, thus requiring narrower station structure, which is more preferred in case of underground station
- Easy access to both directions from concourse
- Desirable at station located in suburban area where the peak passenger volume in each direction differs, e.g. peak in up-bound trains for boarding passengers in the morning and in down-bound trains for alighting passengers in the evening
- Less number of escalators/elevators
- Difficult or requiring longer distance between stations to lower the elevation (height) of sections between stations to reduce the construction cost due to the provision of curve sections between mainline and station
- Not possible to achieve energy saving by down-up operation between stations due to difficulty in lowering the elevation (height) between stations
- Difficult or impossible to extend the platform length in the future to increase transport capacity

(2) Separate Platforms

- Wider platform width compared to the island platforms due to 2 platforms thus requiring wider station structure
- May cause inconvenience to passengers who went up (or down) from concourse to platform of wrong direction
- Desirable at station located in urban area/downtown where the difference of passenger volume in the morning and in the evening is small, i.e. evenly congested to both directions throughout the operation hours
- More number of escalators/elevators due to 2 platforms
- Easier to lower the elevation (height) of sections between stations due to straight tracks throughout mainline and station sections
- Possible to achieve energy saving by down-up operation between stations by lowering the elevation (height) between stations
- Easier to increase platform length in the future to increase transport capacity

Source: *JICA Study Team*

Figure 6.3.2-2 Example of Island Platform (Underground – Bangkok Blue Line)

Source: *JICA Study Team*

Figure 6.3.2-3 Example of Separate Platform (Elevated – Bangkok Airport Rail Link)

6.3.3 Architectural Design of Station

Before, the concept of station design was determined by the regional feature and landmark function of the area. Recently, however, the trend is a shift in focus on formative design and leading the growth of urban development. As for design characteristics, shapes of circles and curves are applied more, and materials of glass, aluminum and canvas are used (Figures 6.3.3-1 and 6.3.3-2).

Source: *metrobits.org*

Figure 6.3.3-1 Canopy Covered Station (KL Monorail)

Source: *JICA Study Team*

Figure 6.3.3-2 Canopy Covered Station (Toneri Liner)

Source: *Tokyo Metro*

Figure 6.3.3-3 Multipurpose Restroom

Architectural design is not only important for aesthetic impact, but also from function viewpoints. For example, roof with void at the platform provides natural ventilation at the open area yet shutting rainfalls onto the platform. Provision of commercial facilities, e.g. kiosk, shops, etc. inside station concourse area as well as at platform, offers convenience to railway users. Well organized and planned facility layout makes smooth flow and movement of passengers during peak hours. Signage and various types of Information Displays largely help passengers to obtain necessary information. Installation of Multipurpose Restroom is one of the amenities desired especially by women. (Figure 6.3.3-3)

6.3.4 Elevator/Escalator

With the increase in elevated or underground installation of railways, the stations are constructed with steric structures. Consequently, vertical movement facilities are required and the travel distance of passengers tends to increase. To address the sense of resistance to vertical movement, the roles of elevators and escalators are important and the installation of these facilities tends to increase. Such facilities are also effective means of aiding the movement for elderly, disabled and mobility impaired passengers. Two-way door opening elevators were developed, that can be installed in existing stations with limited space. Such two-way door opening elevators are also friendly to passengers on wheelchairs as they do not change the direction when getting out from the elevator. Equipment to assist passengers on wheelchairs going up stairs have been also introduced in some existing stations where provision of an elevator is not possible due to space restriction. (Figures 6.3.4-1 and 6.3.4-2).

Source: *JICA Study Team*

Figure 6.3.4-1 Two-way Open Door Elevator

Source: *Tokyo Metro*

Figure 6.3.4-2 Escalator/Stairs Accommodating Wheelchair Transport

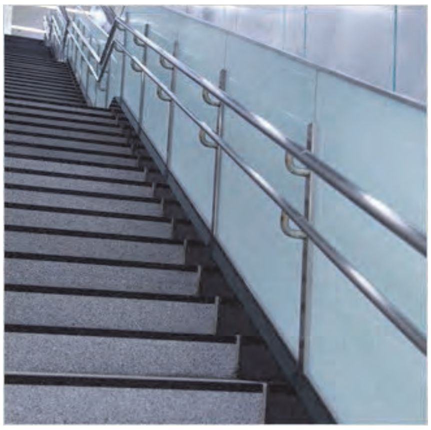
6.3.5 Universal Design and Special Considerations (Women Only Cars, Priority Seats, etc.)

Universal design, which enables easier access to any type of passengers, e.g. children, elders, mobility impaired persons, expectant mothers, blind persons, etc., has been a trend nowadays and also a mandatory in designing stations nowadays. Flat access for passengers on wheel chairs shall be considered wherever possible by providing slopes (Figure 6.3.5-1) and/or elevators, balustrades along stairs with 2 levels for persons with different height (Figure 6.3.5-2), etc.

Women only cars, either entire day or during peak hours, which are exclusive use for women and small children, have been introduced in some railway companies (Figure 6.3.5-3). Cars with priority seats (Figure 6.3.5-4) for elderly passengers, disabled passengers and expectant mothers, as well as those equipped with wheelchair spaces (Figure 6.3.5-5) are widely used in many railways. To promote and assist disabled persons to use railways as a mean of their transportation, special cares have been introduced in station facilities, such as braille signage at the Ticket Vending Machine, etc. (Figure 6.3.5-6)

Source: *Tokyo Metro*

Figure 6.3.5-1 Slope Access



Source: *Tokyo Metro*

Figure 6.3.5-2 Two Levels Balustrade

Source: *JICA Study Team*

Figure 6.3.5-3 Women Only Cars

Source: *JICA Study Team*

Figure 6.3.5-4 Priority Seats

Source: *Tokyo Metro*

Figure 6.3.5-5 Wheelchair Space in Train

Source: *Tokyo Metro*

Figure 6.3.5-6 Braille Signage at Ticket Vending Machine

6.4 Trackwork

6.4.1 Role of Trackwork

Tracks are to secure a train running path and to direct the movement of trains, as well as to absorb the vibration and to support load of trains. Then, tracks are designed to distribute the force to roadbed and structures at the bottom of the tracks.

Trackwork has been developed, consisting of rails, ballast, sleepers, fastening devices. However, in recent years, new types of trackwork has been also developed and in use, which are superior in workability, accuracy of holding, reduction in maintenance works and cost..

6.4.2 Various Types of Trackwork

Various types of trackwork are presented in Table 6.4.2-1 below.

Table 6.4.2-1 Various Types of Trackwork

Track type	Ballast Track		Slab track	
	Ballast Track	Ballast ladder track	Flat slab track	Flame shaped slab track
Photograph				
Applicable section	Aboveground section Elevated section Underground section	Aboveground section Elevated section Underground section	Aboveground section Elevated section Underground section	Elevated section Underground section
Displacement of track	Liable to occur	Less likely to occur		
Replace of sleeper	Available	–		
Maintenance work	Constant maintenance work is required.	Maintenance work will be greatly reduced.		

Track type	Direct fastened track			
	Direct fastened track on concrete bed	Solid bed track with removable resilient sleepers	Solid bed track with removable resilient sleepers (with noise reduction ballast)	Floating radder track
Photograph				
Applicable section	Elevated section Underground section	Elevated section Underground section	Elevated section Underground section	Elevated section Underground section
Displacement of track	Less likely to occur			
Replace of sleeper	Not available	Available		–
Maintenance work	Maintenance work will be greatly reduced.			

Characteristics of each trackwork type are described below.

(1) Ballast Track

Ballast track is a track structure that has been widely used for a long time. Advantages and disadvantages of the ballast track can be summarized as follows:

Advantages

- It absorbs the vibration and noise due to the passage of trains
- Low construction cost

Disadvantages

- Due to the relatively low dispersion of train load, subsidence and unevenness of rails occur by the deformed ballast
- Vulnerable to rail buckling due to high temperature and earthquakes, etc.

Ballast track requires frequent maintenance works, such as replacement and tamping of ballast, and thus requires certain maintenance cost.

Therefore, to cover the disadvantages of the ballast track, ballast ladder track was developed that could reduce maintenance works and has been in practical use. Ballast ladder track is different from the conventional ballast track in terms of the direction of sleepers, where sleepers are laid in the same direction as rails, to improve the dispersibility of the train load, resulting in less occurrence of track deviation. Accordingly, ballast ladder track has been introduced to places where maintenance works during night time is difficult as well as sections where there are steep curves, inside tunnels and so on.

However, in a depot where the train running speed slow, conventional ballasted track at cheaper construction cost is still often used.

(2) Slab Track

Slab track is one of the track structures that have been developed to reduce maintenance works. Slab track is a track with precast concrete directly placed on viaduct and rails on such precast concrete. Advantages and disadvantages of slab track are shown below.

Advantages

- Excellent durability
- Light structural weight
- Less likely of subsidence and floating of tracks due to train load
- Greatly reduced maintenance compared with ballast track

Disadvantages

- Higher noise and vibration inside and outside of trains compared with ballast track due to no gap to create damping effect of sound between roadbed and rail as well as reflected sound at slab or concrete roadbed surface
- When deviation occurs in the track in such a disaster, it takes time and cost to correct it.

Recently, frame type slab track, which has hollow at the center of the concrete slab, has been developed, which enables reduction in weight and also the manufacturing cost.

(3) Direct Fastened Track

Direct fastened track is also one of the track structures that has been developed to reduce maintenance works. Track bed of the direct fastened track is made of concrete and concrete sleepers are fixed to the concrete track bed. Advantages and disadvantages of the direct fastened track are shown below.

Advantages

- Track deviation hardly occurs
- Greatly reduced maintenance cost due to less maintenance works

Disadvantages

- In sections where subsidence could occur due to soft ground or over time, adjustment of height and lateral displacement of track bed is difficult if the concrete track bed sink itself by the subsidence of the ground

Many types of direct fastened track have been developed. Direct fastened track consists of rails on sleepers directly fixed on concrete track bed. Thus, deviation of the track hardly occur and accordingly maintenance work is reduced. Direct fastened track has been adopted in long tunnels or subway where ground is firm and track maintenance of the work environment is difficult. However, there are some disadvantages as follows:

- Little elasticity and thus less absorption of vibration from train
- Large noise like slab track
- Difficult in easy modification in case of track deviation due to accidents or normal use has occurred

Therefore, a solid bed track with removable resilient sleepers to overcome the above disadvantages has been developed. The solid bed track with removable resilient sleepers, an elastic material attached to the sleepers and concrete road beds, has a structure to reduce vibration and noise. It is also used in places requiring consideration for vibration and noise reduction in urban areas. Moreover, replacement of elastic material without destroying track bed, adjustment of rail positions and also replacement of sleepers are possibe with recent solid bed track with removable resilient sleepers. In order to further reduce noise, silencing ballast track was developed where ballast are spread surrounding slab track.

Also, a floating ladder track was developed where the sleepers are laid in the rail direction and steel pipes are installed at regular intervals between rails to maintain the gauge. Following are some of the key features of the floating ladder track.

- Low vibration and low noise due to insertion of vibration isolating material between concrete roadbed and ladder sleepers
- Reduction of viaduct construction cost due to its lightweight and anti-vibration
- Shortened construction period of track laying

In recent years, floating ladder track has been adopted in various elevated railways and subways in urban areas.

The Mega Manila Subway is expected to be one of the major public transports in Manila and surrounding areas and shall be continuously operational for a long period. To enable continuous operation, proper maintenance will be important, thus trackwork for the Mega Manila Subway shall be of less maintenance works and accordingly less running / maintenance cost.

Solid bed track with removable resilient sleepers, floating ladder track, etc. mentioned above were designed with labor-saving construction and low maintenance cost. Because of many advantages over the long period, such types of trackwork are assumed to become the mainstream in construction of new railway lines. However, ballast track would be practical in depot where train running speed is low and thus the burden to track is less.

6.5 Depot

6.5.1 Criteria for Identifying Depot Location

There are several criteria for identifying an appropriate depot location. Foremost of these requirements is that the proposed depot location must satisfy future operational plans and traffic demand. As for the shape of the depot, the area to be acquired should be long and narrow. The proposed site should be flat and allows for possible land leveling. In identifying the ideal depot location, preference should be given to the proposed location where short operating time of a deadhead train should be attained.

6.5.2 Functions of Depot

The main functions of a depot are stabling, maintenance, inspection and repair of trains. In addition, efficient dispatch control for trains based on the operation schedule and work schedule in a depot is required as the main function of a depot. As one of the types of depots, a comprehensive depot is equipped with a central command office which conducts the operation control of the main line and the integrated management of electricity, facilities for the crew, and the maintenance base for track, power supply system, signaling, communication systems, and civil and architectural facilities.

In the depot, various types of tracks are installed with corresponding functions. The buildings in the depot are mainly categorized by section, such as total management section, workshop section with assembling and disassembling repair, train inspection section, maintenance section, power supply section, etc. Table 6.5.2-1 shows the description of each building. Each facility is equipped inside or outside the abovementioned buildings. Figure 6.5.2-1 presents some examples of depot.

Table 6.5.2-1 Facilities and Functions of Depot

<table>
<tr><th colspan="3">Facilities</th><th>Function</th></tr>
<tr><td rowspan="9">Tracks</td><td colspan="2">Stabling Track</td><td>Stabling cars</td></tr>
<tr><td colspan="2">Daily Inspection Track</td><td>Daily inspection</td></tr>
<tr><td colspan="2">Monthly Inspection Track</td><td>Periodic inspection</td></tr>
<tr><td colspan="2">Critical/General Inspection Track</td><td>Inspection with car disassembling</td></tr>
<tr><td colspan="2">Departure/Arrival Inspection Track</td><td>Inspection at departure and arrival</td></tr>
<tr><td colspan="2">Car Washing Track</td><td>Machine washing and hand washing of cars</td></tr>
<tr><td colspan="2">Lead Track</td><td>Shunting trains</td></tr>
<tr><td colspan="2">Test Track</td><td>Test run</td></tr>
<tr><td colspan="2">Stabling Track for Maintenance Vehicle</td><td>Stabling of maintenance and repair vehicle</td></tr>
<tr><td rowspan="9">Building/ Facilities</td><td rowspan="7">Main Facilities</td><td>Central Management Building</td><td>Central command office, depot command room, equipment room, office room, welfare facility</td></tr>
<tr><td>Inspection and Repair Shed</td><td>For inspection with disassembling, repair facilities, workshop, warehouse, electric room</td></tr>
<tr><td>Monthly Inspection Shed</td><td>Periodic inspection</td></tr>
<tr><td>Daily Inspection Shed</td><td>Daily inspection</td></tr>
<tr><td>Store Shed for Maintenance Vehicle</td><td>Stabling of maintenance and repair vehicle</td></tr>
<tr><td>Power Receiving and Substation</td><td>Power supply for mainline and depot</td></tr>
<tr><td>Other Buildings</td><td>Oil warehouse, emergency power generation room, storehouse, cleaning stand, footboard</td></tr>
<tr><td rowspan="2">Other Facilities</td><td>Road Inside Depot</td><td>Access road to facilities and each track in depot</td></tr>
<tr><td>Gate</td><td>Gate at the access entrance of depot</td></tr>
</table>

Facilities			Function
		Fence	Fence to prevent intrusion for safety
		Green Belt, Car Park	-
Facilities/ Equipment	Inspection and Repair Facilities		Facilities for inspection and repair of cars
	Automatic Car Wash Machine		Automatic washing for exterior car body panel
	Drainage Treatment Facilities		Treatment facilities that meet the emission standards of drainage from workshop and car washing
	Outside Lighting Facilities		Lighting for stabling track, washing track and road inside the depot etc.
	Maintenance Vehicle		Maintenance vehicle for maintenance and inspection of main line facilities during nighttime
	Incinerator		Incineration of waste from workshop etc.

Source: *JICA Study Team*


Stabling Tracks (MRT)


Stabling Tracks (Monorail)


Workshop (MRT)


Workshop (Monorail)


Washing Machine (MRT)


Washing Machine (Monorail)

Source: *JICA Study Team*

Figure 6.5.2-1 Examples of Depots

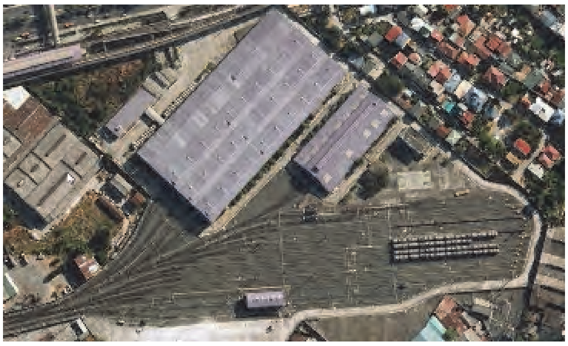
6.5.3 Required Area of Depot

The required areas for depots of different transport systems are shown in Table 6.5.3-1. The average required area per car will be assumed from the gross area of each depot, and the number of cars that can be accommodated is also estimated. Figure 6.5.3-1 shows examples of existing depot areas in some countries.

Table 6.5.3-1 Required Areas for Depots

System		No of Cars	Depot Area (ha)	Area/Car (m^2)
Metro Manila	LRT1 (LRT)	139	7.76	558
	LRT2 (MRT)	144 (future)	8.80	772
	MRT3 (LRT)	120	8.40	700
MRT	Sendai Subway North South Line (Japan)	84	8.80	1,047
	Fukuoka Subway Airport Line (Japan)	108	7.15	662
LRT	Fukuoka Subway Nanakuma Line (Japan)	68 (beginning of service)	7.90	1,161
Monorail	Kitakyushu Urban Monorail (Japan)	72 (future)	5.56	772
	Osaka Monorail (Japan)	72 (future)	5.10	708
	Tokyo Monorail (Japan)	54 cars	3.00	556
	Okinawa Monorail (Japan)	44 (future)	3.50	795
	Tama Monorail (Japan)	92 (future)	5.50	598
	Chiba Urban Monorail (Japan)	34 96 (future)	4.74	1,394 493 (future)
AGT	Yokohama Seaside Line (Japan)	85 (operation) 170 (future)	7.00	823 411 (future)
	Yurikamome (Japan)	156	5.60	359
Urban Maglev	Aichi Rapid Transit LINIMO (Japan)	24	3.50	1,458

Source: *JICA Study Team*


Manila LRT2 (8.8 ha)


Manila LRT1 (7.8 ha)


Fukuoka Subway Nanakuma Line (7.9 ha)


Fukuoka Subway Airport Line (7.2 ha)

Yurikamome (5.6 ha)

Tama Monorail (5.5 ha)

Aichi Rapid Transit LINIMO (3.5 ha)

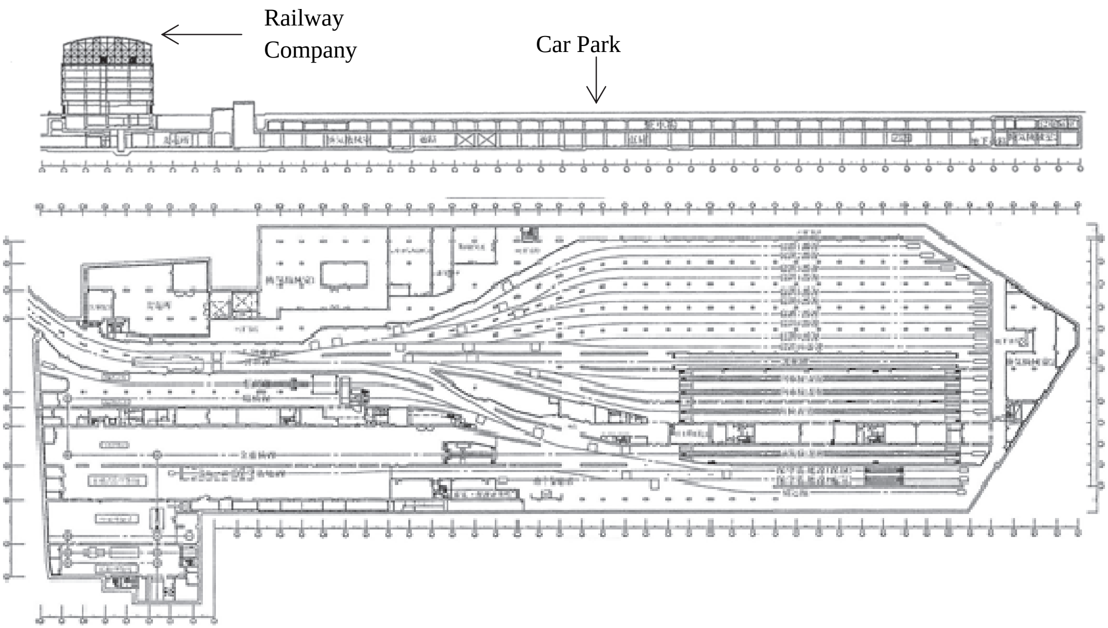
Chiba Urban Monorail (4.7ha)

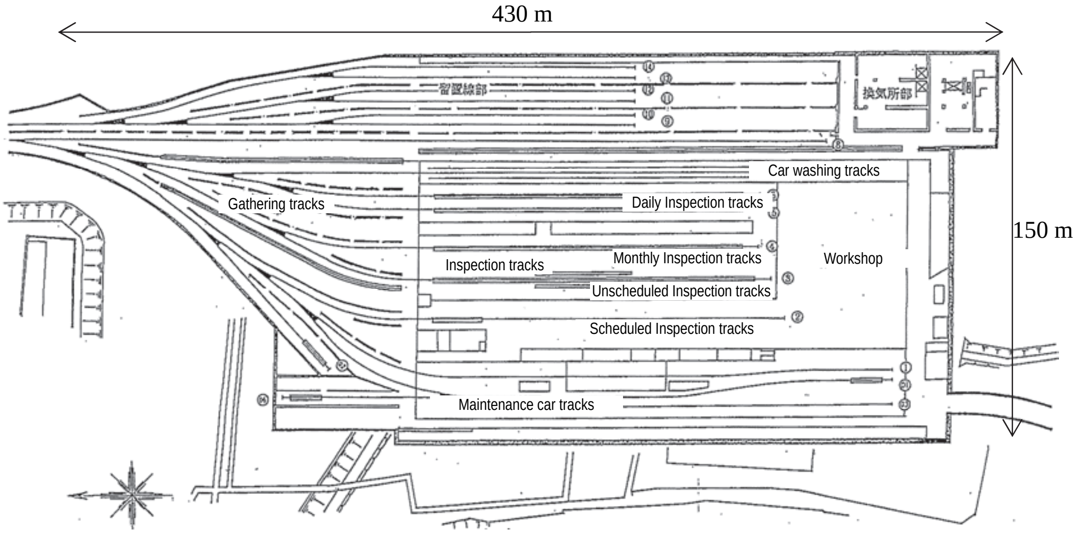
Source: *JICA Study Team*

Figure 6.5.3-1 Profile of Existing Depots for Each Transport System

6.5.4 Underground Depot

Figures 6.5.4-1 shows examples of the underground depots for Metro in Japan.   There are buildings of the railway company and car parking on the depot.

<table>
<tr><th></th><th>Example of Underground Depot</th></tr>
<tr><td>Kobe City Metro</td><td>
</td></tr>
</table>

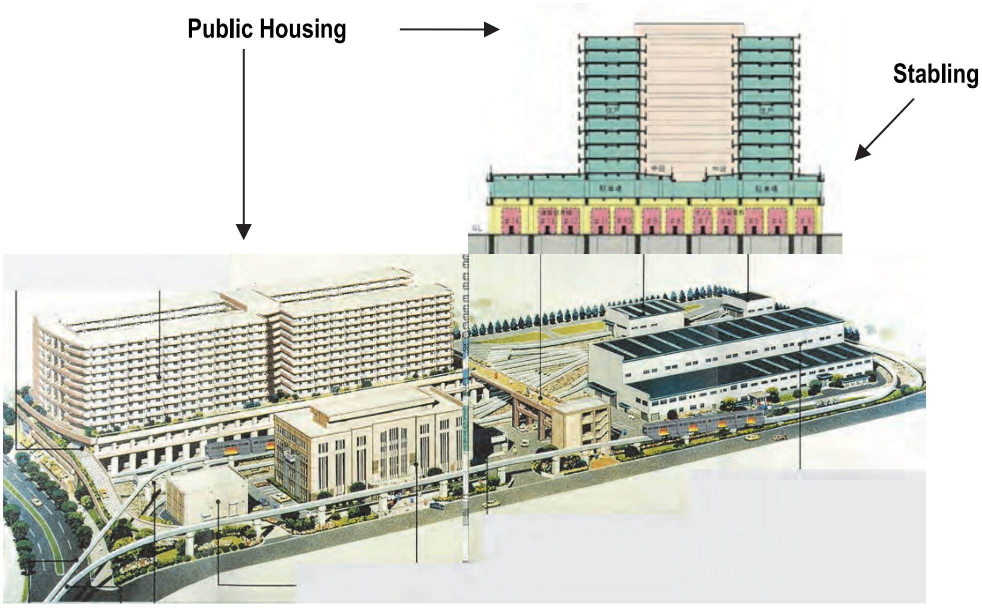
	Example of Underground Depot
Osaka Metro	 * Depot is located under the building.

Source: *JICA Study Team*

Figure 6.5.4-1 Example of Underground Depot in Japan

6.5.5 Depot inside the Building

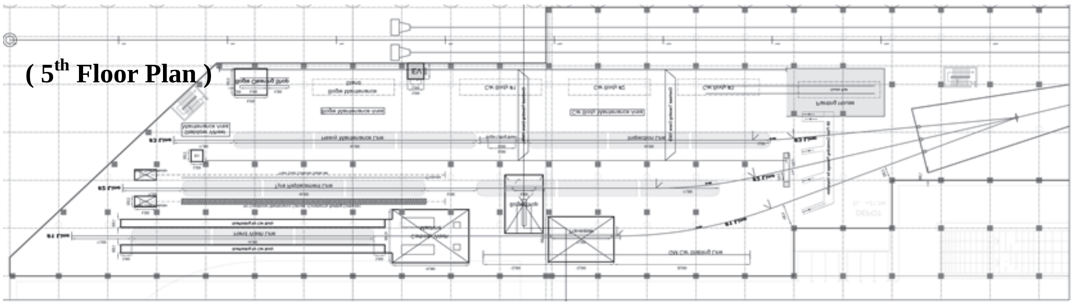
Figure 6.5.5-1 shows an overview of the depot of the Tama Monorail in Japan. The public housing estate of Tokyo Metropolis was built on the stabling tracks.



Source: *HITACHI company brochure*

Figure 6.5.5-1 Depot of Tama Monorail in Japan

Figure 6.5.5-2 is an example floor plan of a monorail depot inside a building.



Source: *HITACHI company brochure*

Figure 6.5.5-2 Example of Floor Plan of Monorail Depot inside Building

6.5.6 Size of Depot for MMSP

Referring to the above concept and example, train depot for the MMSP shall be planned taking into account the dimensions and capacity necessary at the time of the initial opening, i.e. Phase 1, and also when the future extension is implemented, i.e. Phase 2. In addition, taking into account the preliminary train operation plans as described in Chapter 7.2, the depot for the MMSP is assumed to be as follows:

(1) Initial Opening (2025 year) – Phase 1

Location:	North-West side of Mindanao Avenue – Quirino Highway station
Area:	Approximately 16ha (Figure 6.5.6-2)
Number of stabling cars:	Approximately 200 cars
Function of the depot:	Stabling, Washing car body, all the inspection and repair, facilities for train crew, maintenance for railway facilities, etc.

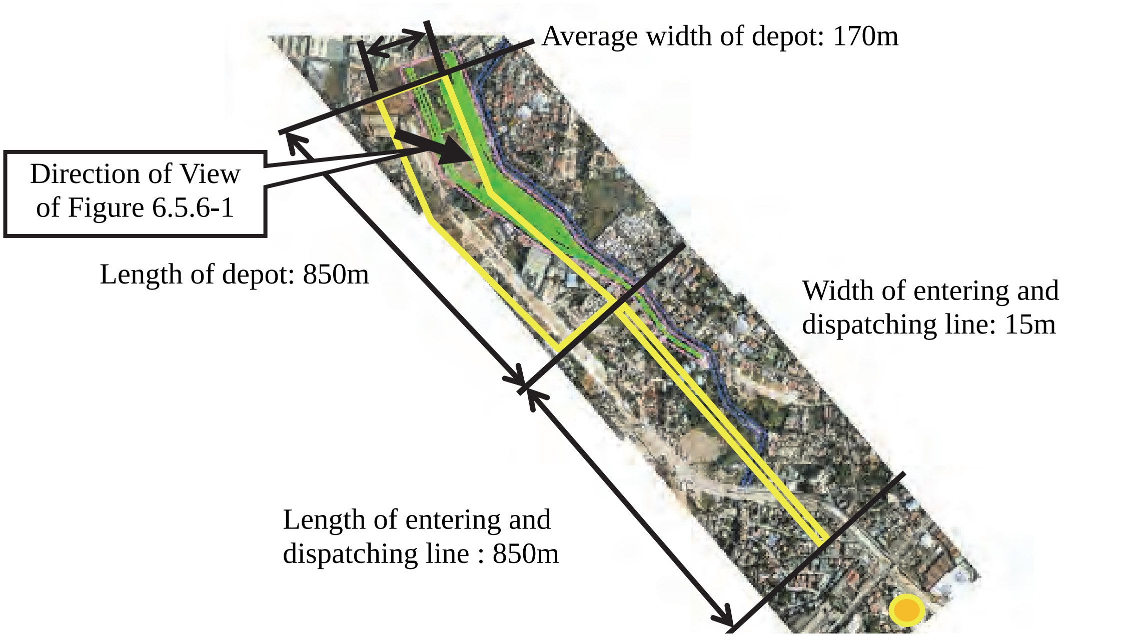
(2) Additional Depot (2035 year) – Phase 2

Location:	South side of Governor's Drive station
Area:	Approximately 19.5ha
Number of stabling cars:	Approximately 450 cars maximum
Function of the depot:	Stabling, Washing car body, facilities for train crew, maintenance for railway facilities, etc. Inspection and repair of the train is carried out by extending the inspection and repair facilities in Mindanao Avenue depot.

Source: *JICA Study Team*

Figure 6.5.6-1 Existing Condition of Depot Candidate Area for Initial Phase (Phase 1)

The whole size plan of the proposed depot site for the initial opening (Phase 1) is shown in Figure 6.4.6-2.



Source: *JICA Study Team*

Figure 6.5.6-2 Overall Plan of Depot Candidate Area for Initial Phase (Phase 1)

6.6 Utilization of Japanese Technology (Civil Works)

6.6.1 Civil Structures (Elevated)

(1) Seismic design concept and method

(a) Background

Seismic impact should be considered in the design of all new structures and public work facilities in Japan for safety of structures, facilities and people during serious earthquakes.

Improvement of conventional Japanese Seismic Design Standards after well-known Kobe Earthquake (1995), which was proved in Great Tohoku Earthquake in 2011 (No injury or life-loss was recorded for passengers on Shinkansen (High Speed Rail) where structural facilities were designed and constructed according to the New Seismic Design Standards)

(b) Practice of Seismic Design Standards

Seismic design standards shall be applied based on the allowable level of damage expected due to earthquake type.

Allowable level of damage for structural components (particularly piers as the most important structural component) shall be set to reduce crucial damage of railway structures.

Dynamic analysis shall be applied by simulations of occurrence of actual earthquake

(c) Merits of Japanese Seismic Design Standards

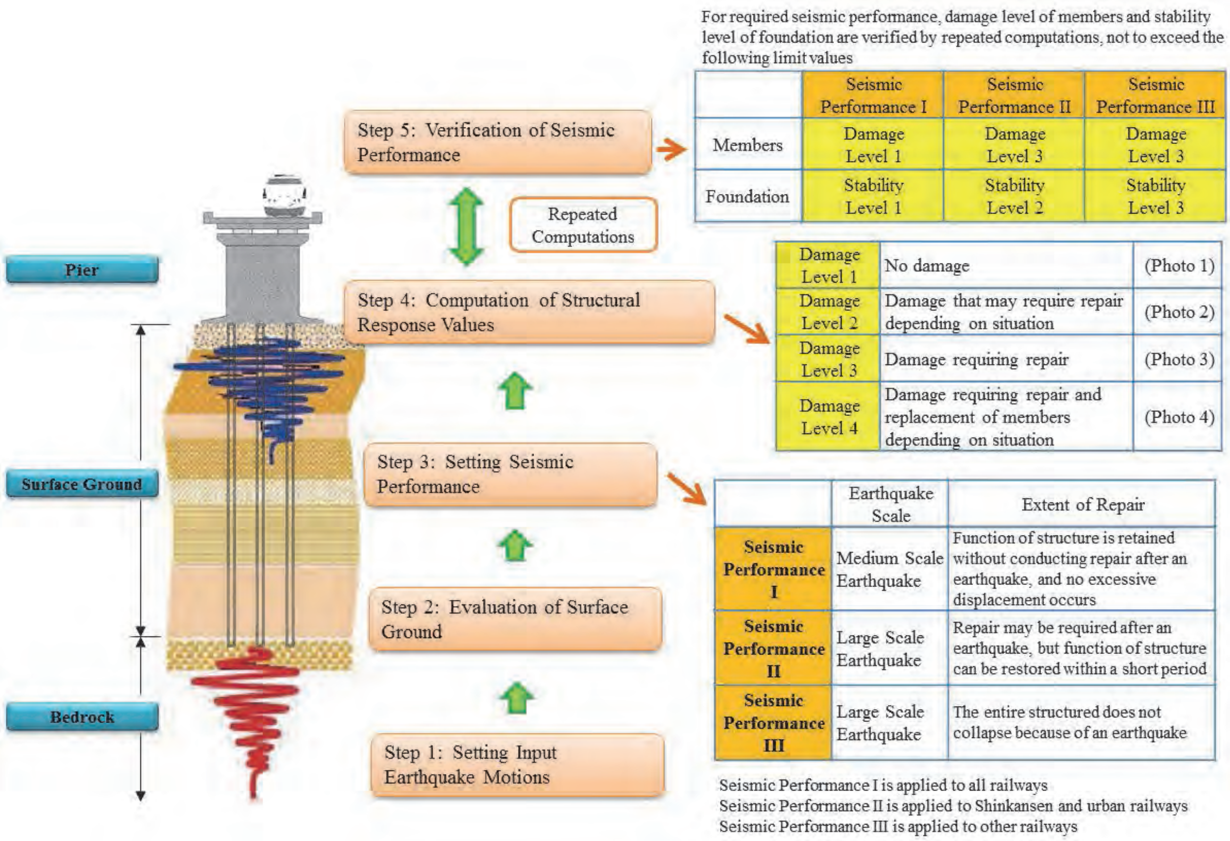
Japanese seismic design standards extensive past (actual) records in Japan compared with other international seismic design standards, and moreover they have been proven that the damages of the structures designed based on these standards were minimum and the injury and life-loss were also minimum.

Safety of railway structural facilities and passengers can be ensured during major earthquakes, yet securing economical design

The standards are also concerned about the aesthetic aspects with slim cross sections for structural components.

(d) Seismic Design Procedure

The procedure of seismic design of Japan is shown in Figure 6.6.1-1.



Source: *JICA Study Team*

Figure 6.6.1-1 Seismic Design Procedure

(e) Examples of Actual Damages by Level

Examples of actual damages at different damage level are shown in Figure 6.6.1-2.

(Photo 1)
Damage Level 1
No damage

(Photo 2)
Damage Level 2
Damage that may require repair depending on situation

(Photo 3)
Damage Level 3
Damage requiring repair

(Photo 4)
Damage Level 2
Damage requiring repair and replacement of members depending on situation

Source: *JICA Study Team*

Figure 6.6.1-2 Example of Damages at Different Damage Level

(2) Cast-in-place piling method beneath limited clearance

In big cities of Japan, civil engineering works have been required to be carried out in small and limited working places. In order to deal with the difficulties of construction under such circumstances, effective construction methods have been established by use of advanced machines and equipment.

Examples of Cast-in-place piling methods are shown in Figure 6.6.1-3.

Sheet piling

Cast-in-place piling

Source: *Kajima Corporation*

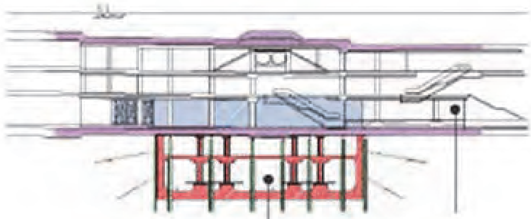
Figure 6.6.1-3 Examples of Cast-in-place Piling Method

6.5.2 Civil Structures (Underground)

(1) Underpinning

Underpinning is a construction method which enables constructing new underground structures underneath the existing underground structures without impact (Figure at right below shows the cross-section of Shibuya station with Fukutoshin line constructed underneath Hanzoumon line.)

Flat jack inserted between building frame and beam



Shinbuya st. of Fukutoshin Line

Shinbuya st. of Hanzoumon Line

Source: *Kajima Corporation*

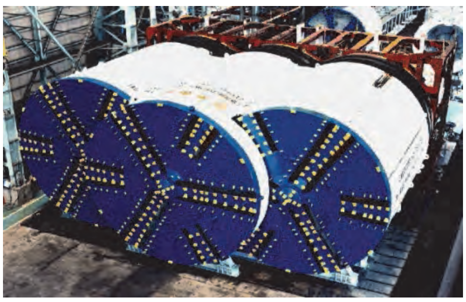
Figure 6.6.2-1 Examples of Construction Method of Underpinning

(2) Tunnel Boring Machines (TBM) / Shield Machines

Through the construction of many underground structures over the long years, various types of construction methods and equipment have been developed and applied in Japan to suit the specific geological conditions and to overcome difficulties in construction at limited space or in restricted conditions. Optimum method can be proposed from various methods. Examples of TBM / Shield Machines are shown in Figure 6.6.2-2.

H&V (Horizontal Variation & Vertical Variation) Shied Machine with 4-circles

Spiral Boring by H&V Shield Machine



Multi-face Shield Machine

Source: *Hazama Ando Corp. / Shield Tunneling Association of Japan*

Figure 6.6.2-2 Examples of TBM / Shield Machines

(3) Flood Protection

Examples of the facilities with measures from flooding actually adopted in subways in Japan are shown in Figure 6.6.2-3. More detailed measures against flooding adopted in Japan are described in Chapter 11.

Water-shut Panels at Subway Station Entrance

Water-shut Door on Mainline of Subway

Water-shut Door and High-level Entrance to Station Area

Source: *Tokyo Metro*

Figure 6.6.2-3 Examples of Flood Protection Facilities

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Chapter 7

RAILWAY SYSTEMS

Chapter 7 RAILAWAY SYSTEMS

7.1 Existing Railways in Metro Manila

There are 4 railway lines (Philippine National Railway (PNR), LRT Line 1, LRT Line 2 and MRT Line3) being in revenue operation in Metro Manila. In planning the railway system suitable for the Mega Manila Subway Project (MMSP), characteristics of these lines were reviewed, which is summarized in Table 7.1-1.

PNR is a narrow gage (1,067mm) non-electrified railway, which is operated by old type systems. Used (second handed) passenger cars hauled by the diesel engine, as well as trains with Diesel Multiple Unit (DMU) are being operated at present, but the track condition is not very well.

The LRT Line 1 and the MRT Line 3 are constructed by the light railway system and the capacities of these railways are not so large. Because of the recent decrease in maintenance level of the railway system including railway cars, train operating speed and the number of trains has been also decreasing, resulting in difficulty in handling passengers during commuting rush hours due to insufficient capacity against the passenger demand.

Although the LRT Line 2 is named LRT (light rail transit), but the system is a heavy rail type. Regarding the capacity point of view, wide car body seems sufficient for transporting the required passenger volume. However, poor maintenance including rolling stock has affected to the decrease in passenger service level. (e.g. decreasing number of the trains)

Table 7.1-1 Comparison of Railway Systems of Existing Railway in the Philippines

	LRT Line 1	LRT Line 2	MRT Line 3	PNR
Outline	Light railway system, small passenger transportation capacity, articulated bogie construction	Heavy railway system, large passenger transportation capacity, all motor car construction	Light railway system, small passenger transportation capacity, articulated bogie construction	Passenger car hauled by diesel locomotive, some of them are DMU train, narrow gage (1067mm)
Rolling stock	3rd-age train cars are constructed with stain-less steel body, AC motor propulsion system	Stain-less steel car body, AC motor propulsion system with VVVF control method	Soft steel car body, DC motor propulsion system with chopper control method	Almost of car is used car (EMU) from Japanese railway etc., some of the car is DMU with stain-less steel body
Electrification	DC750V, OCS	DC1500V, OCS	DC750V, OCS	Not electrified
Signaling System	Wayside signal, automatic block system, ATP	Cab signal, automatic block system, ATP, ATO	Wayside signal, automatic block system, ATP	Wayside signal, non-automatic block system
Train Control and Supervision	Centralized train control from OCC applying CTC, PRC	Centralized train control from OCC applying CTC, PRC	Centralized train control from OCC applying CTC, PRC	Manual control by station staff

Source: *JICA Study Team*

All urban railway lines, excluding PNR line, are all DC electrified and are centrally controlled from the Operation Control Centers (OCC) applying Centralized Train Control (CTC) system and Programmable Route Control (PRC) system.

Signaling Systems for the LRT Line 1 and the MRT Line3 are double track automatic block system based on the wayside signaling (indicating 2 aspects for signalling: proceed and stop) with Automatic Train Protection (ATP) function. The LRT Line2 has double track automatic block system based on the cab signaling with ATP and ATO functions.

As described above, facilities of each LRT line is different due to their histories, required transportation volume and application of systems of the lines. The LRT Line 1 and the MRT Line 3 apply similar signaling systems, but different systems in detail (e.g. CTC, ATP, etc.). Through operation by trains of each line is impossible at present. There are caused by the reason of less consideration in the interoperability when the each railway system was introduced.

7.2 Rolling Stock

7.2.1 Basic Concept of Rolling Stock

The MMSP aims at the construction of a railway that functions as one of the main north-south transport backbone running through the Metro Manila and having approximately 60 km of total distance. The demand forecast predicts high concentration of railway passengers during morning commuting period. Therefore, the railway system for the MMSP is required to transport passengers with large volume in a limited timeframe and with comfort to passengers. Rolling Stock shall be designed to suit the main objective of the railway, to meet the required demand and to maintain its performance with sustainability. Detail specifications of the rolling stock shall be determined considering various factors and characteristics of the route alignment to be selected.

In this Study, a consideration was made regarding the basic specifications required for the rolling stock suitable for the MMSP, which can be summarized as follows:

(1) Train Running Performance

Subway is usually constructed in limited spaces with various restrictions, avoiding existing structures and in spaces below existing roads. There are typically many sharp curves and steep gradients along the route. Average distance between stations is relatively short. Therefore, rolling stock for subway shall have high performance, e.g. high acceleration and deceleration, high climbing ability, etc.

(2) Safety

Rolling stock for the MMSP will run on sections where there are many curves and poor and limited view, thus the rolling stock should be equipped with the train protection system that assures high safety, such as Automatic Train Control (ATC), Automatic Train Operation (ATO) in order to avoid collision of trains. In addition, incombustibility is of high importance and shall be thoroughly incorporated in the selection of materials used in the rolling stock to reduce damages in case of fire of the train. The base of the rolling stock to be selected shall be proven in terms of safety, without serious accidents in the past, since the evacuation in case of emergency, such as fire, is difficult for subway.

(3) Reliability

Rolling Stock for the MMSP should have a low failure rate as well as redundancy that ensures uninterrupted operation of trains even in case of failure of propulsion units as evacuating from trains in the subway corridor is difficult and dangerous, thus should be avoided as much as possible.

(4) Transport Capacity

The capacity for carrying passengers should meet huge demand and the passengers can be loaded and unloaded easily.

(5) Life Cycle Cost

MMSP's rolling stock should purse high efficiency throughout its life cycle and social needs like 3R (Reduce, Reuse, Recycle)

(6) Environmentally Friendliness

MMSP's rolling stock should be constructed that achieves reduction of heat, noise, vibration as much as possible for the benefit of passengers and residents along the railway route.

(7) Comfort

MMSP's rolling stock should meet various passenger demands. The riding comfort of passengers should be ensured during the travel at all times.

In this Study, Series E233, which is the JR-East's most popular rolling stock, and Series 16000, which is the Tokyo Metro's advanced rolling stock that satisfies all the conditions described above and also have reliability and proven records of transporting passengers of severely huge volume in Tokyo, Japan, are proposed for the rolling stock for the MMSP.

Series E233

Series16000

Source: *JICA Study Team*

Figure 7.2.1-1 Series E233 and Series 16000 Trains

7.2.2 Basic Specifications of Rolling Stock

Table 7.2.2-1 shows the basic specifications of the rolling stocks that are proposed for the MMSP on the basis of Series E233 and Series 16000.

Table 7.2.2-1 Basic Specifications of Proposed Rolling Stocks

Items			Specifications	
Type			Series E233	Series 16000
Configuration Tc: Trailer car with driver's cabin M: Motor car T : Trailer car			EMU type 10 cars：6M4T Tc+M+M+T+M+M +T+M+M+Tc 8 cars：6M2T Tc+M+M+M+M+M+M+T 6 cars：4M2T Tc+M+M+M+M;Tc	EMU type 10 cars：4M6T Tc+M+T+M+T+ T+M+T+M+Tc
Major Dimensions (mm)	Lead car length		20150	20470
	Intermediate Car length		20000	20000
	Body Wide		2770	2800
Passenger Capacity Per Train	seat		522	522
	standard		1474	1518
Weight per train (empty) (t)			Approx. 310	Approx. 300
Body Material			Light stainless	Aluminum ally
Interior	Door numbers		4 (both side)	4 (both side)
	Open type		Both open: Wide1300	Both open: Wide1300
	Seat type		Long seats	Long seats
Maximum train operation speed （km/h）			120	110
Running Performance	Acceleration deceleration (m/s^2)		0.92	0.92
	Deceleration (m/s^2)	Normal	1.3	1.0
		Emergency	1.3	1.3
Propulsion System	Pantograph		Single- arm	
			3 units (per a train) (1 unit repair)	4 units (per a train)
	Control system		VVVF inverter control (IGBT)	
			3 sets (per train)	4 sets (per a train)
	Main motors		Induction motor	PWM (using IGBT)
Braking system			Electric command brake equipment with regenerative brake	
Truck			Bolsterless	Bolster
Air-condition System			Concentrated Type on the roof	
Passenger Information System			LCD Display type: Automatically voice information system	LCD Display type: Automatically voice information system
Train Information Management System			TIMS	TIS
Signal System			Cab Signal	
Train Protection System			ATC (corresponding)	
Train Radio			Digital Radio	

Source: *JICA Study Team*

7.2.3 Major Features of Rolling Stock for MMSP

(1) Train Running Performance

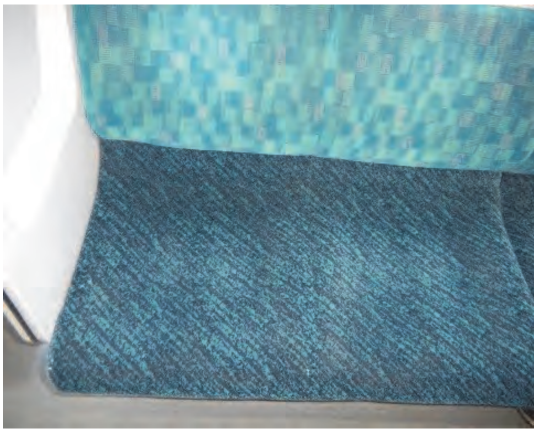
Commuter and subway trains usually stop and restart very frequently with short distance between stations and short headway. Thus, high acceleration and deceleration performance and climbing performance on steep gradient are of importance. On the other hand, distances between stations of MMSP vary from minimum 1.1km to maximum 4.1km depending on the section and also route options, where most of station distances are more than 2km. The average distance between stations of each route option is approx. 2.3km. This long distance between stations allows train to achieve faster operation speed. Therefore, train running performance should consider the balance of acceleration and deceleration performance and high-speed performance. The proposed rolling stock for the MMSP has high climbing performance on steep gradient and high performance of restarting even under the same condition in emergency case as well.

(2) Safety

The proposed rolling stock for the MMSP has cab signal and it's protection system is equipped with ATC that have been sufficient proven records in Japan.

Emergency escape door will be provided at the front of the driver's cabin. The rolling stock will use incombustible material, e.g. burning resistance fiber, to pursue burning resistance. The rolling stock will apply impact buffer structure to the body and strengthened body.

Emergency Escape Front Door



Seats with Incombustible Material

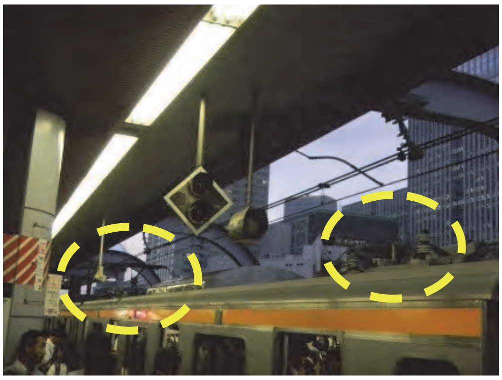
Source: *JICA Study Team*

Figure 7.2.3-1 Safety Facilities in Rolling Stock

(3) Reliability

In order to reduce maintenance work, the number of components used in bogy and other equipment of rolling stock should be reduced, especially consumption parts, to enhance reliability. The rolling stock will have two pairs of same importance main equipment like pantograph and the train protection system with redundancy, so that the trains will be able to continue running by using one of those equipment.

Multiple propulsion units ensure uninterrupted train operation even in case of failure in any of these units. Train information system which is used by drivers to fully understand conditions of equipment in the train from the driver's cabin shown on the display, is able to reduce down time in emergency case by using digital radio that enables communication between the cabin and the control center on both ways. This function assists the driver's recovery work.



Redundant System

TIMS Driver's Monitor

Source: *JICA Study Team*

Figure 7.2.3-2 Equipment Ensuring Reliability and Redundancy

(4) Transport Capacity

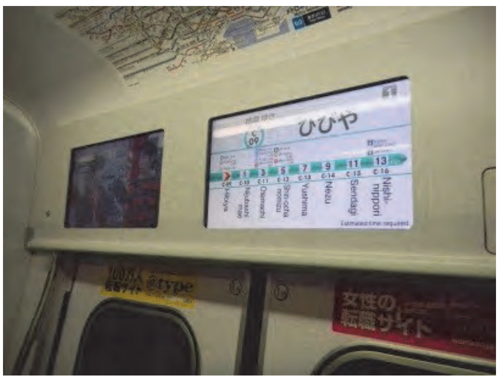
It is assumed that the MMSP's rolling stock requires approximately 1,500 passengers per train in 2045. There are some sharp curves in the railway route, where stress for body is increased if long and wide body will be applied. In addition, it will also increase the construction cost due to its heavy body. Therefore, MMSP's rolling stock size shall be the Japanese standard size for rolling stock (20000 mm x 2950 mm). The maximum configuration of the train is assumed to be 10 cars.

(5) High Efficient - Environmentally Friendly

Commuter and subway trains usually stop and restart frequently with short distance between stations. Thus, high acceleration and deceleration performance are important. Light weight rolling stock will enhance reducing energy consumption while running. Stainless or aluminum ally body is suitable to the rolling stock for the MMSP, which increases recyclability by the use of same materials in body's steel. For the propulsion system, the equipment which has high efficiency and is of maintenance-free will be adopted

(6) Comfort

Universal design and barrier-free equipment will be promoted to be used for interiors, which increases comfort in the train. There will be 4 doors which have both side opening type at both sides of the body to ease passengers to board and alight. The Passenger Information System will be introduced to provide variety of information to passengers by LED and LCD displays. The air-conditioning system will be provided with dehumidification function.



Information Display (1)

Information Display (2)

Priority Seats

Multipurpose Space

Source: *JICA Study Team*

Figure 7.2.3-3 Facilities in Train Providing Comfort to Passengers

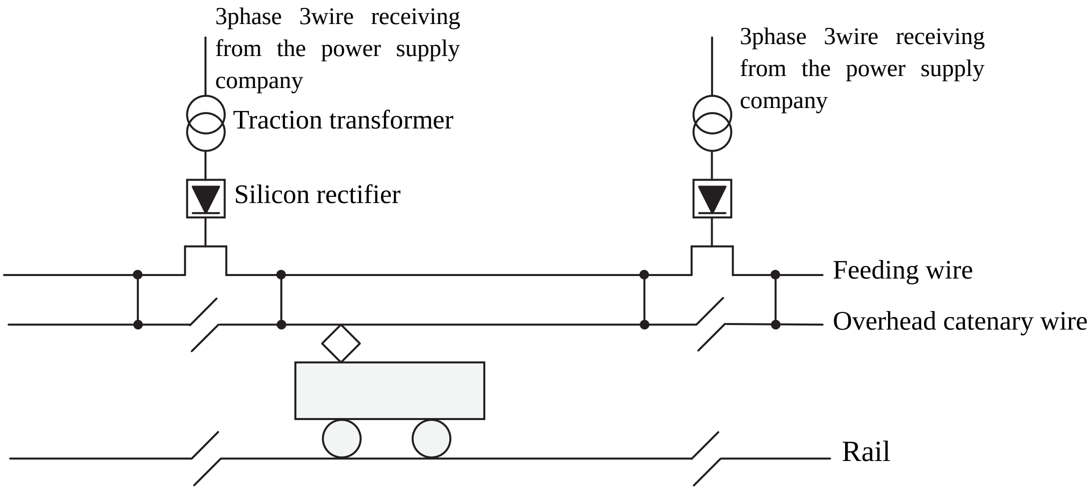
7.3 Electric and Machinery Facilities

7.3.1 Power Supply Facilities

(1) Traction Power Supply System

Three types of traction power supply systems that can be considered as options for use in the MMSP were studied and compared, which are 1,500V DC with Overhead Catenary System (OCS), 750V DC (either 3rd rail system or OCS) and 25kV x 2 AT type with OCS. Overview of each traction power supply system type are shown in Figures 7.3.1-1 and 7.3.1-2.

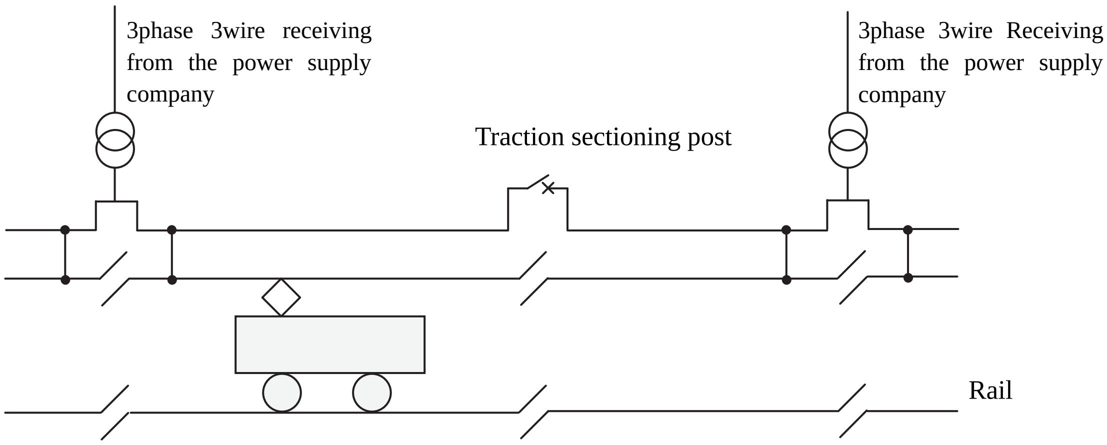
1,500V DC Traction Power Supply System



Source: *JICA Study Team*

Figure 7.3.1-1 Overview of DC Traction Power Supply System (DC 1,500V OCS)

<u>AT Type AC Traction Power Supply System (2 x 25 kV)</u>



Source: *JICA Study Team*

Figure 7.3.1-2 Overview of AT Type AC Traction Power Supply System (AC 2×25kV)

Traction power supply system to be adopted for the MMSP shall be designed with no conflict and under high level harmonization, fulfilling the items described below:

- Introducing technology with high level safety and reliability which has a proven record of application urban railways.
- Minimization of cost with consideration to achieve the best performance as a total railway system.
- Implementation of environmental friendly energy saving system by introducing state of art technology.
- Decrease in overall construction cost.

Comparison of the DC traction power supply system (DC 1,500V with OCS, DC750V with 3rd-rail system and AC 2 x 25kV AT type with OCS was examined, which are summarized as below:

Table 7.3.1-1 Comparison of Traction Power Supply System

Item		DC Traction System OCS (DC 1,500V)	AC Traction System AT type: OCS (AC 2×25kV)	DC Traction System 3rd Rail System (DC 750V)
1. Substations interval Number of Substations required in case of MMSP		Approx. 3 - 10km Approx. 10 -15 substations	Approx. 10 - 35km 2 - 3 substations	Approx. 2 - 3km Approx. 20 - 30 substations
2. Feeding Voltage		DC 1,500V	AC 25kV	DC 750V
3. Catenary System		Overhead Catenary System (OCS)		3rd Rail System
4. Receiving Substation	Receiving Voltage	69 kV or 34.5 kV	230 kV or 115 kV	34.5 kV
	Capacity of Receiving Transformer	3 – 12 MVA	10 – 50 MVA	1.5 – 6 MVA

5. Max Operation Speed	90 – 130 km/h	100 – 160 km/h	60 – 80 km/h
6. Advantages	• Many record of urban line • Rolling stock is cheap	• Wayside power facilities are slim • Less voltage down • Small current	• Small diameter of the tunnel • Rolling stock is cheap
7. Disadvantages	• Middle voltage down • Middle current • Need measure of electric corrosion prevention	• Need larger gap for isolation • Need measures of EMI prevention for telecommunication line, • Electric car is expensive	• Need measures of electrocution prevention • Problems of line cross section (long span dead section) • Higher voltage down and larger current
8. Construction Cost (for urban line)	Less Expensive	Expensive (approx. 20,000m^2 is required)	Less Expensive
9. Usage	• Popular for urban line • Middle speed and middle distance congesting line	• Running through middle distance line • High speed middle or long distance line or local line	• Low speed short distance subway • Low speed short distance congesting line
10. Others	Less expensive in system cost (Availability of standardized facilities)	Good for high speed and middle or long distance line	Less Expensive in civil construction cost (e.g. for tunnel construction)

Source: *JICA Study Team*

- AC traction system is not applicable for the MMSP because it is a middle distance line including underground section and there is no need of high speed operation and train will be expensive.
- DC 750V traction system is also not applicable for the MMSP because measures for the prevention of passenger electrocution and the long span dead section, etc. are required and the number of substations will be increased for the railway with middle line distance (60km).
- Accordingly as a result, 1,500V DC traction power supply system that has records of application in middle distance congested urban lines and the train car is less expensive, thus is recommended for the MMSP.

(2) Traction Substation System

(a) Number and Receiving Voltage of Traction Substations

It is common that the rectifier substations of the DC traction power supply system in a typical Japanese urban metro lines directly receive the power from the electricity grid at multiple substations at 66 kV or 22 kV as receiving voltage.

On the other hand, the existing railways in Manila have their rectifier substations and receive at 34.5 kV.

(b) Location of Substation

The locations of substations have to meet the following conditions:

- Accessible from the road
- Easy land acquisition
- Area of around 400 square meters that is necessary for DC traction substation
- Availability of grid connection from a power company

(c) Capacity of Substation

The capacity of a substation is estimated as the sum of the total power consumption, including traction power and the auxiliary supply power for station facilities. This shall be based on the assumptions of minimum headway, the number of cars and passenger density during operation periods, as shown in Table 7.3.1-2.

Table 7.3.1-2 Major Assumptions for Estimation of Power Consumption

Year	2025	2035	2045
Minimum headway	5	4	4
Number of Trainsets	6 cars x 18	8 cars x 44	10 cars x 44

Source: *JICA Study Team*

The power demand has been estimated based on the estimate of traction power and the auxiliary supply power. The estimate included 120% of a reserve factor for the substation transformers. The auxiliary supply power was estimated in proportion to the number of stations. The results of the estimates are summarized in Table 7.3.1-3.

Table 7.3.1-3 Estimated Power Demand

Year	2025	2035	2045
Traction power [MVA]	20	50	65
Auxiliary supply power [MVA]	40	50	50

Source: *JICA Study Team*

(d) System Requirement for Traction Substation

The system requirement for substation design, i.e. determination of intervals between substations and the capacity of rectifiers, are as follows:

- When one substation is down, neighboring substation shall be able to compensate;
- In compliance with the IEC standards (described in Table 7.3.1-4), the voltage of the contact line should not be permissive,

Table 7.3.1-4 Min. and Max. Traction Voltage required in IEC Standard

Traction Voltage	Minimum Voltage	Standard Voltage	Maximum Voltage
DC 1.5kV	1,000V	1,500V	1,800V

Source: *IEC 60850 Ed.2*

(e) Calculation of Voltage Drop

The maximum interval distance between the substations was determined by calculating the contact line voltage to meet above-mentioned requirements. The diagram was assumed for the calculation of voltage drops. This design of substations under the most severe condition is reasonable. Under these conditions, cost effective design is also required.

(3) Overhead Catenary System

Overhead Catenary System (OCS) is widely used in railways all over the world. The type of OCS to be applied should be considered for the entire route, with the selected catenary system which has to be suitable for its entire line.

The OCS used in the existing LRT and MRT is also of this type. The overhead catenary systems have a long technical history of many years and it is known for high performance under high speed operation.

The main features of four kinds of overhead catenary systems considered for the MMSP are described in Table 7.3.1-5.

A simple catenary is the most basic structure for an overhead catenary. This also has a cost advantage, and is popularly installed except for HSR. One of this type of catenary system, a feeder messenger system, has a wire that functions both as a messenger and a feeder. The system enables a cost reduction of construction and O&M. It also has a simple appearance which is preferable from the aesthetic point of view. The type is recommended for the DC traction system.

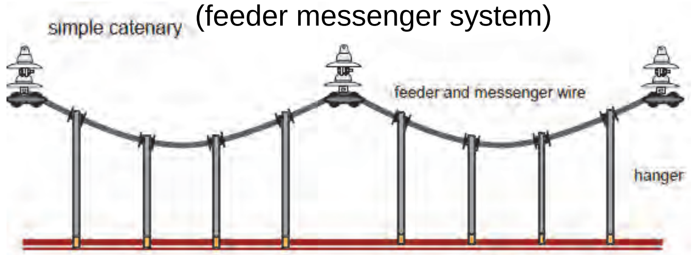
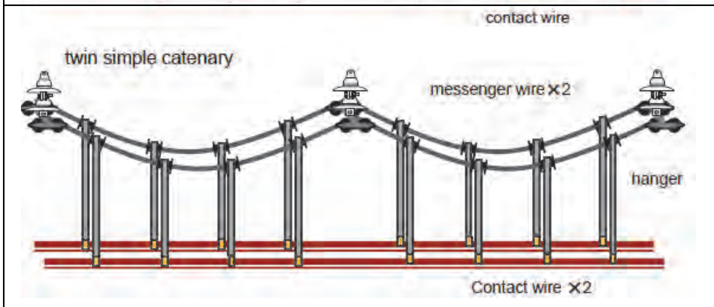
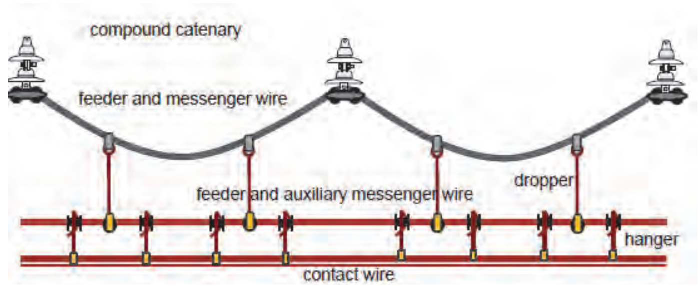
A twin simple catenary is used in congested urban railway lines that require high load demand and availability of high speed operation. Due to the complex structure of the overhead catenaries, the system has a cost disadvantage and is not suitable for the MMSP. Not only the construction cost but maintenance cost is also higher than that of other systems because of its complexity.

A compound catenary is simpler than the twin simple catenary system. The catenary is recommended to be installed on the main line of the HSR.

Overhead rigid conductor rail system comprises a formed rigid aluminum conductor profile with a catenary wire inserted at the bottom. Although the system has a weak point of loss contact of pantograph in high speed operation, it has an advantage for maintainability with simple construction, less risk of cutting catenary wire and ability of decreasing diameter of the tunnel, and always used in tunnel sections of subway, etc. without high speed operation.

Accordingly, the most suitable OCS for the MMSP is considered as the feeder messenger system for the elevated section and overhead rigid conductor rail system for the underground section, if high speed operation is not required in underground section.

Table 7.3.1-5 Outlines of Overhead Catenary Systems

Type of OCS	Feature	Usage
	Messenger wire has a function of feeder wire. This system does not require additional feeder wire. Good for medium speed line (Under 100km/h)	Middle speed mainline, Workshop /Depot
	This system requires additional feeder wire. It is complex structure, and the maintenance costs are higher than the others systems. Good for high speed line. (Under 160km/h)	Congesting line, High speed mainline
	Messenger wire and auxiliary wire have a function of feeder wire. This system does not require additional feeder wires. Japanese Keisei Sky Liner adopts this system. Good for high speed line. (Under 160km/h)	High speed mainline
Overhead Rigid Conductor Rail System 	Because of the simple construction applying formed rigid profile with catenary wire inserted at the bottom, it can decrease tunnel diameter and has advantage for maintainability. Good for subway without high speed operation (under 80km/h)	Subway without high speed operation

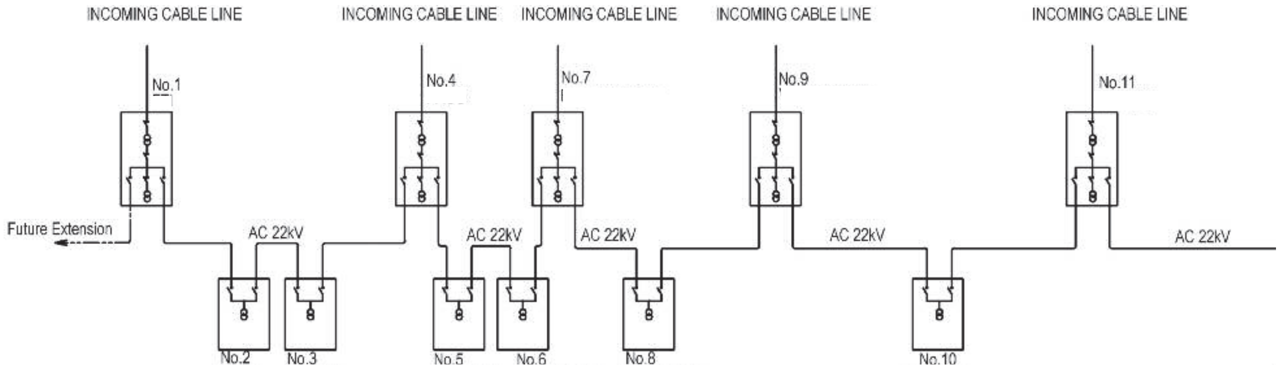
Source: *JICA Study Team*

(4) Power Distribution System for Station Facilities

Similar to existing railways in Manila, auxiliary power supply for all station electrical facilities will be fed from an auxiliary substation by low voltage, AC 220V for a single phase or AC 480V for three phase. Power to auxiliary substation will be fed from the traction substation by two route power cables for redundancy. A transformer for the auxiliary substations changes high voltage to low voltage.

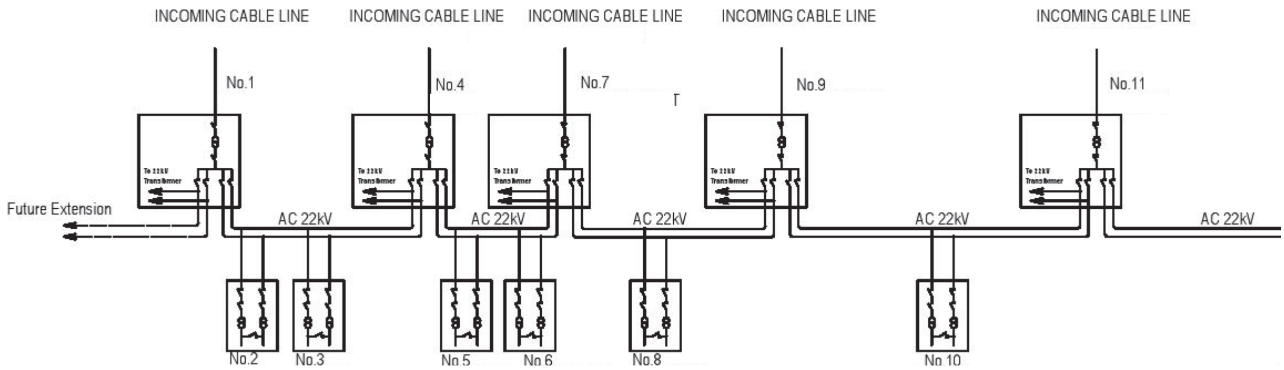
Especially for the underground stations and the tunnel sections, emergency diesel generator set needs to be provided to supply at least required emergency load of disaster prevention point of view in case of long time power failure at the facility malfunction, etc.

Two type of power distribution systems are considered for the MMSP. One is a loop system, and the other is a parallel system. The loop system is shown in Figure 7.3.1-3, whereas the parallel system is shown in Figure 7.3.1-4. It would be better to adopt the loop system because the loop system is lower in cost than the parallel system, and the loop system has been already used in the Philippines. If more reliability will be required than the existing lines, the parallel system should be considered for the MMSP. It should be carefully studied which system should be adopted during the design phase.



Source: *JICA Study Team*

Figure 7.3.1-3 Example of Loop Type Power Distribution System



Source: *JICA Study Team*

Figure 7.3.1-4 Example of Parallel Type Power Distribution System

(5) Lighting System

Customer safety and comfortably should be considered for the lighting system level of each part of the underground stations. With consideration of ridership of the station, etc. lighting system level is designed 200 – 300 lux for platform and concourse, etc. respectively. Power supply plan for the lighting system should consider the redundancy of the system and black out should be prevented even when the power failure accident occurs by adding emergency power distributing line for lighting system excluding from generally using duplex power line. Lighting distributed power from the emergency power distributing line is excluded as an emergency lighting, and should have capability of lighting about 4 hour long being fed by the Diesel Generator set and should support the evacuation of passengers, station staff and the fire-fighting staff.

(6) Power SCADA

Supervision and control at traction substations, and auxiliary substations of station and depot are performed by unmanned operation and remotely from OCC. Centralized supervising system (Power SCADA) shall be installed at OCC that will automatically perform the safety interlocking function in case the malfunction of some components of each substation is detected.

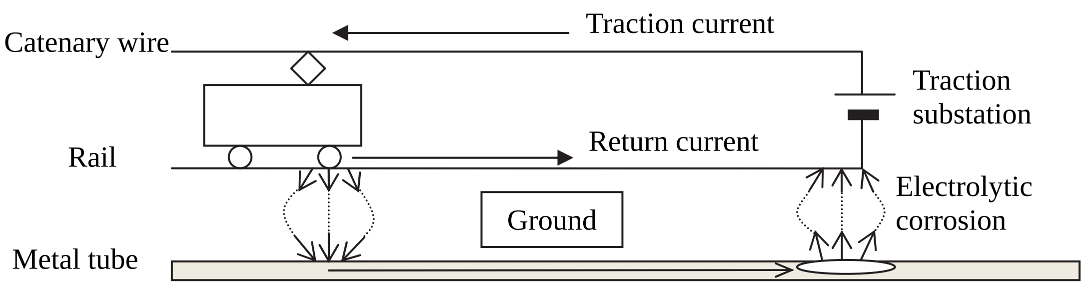
(7) Stray Current

Stray current is a leakage current from the rails to ground. A stray current that flows into the ground instead of the rails, may cause electrolytic corrosion of underground metal tubes buried in the vicinity of the rails. In addition, a rail current tends to flow from the main line toward the workshop/depot, where the combined electrical resistance of the rails is lower than the mainline since many rails lie in parallel. This could lead to an electrocution hazard to workers on the tracks for inspection and repair.

(a) Electrolytic Corrosion caused by Stray Current

Electrolytic corrosion is a kind of galvanic corrosion by an electrochemical process in which one metal corrodes when in electrical contact with a different type of metal with both metals immersed in an electrolyte.

As shown in Figure 7.3.1-5, electrolytic corrosion is generally caused the metal tube near a substation where return current flows into it. Stray currents tend to flow toward the rails in the workshop/depot from the main line, for the parallel connection of congested rails in the workshop/depot makes a lower combined ground resistance. Consequently, corrosion problems tend to happen especially in the workshop/depot.



Source: *JICA Study Team*

Figure 7.3.1-5 Electrolytic Corrosion Caused by Return Current

(b) Mitigation Measures against Influence of Stray Current

Reduction of stray current is the most basic mitigation measure to prevent electrolytic corrosion. It can be achieved by decreasing the leakage current, return conductor resistance and leakage time.

- Leakage current: average leakage current will be decreased by increasing insulation resistance between rail and ballast. e.g. by improving drainage of railroad ballast;
- Return conductor resistance: installation of thicker and longer rails, and appropriate maintenance of rail bonds will decrease the return conductor;
- Leakage time: it is difficult to decrease the leakage time from rails in the main line because of the constraints of operation schedules. It is possible, however, to decrease the leakage time in a workshop/depot if the rails will be installed at an appropriate point with automatic return current switchgear; allowing a one-way flow of return current. A two-pole disconnector also will be able to decrease the leakage time. It insulates both contact line and rails by opening an isolator when there are no rolling stock at the workshop/depot.

7.3.2 Machinery Facilities

(1) Ventilation and Air conditioning System

(a) Station Ventilation Facilities

For the ventilation of the underground station, platform, concourse, staff rooms, equipment rooms are all ventilated by fresh air by forced ventilation. In addition, smoke exhaust system and station air conditioning system which correspond to the disaster prevention measures for the underground station should be considered. Design for the ventilation system (e.g. ventilation fan, air duct, etc.) shall be considered separately for the platform, concourse, staff rooms and equipment rooms respectively and customized for each function. (e.g. Air duct for the station concourse provides heat isolation design with consideration of station air cooling)

(b) Station Air Conditioning Facilities

For the station air cooling, capacity of the chilling machine is determined with consideration of air conditioning area of each station. For the system design, environmental measures (e.g. energy saving operation, etc.) shall be also considered.

(c) Tunnel Ventilation System

For the tunnel ventilation system, forced ventilation system which has function of tunnel air ventilation and emergency smoke exhausting shall be provided. There are two type of method for the ventilation system one is a longitudinal ventilation and another one is a transverse ventilation. Longitudinal ventilation is the method that facilitate the ventilation machine room at end of the stations and from one station fresh air is directly supplied to the tunnel and is vacuumed and exhausted at adjacent station to outside. Normally for the single line shield tunnel section, ventilation is performed same direction as train running. Transverse ventilation is the method that facilitate the ventilation machine room and ventilation shaft at the middle of the tunnel section between the stations and vacuum the air supplied from stations into the tunnel and exhaust to outside. Plural number of ventilation fan are facilitated at each tunnel ventilation machine room and for ensure the necessary ventilation capacity to exhaust the heat of the tunnel, energy saving operation is performed by running fan number control. For smoke exhausting operation, remote control is capable from OCC. All ventilation fan run when the smoke exhausting operation is performed to secure effective smoke exhausting.

(2) Drainage pump facilities

It is the facility to pump up inflow water from outside ground level (rain water, etc.) and spring water from inside the tunnel by pre-set pump facilitated lowest position of each drainage section, and send them to the sewer. The number of pumps per drainage machine room is normally 3 sets with consideration of malfunction and maintenance of each pump. For the pump operation, drainage operation is automatically performed by detecting high water level by pre-set ultrasonic waves water gage. Pump operation is able to be monitored and controlled from OCC.

(3) Elevators and Escalators

(a) Escalators

More than 2 escalators need to be installed between platform and concourse of each station, in order to consider efficiency of boarding and alighting passengers. In case of a few number of passengers, energy saving operation can be considered by changing to the low operation speed mode.

(b) Elevators

More than 1 route from the platform to the ground level shall be secured. Facilities can accommodate wheelchairs and the visual and hearing handicapped persons. By installing video camera and monitoring from the station staff room, prevention of crime shall be also considered.

(4) Platform Screen Door (PSD)

PSD is installed for the purpose of improving safety on the platform (preventing accidental contact with a train, preventing passengers falling on tracks, etc.), as mentioned below.

There are 2types of PSD and the characteristic of each type are as follows.

(a) Full-height Type

This is called a full screen type. There are full-closed types, where the platform is fully covered to ceiling and semi-closed type, where there is a space between upper part of the screen doors and the ceiling. The full closed type improves air conditioning effect of the platform. The cost is the most expensive among all PSD systems and the installation could be difficult depending on ceiling structures.

(b) Half-height Type

This is called a movable platform fence. The cost is cheaper than that of the full-height type. Therefore, the installation has been increasing on existing railways which is operated by driver-only trains or for the purpose of safety enhancement, etc.

(c) Platform Fence

In addition, although not a PSD (not automatically opening and closing), there is a platform iron fence which has the same function as the PSD and cab be opened around the train doors only. The cost is the cheapest.

Full-height Type

Half-height Type

Platform Fence

Source: *JICA Study Team*

Figure 7.3.2-1 Type of PSD System

In performing the automatic PSD control, it is necessary that the door positions of all trains are uniform and corresponding with the places where the PSDs are installed. The door opening /closing is controlled by exchanging commands and information (e.g. stopped position of the train, opening/closing status of train doors and PSD, etc.) for opening and closing doors between track-mounted beacons and PSD control units which are installed on the train and platform with considering below:

- Stopping position of the train is consistent with the position where the PSD is installed.
- There are no passengers being left between the train and the PSD.

(5) Station Facility SCADA

Safe and dependable management will be considered for the station operation monitoring board which is installed for improving passenger service and safety management of station facilities, and facility maintenance control board which is installed for maintenance and operation of station machinery facilities. Main facilities to monitor and control are described below.

(a) Ventilation and Air conditioning system

(b) Tunnel ventilation and smoke exhaust system

(c) Fire-fighting, sprinkler and drainage pump system

(d) Elevator and Escalator

(e) Lighting system

(f) PSD

7.4 Signalling System and Tele-communication Systems Facilities

7.4.1 Signalling System Facilities

(1) Train Control System for Urban Line including Underground Section

For train control system of the urban line including underground section, ATC (Automatic train control) or ATP (Automatic train protection: continuous control type) with cab signal and continuous control are typically recommended, which is designed independently from previous signal equipment such as ATP (point to point control type) for existing lines, because of considering correspondence for congesting urban line train operation, increasing safety of the blind curve underground section and also increasing operation efficiency. (e.g. introducing one man train operation) Especially for recently established urban lines, mainstream of the ATC equipment has been changed from analog type system to digital type system which can realize the high level control with consideration about difference of car's performance. Characteristics of the train control system respectively for newly constructing urban line and for existing line are described below.

(a) Analog ATC and ATP (continuous control)

This is the firstly installed system for the urban line and was to make sure of high-level safety and reliability by saving difficulty of seeing aspect of wayside signal in the underground curve section of congested line with cab signal and continuous train control. Because of applying fix block system and using analog signal for signal transmission (sending frequency signal to the track circuit) like existing lines, time loss caused by fix block and poor capacity of transmitting control information does not match the later control needs and requirements, such as decreasing headway. (maximum of about 24 trains/h)

(b) Digital ATC and ATP (continuous control)

This is the digital type of ATC and ATP (continuous control type) using digital data transmission (by track circuit or space radio) for signal transmission can correspond to varies needs e.g. decreasing train head (over 24 trains/h) etc. by increasing data transmitting capacity of signal information.

It is also changed from the conventional type of ATC system with only speed control which depends on the ground signal equipment, to the system with transmitting the currently on track position of the preceding train to onboard by digital data transmission and it realizes the high-level train control which is mainly using the onboard control logic (e.g. considering the car's maximum speed and brake performance for train control) without changing conventional fix block based wayside signaling facilities.

(c) Basic ATP (point to point control type) and ATS-P

This is the train control system of the existing lines and is currently applied for the mix operating section with urban line train and middle or long distance train (express, local, freight train: commuter line of metropolitan area, suburban line), for consideration of the signaling compatibility with the middle or long distance train and is using existing signaling equipment.

(d) New Type of Digital ATC and ATP (moving block type)

The new type of digital ATC and ATP does not use ground signal equipment (e.g. track circuit) for detecting the current on-track position of the train, instead using the onboard train positioning data transmitted to the ATC equipment for train control. (Moving block control function is available.) This type of system requires less ground signal equipment compared with conventional ATC and also reduces the train headway time (more than 24 trains/h), and lately it has been installed on urban lines (e.g. subway line) with shorter headway and on lines requiring less ground signal equipment and to improve efficiency of train operation. (e.g. monorail, Automated Guideway Transit (AGT), local line, etc.)

Analog ATC (Automatic Train control) and
ATP (Automatic Train protection：continues control)

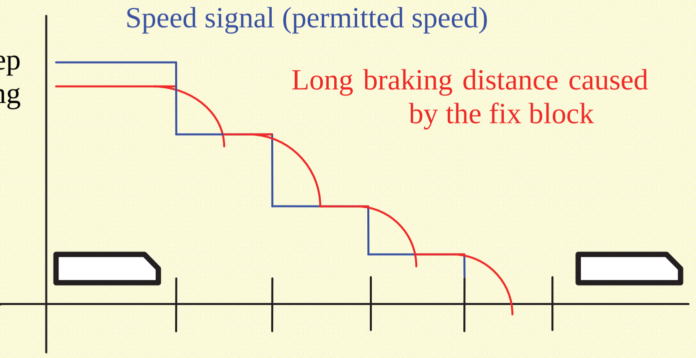
- Depends on ground signaling equipment
- Sends speed signal to onboard equipment
- Next train brakes so as not to exceed the permitted speed of the speed signal

Used by:
- Old type of ATC and ATP (Japan, Europe, America)

Advantage:
- Safe and reliable continuous control

Disadvantage:
- Loss time due to step-by-step braking (train headway, traveling time)
- No variation of control for many types of cars

Used for
- Old type of ATC for urban line and HSR trains



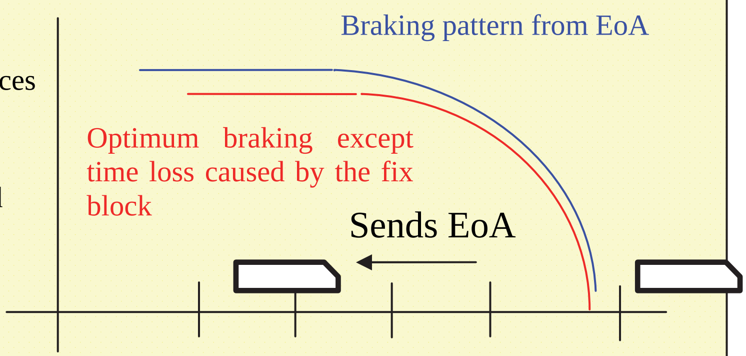
Digital ATC and ATP (continuous control)

- Depends on on-board signaling device
- Sends EoA (End of Authority) to onboard equipment
- Next train brakes adequately from EoA

Used by:
- D-ATC (Japan：JR East)
- C-ATC (France, Korea),
- LZB (Germany, Spain)
- ETCS L2 (Europe), CTCS L3 (China)

Advantages:
- Single level brake control reduces loss time
- Optimum brake control for many types of cars is available (onboard logic type)

Used for
- Current mainstream ATC for urban lines and HSR trains.



Source: *JICA Study Team*

Figure 7.4.1-1 Breakthrough in Train Control System for urban lines including

Basic ATP (Automatic Train Protection : point-to-point control)

Consists of:

- Wayside signal
- Cab signal

Used by:

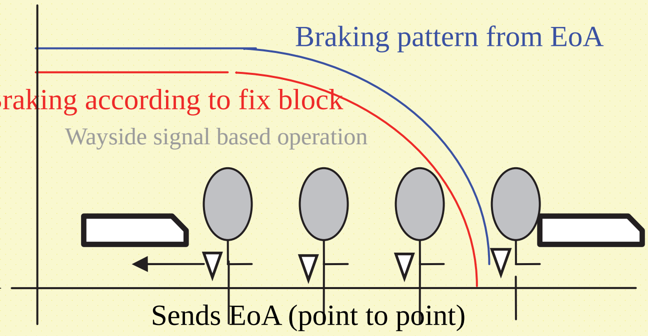
- ATP (Europe, Asia, America), ATS-P (Japan)
- ETCS L1 (Europe, Asia)
- CTCS L2 (China)

Advantage:

- Can use the existing signaling facilities

Disadvantages:

- Discontinuous control (point-to-point)
- Difficulty of seeing wayside signal aspect (for subway)



Used for:

- Good for mixed operation with existing trains
- Not good for subway line

New Type of Digital ATC (Moving Block)

- Depends on on-board signaling device
- Reduces ground signal equipment
- Next train brakes adequately from EoA
  (EoA is continuously moving with preceding train : moving block)

Used by:

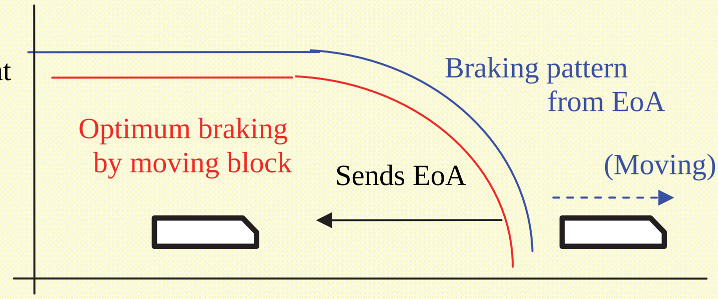
- ATACS (Japan)
- CBTC (Europe, Asia, America)
- ETCS L3 (Regional : Europe)

Advantages:

- Reduces train headway time
- Reduces ground signal equipment

Disadvantages:

- Difficult to mix operation with CBTC unequipped car
- Difficult to design (strictly preparation of control data and radio environment measures are needed)



Used for:

- Good for commuter trains (more than 24 trains/ hour)
- Good for monorail, AGT and regional trains (reduces cost of ground signaling equipment)

Source: *JICA Study Team*

Figure 7.4.1-2 Conventional Type and New Type of Train Control System

(2) Signaling Methods for Urban Line including Subway Section around the World

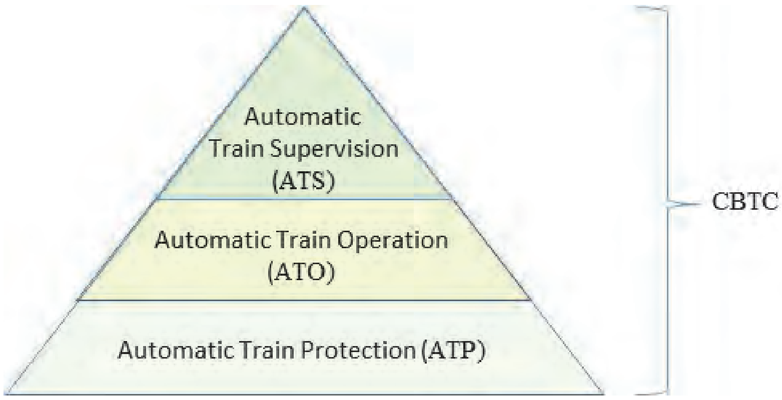
In Europe from old years, urban lines including subway line section were constructed in England, France, Germany, America and any other countries which had their own original signal control systems and Automatic Train Protection (ATP), cab signaling system and multi aspect signaling system were introduced from early years to improve signaling safety in underground section. Moreover, with the progress in IT technology, digital signaling system has been introduced and Automatic Train Operation (ATO) has been implemented.

In recent years, new signaling type of Communications Based Train Control (CBTC) system according to the IEEE1474 standard was developed aiming to increase operation efficiency and reduce installation cost. The CBTC system has been already introduced in many countries. The CBTC system can perform the high level onboard logic based train control with application of high speed communication network aided data transmission between wayside and onboard.

The CBTC system has not only standard Automatic Train Protection (ATP) function, but also has

- Automatic Train Supervision (ATS)
- Automatic Train Operation (ATO)
- Automatic Train Protection (ATP)

functions as comprehensive train control system which can achieve the short headway operation with moving block and increase the total management efficiency by applying ATS and ATO functions. This system has been introduced to urban lines and subway lines in many countries around the world including Asian countries in recent years.



Source: *JICA Study Team*

Figure 7.4.1-3 System Structures of CBTC

With the progress of the CBTC systems, the system specifications have been different among each manufacturer, thus connection between different systems are difficult and through operation between these lines is impossible at present and causes a problem of the system. Suburban lines also have increasing needs of through operation in metropolitan subway sections in recent years. Similar problem between the CBTC and the existing signaling system (e.g. ETCS) has occurred.

In Japanese urban railway lines of mix operation with middle and long distance trains including express trains and freight trains, wayside signaling system with ATS-P (point to point control based ATP) was installed for consideration of consistency of onboard ATP equipment and maximum 29 trains/h operation has been performed. (e.g. JR East Chuo-express line by 10 cars trainsets)

For the train control system of urban lines without mix operation, conventional analog ATC has been replaced to the digital ATC gradually. Maximum 25 trains/h operation has been performed by high level ATC function. (e.g. onboard logic based optimum braking control, JR East Yamate-Keihintohoku line by 10 cars trainsets)

Regarding the system of subway lines (e.g. Tokyo Metro, etc.), multi speed level aspect type of digital ATC has been the mainstream and 31 trains/h operation has been performed (Tokyo Metro Marunouchi line by 6 cars trainsets)

As a new examination new type of radio communication based train control system (ATACS) that has moving block function (same as CBTC) was installed on the JR East Senseki line in 2011, and introduction to the Tokyo Metropolitan area is under consideration. Introduction of CBTC system according to the IEEE1474 is also under consideration.

For the reference for the selection of the most suitable system for the MMSP, a comparison of signaling system that is installed to the urban line (including subway section) around the world is described in Table 7.4.1-1.

Table 7.4.1-1 Comparison of Signaling Systems for Subway

	Japan (Tokyo Metro)	France (Paris RATP)	Germany (Berlin)	Spain (Madrid)	Korea (Seoul Metro)	China (Beijin Subway)
Signaling Method	ATC, ATS: (continues control)	CATC, CBTC	ATP (continues control)	ATP (continues control), CBTC	CATC, ATS, CBTC	ATC (continues control), CBTC
Signaling	Cab signal, Wayside signal	Cab signal	Cab signal, Wayside signal	Cab signal	Cab signal, Wayside sig nal	Cab signal
Max. Operation Speed	65 – 100km/h	70 – 80km/h	72 km/h	70 – 100km/h	80 – 100km/h	80 – 100km/h
Min. Headway	1min.50sec.	1min.35sec.	3min.	2min.	2min.30sec.	2min.45sec.
Cars of Trainsets	6 – 10 cars	3 – 6 cars	6 – 8 cars	3 – 6 cars	4 – 10 cars	4 – 6 cars
Train Control	Continuous control	Continuous control	Continuous control	Continuous control	Continuous control, point to point control	Continuous control
Signal transmission	Digital, Analog	Digital, Analog	Digital, Analog	Digital, Analog	Digital, Analog	Digital, Analog
Country of Original Technology	Japan	France	Germany	Germany, etc.	Japan, France, etc.	France, Germany, etc.
Operaton Length (Stations)	304 (285)	202 (300)	153 (170)	275 (239)	314 (280)	442 (318)
Number of Passengers (Mil.) (per operation length)	2,454 (12.6)	1,541 (7.5)	473 (3.1)	689 (2.5)	1,453 (10.5)	2,738 (6.8)
Later System Introduced (Subway established)	1993 (1927)	2007 (1900)	2008 (1902)	2008 (1919)	2011 (1974)	2008 (1969)

Source: *JICA Study Team*

(3) Signalling System for MMS

For urban lines including subway section, all the countries have adopted cab signaling and a continuous control system (excluding part of lines in Korea). From these systems, a detailed comparison among the cab signalling type Digital ATC, ATP (continues control), CBTC, which are considered as new and influential types of signalling system as well as the Basic ATP, which is based on the existing wayside signaling type, with provision of the necessary functions, was made to determine the most suitable system for the MMSP as shown in Table 7.4.1-2 below.

Table 7.4.1-2 Comparison of Cab Signalling System (Candidate Signaling System for MMS) and Wayside Signaling System for Detail Functions

	Digital ATC, ATP (Continuous control: Japan, Asia, Europe, etc.)	CBTC (Asia, Europe, etc.)	Basic ATP (All over the world)
Block System	Fixed block	Fixed block	Fixed block
Train Detection	Wayside equipment (track circuit, axle counter, etc.)	Onboard equipment (on the way transponder is installed for back up)	Wayside equipment (track circuit, axle counter, etc.)
Transmission of MA	Rail : Digital Track circuit, inductive radio, etc.	Wireless LAN: according to IEEE802.11 x protocol, inductive radio, etc.	Transponder, track circuit, etc.
Main Signaling System Equipment	ATC controller, Interlocking device, Programmable Route Control (PRC) function is available	Zone controller (ZC), Data Communication Equipment (DCE) Automatic Train Supervision (ATS)	ATP (ATS-P) equipment, Interlocking device, Programmable Route Control (PRC) function is available
Method of Braking Control	ATC controller continually transmit the single step braking pattern to onboard, or onboard controller continually calculate it	Onboard controller continually calculate the single step braking pattern from EoA transmitted from ZC	ATP controller transmit the EoA, etc. to onboard. Onboard controller calculate the braking pattern (point to point)
Deceleration Control in Train Stops	ATO or manual control (Automatic stop-position control function is available)	Automatic Train Control (ATO)	Manual control (Automatic stop-position control function is available)
Minimum Delay Time of Signal Transmission	○ approx. 3sec. (emergency braking)	○ approx. 3sec. (emergency braking)	△ over 3sec. (immediate braking is impossible due to point to point control)
Max Number of Train during Most Congested Hour	◎ over 30train/h	◎ over 30train/h	○ approx. 30train/h
Construction Cost	○	○	◎
Others	Rail breakage detection is available if the track circuit is installed.	Additional application (ATO, PSD control, etc.) is easy to introduce.	Difficult to see wayside signal aspect continually (underground section)

Source: *JICA Study Team*

In terms of train protection functions, both of Digital ATC and CBTC use digital transmission-aided cab signals and single step braking control. In addition, CBTC has ATO and ATS function as a comprehensive train control system. Wayside signaling method is based on manual control by train driver and addition of ATO function is infeasible.

In terms of performance, there is almost no difference in the signal transmission time between the Digital ATC and the CBTC system, but wayside signaling system has a disadvantage for emergency control (e.g. emergency braking control, etc.) due to the problem of difficulty in continuous signal aspect identificationy and point to point control.

In terms of construction cost, cab signaling system is usually a little bit expensive than wayside signaling system.

Overall, cab signaling method is applicable with consideration of increase in safety at underground section where continuous identification of signal aspect is difficult. In addition, from cab signaling system, a detailed comparison will be required during the Feasibility Study phase, whether any of CBTC for increasing operation efficiency by application of one man train operation with ATO, or Digital ATC with proven records of reliable operation, or other system. (e.g. Japanese ATACS which has moving block function, etc.) is most suitable for the MMSP.

7.4.2 Tele-communication Systems Facilities

(1) Trunk Optical Data Transmission System

In order to operate trains safely and punctually, an introduction of the centralized supervision and automatic control system has been rapidly increasing as systems for signaling control at each station and substation control, etc. For the high speed data transmission with high reliability, it is important to have communication lines that will connect various pieces of equipment that will be installed along the tracks and at stations.

Thanks to recent developments in technology, optical-fiber cables for communication based on transmission of light have come to be used widely as communication lines replacing metal cables that use conventional conductive wires. Particularly for the trunk data transmission system of railway which is required high speed information communication (e.g. information of signaling equipment and train status at each station) as is the case with the present plan (congesting urban line including subway section), high speed broad band data transmission is necessary. Specifically, optical cables are required if an entire sections of a railway line is to be comprehensively controlled from OCC using CBTC system that has traffic management function.

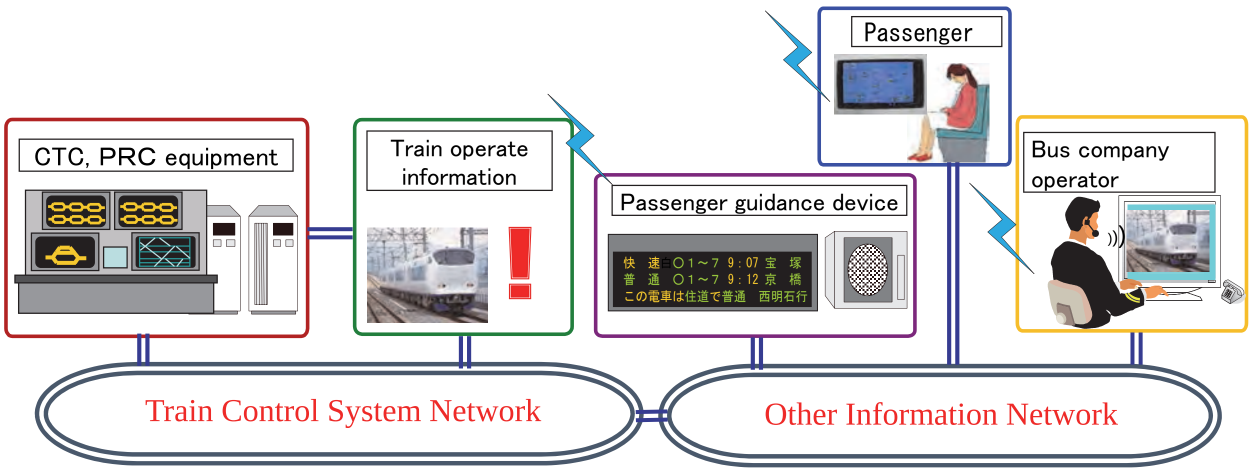
Optical fiber-fiber cables are able to transmit much more information than metal cables. A wide range of information other than information from a signal system can be transmitted through optical-fiber transmission lines of a railway system; including information for train radio, passenger information, centralized monitoring and remote control (e.g. Power, Signalling, tele-communication, machinery, disaster prevention facilities), command telephone, ticket facility (par of AFC), platform video monitoring, and train operation status information, etc.. Optical-fiber cables will be installed on both sides of the main line of a double system (up and down) for immediate detection of malfunction of optical fiber lines and system components.

A multi-media transmission line employs gigabyte ether technology that effectively transmits video image data that are much larger than voice data. Thus, it will be used to transmit video image data for monitoring the safety of platforms during rush hours and for prevention of overcrowding, accidents, crime etc. on platforms. Also, a transmission channel capable of sending and receiving necessary information instantaneously will be installed for a

Supervisory Control and Data Acquisition (SCADA) system and an information service that provides passengers and other train operators, etc. with train operation information.

However, optical transmission lines for signaling systems for train control and those through which other types of information are communicated will be built separately, for consideration of train control dependability and security reason.

Also, railway operators can provide services in which they lend out optical-fiber lines channels to other companies for use unrelated to railway operations. Optical-fiber transmission lines secure large capacity in anticipation of increased future demand, but such a service allows companies to also make use of unused capacity of the lines (dark fiber). Optical-fiber transmission lines employed by signal systems make it possible to offer functions within a scope that will not interfere with train operation control.



Source: *JICA Study Team*

Figure 7.4.2-1 Construction of Railway Operation System Applying Dedicated Optical Fiber Network

(2) OCC command communication system

Communication between a train crew and a train dispatcher is carried out via radio. Analog train radio involves voice transmission. However, with the introduction of digital train radio, it is possible to transmit various types of data over a single line. Thus, existing railways are increasingly adopting digital radio to transmit various types of data. A modern digital train radio is capable of performing the following functions.

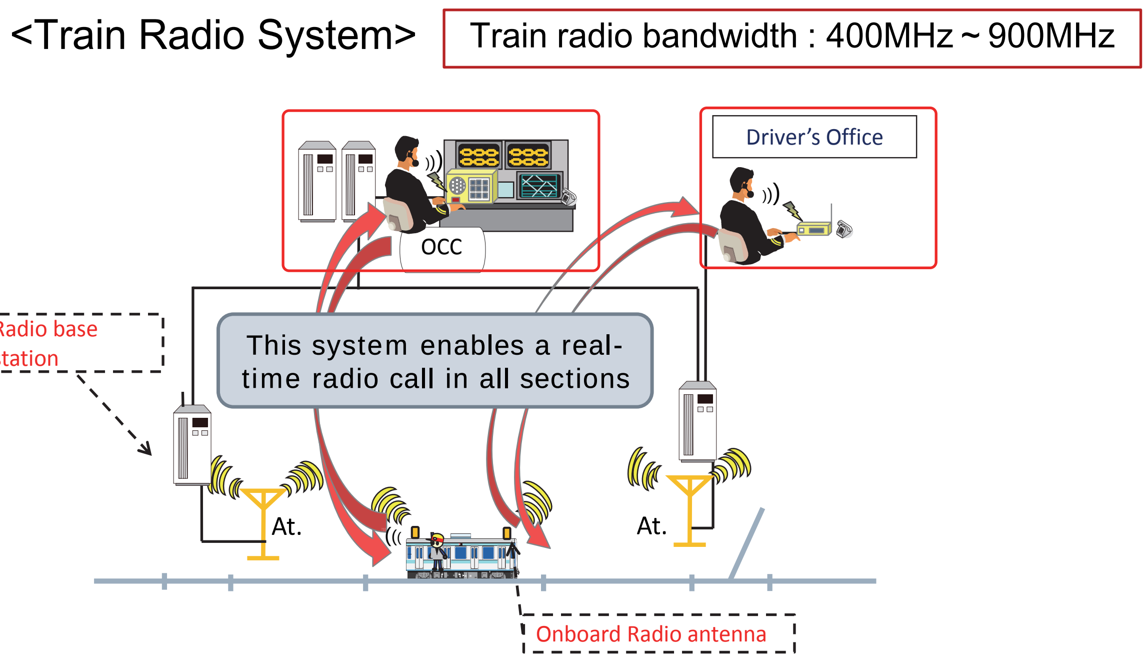
Call system
- Call to designated train from a dispatcher (multiple lines);
- Call to all train from a dispatcher
- Call to dispatcher from a train crew.

Emergency system
- Emergency train protection signal sent from a train with stop command sent to nearby trains;
- Emergency interruption by a train crew of a dispatcher talking on the phone;
- Emergency train protection signal from a wayside staff with stop command sent to nearby trains;

Maintenance work system
- Call to various places along the tracks from maintenance crews via cell phone.

Data transmission system	• Speedy confirmation of images displayed on a cab monitor (operation schedule changes, speed limits, etc.); • Train operation status information provided to a conductor (condition of connection trains, delay time, etc.); • Display on LCD in a cabin (traffic information during accidents, delays, etc.); • Quick transmission to a car depots (information concerning malfunction of on-board equipment).

The present plan for the MMSP is to adopt the digital train radio system.



Source: *JICA Study Team*

Figure 7.4.2-2 Overview of Digital Train Radio System Operation

(3) Passenger Information Facilities, Information Terminals, Others

(a) Passenger information system

The passenger information guidance device, that notifies passengers on a platform of approaching trains and train operation status, is another important piece of equipment. Since announcements that accurately inform the train operation status are demanded, a passenger information guidance device will be designed so that it will be able to obtain information concerning train operation status on a timely basis by linking it to a centralized traffic control system of OCC by which train operations are centrally controlled.

(b) Video monitoring system

In order to carry out smooth operations of trains during rush hours, station attendants and OCC train dispatchers have to be able to grasp the actual conditions on platforms and concourses. Fixed- and remote controlled cameras will be used to check the security of train facilities. Fixed cameras will be set in locations where it is difficult for a conductor to confirm the situation by sight; while a TV monitor will be installed where a conductor can confirm the safety of passengers getting on and off the train. Cameras will be installed at important locations such as OCCs, depot and substations to implement disaster prevention monitoring and security management.

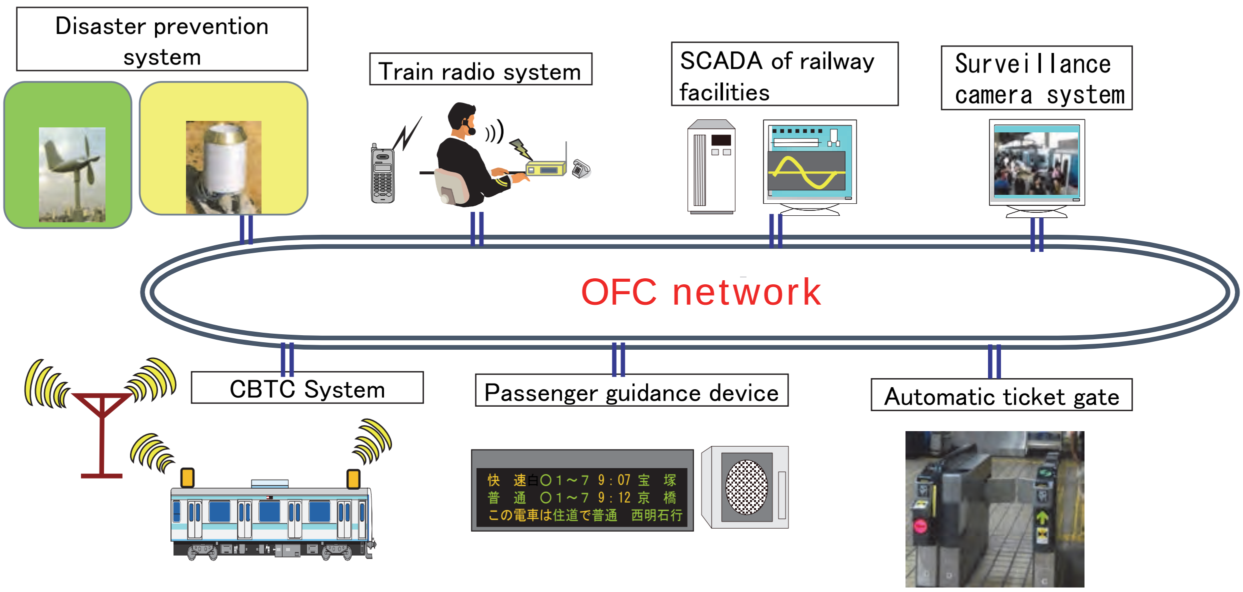
CCTV technology has made remarkable advances, including multi-display screen images, display screen images switching, and image storage. Broadcast facilities that issue voice based caution and warnings from the OCC will be provided. Optical transmission lines will bring large capacity communication into action with the installation of these types of equipment.

(c) Accurate time indication

In order to indicate the accurate time at station, OCC, Depot, etc. and to manage the system clock for the AFC, SCADA, CCTV, etc. synchronizing system clock for each system with accurate time is necessary. Master clock provides the accurate time to all clocks, train control system, passenger information system, etc. through the tele-communication network.

(d) Facility SCADA

Facility SCADA system that monitors the steady-state situation of electronic and electric devices such as signals and tele-communication equipment, and alarms and switches systems if the malfunction of components will occur, will be introduced using the state-state-of –the-art equipment to providing suitable preventive maintenance. In this way, the incidence of railway system malfunction will be reduced as much as possible, and a railway can be maintained as a safe and secure means of transportation. Toward this end, a study will be conducted to determine the best way to obtain and make use of information concerning, among other things, civil and track structures like rails and weather conditions along the tracks, and earthquake and other disaster prevention information, with a view to achieving a more stable train operation.



Source: *JICA Study Team*

Figure 7.4.2-3 Overview of OFC Tele-communication Systems Network for Railway System

(4) Automatic Fare Collection system (AFC)

(a) Outline of AFC System

AFC systems have been installed in many urban railways around the world and consist of Ticket Vending Machines (TVM), Automatic Gates (AG), Automatic Fare Adjustment Machines, Data Collecting Machines and office booking machines. The main concept of the AFC equipment are summarized below.

- TVM

TVM is used for ticket selling and is a machine which automatically issues tickets by passengers paying money and choosing boarding destination. TVM which is operated by the passengers is required to be simple and easy to use.

- AG

AG, which is installed at ticket gates or ticket collection gates, is a machine to rapidly and accurately read or collect tickets on behalf of station staff. The type of AGs are for entrance only, exit only and both entrance and exit. At entrances, the AG reads necessary information from a card or ticket and writes the entrance record onto it. On exit, the card is again passed over the card reader. At this time the fare is adjusted and confirmed based on the entrance record. If required information is not obtained on entrance or exit, the gate will be closed and information will be confirmed by station staff.

- Automatic fare adjustment machines

A fare adjustment machine is installed inside ticket gates and used by passenger themselves for fare adjustment such as excess fare. The fare machines reads the ticket information when the ticket is inserted into the machine. At this time, the fare is deducted from the remaining balance on the ticket and balance due is displayed. After inserting the necessary amount of money, the adjusted fare ticket will be dispensed, with which the passenger can pass through the AG.

- Data collecting machines

A data collecting machine is a piece of equipment to collect and save daily data from the AFC system such as AGs, TVMs and fare adjustment machines, etc. The aggregated data is transferred to the data management department through online communication facilities. The data is also transferred from this department to the administration department and used for the administrative strategic planning and the improvement of passenger services.

- Ticket checker

A ticket checker is installed in an information counter next to the fare gates. Recorded information on the card or ticket, such as entrance record, exit record, fare adjustment record, is checked and updated by a station staff.

(b) Estimated Number of AFC System Equipment

The required number of TVMs, AGs and automatic fare adjustment machines are obtained from the following equation.

$$N = P \times C / T$$

Where; N: Number of required machines (unit)
P: Number of passengers using equipment at peak 1 hour (person/hour)
C: Fluctuation ratio of passengers (events or transfer from/to other transportation modes)
T: Performance of machines per unit per hour (person/unit/hour)

(c) Consideration for AFC Installation

- AGs shall correspond to a contactless IC ticket or card
- The process performance of AGs assumes that the maximum rate is approximately 60 persons per minute.
- Basically, TVMs shall be installed for ticket sales. However, tickets shall be temporally sold by both station staff at the ticket counter in Philippine and TVMs depending on the situation of banknote and coin circulation.
- Every station shall have ticket gates that are wheelchair accessible, generally located next to the information counter. The passage width shall be approx. 90cm.
- TVMS and fare adjustment machines shall be designed to be operated easily by wheelchair users, and be equipped with Braille display and brightness adjustment, etc. for visually impaired people.
- This AFC system is integrated in common ticket system in Metro Manila.

Source: *JICA Study Team*

Figure 7.4.2-4 Horizontal Flap Type Automatic Gate in Japan

7.5 Train Operation Plan

The planning route of the MMSP will connect regions where will have high latent demand and many passengers are attracted for railway. Accordingly, the train operation plan on the planned route should satisfy the following requirements:

- Corresponding to high dense and large quantities transportation for commuter in the morning and evening peak hours.
- Keeping adequate frequency to assured passenger's convenience at deserted time, etc.

In the planning of route running through concurrently with existing PNR line and MRT line at middle section of the MMSP route, competing domination with existing railway services, such as convenience, speed, etc. should be also considered.

7.5.1 Route Plans

A total of 12 route alignment options was proposed and studied in this Study. Tables 7.5.1-1 and 7.5.1-2 show the outline of the each route in relation to the train operation plan.

The inter-station distance of each route option varies from minimum 1.1 km to maximum 4.1 km, where many stations have more than 2 km inter-station distance. The average inter-station distances of each route is approximately 2.3km. This relatively long inter-station distance allows trains to achieve running at high operation speed.

Table 7.5.1-1 Outline of Each Route (1)

Alternative Routes		A1a	A2a	A3a	A1b	A2b	A3b
Route distance (km)		59.1	60.1	63.4	59.1	60.1	63.4
Station number		27	27	29	27	27	29
Maximum inter-station distance (km)		4.1	4.1	4.1	4.1	4.1	4.1
Minimum inter-station distance (km)		1.3	1.2	1.1	1.3	1.2	1.1
Average inter-station distance(km)		2.3	2.3	2.3	2.3	2.3	2.3
Structure	Underground (km)	23.0	24.0	27.3	36.2	37.2	22.9
	Elevated (km)	36.1	36.1	36.3	22.9	22.9	40.5

Table 7.5.1-2 Outline of Each Route (2)

Alternative Routes		A1a	A2a	A3a	A1b	A2b	A3b
Route distance (km)		58.8	59.9	63.2	58.8	59.9	63.2
Station number		27	27	29	27	27	29
Maximum inter-station distance (km)		4.1	4.1	4.1	4.1	4.1	4.1
Minimum inter-station distance (km)		1.1	1.1	1.1	1.1	1.1	1.1
Average inter-station distance(km)		2.3	2.3	2.3	2.3	2.3	2.3
Structure	Underground (km)	24.0	24.0	27.3	36.2	37.3	40.6
	Elevated (km)	35.9	35.9	35.9	22.6	22.6	22.6

Source: *JICA Study Team*

7.5.2 Train Operation Plan

(1) Pre-conditions of Train Operation

Pre-conditions of the train operation assumed in this Study are given below;

- MMSP will be implemented in 2 phases.
- First phase is between Mindanao Avenue-Quirino Highway and FTI, and will be opening during 2025. During the first phase only will be operated on underground section.
- The second phase is between Mindanao Avenue-Quirino Highway and L. Langit Road or Mindanao Avenue-Quirino Highway and Bahay Pare Road in North Zone, and between FTI and Governor’s Drive in South Zone, and will be opened for revenue operation in 2035. After second phase, trains will be operated on the entire section.
- Only commuter trains will be operated on the MMSP route.

(2) Operations’ Philosophy

The train operation plan in this Study was mainly planned to presume and understand the project volume. Thus, pre-conditions and philosophy regarding train operation were applied correspondingly referring the current cases with other countries’ subways and commuter trains.

(a) Train Operation Service

The service runs 18 hours per day (6 a.m. to midnight). After finishing service, concentrated working windows will be held.

(b) Concentrated Rate of Passenger during Peak Hour

Demand for the MMSP service is expected from commuter and students in the morning and evening on the planned route. The peak hours is assumed between 7 a.m. and 8 a.m.

It is assumed that 15% of passengers per day will concentrate in this peak hour. Maximum congestion ratio in a train will be allowed until 180% over to the standard passenger capacity of a train. Extreme congestion of the commuting transportation had been a serious social problem in Japan. The target of congestion ratio will be 150% in future according to the Japanese government guidance.

(c) Standard Passenger Capacity

Only local trains which stop at all stations will be operated on the line. The standard passenger capacity of a train should consider congestion of a train during rush hours in morning and evening enough beforehand and it should have room to keep comfort of passengers. The standard passenger capacity will be estimated to be 150 per car which similar to Japanese typical commuter trains and subway trains. Recently, the subway and commuter trains in many countries have introduced female-only car, but it is not considered in the calculation of required cars per trainsets.

(d) Running Performance

The construction of subway usually is limited on narrowness and bottleneck section like under main road because of avoiding existing structures. There are many sharp curves and steep gradients on the route and the distance between stations is relatively short.

As for rolling stock running performance, high acceleration and deceleration performance and run up performance on rapid gradients is valued more than high-speed performance. The inter-station distance of the MMSP varies from minimum 1.1 km to maximum 4.1 km and many stations with more than 2 km of inter-station distance. The average inter-station distances for each route are 2.3 km. This high inter-station distance allows trains to achieve running at high operation speed. As for maximum running speed, about 80 - 100kmph was assumed, including underground section.

(3) Train Operation Plan

Train operation plan was made by estimating the required number of trainsets and cars and trains running volume for presuming and understanding the scale of the MMSP as well as the O&M requirement and cost based on the pre-conditions and philosophy described above.

(a) Demand Forecast

Based on the results of demand forecast, he maximum cross section traffic volume and Peak Hour Peak Direction Traffic (PHPDT) as shown in Tables 7.5.2-1 to 7.5.2-4 were considered as the basis in the train operation plan.

Table 7.5.2-1 Maximum Cross section Traffic Volume and PHPDT (A1a, A2a, A3a)

Option	A1a				A2a				A3a			
Year	2025	2034	2035	2045	2025	2034	2035	2045	2025	2034	2035	2045
Dayly Peek Section Volume	122,077	124,436	154,135	237,337	121,739	118,454	154,673	241,755	118,831	120,527	152,950	243,303
PHPDT(15%)	18,312	23,120	23,120	35,601	18,261	17,769	23,201	36,263	17,825	22,943	22,943	36,495

Table 7.5.2-2 Maximum Cross section Traffic Volume and PHPDT (A1b, A2b, A3b)

Option	A1b				A2b				A3b			
Year	2025	2034	2035	2045	2025	2034	2035	2045	2025	2034	2035	2045
Dayly Peek Section Volume	122,077	124,436	154,135	237,337	121,739	118,454	154,673	241,755	118,831	120,527	152,950	243,303
PHPDT(15%)	18,312	23,120	23,120	35,601	18,261	17,769	23,201	36,263	17,825	22,943	22,943	36,495

Table 7.5.2-3 Maximum Cross section Traffic Volume and PHPDT (B1a, B2a, B3a)

Option	B1a				B2a				B3a			
Year	2025	2034	2035	2045	2025	2034	2035	2045	2025	2035	2045	2034
Dayly Peek Section Volume	–	–	154,497	252,681	–	–	152,373	246,104	–	–	160,006	254,459
PHPDT(15%)	–	–	23,175	37,902	–	–	22,856	36,916	–	–	24,001	38,169

Table 7.5.2-4 Maximum Cross section Traffic Volume and PHPDT (B1b, B2b, B3b)

Option	B1b				B2b				B3b			
Year	2025	2034	2035	2045	2025	2034	2035	2045	2025	2035	2045	2034
Dayly Peek Section Volume	–	–	154,497	252,681	–	–	152,373	246,104	–	–	160,006	254,459
PHPDT(15%)	–	–	23,175	37,902	–	–	22,856	36,916	–	–	24,001	38,169

Source: *JICA Study Team*

(b) Train Planning

The required number of trains shall be calculated to meet the highest cross section traffic volume. There are slight differences in cross section traffic volume among sections, but it is not extreme for considering reduction of the number of trains by sections. Thus, the number of trains required was considered to be the same throughout the route. The train numbers was planned to meet the congestion ratio which is limited under 180% during peak hour, and it will consider some change depending on passenger volume at deserted time. However, it will keep adequate frequency to assured passenger’s convenience. Tables 7.5.2-5 to 7.5.2-8 show the number of trains and headway during peak hour in each target year. Tables 7.5.2-9 to 7.5.2-12 show the number of trains per day (one direction) in each year.

Table 7.5.2-5 Train Numbers and Headway at Peak Hour (A1a, A2a, A3a)

Option	A1a				A2a				A3a			
Year	2025	2034	2035	2045	2025	2034	2035	2045	2025	2034	2035	2045
Configuration	6	6	8	10	6	6	8	10	6	6	8	10
Train Numbers	14	14	13	16	13	13	13	16	13	13	13	16
Headway (Min)	5	5	5	4	5	5	5	4	5	5	5	4

Table 7.5.2-6 Train Numbers and Headway at Peak Hour (A1b, A2b, A3b)

Option	A1b				A2b				A3b			
Year	2025	2034	2035	2045	2025	2034	2035	2045	2025	2034	2035	2045
Configuration	6	6	8	10	6	6	8	10	6	6	8	10
Train Numbers	14	14	13	16	13	13	13	16	13	13	13	16
Headway (Min)	5	5	5	4	5	5	5	4	5	5	5	4

Table 7.5.2-7 Train Numbers and Headway at Peak Hour (B1a, B2a, B3a)

Option	B1a				B2a				B3a			
Year	2025	2034	2035	2045	2025	2034	2035	2045	2025	2034	2035	2045
Configuration	6	6	8	10	6	6	8	10	6	6	8	10
Train Numbers	–	–	13	17	–	–	13	17	–	–	13	17
Headway (Min)	–	–	5	4	–	–	5	4	–	–	5	4

Table 7.5.2-8 Train Numbers and Headway at Peak Hour (B1a, B2a, B3a)

Option	B1b				B2b				B3b			
Year	2025	2034	2035	2045	2025	2034	2035	2045	2025	2034	2035	2045
Configuration	6	6	8	10	6	6	8	10	6	6	8	10
Train Numbers	–	–	13	17	–	–	13	17	–	–	13	17
Headway (Min)	–	–	5	4	–	–	5	4	–	–	5	4

Source: *JICA Study Team*

Table 7.5.2-9 Train Numbers per Day (A1a, A2a, A3a)

Option	*A1a*				*A2a*				*A3a*			
Year	2025	2034	2035	2045	2025	2034	2035	2045	2025	2034	2035	2045
Configuration	6	6	8	10	6	6	8	10	6	6	8	10
Daily Train Numbers(One Way)	97	97	95	118	96	96	95	118	95	95	94	118

Table 7.5.2-10 Train Numbers per Day (A1b, A2b, A3b)

Option	*A1b*				*A2b*				*A3b*			
Year	2025	2034	2035	2045	2025	2034	2035	2045	2025	2034	2035	2045
Configuration	6	6	8	10	6	6	8	10	6	6	8	10
Daily Train Numbers(One Way)	97	97	95	118	96	96	95	118	95	95	94	118

Table 7.5.2-11 Train Numbers per Day (B1a, B2a, B3a)

Option	*B1a*				*B2a*				*B3a*			
Year	2025	2034	2035	2045	2025	2034	2035	2045	2025	2034	2035	2045
Configuration	6	6	8	10	6	6	8	10	6	6	8	10
Daily Train Numbers(One Way)	–	–	95	119	–	–	94	118	–	–	96	119

Table 7.5.2-12 Train Numbers per Day (B1a, B2a, B3a)

Option	*B1b*				*B2b*				*B3b*			
Year	2025	2034	2035	2045	2025	2034	2035	2045	2025	2034	2035	2045
Configuration	6	6	8	10	6	6	8	10	6	6	8	10
Daily Train Numbers(One Way)	–	–	95	119	–	–	94	118	–	–	96	119

Source: *JICA Study Team*

(c) O&M Parameter

1) Required Train Sets and Car Numbers

Tables 7.5.2-13 to 7.5.2-16 show the required number of trainsets that meet the passenger demand in each target year. Reserve trainsets was supposed to be about 15% of the net necessary trainsets.

Table 7.5.2-13 Required Train Sets and Car Numbers (A1a, A2a, A3a)

Option	A1a				A2a				A3a			
Year	2025	2034	2035	2045	2025	2034	2035	2045	2025	2034	2035	2045
Configuration	6	6	8	10	6	6	8	10	6	6	8	10
Required Train Sets (Including Spare)	25	25	46	55	23	23	46	55	26	26	49	58
Required Train Sets (Including Spare)	150	150	368	550	138	138	368	550	156	156	392	580

Table 7.5.2-14 Required Train Sets and Car Numbers (A1b, A2b, A3b)

Option	A1b				A2b				A3b			
Year	2025	2034	2035	2045	2025	2034	2035	2045	2025	2034	2035	2045
Configuration	6	6	8	10	6	6	8	10	6	6	8	10
Required Train Sets (Including Spare)	25	25	46	55	23	23	46	55	26	26	49	58
Required Train Sets (Including Spare)	150	150	368	550	138	138	368	550	156	156	392	580

Table 7.5.2-15 Required Train Sets and Car Numbers (B1a, B2a, B3a)

Option	B1a				B2a				B3a			
Year	2025	2034	2035	2045	2025	2034	2035	2045	2025	2034	2035	2045
Configuration	–	–	8	10	–	–	8	10	–	–	8	10
Required Train Sets (Including Spare)	–	–	46	58	–	–	46	58	–	–	49	62
Required Train Sets (Including Spare)	–	–	368	580	–	–	368	580	–	–	392	620

Table 7.5.2-16 Required Train Sets and Car Numbers (B1a, B2a, B3a)

Option	B1b				B2b				B3b			
Year	2025	2034	2035	2045	2025	2034	2035	2045	2025	2034	2035	2045
Configuration	–	–	8	10	–	–	8	10	–	–	8	10
Required Train Sets (Including Spare)	–	–	46	58	–	–	46	58	–	–	49	62
Required Train Sets (Including Spare)	–	–	368	580	–	–	368	580	–	–	392	620

Source: *JICA Study Team*

2) Assumption train kilometers

Tables 7.5.2-17 to 7.5.2-20 show train kilometers per day in each target year according to the results of estimated train operation plan in each target year.

Table 7.5.2-17 Train Kilometers per Day (A1a, A2a, A3a)

Option	A1a				A2a				A3a			
Yea	2025	2034	2035	2045	2025	2034	2035	2045	2025	2034	2035	2045
Configuration	6	6	8	10	6	6	8	10	6	6	8	10
Train Km/Day (km)	4,384	4,384	11,229	13,948	4,550	4,503	11,419	14,184	5,130	5,130	11,919	14,962

Table 7.5.2-18 Train Kilometers per Day (A1b, A2b, A3b)

Option	A1b				A2b				A3b			
Yea	2025	2034	2035	2045	2025	2034	2035	2045	2025	2034	2035	2045
Configuration	6	6	8	10	6	6	8	10	6	6	8	10
Train Km/Day (km)	4,384	4,384	11,229	13,948	4,550	4,503	11,419	14,184	5,130	5,130	11,919	14,962

Table 7.5.2-19 Train Kilometers per Day (B1a, B2a, B3a)

Option	B1a				B2a				B3a			
Yea	2025	2034	2035	2045	2025	2034	2035	2045	2025	2034	2035	2045
Configuration	–	–	8	10	–	–	8	10	–	–	8	10
Train Km/Day (km)	–	–	11,172	13,994	–	–	11,242	14,113	–	–	12,134	15,042

Table 7.5.2-20 Train Kilometers per Day (B1a, B2a, B3a)

Option	B1b				B2b				B3b			
Yea	2025	2034	2035	2045	2025	2034	2035	2045	2025	2034	2035	2045
Configuration	–	–	8	10	–	–	8	10	–	–	8	10
Train Km/Day (km)	–	–	11,172	13,994	–	–	11,242	14,113	–	–	12,134	15,042

Source: *JICA Study Team*

7.6 Utilization of Japanese Technologies in Rolling Stock and Railway Systems

Japanese companies which has been developing overseas business in railway market, particularly in Asia including the Philippines, are considered as follows:

Trading Company: Marbeni, Soujitsu, Mitsubishi, Sumitomo

Machinery: Toshiba Elevator, Mitsubishi Heavy Industry

Rolling Stock Manufacturer: Hitachi, Kawasaki Heavy Industry, Kinki Sharyo

Railway Systems Manufacture: Nippon signal, Kyosan, Hitachi, Mitsubishi Electric, Toshiba

AFC/Security Equipment Supplier: SONY

7.6.1 Past Records of Contract in the Philippine

Past records of contracts awarded to Japanese companies are shown in Table 7.6.1-1. To date, Japanese companies (3 for rolling stock, 1 for signaling system (E&M contract by the trading company) and 1 for power supply) were awarded contracts which are related to the Metro.

Table 7.6.1-1 Records of Awarded Contract in the Philippines

Line	Item	Contractor	JV, etc.
LRT1	Rolling stock		Kinki sharyo, Nippon sharyo (3rd generation)
	Signaling		Siemens, BBR
LRT2	Rolling stock	Marbeni	Hyundai Rotem, Adtranz (Bombardier)
	Signaling	Marubeni (E&M)	Dimetronics
	Power		Meidensha
MRT3	Rolling stock		CKD Doprovni System
	Signaling		Bombardier

Source: *JICA Study Team*

7.6.2 Current Status and Interest of Japanese Companies

7.6.2.1 Superiority of Japanese Rolling Stock Technologies of Commuter Trains

Japan has one of the largest volumes of commuter train transportation with safety and accuracy and stability in the world. Electric Multiple Unites (EMUs) for commuter trains have acquired reliablity and proven results compared with those of foreign countries. Railway technologies in Japan has been continually improved and developed to enhance passenger riding comfort, efficiency, reliability and environmentally friendliness. These advanced technologies are able to be applied in the rolling stock for the MMSP. Salient features of such advanced technologies in Japanese rolling stock are shown below

(1) Light-weight technology

The weight of rolling stock directly affects the energy consumption during operation, thus Japanese railway operating companies along with Japanese rolling stock manufactures have been pursuing light weight technologies from the viewpoint of cost reduction and environmentally friendliness. Japanese rolling stock manufacturers' technologies are ranked as highest level in the world and many Japanese subway and commuter train manufacturers have gained trust and proven records regarding operation cost reduction and achievement of environmentally friendliness.

(2) Efficient Propulsion and Braking System and Easy Maintenance Structure

Japanese commuter trains and subway trains have achieved benefits from developing and using new propulsion systems, like Permanent Magnet Synchronous Motor (PMSM), Variable Voltage Variable Frequency (VVVF) using SiC devise. PMSM has permanent magnets in its rotor, and makes the most use of the magnetic energy. In addition, they also have been developed and used in all or net braking system which use only electric power for controlling breaking performance. It has achieved high acceleration and deceleration performance and simplified and lightened the braking system as well as reduced dusts. Reduction of bogy and other equipment in rolling stock, especially consumption parts, has been contributing to reduce maintenance works dramatically. Furthermore, automatic inspection function of train information management system, which have high transmission speed and large volume of data size compared with those of foreign countries products, and self- diagnosis function for major equipment have saved the volume of maintenance works.

Rolling stock manufactured with Japanese technologies satisfy both high reliability and easy-maintenance and it is in the highest level in the world.

(3) Unmanned Operation

Although the driving method in the MMSP, will be examined in the next phase, the unmanned operation or one man operation on railway has been put to practical use in various railways in the world, e.g. France, Taiwan, Singapore, Canada, USA and Japan. Unmanned operation in Japan had been put to practical use in the world first. It has been over 30 years since the start of the first unmanned operation. There are 9 lines on operation in Japan now. Japanese's unmanned operation system and technology have gained trust and proven records in a technological level and safety.

7.6.2.2 Electric and Machinery Facilities

Some power supply system manufacturers were awarded the contract of the substation system and seem to have interest in the railway projects in the Philippines.

7.6.2.3 Signalling System and Tele-communication Systems

Some Signalling System manufacturers show interest in the railway projects in the Philippines. There are some manufacturers who have their own offices in the Philippines.

For the Signaling System, the CBTC system is applicable and there are some systems which have high reliability and high availability for train control function, and are recommended to be considered as the technical requirement during the design phase. (e.g. Dependable original radio communication system for control data transmission, Automatic system recovery function from malfunction)

For the Tele-communication Systems, there is a manufacturer that is examining to have a certification of an international standard (ITU-R) for new type of digital train radio system which is different from TETRA certificated European standard (ETSI) and is popularly installed in Japanese urban railways, and is interested in bidding for the Ahmedabad Metro in India. A comparison of the system and the TETRA is described below.

Table 7.6.2.3-1 Comparison of TETRA and New Type of Digital Train Radio System

Item	TETRA	New Type of Digital Train Radio	Advantage of New System
Outline	Radio system developed for private business use (police fire station). Popular for the business use, train radio, etc.	Exclusively developed for the train radio system. Using for the commuter lines of Tokyo metropolitan area.	・System design and communication service for original use of the train radio ・Using for the busiest lines
Handover of base station	by changing radio frequency	Can hand over without changing radio frequency	Hand over with high radio communication quality
Voice codec method	Popular voice codec method for mobile phone (ACELP)	Original voice codec method for train radio (RL-CELP)	High quality sound communication is available without the influence of train noise, transmission error, etc.
Reliability of the system	In case of the malfunction of components or the communication failure (e.g. radio frequency interference), usually all 4 channel is affected.	Because of channel separated unit design and discrete allocation of radio frequency, all channel is not affected in malfunction	・All channel is not affected by jamming, noise, etc. ・Trouble channel can easy to separate
Frequency allocation, speed rate	Band width: 25kHz/4ch speed rate: 7.2kbps/ch	Band width:6.25 kHz/ch Speed rate: 9.6kbps/ch	Flexible allocation of frequency and having advantage for busy frequency use area.
System design flexibility	Strictly system designing work is required. (e.g. consideration for frequency allocation, type and alignment of radio base station, etc. is needed)	System designing work is easier. (e.g. System can construct with one radio frequency for one line.)	・Decreasing construction cost. ・Flexibility for change of radio environment, system modification, etc.
Technical standard	ETSI (European standard)	Candidate of ITU-R (international standard)	

Source: *JICA Study Team*

For the AFC System, there are 3 types of Contactless Smart Cards in line with ISO14443, i.e. Type A, Type B and Type C. Japanese Type C that has advantage in performance (double R/W speed), high security and reliability can increase the performance of Automatic Gates and most suitable for use in the congested urban lines in Metropolitan area. A comparison of these systems are shown in Table 7.6.2.3-2.

Table 7.6.2.3-2 Comparison of AFC System

		ISO 14443		
		Type-A	Type-B	Type-C candidate
Reader/ Writer	Speed	106 kbps		**212 kbps**
	Freq.	13.56 MHz		
	ASK	100%	10%	10%
	Bit Coding	Modified Miller	NRZ	Manchester
Card	Freq.	13.56 MHz		
	Subcarrier	847 kHz		(Symmetry)
	Bit Coding	Modified Miller	NRZ	Manchester
Providers		Micron Philips Infineon	Innovatron ASK ST Micro	SONY Panasonic Hitachi

Source: *JICA Study Team*

7.6.3 Issues and Concerns

Although there are many railway projects in the Philippines implemented with Japanese ODA Loan, not many Japanese manufacturers have been awarded in these projects. Especially for the Signalling System and Tele-communication Systems, there are no records of being awarded in railways in the Philippines. In order for the GOP to ensure good quality and reliable subway service in the future, it might be worth exploring to establish new evaluation methods in order to tap into the advanced and proven Japanese technologies described above and previous sections

(1) Method of Bidding and Contract Packaging

- Tied method (competition among Japanese companies with Philippines companies) is expected by many Japanese companies, rather than the untied method (competition with foreign companies) for the bidding in order to maintain the highest quality of the project in every aspects, i.e. proven records, life cycle cost, etc., and to avoid mere financial competition that could lead lower quality.
- There are some companies that can join one of the manufacturers of large package (e.g. E&M turnkey contract by trading companies), and others expect in smaller packages for own contract. (e.g. signaling companies)

(2) Evaluation Method

- Cost is mainly the decisive factor in the evaluation of the proposals at present, which partly obstructs the use of Japanese technologies that are higher in performance but also a bit higher in cost. As already introduced in some technical evaluations, consideration might be made to give higher points in overall evaluation if technical proposals include energy saving approach, higher reliability and safety with proven records, life cycle cost, etc., so that the Philippines people who are the users of the subway service will be able to enjoy maximum benefit from this important project.

Chapter 8

PRELIMINARY IMPLEMENTATION PLAN AND PROJECT COST

Chapter 8 PRELIMINARY IMPLEMENTATION PLAN AND PROJECT COST

8.1 Preliminary Implementation Plan

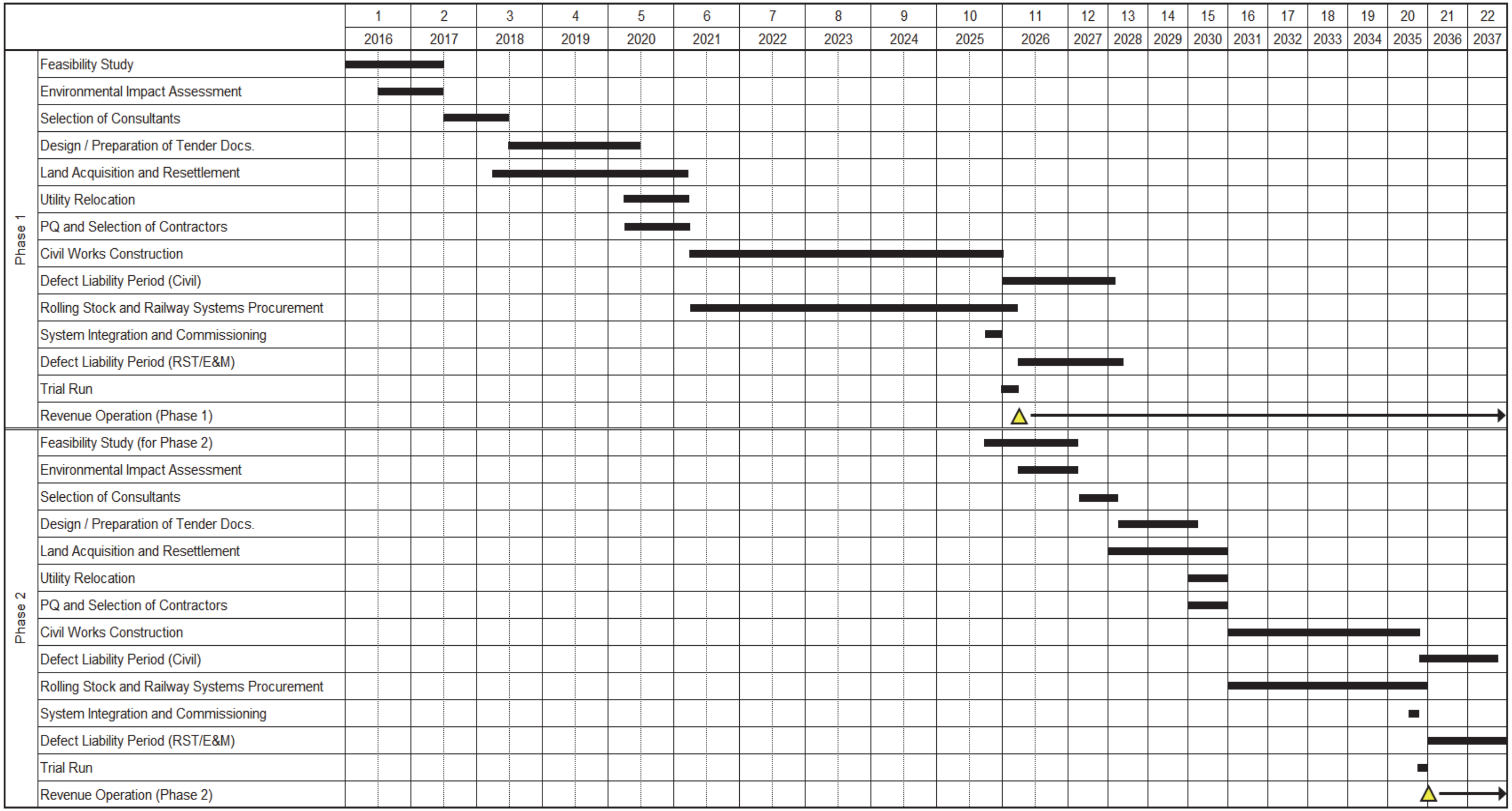
8.1.1 Preliminary Project Implementation Schedule

After identification of several route options in this Study, a Feasibility Study needs to be carried out to study and compare of each route option in more detail and to consequently select the most feasible and desirable route option among the several options. An Environmental Impact Assessment needs to be carried out during the Feasibility Study stage, in which areas to be acquired and households/buildings to be relocated will be identified. After the completion of the Feasibility Study, a Preliminary Design will be carried out for the selected route, which will be the basis for the preparation of the Tender Documents. Land acquisition and resettlement need to be completed before the commencement of the construction in order to prevent delay to the construction works. Similarly, relocation of major utilities along and crossing the subway corridor and the construction sites shall be completed before the commencement of the construction.

If the Civil Works is implemented with Design-build Contract basis, the utility relocation could be included in the Civil Works contract, however its cost would be higher than the case done by the government since the contractor for Civil Works normally includes risk premium to such utility relocation works due to its uncertainty and unforeseen condition. Therefore, it is recommended that the relocation of major utilities be carried out by the government. It is essential to complete the utility relocation before the commencement of the construction, whether the Civil Works contract is with the Design-Build basis or the Employer’s Design basis, since a delay in the utility relocation has a direct impact to the site works, by which contractors will be entitled to claim for time extension and/or additional cost.

It is roughly estimated that the Phase 1, mainly comprising underground section in the Central Zone, would take approximately 5 years for construction of Civil Works and procurement of Rolling Stock and E&M Systems (including manufacturer’s design, manufacturing, installation at site, and individual functional and performance tests), system integration, commissioning and trial running to be ready for revenue operation. The Phase 2 works, consisting of the elevated structures in the North Zone and either underground or elevated structures in the South Zone, would take 4 to 5 years, depending on the volume of underground structure works which depend on the option. Contract packaging shall be considered and determined to achieve the target period overall. Defect Liability Period of contractors is typically 2 years after the completion of the contract, i.e. handover of all works to the Employer.

Table 8.1.1-1 Preliminary Project Implementation Schedule for MMSP



Source: *JICA Study Team*

8.1.2 Project Phasing Schedule

8.1.2.1 Phasing with Phase 1 and Phase 2

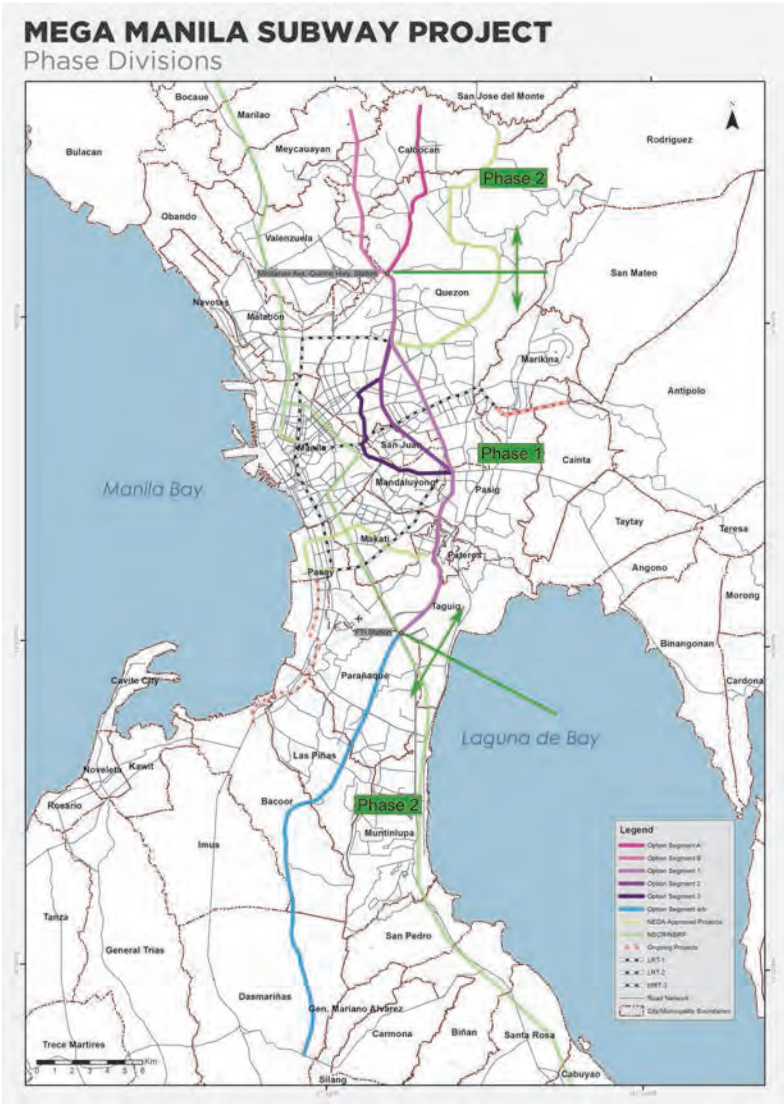
The entire route length of MMSP is estimated to be around 60 km, varying a few kilometers among options. It is considered that the construction of the entire route at one time is too large since it requires not only large budget, availability of skilled contractors as well as sufficient construction equipment and material, but also the management of many contractors in many contract packages. Therefore, we propose to divide the project into 2 phases.

8.1.2.2 Boundary between Phase 1 and Phase 2

As mentioned above, it is proposed that the Phase 1 covers the Central Zone and the Phase 2 covers both North and South Zones. Tentatively, the north end of the Phase 1 is set at Mindanao Avenue-Quirino Highway Station (chainage at 10.381 km in case of Option A1a), whereas the south end is set at FTI Station (chainage at 33.044 km in case of Option A1a and 37.383 km in case of Option A3a), having total distance of approximately 23 to 27 km and 13 to 15 stations depending on the option. The Phase 1 section consists of entirely underground structure, except the transition section from the underground to the elevated structures between Tandang Sora Avenue Station and Mindanao Avenue-Quirino Highway Station as well as Mindanao Avenue-Quirino Highway Station as the elevated station. FTI Station at the south end is an underground station, regardless of the structures in the South Zone.

Phase 2 includes both North Zone and South Zone with approximately 36 km in distance and 14 stations in all options, where the elevated structure is proposed in the North Zone for both option (Options A-X-X and B-X-X) and either entirely elevated (Option XXa) or the combination of underground and elevated structures (Option X-X-b) in the South Zone.

Depot is planned to be constructed in both phases, where the capacity of the depot to be constructed in Phase 1 needs to be sufficient enough to serve for maintenance activities and stabling of train sets until the commencement of Phase 2, in which a second depot is to be constructed. The capacity and the function of the second depot may or may not be slightly different from those of the first depot, depending on the maintenance policy and planning, number of trainsets required, etc.



Source: *JICA Study Team*

Figure 8.1.2.1-1 Phasing of MMSP with Phase 1 and Phase 2

8.2 Preliminary Project Cost

8.2.1 Summary of Project Cost

Based on the preconditions set by the JICA Study Team, rough Project Cost for each option have been estimated. The rough cost estimate includes construction cost, utility relocation cost, tax, consultants cost and physical contingency as Direct Project Cost, and land acquisition / compensation cost and ancillary road construction cost as Indirect Project Cost. Construction cost consists of Civil Work, Trackwork, Rolling Stock and E&M Systems. The Project Cost is indicated for Phase 1, Phase 2 and in total of the entire project. For those comprising foreign currency (FC) portion, the rough estimated ratio between FC and LC (local currency) is indicated and the costs are shown for FC portion and LC portion accordingly.

The unit cost per km of the MMSP, including both direct and indirect project costs, was estimated at approx. 190 to 197 Million USD for Phase 1, where almost all the sections are underground, and approx. 100 to 107 Million USD for Option b of Phase 2, where almost all the sections are elevated, depending on options varying the total route distance and the number of stations.

Table 8.2.1-1 Preliminary Project Cost (Option A1a)

Option A1a (Unit: Million USD)

Item		FC : LC	Phase 1 (Year 2025)			Phase 2 (Year 2035)			Total
			FC	LC	Total	FC	LC	Total	
Construction Cost	Civil Structures	10 : 90	239.84	2,158.56	2,398.40	122.41	1,101.69	1,224.10	3,622.50
	Trackwork	70 : 30	56.41	24.18	80.59	73.45	31.48	104.93	185.52
	Rolling Stock	95 : 5	301.69	15.88	317.57	804.50	42.34	846.85	1,164.41
	E&M Systems	90 : 10	272.99	30.33	303.32	339.00	37.67	376.66	679.98
	Sub-total	-	870.93	2,228.95	3,099.87	1,339.36	1,213.17	2,552.53	5,652.41
Utility Relocation		-		62.00	62.00		51.05	51.05	113.05
Tax	Import Tax	-	63.11		63.11	121.69		121.69	184.80
	VAT	-			371.98			306.30	678.29
Consultants Cost		60 : 40	208.31	138.87	347.19	171.53	114.35	285.88	633.07
Physical Contingency		-			291.16			244.98	536.14
Total of Direct Project Cost					**4,235.31**			**3,562.45**	**7,797.76**
Land Acquisition / Compensation		-		230.91	230.91		84.00	84.00	314.91
Ancillary Road Construction		-		0.00	0.00		4.29	4.29	4.29
Total of Indirect Project Cost					**230.91**			**88.29**	**319.20**
Total Project Cost					**4,466.22**			**3,650.74**	**8,116.96**

Source: *JICA Study Team*

Table 8.2.1-2 Preliminary Project Cost (Option A2a)

Option A2a (Unit: Million USD)

Item		FC : LC	Phase 1 (Year 2025)			Phase 2 (Year 2035)			Total
			FC	LC	Total	FC	LC	Total	
Construction Cost	Civil Structures	10 : 90	245.18	2,206.60	2,451.78	122.41	1,101.69	1,224.10	3,675.87
	Trackwork	70 : 30	58.63	25.13	83.76	73.45	31.48	104.93	188.69
	Rolling Stock	95 : 5	277.55	14.61	292.16	828.64	43.61	872.25	1,164.41
	E&M Systems	90 : 10	281.53	31.28	312.81	339.00	37.67	376.66	689.47
	Sub-total	-	862.89	2,277.62	3,140.51	1,363.49	1,214.45	2,577.94	5,718.45
Utility Relocation		-		62.81	62.81		51.56	51.56	114.37
Tax	Import Tax	-	61.77		61.77	124.11		124.11	185.88
	VAT	-			376.86			309.35	686.21
Consultants Cost		60 : 40	211.04	140.69	351.74	173.24	115.49	288.73	640.47
Physical Contingency		-			294.82			247.51	542.33
Total of Direct Project Cost					**4,288.51**			**3,599.19**	**7,887.70**
Land Acquisition / Compensation		-		241.12	241.12		84.00	84.00	325.13
Ancillary Road Construction		-		0.00	0.00		4.29	4.29	4.29
Total of Indirect Project Cost					**241.12**			**88.29**	**329.42**
Total Project Cost					**4,529.63**			**3,687.49**	**8,217.12**

Source: *JICA Study Team*

Table 8.2.1-3 Preliminary Project Cost (Option A3a)

Option A3a (Unit: Million USD)

Item		FC : LC	Phase 1 (Year 2025)			Phase 2 (Year 2035)			Total
			FC	LC	Total	FC	LC	Total	
Construction Cost	Civil Structures	10 : 90	278.78	2,508.98	2,787.76	122.41	1,101.69	1,224.10	4,011.85
	Trackwork	70 : 30	65.59	28.11	93.71	73.45	31.48	104.93	198.63
	Rolling Stock	95 : 5	313.76	16.51	330.27	852.77	44.88	897.66	1,227.93
	E&M Systems	90 : 10	316.99	35.22	352.21	339.00	37.67	376.66	728.88
	Sub-total	-	975.12	2,588.83	3,563.94	1,387.63	1,215.72	2,603.34	6,167.29
Utility Relocation		-		71.28	71.28		52.07	52.07	123.35
Tax	Import Tax	-	69.63		69.63	126.52		126.52	196.16
	VAT	-			427.67			312.40	740.07
Consultants Cost		60 : 40	239.50	159.66	399.16	174.94	116.63	291.57	690.74
Physical Contingency		-			334.53			250.04	584.57
Total of Direct Project Cost					**4,866.22**			**3,635.94**	**8,502.17**
Land Acquisition / Compensation		-		258.65	258.65		84.00	84.00	342.65
Ancillary Road Construction		-		0.00	0.00		4.29	4.29	4.29
Total of Indirect Project Cost					**258.65**			**88.29**	**346.94**
Total Project Cost					**5,124.87**			**3,724.24**	**8,849.11**

Source: *JICA Study Team*

Table 8.2.1-4 Preliminary Project Cost (Option B1a)

Option B1a (Unit: Million USD)

Item		FC : LC	Phase 1 (Year 2025)			Phase 2 (Year 2035)			Total
			FC	LC	Total	FC	LC	Total	
Construction Cost	Civil Structures	10 : 90	239.84	2,158.56	2,398.40	124.03	1,116.23	1,240.26	3,638.66
	Trackwork	70 : 30	56.41	24.18	80.59	72.96	31.27	104.23	184.82
	Rolling Stock	95 : 5	301.69	15.88	317.57	864.84	45.52	910.36	1,227.93
	E&M Systems	90 : 10	272.99	30.33	303.32	337.56	37.51	375.07	678.38
	Sub-total	-	870.93	2,228.95	3,099.87	1,399.39	1,230.53	2,629.91	5,729.79
Utility Relocation		-		62.00	62.00		52.60	52.60	114.60
Tax	Import Tax	-	63.11		63.11	127.54		127.54	190.64
	VAT	-			371.98			315.59	687.57
Consultants Cost		60 : 40	208.31	138.87	347.19	176.73	117.82	294.55	641.74
Physical Contingency		-			291.16			252.57	543.73
Total of Direct Project Cost					**4,235.31**			**3,672.76**	**7,908.07**
Land Acquisition / Compensation		-		230.91	230.91		75.05	75.05	305.96
Ancillary Road Construction		-		0.00	0.00		7.43	7.43	7.43
Total of Indirect Project Cost					**230.91**			**82.48**	**313.39**
Total Project Cost					**4,466.22**			**3,755.24**	**8,221.46**

Source: *JICA Study Team*

Table 8.2.1-5 Preliminary Project Cost (Option B2a)

Option B2a (Unit: Million USD)

Item		FC : LC	Phase 1 (Year 2025)			Phase 2 (Year 2035)			Total
			FC	LC	Total	FC	LC	Total	
Construction Cost	Civil Structures	10 : 90	245.18	2,206.60	2,451.78	124.03	1,116.23	1,240.26	3,692.04
	Trackwork	70 : 30	58.63	25.13	83.76	72.96	31.27	104.23	187.99
	Rolling Stock	95 : 5	277.55	14.61	292.16	888.98	46.79	935.76	1,227.93
	E&M Systems	90 : 10	281.53	31.28	312.81	337.56	37.51	375.07	687.88
	Sub-total	-	862.89	2,277.62	3,140.51	1,423.52	1,231.80	2,655.32	5,795.83
Utility Relocation		-		62.81	62.81		53.11	53.11	115.92
Tax	Import Tax	-	61.77		61.77	129.95		129.95	191.72
	VAT	-			376.86			318.64	695.50
Consultants Cost		60 : 40	211.04	140.69	351.74	178.44	118.96	297.40	649.13
Physical Contingency		-			294.82			255.10	549.91
Total of Direct Project Cost					**4,288.51**			**3,709.51**	**7,998.01**
Land Acquisition / Compensation		-		241.12	241.12		75.05	75.05	316.17
Ancillary Road Construction		-		0.00	0.00		7.43	7.43	7.43
Total of Indirect Project Cost					**241.12**			**82.48**	**323.60**
Total Project Cost					**4,529.63**			**3,791.99**	**8,321.62**

Source: *JICA Study Team*

Table 8.2.1-6 Preliminary Project Cost (Option B3a)

Option B3a (Unit: Million USD)

Item		FC : LC	Phase 1 (Year 2025)			Phase 2 (Year 2035)			Total
			FC	LC	Total	FC	LC	Total	
Construction Cost	Civil Structures	10 : 90	278.78	2,508.98	2,787.76	124.03	1,116.23	1,240.26	4,028.02
	Trackwork	70 : 30	65.59	28.11	93.71	72.96	31.27	104.23	197.93
	Rolling Stock	95 : 5	313.76	16.51	330.27	933.22	49.12	982.34	1,312.61
	E&M Systems	90 : 10	316.99	35.22	352.21	337.56	37.51	375.07	727.28
	Sub-total	-	975.12	2,588.83	3,563.94	1,467.77	1,234.13	2,701.90	6,265.84
Utility Relocation		-		71.28	71.28		54.04	54.04	125.32
Tax	Import Tax	-	69.63		69.63	134.37		134.37	204.01
	VAT	-			427.67			324.23	751.90
Consultants Cost		60 : 40	239.50	159.66	399.16	181.57	121.04	302.61	701.77
Physical Contingency		-			334.53			259.73	594.26
Total of Direct Project Cost					**4,866.22**			**3,776.88**	**8,643.10**
Land Acquisition / Compensation		-		258.65	258.65		75.05	75.05	333.70
Ancillary Road Construction		-		0.00	0.00		7.43	7.43	7.43
Total of Indirect Project Cost					**258.65**			**82.48**	**341.13**
Total Project Cost					**5,124.87**			**3,859.36**	**8,984.24**

Source: *JICA Study Team*

Table 8.2.1-7 Preliminary Project Cost (Option A1b)

Option A1b (Unit: Million USD)

Item		FC : LC	Phase 1 (Year 2025)			Phase 2 (Year 2035)			Total
			FC	LC	Total	FC	LC	Total	
Construction Cost	Civil Structures	10 : 90	239.84	2,158.56	2,398.40	197.34	1,776.08	1,973.42	4,371.82
	Trackwork	70 : 30	56.41	24.18	80.59	78.11	33.48	111.59	192.18
	Rolling Stock	95 : 5	301.69	15.88	317.57	804.50	42.34	846.85	1,164.41
	E&M Systems	90 : 10	272.99	30.33	303.32	359.11	39.90	399.01	702.33
	Sub-total	-	870.93	2,228.95	3,099.87	1,439.07	1,891.80	3,330.87	6,430.74
Utility Relocation		-		62.00	62.00		66.62	66.62	128.61
Tax	Import Tax	-	63.11		63.11	124.17		124.17	187.28
	VAT	-			371.98			399.70	771.69
Consultants Cost		60 : 40	208.31	138.87	347.19	223.83	149.22	373.06	720.24
Physical Contingency		-			291.16			317.09	608.25
Total of Direct Project Cost					**4,235.31**			**4,611.51**	**8,846.82**
Land Acquisition / Compensation		-		230.91	230.91		78.60	78.60	309.50
Ancillary Road Construction		-		0.00	0.00		0.00	0.00	0.00
Total of Indirect Project Cost					**230.91**			**78.60**	**309.50**
Total Project Cost					**4,466.22**			**4,690.10**	**9,156.32**

Source: *JICA Study Team*

Table 8.2.1-8 Preliminary Project Cost (Option A2b)

Option A2b (Unit: Million USD)

Item		FC : LC	Phase 1 (Year 2025)			Phase 2 (Year 2035)			Total
			FC	LC	Total	FC	LC	Total	
Construction Cost	Civil Structures	10 : 90	245.18	2,206.60	2,451.78	197.34	1,776.08	1,973.42	4,425.20
	Trackwork	70 : 30	58.63	25.13	83.76	78.11	33.48	111.59	195.35
	Rolling Stock	95 : 5	277.55	14.61	292.16	828.64	43.61	872.25	1,164.41
	E&M Systems	90 : 10	281.53	31.28	312.81	359.11	39.90	399.01	711.82
	Sub-total	-	862.89	2,277.62	3,140.51	1,463.20	1,893.07	3,356.28	6,496.79
Utility Relocation		-		62.81	62.81		67.13	67.13	129.94
Tax	Import Tax	-	61.77		61.77	126.59		126.59	188.36
	VAT	-			376.86			402.75	779.61
Consultants Cost		60 : 40	211.04	140.69	351.74	225.54	150.36	375.90	727.64
Physical Contingency		-			294.82			319.61	614.43
Total of Direct Project Cost					**4,288.51**			**4,648.26**	**8,936.76**
Land Acquisition / Compensation		-		241.12	241.12		78.60	78.60	319.72
Ancillary Road Construction		-		0.00	0.00		0.00	0.00	0.00
Total of Indirect Project Cost					**241.12**			**78.60**	**319.72**
Total Project Cost					**4,529.63**			**4,726.85**	**9,256.48**

Source: *JICA Study Team*

Table 8.2.1-9 Preliminary Project Cost (Option A3b)

Option A3b (Unit: Million USD)

Item		FC : LC	Phase 1 (Year 2025)			Phase 2 (Year 2035)			Total
			FC	LC	Total	FC	LC	Total	
Construction Cost	Civil Structures	10 : 90	278.78	2,508.98	2,787.76	197.34	1,776.08	1,973.42	4,761.18
	Trackwork	70 : 30	65.59	28.11	93.71	78.11	33.48	111.59	205.30
	Rolling Stock	95 : 5	313.76	16.51	330.27	852.77	44.88	897.66	1,227.93
	E&M Systems	90 : 10	316.99	35.22	352.21	359.11	39.90	399.01	751.22
	Sub-total	-	975.12	2,588.83	3,563.94	1,487.34	1,894.34	3,381.68	6,945.62
Utility Relocation		-		71.28	71.28		67.63	67.63	138.91
Tax	Import Tax	-	69.63		69.63	129.00		129.00	198.63
	VAT	-			427.67			405.80	833.47
Consultants Cost		60 : 40	239.50	159.66	399.16	227.25	151.50	378.75	777.91
Physical Contingency		-			334.53			322.14	656.67
Total of Direct Project Cost					**4,866.22**			**4,685.01**	**9,551.23**
Land Acquisition / Compensation		-		258.65	258.65		78.60	78.60	337.25
Ancillary Road Construction		-		0.00	0.00		0.00	0.00	0.00
Total of Indirect Project Cost					**258.65**			**78.60**	**337.25**
Total Project Cost					**5,124.87**			**4,763.60**	**9,888.48**

Source: *JICA Study Team*

Table 8.2.1-10 Preliminary Project Cost (Option B1b)

Option B1b (Unit: Million USD)

Item		FC : LC	Phase 1 (Year 2025)			Phase 2 (Year 2035)			Total
			FC	LC	Total	FC	LC	Total	
Construction Cost	Civil Structures	10 : 90	239.84	2,158.56	2,398.40	198.96	1,790.63	1,989.59	4,387.99
	Trackwork	70 : 30	56.41	24.18	80.59	77.63	33.27	110.89	191.48
	Rolling Stock	95 : 5	301.69	15.88	317.57	864.84	45.52	910.36	1,227.93
	E&M Systems	90 : 10	272.99	30.33	303.32	357.67	39.74	397.41	700.73
	Sub-total	-	870.93	2,228.95	3,099.87	1,499.10	1,909.16	3,408.25	6,508.13
Utility Relocation		-		62.00	62.00		68.17	68.17	130.16
Tax	Import Tax	-	63.11		63.11	130.01		130.01	193.12
	VAT	-			371.98			408.99	780.98
Consultants Cost		60 : 40	208.31	138.87	347.19	229.03	152.69	381.72	728.91
Physical Contingency		-			291.16			324.67	615.84
Total of Direct Project Cost					**4,235.31**			**4,721.82**	**8,957.13**
Land Acquisition / Compensation		-		230.91	230.91		69.64	69.64	300.55
Ancillary Road Construction		-		0.00	0.00		3.14	3.14	3.14
Total of Indirect Project Cost					**230.91**			**72.78**	**303.69**
Total Project Cost					**4,466.22**			**4,794.60**	**9,260.82**

Source: *JICA Study Team*

Table 8.2.1-11 Preliminary Project Cost (Option B2b)

Option B2b (Unit: Million USD)

Item		FC : LC	Phase 1 (Year 2025)			Phase 2 (Year 2035)			Total
			FC	LC	Total	FC	LC	Total	
Construction Cost	Civil Structures	10 : 90	245.18	2,206.60	2,451.78	198.96	1,790.63	1,989.59	4,441.36
	Trackwork	70 : 30	58.63	25.13	83.76	77.63	33.27	110.89	194.65
	Rolling Stock	95 : 5	277.55	14.61	292.16	888.98	46.79	935.76	1,227.93
	E&M Systems	90 : 10	281.53	31.28	312.81	357.67	39.74	397.41	710.22
	Sub-total	-	862.89	2,277.62	3,140.51	1,523.23	1,910.43	3,433.66	6,574.17
Utility Relocation		-		62.81	62.81		68.67	68.67	131.48
Tax	Import Tax	-	61.77		61.77	132.43		132.43	194.20
	VAT	-			376.86			412.04	788.90
Consultants Cost		60 : 40	211.04	140.69	351.74	230.74	153.83	384.57	736.31
Physical Contingency		-			294.82			327.20	622.02
Total of Direct Project Cost					**4,288.51**			**4,758.57**	**9,047.08**
Land Acquisition / Compensation		-		241.12	241.12		69.64	69.64	310.76
Ancillary Road Construction		-		0.00	0.00		3.14	3.14	3.14
Total of Indirect Project Cost					**241.12**			**72.78**	**313.91**
Total Project Cost					**4,529.63**			**4,831.35**	**9,360.98**

Source: *JICA Study Team*

Table 8.2.1-12 Preliminary Project Cost (Option B3b)

Option B3b (Unit: Million USD)

Item		FC : LC	Phase 1 (Year 2025)			Phase 2 (Year 2035)			Total
			FC	LC	Total	FC	LC	Total	
Construction Cost	Civil Structures	10 : 90	278.78	2,508.98	2,787.76	198.96	1,790.63	1,989.59	4,777.34
	Trackwork	70 : 30	65.59	28.11	93.71	77.63	33.27	110.89	204.60
	Rolling Stock	95 : 5	313.76	16.51	330.27	933.22	49.12	982.34	1,312.61
	E&M Systems	90 : 10	316.99	35.22	352.21	357.67	39.74	397.41	749.63
	Sub-total	-	975.12	2,588.83	3,563.94	1,567.48	1,912.75	3,480.23	7,044.18
Utility Relocation		-		71.28	71.28		69.60	69.60	140.88
Tax	Import Tax	-	69.63		69.63	136.85		136.85	206.49
	VAT	-			427.67			417.63	845.30
Consultants Cost		60 : 40	239.50	159.66	399.16	233.87	155.91	389.79	788.95
Physical Contingency		-			334.53			331.84	666.37
Total of Direct Project Cost					**4,866.22**			**4,825.94**	**9,692.17**
Land Acquisition / Compensation		-		258.65	258.65		69.64	69.64	328.29
Ancillary Road Construction		-		0.00	0.00		3.14	3.14	3.14
Total of Indirect Project Cost					**258.65**			**72.78**	**331.43**
Total Project Cost					**5,124.87**			**4,898.73**	**10,023.60**

Source: *JICA Study Team*

Prices in March 2015 were used for the preliminary cost estimate of construction and procurement with the following preconditions. Land acquisition cost and compensation cost is prepared with the rough analysis assumptions by the JICA Study Team. Cost of road construction required minimum to construct the railway is included as the Ancillary Road Construction Cost.

- Exchange Rate
  1 USD = 119.03 JPY
  1 USD = 43.95 PhP
  1 PhP = 2.708 JPY

- Import Duty
  10.0% of Foreign Currency Portion

- VAT
  12% of Total Construction Cost

- Engineering Cost
  10% of Total Construction Cost and Tax (12%)

- Physical Contingency
  7.5% of Construction Cost, Tax and Consultants Cost

- Utility Relocation Cost
  2% of Construction Cost

Summary of the Project Cost of all options are as shown below:

Table 8.2.1-13 Summary of Project Cost of All Options (in Million USD)

(Unit: Million USD)

Option		A1a	A2a	A3a	B1a	B2a	B3a	A1b	A2b	A3b	B1b	B2b	B3b
Phase 1	Direct Project Cost	4,235.31	4,288.51	4,866.22	4,235.31	4,288.51	4,866.22	4,235.31	4,288.51	4,866.22	4,235.31	4,288.51	4,866.22
	Indirect Project Cost	230.91	241.12	258.65	230.91	241.12	258.65	230.91	241.12	258.65	230.91	241.12	258.65
	Sub-total	**4,466.22**	**4,529.63**	**5,124.87**	**4,466.22**	**4,529.63**	**5,124.87**	**4,466.22**	**4,529.63**	**5,124.87**	**4,466.22**	**4,529.63**	**5,124.87**
Phase 2	Direct Project Cost	3,562.45	3,599.19	3,635.94	3,672.76	3,709.51	3,776.88	4,611.51	4,648.26	4,685.01	4,721.82	4,758.57	4,825.94
	Indirect Project Cost	88.29	88.29	88.29	82.48	82.48	82.48	78.60	78.60	78.60	72.78	72.78	72.78
	Sub-total	**3,650.74**	**3,687.49**	**3,724.24**	**3,755.24**	**3,791.99**	**3,859.36**	**4,690.10**	**4,726.85**	**4,763.60**	**4,794.60**	**4,831.35**	**4,898.73**
Overall	Direct Project Cost	7,797.76	7,887.70	8,502.17	7,908.07	7,998.01	8,643.10	8,846.82	8,936.76	9,551.23	8,957.13	9,047.08	9,692.17
	Indirect Project Cost	319.20	329.42	346.94	313.39	323.60	341.13	309.50	319.72	337.25	303.69	313.91	331.43
	Total	**8,116.96**	**8,217.12**	**8,849.11**	**8,221.46**	**8,321.62**	**8,984.24**	**9,156.32**	**9,256.48**	**9,888.48**	**9,260.82**	**9,360.98**	**10,023.60**

Source: *JICA Study Team*

Table 8.2.1-14 Summary of Project Cost of All Options (in Million PHP)

(Unit: Million PHP)

Option		A1a	A2a	A3a	B1a	B2a	B3a	A1b	A2b	A3b	B1b	B2b	B3b
Phase 1	Direct Project Cost	186,142	188,480	213,871	186,142	188,480	213,871	186,142	188,480	213,871	186,142	188,480	213,871
	Indirect Project Cost	10,148	10,597	11,368	10,148	10,597	11,368	10,148	10,597	11,368	10,148	10,597	11,368
	Sub-total	**196,290**	**199,077**	**225,238**	**196,290**	**199,077**	**225,238**	**196,290**	**199,077**	**225,238**	**196,290**	**199,077**	**225,238**
Phase 2	Direct Project Cost	156,569	158,185	159,800	161,418	163,033	165,994	202,676	204,291	205,906	207,524	209,139	212,100
	Indirect Project Cost	3,881	3,881	3,881	3,625	3,625	3,625	3,454	3,454	3,454	3,199	3,199	3,199
	Sub-total	**160,450**	**162,065**	**163,680**	**165,043**	**166,658**	**169,619**	**206,130**	**207,745**	**209,360**	**210,723**	**212,338**	**215,299**
Overall	Direct Project Cost	342,711	346,665	373,670	347,560	351,513	379,864	388,818	392,771	419,777	393,666	397,619	425,971
	Indirect Project Cost	14,029	14,478	15,248	13,773	14,222	14,993	13,603	14,052	14,822	13,347	13,796	14,567
	Total	**356,740**	**361,142**	**388,918**	**361,333**	**365,735**	**394,857**	**402,420**	**406,822**	**434,599**	**407,013**	**411,415**	**440,537**

Note: USD 1 = PHP 43.95 (March 2015, JICA)

Source: *JICA Study Team*

8.2.2 Civil Structures and Trackworks

8.2.2.1 Unit Cost of Civil Structures and Trackworks

The same unit cost of Underground Structures was applied to all section, regardless of the depth. Different unit costs were applied for normal depth underground stations with typical depth, i.e. 23 meters below the ground level, and for deep underground stations which the rail levels are deeper than those of normal depth stations. The cost of underground stations largely varies due to the depth and size of the station, which directly reflects the volume and thus cost of excavation. Unit costs of Elevated Structures and Elevated Stations are categorized into 2 items each, i.e. normal height at 15 meters above the ground level and high height which is higher than the normal height stations, where the unit cost of high height stations are higher due to its longer piers.

Unit costs of Depot Civil Works and Trackwork was estimated referring to the North South Commuter Rail Project, being carried out by JICA, with adjustment to trackwork unit cost for underground section since the type of trackwork in the underground section is different from that in the elevated section.

Unit costs of each work are shown in the tables in the following section.

8.2.2.2 Civil Structures and Trackwork Cost of Each Option

The cost of Civil Works was prepared based on the unit cost and breakdown of Elevated Structures, Elevated Stations, Underground Structures, Underground Stations and Depot Civil Works. Unit cost of each item was estimated referring to projects in the Philippines and Southeast Asian countries with similar nature to the MMSP, with adjustment to suit the particularity of the MMSP based on the rough plan and profile drawings prepared for each option and planned capacity of the MMSP.

Cost estimate for Civil Works was prepared for the purpose of the understanding of the rough project cost of each option and is preliminary level at this stage without detailed route alignment based on the detailed horizontal and vertical alignment considering restrictions at the existing site conditions. Especially, the cost impact of Underground Structures and Underground Stations are significantly high against the total construction cost, however the cost of Underground Structures and Underground Stations can only be estimated more precisely after investigating the soil conditions to determine the type of tunneling method as well as determining the depth of Underground Stations in line with the detailed alignment, existing site conditions near stations, etc.

The unit cost of underground structures including stations in this Project is approximately 105 - 115 Mil. USD per km depending on the length and the number of stations, whereas that of elevated structures including stations is approximately 36 Mil. USD per km, excluding Rolling Stock and E&M Systems.

Tables 8.2.2.2-1 to 8.2.2.2-5 shows the unit costs and the construction costs of underground structures/stations, elevated structures/stations and depot, and Table 8.2.2.2-6 shows those of trackwork for each option of the MMSP, all shown in Million US Dollar.

Table 8.2.2.2-1 Underground Structures Cost

Option		A1a	A2a	A3a	B1a	B2a	B3a	A1b	A2b	A3b	B1b	B2b	B3b
Unit Cost (Mil. USD / km)		50.88	50.88	50.88	50.88	50.88	50.88	50.88	50.88	50.88	50.88	50.88	50.88
Phase 1	Length (km)	19.457	20.506	23.396	19.457	20.506	23.396	19.457	20.506	23.396	19.457	20.506	23.396
	Cost (Mil. USD)	990.04	1,043.42	1,190.47	990.04	1,043.42	1,190.47	990.04	1,043.42	1,190.47	990.04	1,043.42	1,190.47
Phase 2	Length (km)	1.095	1.095	1.095	1.095	1.095	1.095	13.324	13.324	13.324	13.324	13.324	13.324
	Cost (Mil. USD)	55.69	55.69	55.69	55.69	55.69	55.69	677.96	677.96	677.96	677.96	677.96	677.96
Total	Length (km)	20.551	21.600	24.490	20.551	21.600	24.490	32.780	33.829	36.719	32.780	33.829	36.719
	Cost (Mil. USD)	1,045.73	1,099.11	1,246.17	1,045.73	1,099.11	1,246.17	1,668.00	1,721.38	1,868.44	1,668.00	1,721.38	1,868.44

Source: *JICA Study Team*

Table 8.2.2.2-2 Underground Stations Cost

Option		A1a				A2a				A3a			
		Standard Depth	Deep (Phase 1)	Deep (Phase 2)	Total	Standard Depth	Deep (Phase 1)	Deep (Phase 2)	Total	Standard Depth	Deep (Phase 1)	Deep (Phase 2)	Total
Unit Cost (Mil. USD / station)		94.46	139.80	115.24		94.46	139.80	115.24		94.46	139.80	115.24	
Phase 1	No. of Station	8	4		12	8	4		12	10	4		14
	Cost (Mil. USD)	755.69	559.21		1,314.90	755.69	559.21		1,314.90	944.61	559.21		1,503.82
Phase 2	No. of Station	0		0	0	0		0	0	0		0	0
	Cost (Mil. USD)	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.00	0.00
Total	No. of Station	8	4	0	12	8	4	0	12	10	4	0	14
	Cost (Mil. USD)	755.69	559.21	0.00	1,314.90	755.69	559.21	0.00	1,314.90	944.61	559.21	0.00	1,503.82

Option		B1a				B2a				B3a			
		Standard Depth	Deep (Phase 1)	Deep (Phase 2)	Total	Standard Depth	Deep (Phase 1)	Deep (Phase 2)	Total	Standard Depth	Deep (Phase 1)	Deep (Phase 2)	Total
Unit Cost (Mil. USD / station)		94.46	139.80	115.24		94.46	139.80	115.24		94.46	139.80	115.24	
Phase 1	No. of Station	8	4		12	8	4		12	10	4		14
	Cost (Mil. USD)	755.69	559.21		1,314.90	755.69	559.21		1,314.90	944.61	559.21		1,503.82
Phase 2	No. of Station	0		0	0	0		0	0	0		0	0
	Cost (Mil. USD)	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.00	0.00
Total	No. of Station	8	4	0	12	8	4	0	12	10	4	0	14
	Cost (Mil. USD)	755.69	559.21	0.00	1,314.90	755.69	559.21	0.00	1,314.90	944.61	559.21	0.00	1,503.82

Option		A1b				A2b				A3b			
		Standard Depth	Deep (Phase 1)	Deep (Phase 2)	Total	Standard Depth	Deep (Phase 1)	Deep (Phase 2)	Total	Standard Depth	Deep (Phase 1)	Deep (Phase 2)	Total
Unit Cost (Mil. USD / station)		94.46	139.80	115.24		94.46	139.80	115.24		94.46	139.80	115.24	
Phase 1	No. of Station	8	4		12	8	4		12	10	4		14
	Cost (Mil. USD)	755.69	559.21		1,314.90	755.69	559.21		1,314.90	944.61	559.21		1,503.82
Phase 2	No. of Station	2		3	5	2		3	5	2		3	5
	Cost (Mil. USD)	188.92		345.73	534.65	188.92		345.73	534.65	188.92		345.73	534.65
Total	No. of Station	10	4	3	17	10	4	3	17	12	4	3	19
	Cost (Mil. USD)	944.61	559.21	345.73	1,849.54	944.61	559.21	345.73	1,849.54	1,133.53	559.21	345.73	2,038.47

Option		B1b				B2b				B3b			
		Standard Depth	Deep (Phase 1)	Deep (Phase 2)	Total	Standard Depth	Deep (Phase 1)	Deep (Phase 2)	Total	Standard Depth	Deep (Phase 1)	Deep (Phase 2)	Total
Unit Cost (Mil. USD / station)		94.46	139.80	115.24		94.46	139.80	115.24		94.46	139.80	115.24	
Phase 1	No. of Station	8	4		12	8	4		12	10	4		14
	Cost (Mil. USD)	755.69	559.21		1,314.90	755.69	559.21		1,314.90	944.61	559.21		1,503.82
Phase 2	No. of Station	2		3	5	2		3	5	2		3	5
	Cost (Mil. USD)	188.92		345.73	534.65	188.92		345.73	534.65	188.92		345.73	534.65
Total	No. of Station	10	4	3	17	10	4	3	17	12	4	3	19
	Cost (Mil. USD)	944.61	559.21	345.73	1,849.54	944.61	559.21	345.73	1,849.54	1,133.53	559.21	345.73	2,038.47

Source: *JICA Study Team*

Table 8.2.2.2-3 Elevated Structures Cost

Option		A1a			A2a			A3a			B1a			B2a			B3a		
		Standard	High Elv.	Total	Standard	High Elv.	Total	Standard	High Elv.	Total	Standard	High Elv.	Total	Standard	High Elv.	Total	Standard	High Elv.	Total
Unit Cost (Mil. USD / km)		20.29	21.51		20.29	21.51		20.29	21.51		20.29	21.51		20.29	21.51		20.29	21.51	
Phase 1	Length (km)	0.000	0.807	0.807	0.000	0.807	0.807	0.000	0.807	0.807	0.000	0.807	0.807	0.000	0.807	0.807	0.000	0.807	0.807
	Cost (Mil. USD)	0.00	17.34	17.34	0.00	17.34	17.34	0.00	17.34	17.34	0.00	17.34	17.34	0.00	17.34	17.34	0.00	17.34	17.34
Phase 2	Length (km)	28.456	4.087	32.543	28.456	4.087	32.543	28.456	4.087	32.543	21.815	10.451	32.266	21.815	10.451	32.266	21.815	10.451	32.266
	Cost (Mil. USD)	577.30	87.89	665.19	577.30	87.89	665.19	577.30	87.89	665.19	442.57	224.75	667.32	442.57	224.75	667.32	442.57	224.75	667.32
Total	Length (km)	28.456	4.894	33.349	28.456	4.894	33.349	28.456	4.894	33.349	21.815	11.258	33.072	21.815	11.258	33.072	21.815	11.258	33.072
	Cost (Mil. USD)	577.30	105.24	682.54	577.30	105.24	682.54	577.30	105.24	682.54	442.57	242.09	684.66	442.57	242.09	684.66	442.57	242.09	684.66

Option		A1b			A2b			A3b			B1b			B2b			B3b		
		Standard	High Elv.	Total	Standard	High Elv.	Total	Standard	High Elv.	Total	Standard	High Elv.	Total	Standard	High Elv.	Total	Standard	High Elv.	Total
Unit Cost (Mil. USD / km)		20.29	21.51		20.29	21.51		20.29	21.51		20.29	21.51		20.29	21.51		20.29	21.51	
Phase 1	Length (km)	0.000	0.807	0.807	0.000	0.807	0.807	0.000	0.807	0.807	0.000	0.807	0.807	0.000	0.807	0.807	0.000	0.807	0.807
	Cost (Mil. USD)	0.00	17.34	17.34	0.00	17.34	17.34	0.00	17.34	17.34	0.00	17.34	17.34	0.00	17.34	17.34	0.00	17.34	17.34
Phase 2	Length (km)	16.227	4.087	20.314	16.227	4.087	20.314	16.227	4.087	20.314	9.586	10.451	20.037	9.586	10.451	20.037	9.586	10.451	20.037
	Cost (Mil. USD)	329.20	87.89	417.09	329.20	87.89	417.09	329.20	87.89	417.09	194.47	224.75	419.22	194.47	224.75	419.22	194.47	224.75	419.22
Total	Length (km)	16.227	4.894	21.120	16.227	4.894	21.120	16.227	4.894	21.120	9.586	11.258	20.843	9.586	11.258	20.843	9.586	11.258	20.843
	Cost (Mil. USD)	329.20	105.24	434.44	329.20	105.24	434.44	329.20	105.24	434.44	194.47	242.09	436.56	194.47	242.09	436.56	194.47	242.09	436.56

Source: *JICA Study Team*

Table 8.2.2.2-4 Elevated Stations Cost

Option		A1a			A2a			A3a			B1a			B2a			B3a		
		Standard	High Elv.	Total	Standard	High Elv.	Total	Standard	High Elv.	Total	Standard	High Elv.	Total	Standard	High Elv.	Total	Standard	High Elv.	Total
Unit Cost (Mil. USD / station)		31.90	35.41		31.90	35.41		31.90	35.41		31.90	35.41		31.90	35.41		31.90	35.41	
Phase 1	No. of Station	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1
	Cost (Mil. USD)	0.00	35.41	35.41	0.00	35.41	35.41	0.00	35.41	35.41	0.00	35.41	35.41	0.00	35.41	35.41	0.00	35.41	35.41
Phase 2	No. of Station	12	2	14	12	2	14	12	2	14	8	6	14	8	6	14	8	6	14
	Cost (Mil. USD)	382.78	70.81	453.59	382.78	70.81	453.59	382.78	70.81	453.59	255.19	212.44	467.63	255.19	212.44	467.63	255.19	212.44	467.63
Total	No. of Station	12	3	15	12	3	15	12	3	15	8	7	15	8	7	15	8	7	15
	Cost (Mil. USD)	382.78	106.22	489.00	382.78	106.22	489.00	382.78	106.22	489.00	255.19	247.85	503.04	255.19	247.85	503.04	255.19	247.85	503.04

Option		A1b			A2b			A3b			B1b			B2b			B3b		
		Standard	High Elv.	Total	Standard	High Elv.	Total	Standard	High Elv.	Total	Standard	High Elv.	Total	Standard	High Elv.	Total	Standard	High Elv.	Total
Unit Cost (Mil. USD / station)		31.90	35.41		31.90	35.41		31.90	35.41		31.90	35.41		31.90	35.41		31.90	35.41	
Phase 1	No. of Station	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1
	Cost (Mil. USD)	0.00	35.41	35.41	0.00	35.41	35.41	0.00	35.41	35.41	0.00	35.41	35.41	0.00	35.41	35.41	0.00	35.41	35.41
Phase 2	No. of Station	7	2	9	7	2	9	7	2	9	3	6	9	3	6	9	3	6	9
	Cost (Mil. USD)	223.29	70.81	294.10	223.29	70.81	294.10	223.29	70.81	294.10	95.69	212.44	308.14	95.69	212.44	308.14	95.69	212.44	308.14
Total	No. of Station	7	3	10	7	3	10	7	3	10	3	7	10	3	7	10	3	7	10
	Cost (Mil. USD)	223.29	106.22	329.51	223.29	106.22	329.51	223.29	106.22	329.51	95.69	247.85	343.54	95.69	247.85	343.54	95.69	247.85	343.54

Source: *JICA Study Team*

Table 8.2.2.2-5 Depot Civil Works Cost

All Options		Depot and Workshop Building
Unit Cost (USD / m^2)		254.45
Phase 1	Area (m^2)	160,000
	Cost (Million USD)	40.71
Phase 2	Area (m^2)	195,000
	Cost (Million USD)	49.62
Total	Area (m^2)	355,000
	Cost (Million USD)	90.33

Source: *JICA Study Team*

Table 8.2.2.2-6 Trackwork Cost

Option		A1a				A2a				A3a			
		Elevated Slab	UDG Slab	At-grade Ballast	Total	Elevated Slab	UDG Slab	At-grade Ballast	Total	Elevated Slab	UDG Slab	At-grade Ballast	Total
Unit Cost (Mil. USD / km)		2.52	3.02	2.09		2.52	3.02	2.09		2.52	3.02	2.09	
Phase 1	Length (km)	0.907	21.757	6.000	28.663	0.907	22.806	6.000	29.712	0.907	26.096	6.000	33.002
	Cost (Mil. USD)	2.28	65.76	12.54	80.59	2.28	68.93	12.54	83.76	2.28	78.88	12.54	93.71
Phase 2	Length (km)	35.243	1.195	6.000	42.437	35.243	1.195	6.000	42.437	35.243	1.195	6.000	42.437
	Cost (Mil. USD)	88.77	3.61	12.54	104.93	88.77	3.61	12.54	104.93	88.77	3.61	12.54	104.93
Total	Length (km)	36.149	22.951	12.000	71.100	36.149	24.000	12.000	72.149	36.149	27.290	12.000	75.439
	Cost (Mil. USD)	91.06	69.37	25.09	185.52	91.06	72.54	25.09	188.69	91.06	82.49	25.09	198.63

Option		B1a				B2a				B3a			
		Elevated Slab	UDG Slab	At-grade Ballast	Total	Elevated Slab	UDG Slab	At-grade Ballast	Total	Elevated Slab	UDG Slab	At-grade Ballast	Total
Unit Cost (Mil. USD / km)		2.52	3.02	2.09		2.52	3.02	2.09		2.52	3.02	2.09	
Phase 1	Length (km)	0.907	21.757	6.000	28.663	0.907	22.806	6.000	29.712	0.907	26.096	6.000	33.002
	Cost (Mil. USD)	2.28	65.76	12.54	80.59	2.28	68.93	12.54	83.76	2.28	78.88	12.54	93.71
Phase 2	Length (km)	34.966	1.195	6.000	42.160	34.966	1.195	6.000	42.160	34.966	1.195	6.000	42.160
	Cost (Mil. USD)	88.07	3.61	12.54	104.23	88.07	3.61	12.54	104.23	88.07	3.61	12.54	104.23
Total	Length (km)	35.872	22.951	12.000	70.823	35.872	24.000	12.000	71.872	35.872	27.290	12.000	75.162
	Cost (Mil. USD)	90.36	69.37	25.09	184.82	90.36	72.54	25.09	187.99	90.36	82.49	25.09	197.93

Option		A1b				A2b				A3b			
		Elevated Slab	UDG Slab	At-grade Ballast	Total	Elevated Slab	UDG Slab	At-grade Ballast	Total	Elevated Slab	UDG Slab	At-grade Ballast	Total
Unit Cost (Mil. USD / km)		2.52	3.02	2.09		2.52	3.02	2.09		2.52	3.02	2.09	
Phase 1	Length (km)	0.907	21.757	6.000	28.663	0.907	22.806	6.000	29.712	0.907	26.096	6.000	33.002
	Cost (Mil. USD)	2.28	65.76	12.54	80.59	2.28	68.93	12.54	83.76	2.28	78.88	12.54	93.71
Phase 2	Length (km)	22.014	14.424	6.000	42.437	22.014	14.424	6.000	42.437	22.014	14.424	6.000	42.437
	Cost (Mil. USD)	55.45	43.60	12.54	111.59	55.45	43.60	12.54	111.59	55.45	43.60	12.54	111.59
Total	Length (km)	22.920	36.180	12.000	71.100	22.920	37.229	12.000	72.149	22.920	40.519	12.000	75.439
	Cost (Mil. USD)	57.73	109.36	25.09	192.18	57.73	112.53	25.09	195.35	57.73	122.48	25.09	205.30

Option		B1b				B2b				B3b			
		Elevated Slab	UDG Slab	At-grade Ballast	Total	Elevated Slab	UDG Slab	At-grade Ballast	Total	Elevated Slab	UDG Slab	At-grade Ballast	Total
Unit Cost (Mil. USD / km)		2.52	3.02	2.09		2.52	3.02	2.09		2.52	3.02	2.09	
Phase 1	Length (km)	0.907	21.757	6.000	28.663	0.907	22.806	6.000	29.712	0.907	26.096	6.000	33.002
	Cost (Mil. USD)	2.28	65.76	12.54	80.59	2.28	68.93	12.54	83.76	2.28	78.88	12.54	93.71
Phase 2	Length (km)	21.737	14.424	6.000	42.160	21.737	14.424	6.000	42.160	21.737	14.424	6.000	42.160
	Cost (Mil. USD)	54.75	43.60	12.54	110.89	54.75	43.60	12.54	110.89	54.75	43.60	12.54	110.89
Total	Length (km)	22.643	36.180	12.000	70.823	22.643	37.229	12.000	71.872	22.643	40.519	12.000	75.162
	Cost (Mil. USD)	57.04	109.36	25.09	191.48	57.04	112.53	25.09	194.65	57.04	122.48	25.09	204.60

Source: *JICA Study Team*

8.2.3 Rolling Stock

The cost of rolling stock, estimated based on the Japanese standard specifications for a DC 1500V power supply system, is shown in Table 8.2.3-1. The number of rolling stock planned to be procured in each phase is based on the demand forecast of 2034 (the last year of Phase 1, which the demand is based on the initial section without including extended section) for Phase 1 and 2045 (20 years after the commencement of revenue operation) for Phase 2.

Table 8.2.3-1 Rolling Stock Cost

Option		A1a	A2a	A3a	B1a	B2a	B3a	A1b	A2b	A3b	B1b	B2b	B3b
Unit Cost (Mil. USD/car)		2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
Phase 1	No. of Car	150	138	156	150	138	156	150	138	156	150	138	156
	Cost (Mil. USD)	317.57	292.16	330.27	317.57	292.16	330.27	317.57	292.16	330.27	317.57	292.16	330.27
Phase 2	No. of Car	400	412	424	430	442	464	400	412	424	430	442	464
	Cost (Mil. USD)	846.85	872.25	897.66	910.36	935.76	982.34	846.85	872.25	897.66	910.36	935.76	982.34
Total	No. of Car	550	550	580	580	580	620	550	550	580	580	580	620
	Cost (Mil. USD)	1,164.41	1,164.41	1,227.93	1,227.93	1,227.93	1,312.61	1,164.41	1,164.41	1,227.93	1,227.93	1,227.93	1,312.61

Source: *JICA Study Team*

8.2.4 E&M Systems

The cost of E&M Systems, comprising Signaling System, Power Supply System, Telecommunication Systems, Fare Collection System, Depot Workshop Equipment, Platform Screen Doors, etc., which are typically considered necessary as the E&M Systems for urban railways, are shown in Table 8.2.4-1.

Table 8.2.4-1 E&M Systems Cost

Option	A1a	A2a	A3a	B1a	B2a	B3a	A1b	A2b	A3b	B1b	B2b	B3b
Phase 1 (Million USD)	303.32	312.81	352.21	303.32	312.81	352.21	303.32	312.81	352.21	303.32	312.81	352.21
Phase 2 (Million USD)	376.66	376.66	376.66	375.07	375.07	375.07	399.01	399.01	399.01	397.41	397.41	397.41
Total (Million USD)	679.98	689.47	728.88	678.38	687.88	727.28	702.33	711.82	751.22	700.73	710.22	749.63

Source: *JICA Study Team*

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Chapter 9

PRELIMINARY TOD CONCEPT FOR MMSP

Chapter 9 PRELIMINARY TOD CONCEPT FOR MMSP

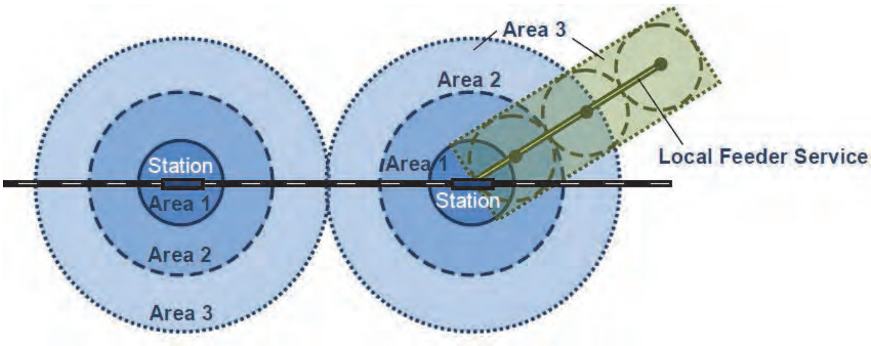
9.1 Considerations on the Examination of TOD Scenario

As discussed in the Section 2.8, it is very essential to incorporate the Transit Oriented Development (TOD) in the implementation of the Mega Manila Subway Project (MMSP) in order to promote the use of public transport and maximize benefits and positive impacts of MMSP itself.

Since TOD encompasses a variety of stakeholders from community level to national level, coordination with the relevant stakeholders at the right moment becomes important for the implementation of TOD.

Implementation schedule also needs to be considered as all improvements cannot be implemented simultaneously. However, certain accessibility needs to be improved prior to the railway operation to maximize its benefits.

In order to formulate a practical and good plan of TOD, the impact of TOD should be analyzed based on the spatial characteristics. In general, three areas are delineated according to the distance from the station, namely (i) Station area within 200 m from the station (Area 1: Transit Core), (ii) Walkable area within approximately 1 km from the station (Area 2: Transit Neighborhood) and (iii) Transit supportive area within approximately 3-5 km from the station (Transit Supportive Area). In the planning of TOD, the following major components of TOD are to be studied.



Classification:

Area 1: Transit Core
(<200m from station)

Area 2: Transit Neighborhood
(<1km from station)

Area 3: Transit Supportive Area
(<3-5km from station)

Source: *Preparatory Survey on Promotion of TOD for Urban Railway in the Philippines (JICA, 2015)*

Figure 9.1-1 Classification of Station's Influence Area

(1) Access Improvement

A basic TOD principle is to provide a safe, convenient and comfort pedestrian access within a walkable area from the station. The walkable area includes significant potential to maximize the benefits of railway by both access improvement and integrated development. Universal access for all passengers including elderly people and persons with disabilities or special needs have to be considered and integrated in the design. Feeder public transportation services such as buses and jeepneys improve the convenience for the passengers and expand the transit supportive area. To implement access improvement, coordination with the relevant public sector such as DPWH and Local Government Units (LGUs) as well as local community will be required.

(2) Promotion of Integrated Development

In order to formulate a practical TOD plan, implementation scheme also needs to be considered based on the current PPP scheme. Therefore, relevant stakeholders as well as necessary implementation scheme and consulting services are to be identified to implement

TOD. Land acquisition is a key to succeed the integrated development along the railway corridor and timely coordination with LGUs is necessary to acquire sufficient land for integrated development such as new township development and public transportation facilities.

(3) Enhancement of Management System for Access Improvement

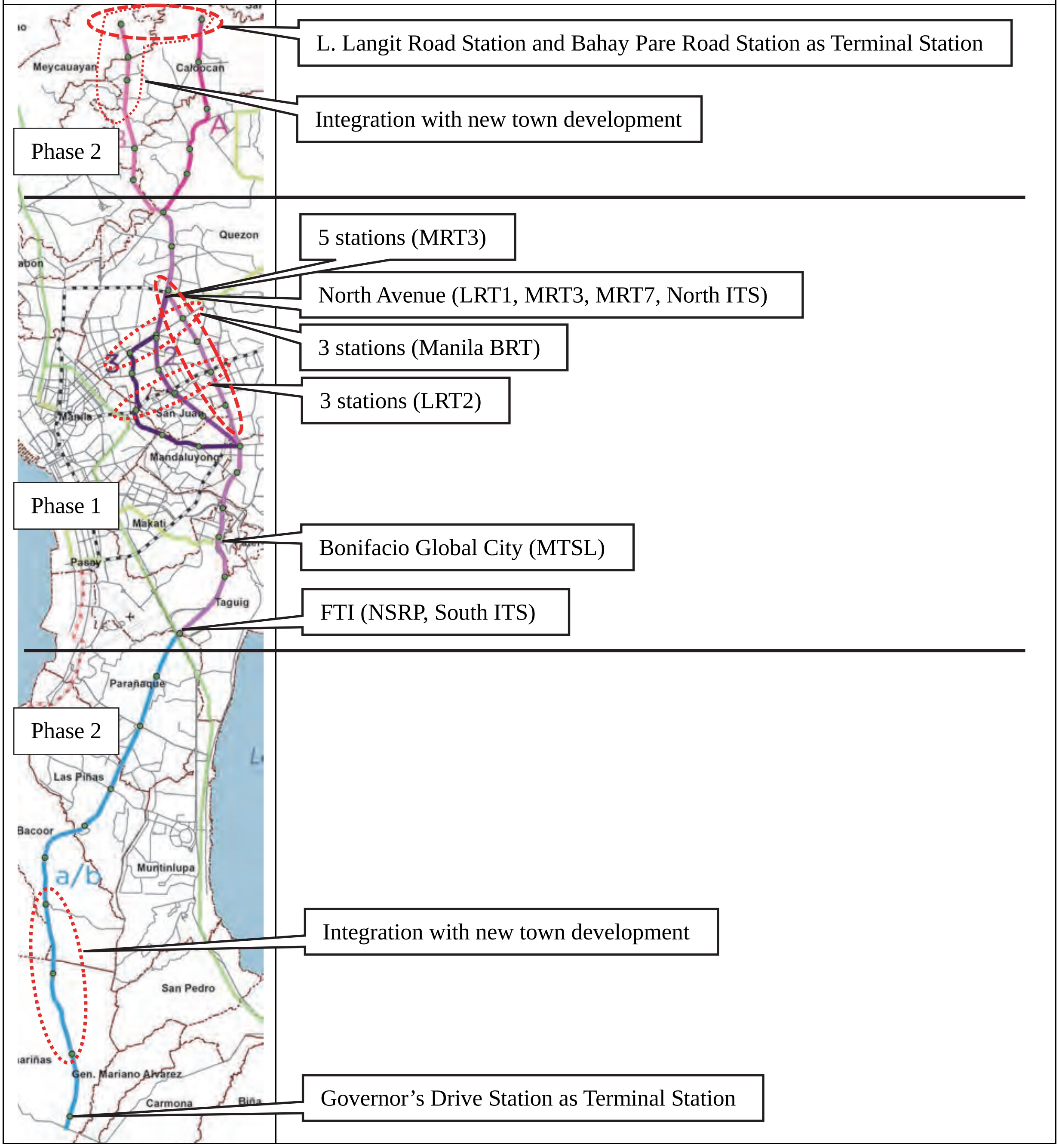
Access improvement cannot be implemented solely through the physical improvements such as road widening. Traffic management is also required to control transportation in a safe, convenient and sustainable manner. In Metro Manila, control of on-street parking and street vendors is necessary to mitigate congestion. To enhance traffic management, coordination among the relevant government agencies such as the DPWH, MMDA, LGUs and local communities such as the barangays will be needed.

9.2 Preliminary TOD Concepts by Station

In this study, several alternative alignments and tentative location of stations for each route section for MMSP are identified and examined. In this section, development concepts for TOD for each station identified for MMSP are examined preliminary. In order to maximize the benefits and positive impacts of the MMSP, the Study identified the opportunity for enhancement of accessibility and integrated development by TOD.

Figure 9.2-1 shows the location of major integrated/multimodal terminals along MMSP. Tables 9.2-1 to show the preliminary TOD concept for each MMSP stations in terms of accessibility and urban development.

Route/Option	Major Integrated/Multimodal Terminal (Connected with other mass transit system and ITS)



Source: *JICA Study Team*

Figure 9.2-1 Major Integrated/Multimodal Terminal along MMSP

Table 9.2-1 Preliminary TOD Concepts for MMSP (Phase 1 Section, Option 1, 2 and 3)

Station Name	Option/ Station Type	Development Issues/TOD Concept	
		Transport/ Traffic	Urban Development
Mindanao Ave.-Quirino Hiwy	Option 1, 2, 3 EV Urban	▪ Transit Square for feeder service (bus, jeepney, K&R), P&R as terminal station of Phase 1 ▪ Traffic circulation	▪ Commercial/business facilities integrated with station
Tandang Sora	Option 1, 2, 3 UG Urban	▪ Transit space along the road for Bus, jeepney	▪ Commercial/business facilities integrated with station (if any)
North Avenue	Option 1, 2, 3 UG Urban	▪ Direct transfer with stations of other railways (LRT1, MRT3, MRT7) and North ITS (bus, jeepney)	▪ Direct connection with neighboring commercial/ business facilities such as SM and Trinoma
Quezon Ave.	Option 1 UG Urban	▪ Direct transfer with stations of MRT3 and Manila BRT ▪ Transit space along the road for Bus, jeepney	▪ Direct connection with neighboring commercial/ business facilities such as Centris Station (mall)
Kamuning	Option 1 UG Urban	▪ Direct transfer with stations of MRT3 ▪ Transit space along the road for Bus, jeepney	▪ Commercial/business facilities integrated with station (if any)
Cubao	Option 1 UG CBD	▪ Direct transfer with stations of MRT3 and LRT2 ▪ Transit space along the road for Bus, jeepney	▪ Direct connection with neighboring commercial/ business facilities
Santolan - Annapolis	Option 1 UG Urban	▪ Direct transfer with stations of MRT3 ▪ Transit space along the road for Bus	▪ Commercial/business facilities integrated with station (if any)
Ortigas North	Option 1, 2, 3 UG CBD	▪ Transit space along the road for Bus, jeepney	▪ Direct connection with neighboring commercial/ business facilities
Ortigas South	Option 1, 2, 3 UG Urban	▪ Transit space for Bus, jeepney utilizing the premises of Capitol Commons	▪ Direct connection with neighboring commercial/ business facilities such as Capitol Commons
Kalayaan Ave.	Option 1, 2, 3 UG Urban	▪ Transit space along the road for Bus, jeepney	▪ Direct connection with neighboring commercial/ business facilities
Bonifacio Global City	Option 1, 2, 3 UG CBD	▪ Transit terminal connecting with MTSL, bus and jeepeny utilizing the premises of Market Market	▪ Direct connection with neighboring commercial/ business facilities such as Market Market and SM
Cayetano Blvd.	Option 1, 2, 3 UG Urban	▪ Transit space along the road for Bus, jeepney	▪ Commercial/business facilities integrated with station (if any)

FTI	Option 1, 2, 3 UG CBD	▪ Direct transfer with NSCR and South ITS (bus, jeepney) ▪ Access to Arca South ▪ Traffic circulation	▪ Commercial/business facilities integrated with station
Timog Ave.	Option 2, 3 UG Urban	▪ Direct transfer with stations of Manila BRT ▪ Transit space along the road for Bus, jeepney	▪ Commercial/business facilities integrated with station (if any)
E. Rodriguez Sr. Ave.	Option 2 UG Urban	▪ Transit space along the road for jeepney	▪ Commercial/business facilities integrated with station (if any)
Gilmore	Option 2 UG Urban	▪ Direct transfer with stations of LRT2 ▪ Transit space along the road for jeepney	▪ Commercial/business facilities integrated with station (if any)
Greenhills	Option 2 UG Urban	▪ Transit space for Bus, jeepney, utilizing Greenhills SC's premises	▪ Commercial/business facilities integrated with station ▪ Direct connection with Greenhills SC
Araneta Ave.	Option 3 UG Urban	▪ Direct transfer with stations of Manila BRT ▪ Transit space along the road for Bus, jeepney	▪ Commercial/business facilities integrated with station (if any)
E. Rodriguez Sr. Ave.	Option 3 UG Urban	▪ Transit space along the road for jeepney	▪ Commercial/business facilities integrated with station (if any)
Jose Rizal Univ.	Option 3 UG Urban	▪ Direct transfer with stations of LRT2 ▪ Transit space for Bus, jeepney, utilizing SM	▪ Commercial/business facilities integrated with station (if any) ▪ Direct connection with SM
Old Wak Wak Road	Option 3 UG Urban	▪ Transit space along the road for bus, jeepney	▪ Commercial/business facilities integrated with station (if any)

Source: *JICA Study Team*

Table 9.2-2 Preliminary TOD Concepts for MMSP (Phase 2-North Section, Option A and B)

Station Name	Option/ Station Type	Development Issues/TOD Concept	
		Transport/Traffic	Urban Development
L. Langit Road	Option A EV Sub-urban	▪ Transit Square for feeder service (jeepney, tricycle, K&R), P&R ▪ Traffic circulation	▪ Commercial/business facilities integrated with station ▪ Newtown development
Camarin Road	Option A EV Sub-urban	▪ Transit space along the road for jeepney, tricycle	▪ Commercial/business facilities integrated with station (if any)
Zabarte Road	Option A EV Urban	▪ Transit space along the road for jeepney, tricycle	▪ Commercial/business facilities integrated with station (if any)
Novaliches	Option A EV Urban	▪ Transit space along the road for jeepney, tricycle	▪ Commercial/business facilities integrated with station (if any)
San Bartolome	Option A EV Urban	▪ Transit space for jeepney, tricycle utilizing SM's premises	▪ Commercial/business facilities integrated with station (if any) ▪ Direct connection with SM
Bahay Pare Road	Option B EV Sub-urban	▪ Transit Square for feeder service (jeepney, tricycle, K&R), P&R ▪ Access roads ▪ Traffic circulation	▪ Commercial/business facilities integrated with station ▪ Newtown development
Mt. Samat Road	Option B EV Sub-urban	▪ Transit Square for feeder service (jeepney, tricycle, K&R), P&R ▪ Access roads ▪ Traffic circulation	▪ Commercial/business facilities integrated with station ▪ Newtown development
Llano Road	Option B EV Sub-urban	▪ Transit Square for feeder service (jeepney, tricycle, K&R), P&R ▪ Access roads ▪ Traffic circulation	▪ Commercial/business facilities integrated with station ▪ Newtown development
Gen. Luis	Option B EV Urban	▪ Transit space along the road for jeepney, tricycle	▪ Commercial/business facilities integrated with station (if any)
Tatalon	Option B EV Urban	▪ Transit space along the road for jeepney, tricycle	▪ Commercial/business facilities integrated with station (if any)

Source: *JICA Study Team*

Table 9.2-3 Preliminary TOD Concepts for MMSP (Phase 2-South Section, Option a and b)

Station Name	Option/ Station Type	Development Issues/TOD Concept	
		Transport/ Traffic	Urban Development
Dona Soledad Ave.	Option a/b EV/UG Urban	▪ Transit space along the road for jeepney, tricycle	▪ Commercial/business facilities integrated with station (if any)
Dr. A. Santos Ave.	Option a/b EV/UG Urban	▪ Transit space along the road for jeepney, tricycle	▪ Commercial/business facilities integrated with station (if any)
Alabang – Zapote Road	Option a/b EV/UG Urban	▪ Transit space along the road for jeepney, tricycle	▪ Commercial/business facilities integrated with station (if any)
Talon Singko	Option a/b EV/UG Sub-urban	▪ Transit space along the road for jeepney, tricycle	▪ Commercial/business facilities integrated with station (if any)
Morino Road	Option a/b EV/UG Sub-urban	▪ Transit space for jeepney, tricycle utilizing RFC Mall's premises	▪ Commercial/business facilities integrated with station (if any) ▪ Direct connection with RFC Mall
Daang Hari	Option a/b EV Sub-urban	▪ Transit space for jeepney, tricycle utilizing SM's premises	▪ Commercial/business facilities integrated with station (if any) ▪ Direct connection with SM
J.A. Santos Ave.	Option a/b EV Sub-urban	▪ Transit Square for feeder service (jeepney, tricycle, K&R), P&R ▪ Traffic circulation	▪ Commercial/business facilities integrated with station ▪ Newtown development
Paliparan Road	Option a/b EV Sub-urban	▪ Transit Square for feeder service (jeepney, tricycle, K&R), P&R ▪ Traffic circulation	▪ Commercial/business facilities integrated with station ▪ Newtown development
Governor's Drive	Option a/b EV Sub-urban	▪ Transit Square for feeder service (Bus, jeepney, K&R), P&R ▪ Traffic circulation	▪ Commercial/business facilities integrated with station ▪ Newtown development

Source: *JICA Study Team*

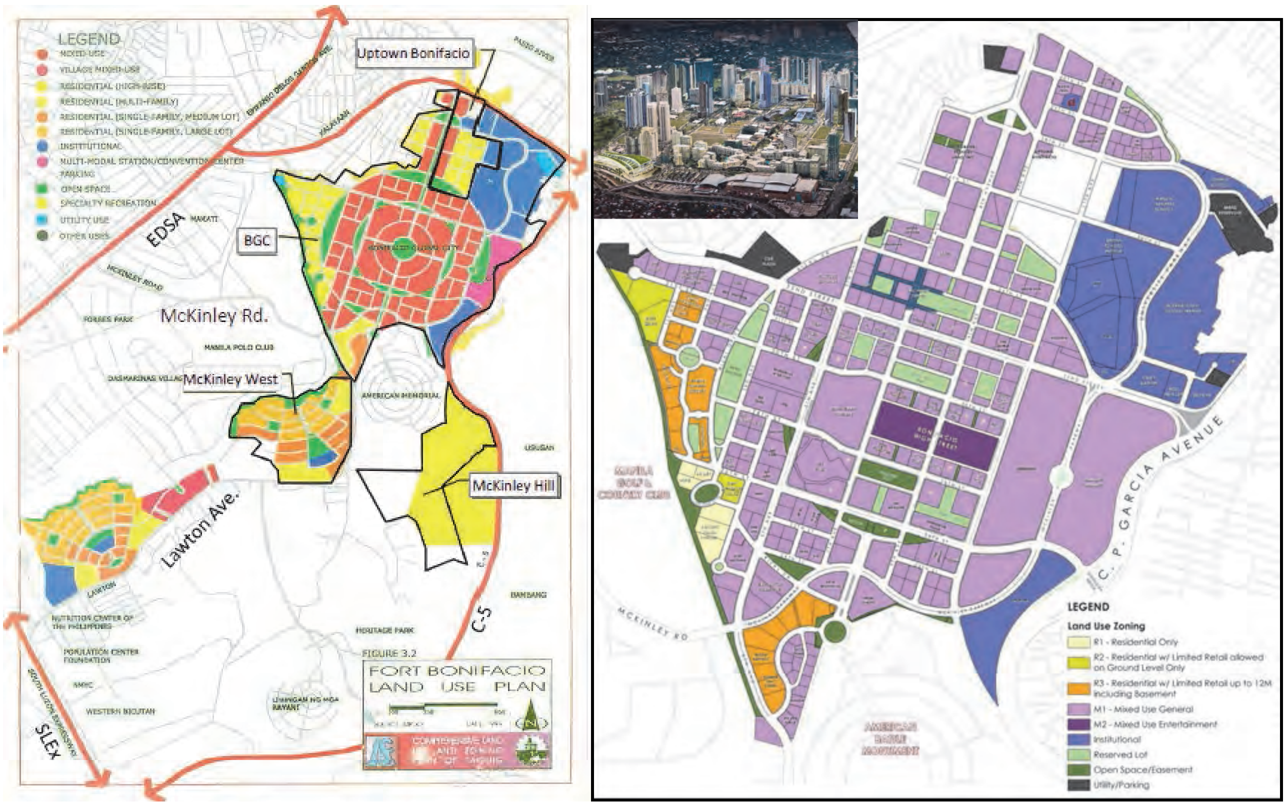
9.3 Case Study on TOD Concept for Station in BGC

(1) Development of BGC

Bonifacio Global City (BGC) is one of CBD in Metro Manila. It is located south-east of the center of Manila in an area disputed between the cities of Makati and Taguig as well as the municipality of Pateros where bordered by three arterial roads: EDSA, C5 and South Luzon Expressway. BGC is a major part of the development district of Fort Bonifacio composed of BGC, McKinley Hills, McKinley West and Uptown Bonifacio with 345ha of the total area. In recent years, the district has experienced robust commercial growth through the sale of military land by the Bases Conversion and Development Authority (BCDA). The entire district used to be the part of the main Philippine Army camp.

In 1995, Bonifacio Land Development Corporation (BLDC) started planning a major urban development of BGC. BLDC made a successful bid to become BCDA's partner in the development of the district. The Ayala Corporation through Ayala Land, Inc., and Evergreen Holdings, Inc. of the Campos Group purchased a controlling stake in BLDC from Metro Pacific in 2003. BCDA and the two companies now control Fort Bonifacio Development Corporation (FBDC), which oversees the master planning of BGC.

52% of the total BGC area is planned to use for building developments such as residential, institutional and mixed-use development. The remaining areas are for roads, parking spaces, open spaces and multimodal station (at Bonifacio Global City Station).



Source: *BCDA*

Figure 9.3-1 Location of Fort Bonifacio and Land Use of BGC

Table 9.3-1 Brief Development Progress of the Fort Bonifacio

Area Name	Land Area (ha)	Gross Floor Area (1,000m2)		No. of Residents/ Employees/ Students	Progress as of Feb.2014
		Completed	Under Construction		
BGC	245	1,197 (residential) 700 (office) 451 (commercial) 250 (institutional)	1020 (residential) 763 (office) 275 (commercial) 21 (institutional)	103	70-100%
McKinley Hill	50	270 (office) + 482 lots Commercial, embassies schools	3 condo building	48	85-91%
McKinley West	34.5	285 lots	1,256 lots	197	92% of land
Uptown Bonifacio	15	500 (residential) 400 (office) 90 (commercial/restaurant)		98	n.a.
Total	344.5	-	-	-	-

Source: *Bonifacio Master Plan, Project Development Update by BCDA*

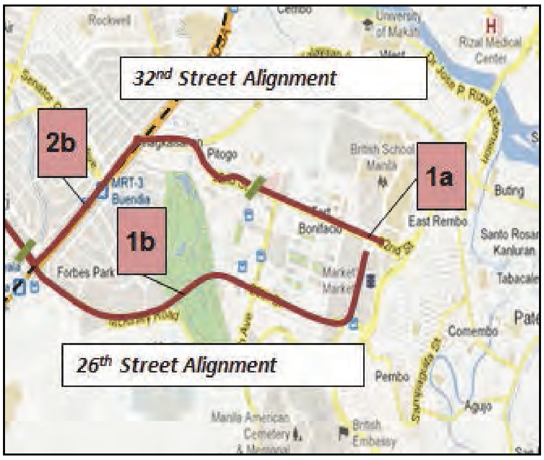
(2) Proposed MMSP Station in BGC

As described in the Section 4.8, some route alignment options and preliminary location of stations for MMSP were identified. Among them, the station in the BGC area is proposed to locate under the McKinley Parkway along the Market Market! (shopping mall) and Serendra (residential compound).

In March 2015, MTSL (Makati-Pasay-Taguig Mass Transit System Loop) Project was endorsed by the PPP Center for approval by the National Economic and Development Authority (NEDA) Board. The MTSL Project is the first subway in the country which aims to reduce peak-hour traffic by providing a higher-capacity mass transit system. The route of MTSL will start from Market Market! in BGC to EDSA/Taft Ave. passing through the major corridors in Makati City and Pasay City such as Ayala Ave., Sen. Gil Puyat Ave, Pres. Diosdado Pacapagal Blvd. and EDSA. However, in the BGC area, there are two options of alignment reaching Market Market!, either 32nd Street or 26th Street.

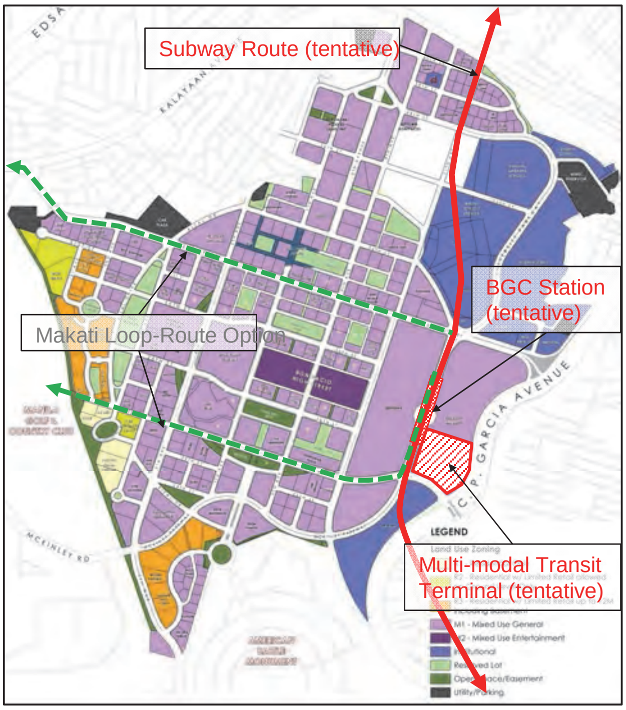
At present there is no railway system to access to BGC. Public transport services are all road-based, especially, PUJ, UV Express and taxi. Most of those routes are terminated at Market Market!. Limited service of bus and habal-habal are also available. Also there are three circular bus service operated by Bonifacio Transport Corporation under FBDC to improve the accessibility inside the BGC.

Since the BGC area is being developed as one of major CBDs in Metro Manila, it is expected that so many people will commute and visit to this place. Therefore, it is very essential to provide a good feeder services to and from the MMSP station serving not only for inside BGC area but also for surrounding area using jeepney and other public transport services. The MMSP station in BGC should be developed as multimodal terminal and directly integrated with the surrounding commercial and business facilities such as Market Market!, SM Aura and High Street, etc.



Source: *DOTC*

Figure 9.3-2 MTSL Alignment Options in BGC



Source: BCDA, *JICA Study Team*

Figure 9.3-3 Proposed MMSP Station in BGC

Table 9.3-2 Current Public Transport Operation for BGC, 2014

Item		PUJ	UV Express	Taxi
Route		EDSA-McKinley EDSA-Market Market! EDSA-Gate2-Market Market! EDSA McKinley-Market Market! Guadalupe-Fort Bonifacio Guadalupe-Fort Bonifacio Gate3 Guadalupe-FTI Guadalupe-Market Market! Market Market!-Ayala Market Market!-Pateros Market Market!-Sucat	Market Market!-Ayala Market Market!-Ayala Pembo Market Market!-Bicutan Market Market!-Marikina Market Market!-Megamall Market Market!-Pasig Market Market!-Rosario Market Market!-Taguig	No fixed routes/ areas
Approximate No. of units		3,200	54	n.a.
Operation time	Start	4:00-10:00	1:00-16:00	4:00-7:00
	End	10:30-0:00	16:00-0:00	12:00-7:00
	Ave.	14 hr. 15 min.	12 hr. 48 min.	17 hr. 24 min.
Ave. No. of trips/day		15-20	5-10	35
Vehicle Ownership	Own %	6.7	29.6	35.5
	Rental%	92.5	70.4	64.5
Fare System		Flat (mainly 40Php)	Distance-based/ base fare: 14Php (mainly) and mileage fare: 5-15/km	Dist.-based/ base fare: 40Php (mainly) and mileage fare: 3.5/km
Ave. Revenue (Php/day)		2,909	3,059	3,245
Ave. Expense	Fuel (Php/day)	965	1,031	1,365
	Maintenance (Php/month)	1,230	2,146	1,485

Source: *Preparatory Survey on Metro Manila CBD Transit System Project (JICA, 2015)*

(3) Preliminary TOD Concept for MMSP Station in BGC

In order to develop the integrated/multimodal terminal at Bonifacio Global City Station, the following TOD concepts are identified preliminary:

(a) To develop Multimodal Transit Terminal: The facilities of all transport modes such as stations of MMSP and MTSL, terminal of BGC Bus, jeepeny, UV Express, taxi are to be directly connected in the same terminal facility for smooth transfer of the passengers. Car parking space for Park & Ride users is also provided within the terminal facility. Particularly for the passengers transferring between underground stations of MMSP and MTSL, concourse of each station should be connected directly on the same underground level.

(b) To connect with surrounding areas by underground access pass: Surrounding commercial and business facilities such as Market Market!, SM Aura and High Street, etc. are to be connected directly with two railway stations and terminal facility for better and convenient access.

(c) To develop commercial/business space: In addition to the terminal facility, its upper levels and underground access pass can be developed for commercial and business use. Since so many passengers will use this terminal, these spaces can rent out with high rent.

(d) To improve traffic management: Effective traffic circulation with proper traffic regulation should be implemented in order to reduce the traffic congestion on the surrounding road network. The rerouting of feeder buses and jeepneys also considered to avoid the duplication of services.

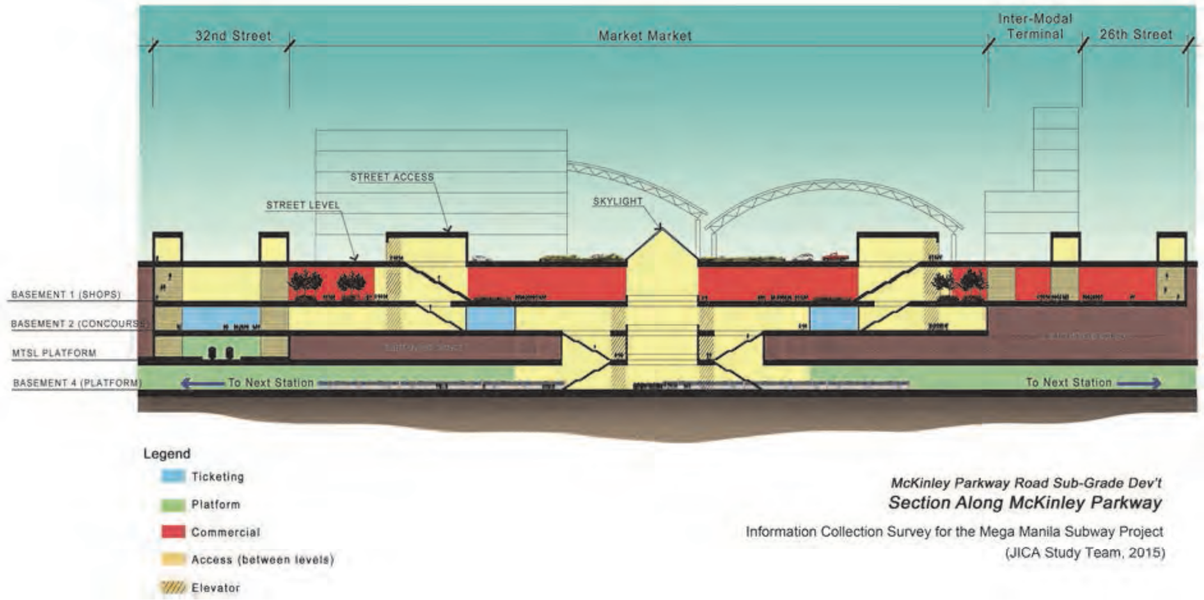
(4) TOD Images of Integrated/Multimodal Terminal Station in BGC

Based on the preliminary TOD concepts for MMSP station in BGC described above, rough image of integrated/multimodal terminal station is examined and illustrated.

Figures 9.3-4 to 9.3-6 illustrate the bird's-eye view and cross sectional view of the terminal station. Figures 9.3-7 and 9.3-8 show the floor plan of each level of the terminal stations. Figures 9.3-9 and 9.3-10 present the rough layout plan and view of multimodal terminal.

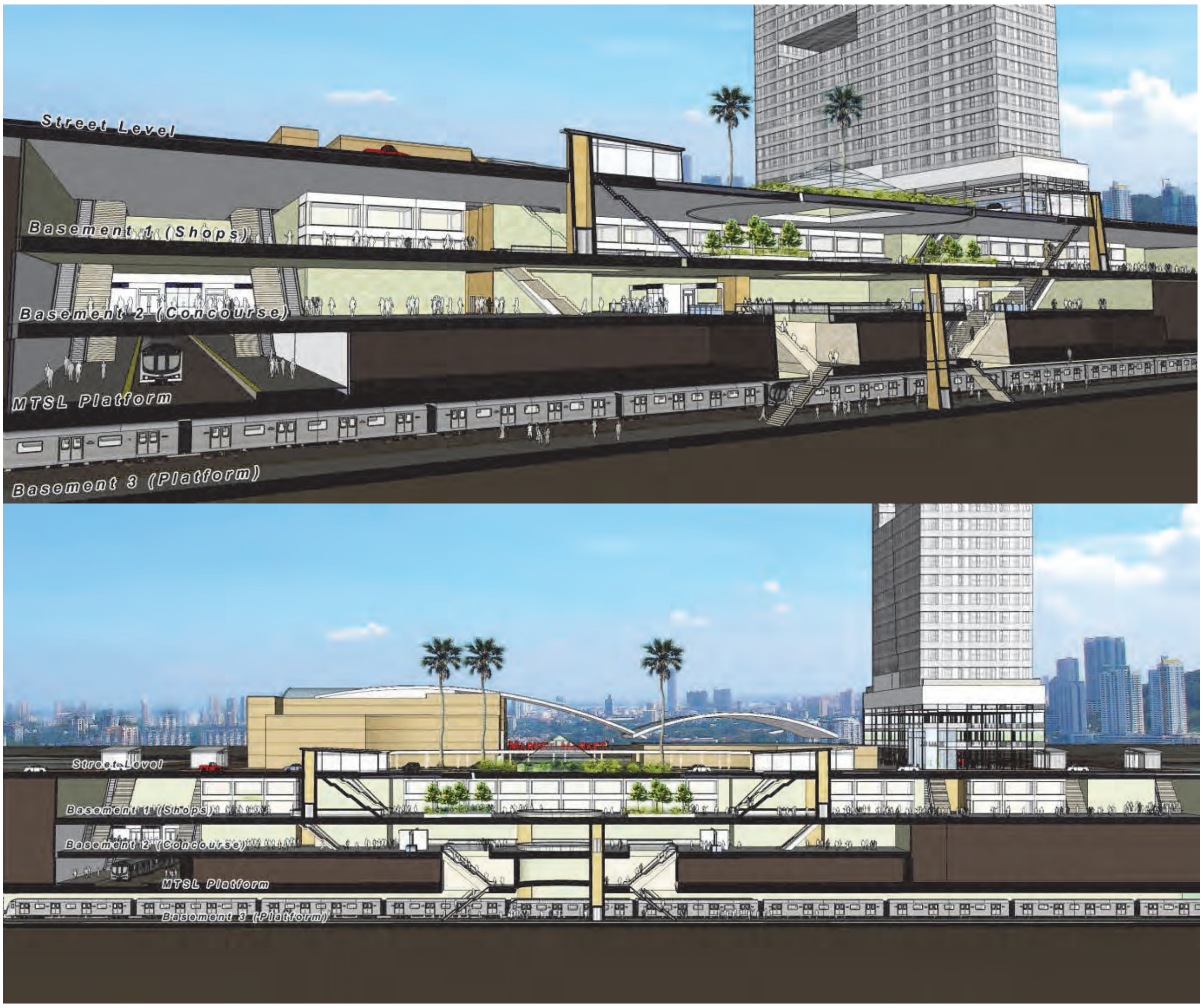
Source: *JICA Study Team*

Figure 9.3-4 Bird's-eye View of Integrated/Multimodal Terminal and MMSP Station in BGC



Source: *JICA Study Team*

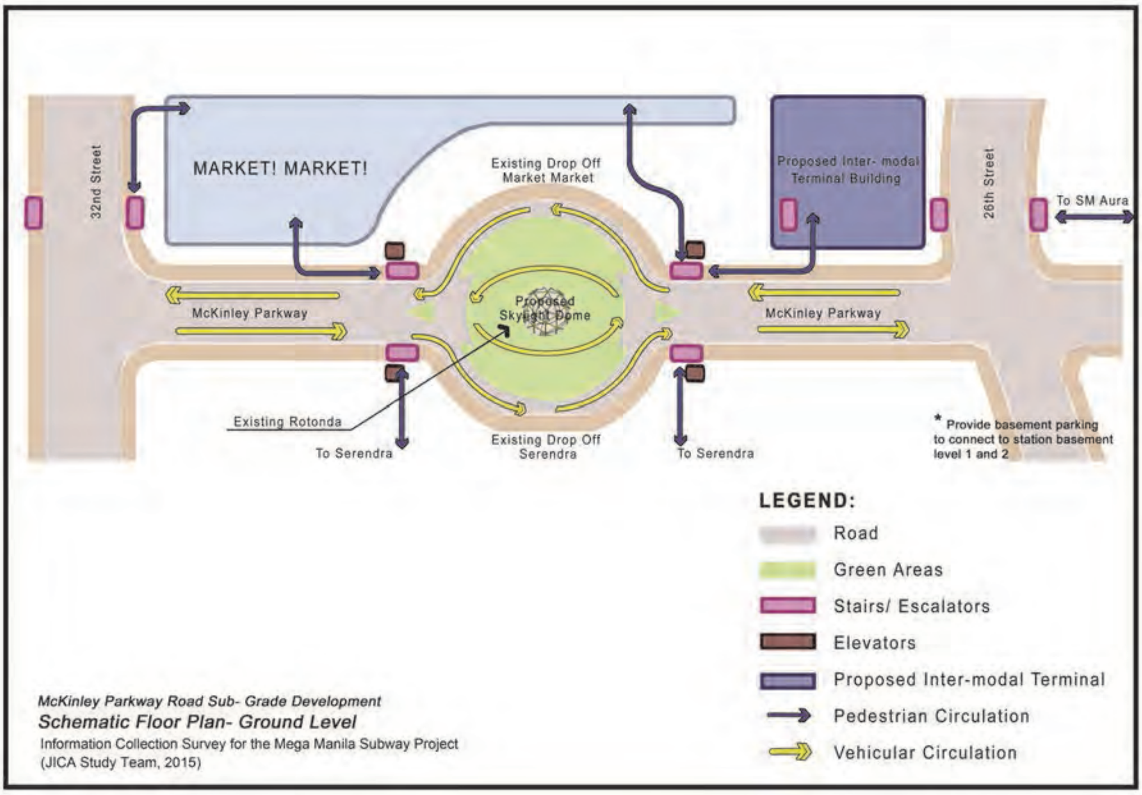
Figure 9.3-5 Cross-sectional Plan of MMSP Station in BGC



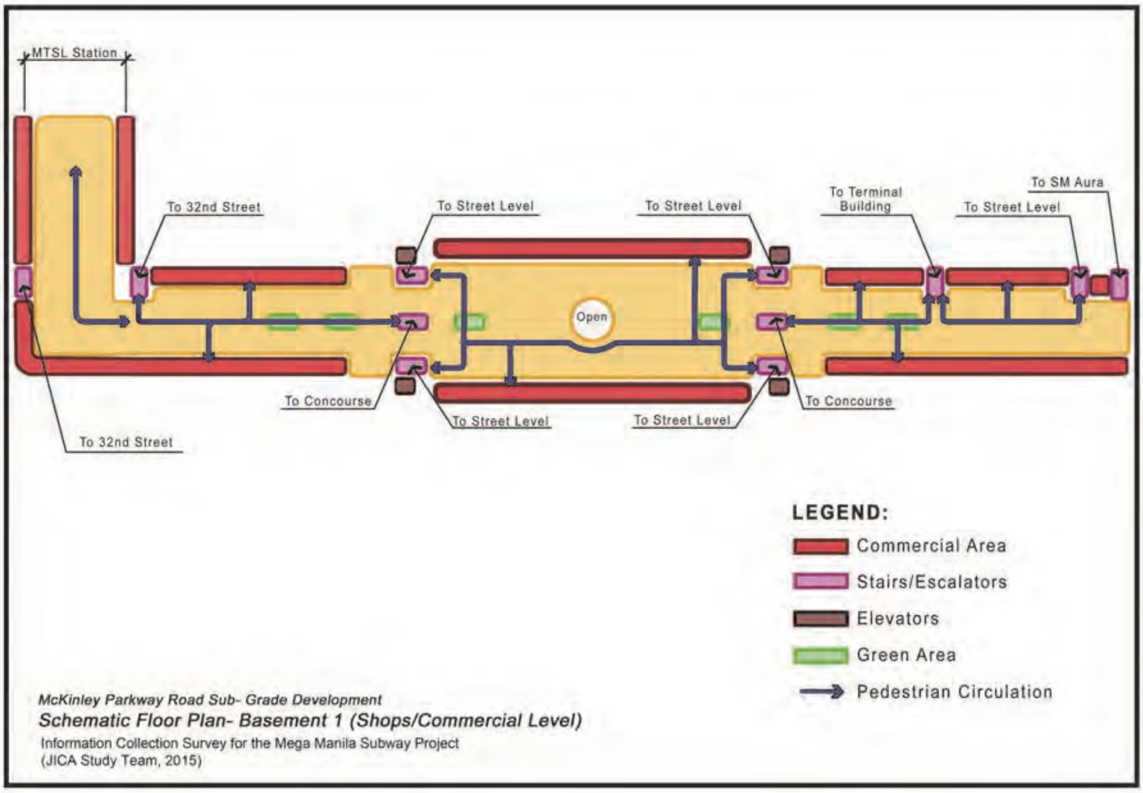
Source: *JICA Study Team*

Figure 9.3-6 Cross-sectional Perspective View of MMSP Station in BGC

Ground Level



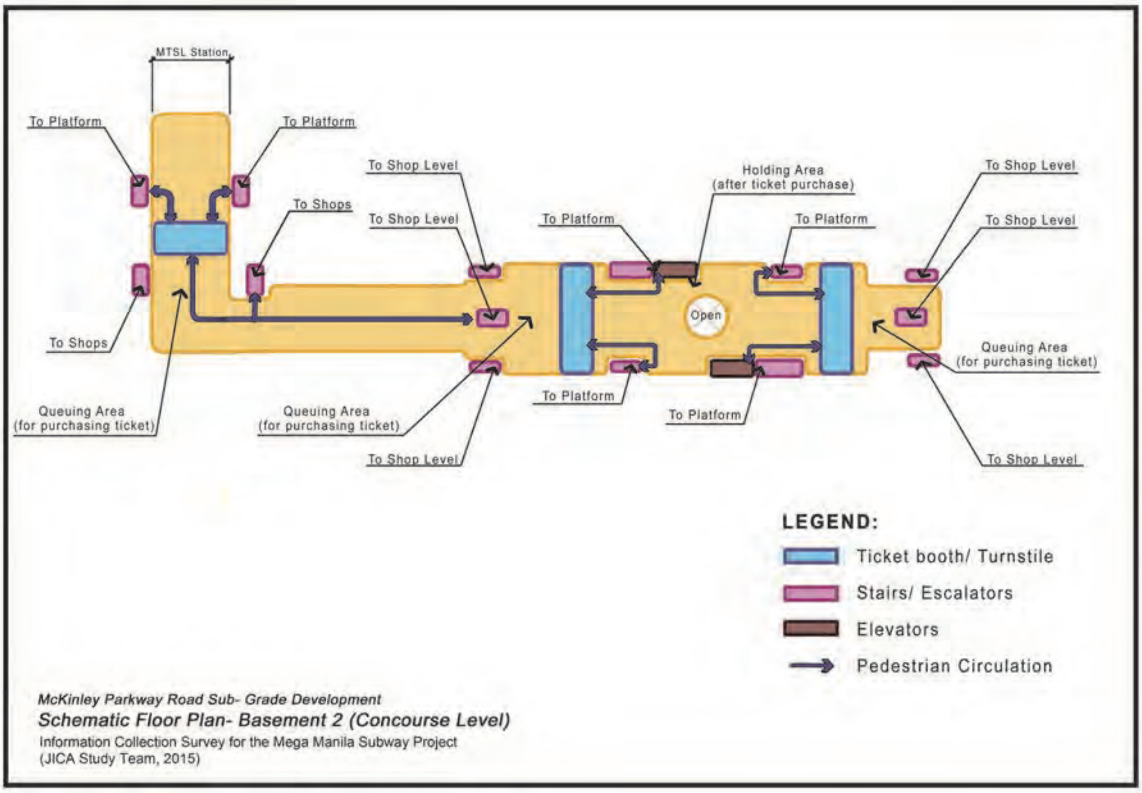
Basement 1 Level



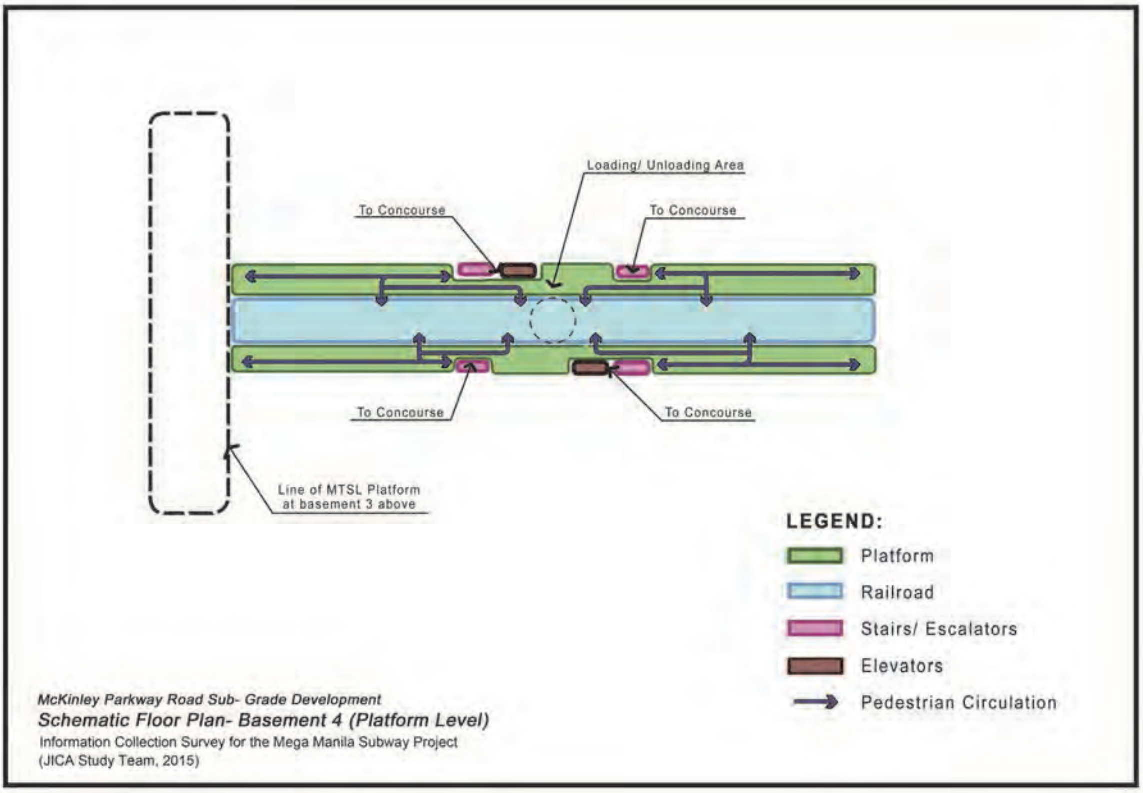
Source: *JICA Study Team*

Figure 9.3-7 Floor Plans of MMSP Station in BGC (1/2)

Basement 2 Level

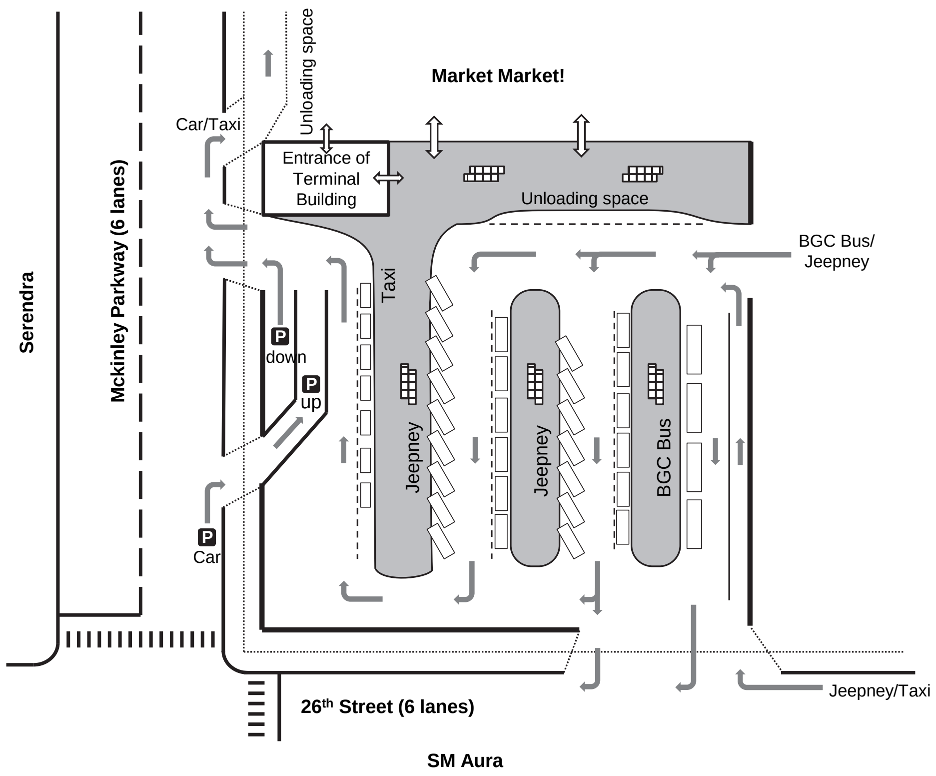


Basement 4 Level



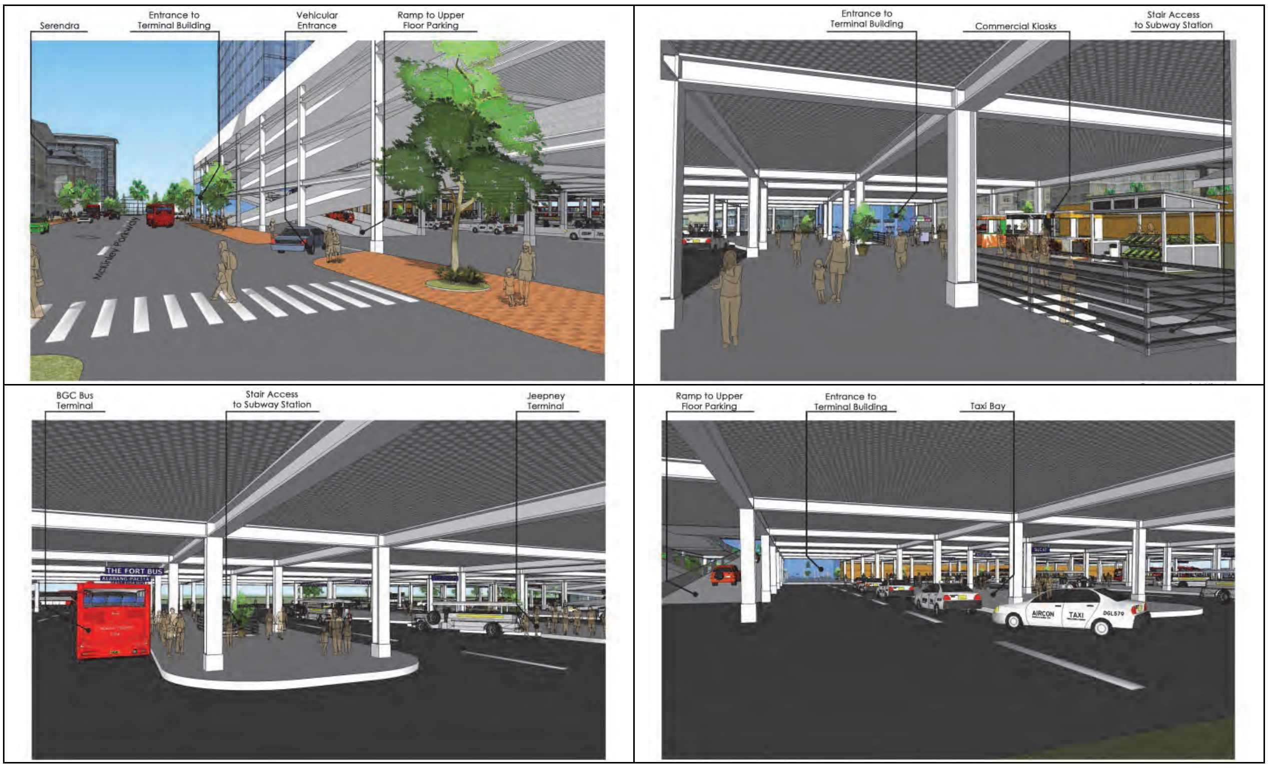
Source: *JICA Study Team*

Figure 9.3-8 Floor Plans of MMSP Station in BGC (2/2)



Source: *JICA Study Team*

Figure 9.3-9 View of Multimodal Terminal in BGC



Source: *JICA Study Team*

Figure 9.3-10 Rough Layout Plan of Ground Floor of Multimodal Terminal in BGC

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Chapter 10

PROJECT IMPLEMENTATION STRUCTURE AND OPERATION AND MAINTENANCE STRUCTURE

Chapter 10 PROJECT IMPLEMENTATION STRUCTURE AND OPERATION AND MAINTENANCE STRUCTURE

10.1 Current Situation of Project Implementation Structure and O&M Structure of Railways in Metro Manila

10.1.1 Department of Transportation and Communications (DOTC)

The Department of Transportation and Communications (DOTC) is the primary policy, planning, programming, coordinating, implementing and administrative entity of the executive branch of the government on the promotion, development and regulation of a dependable and coordinated network of transportation and communications systems, as well as in the fast, safe, efficient and reliable transportation and communications services.

As one of the first government agencies established under the Malolos Constitution on January 21, 1899, the DOTC has played a crucial role in accelerating the country's economic development. DOTC has provided the backbone for growth and enhances the country's competitive edge by providing effective and efficient transportation and communications infrastructure systems that narrow the geographical and physical divide, connecting the country, its islands, and its people to the rest of the world.

10.1.1.1 Sectorial Offices and Attached Agencies

The DOTC has three Sectorial Offices and fifteen Attached Agencies. Among them, there are one sectorial office and four attached agencies related to rail transport.

Sectorial offices related to Rail Transport

(1) Metro Rail Transit (MRT)

MRT3, designated as the Blue Line, is also called the EDSA MRT. It was implemented by the DOTC through a Build-Lease-Transfer contract with the privately owned Metro Rail Transit Corporation (MRTC). It has 13 stations on a 16.9 km rail system along EDSA from North Ave., Quezon City, to Taft Ave., Pasay City. It became fully operational in 2000.

Attached Agencies related to Rail Transport

(2) Office for Transportation Security (OTS)

The Office for Transportation Security (OTS) is the single authority responsible for the security of the transportation systems of the country, including, but not limited to, the following: Civil Aviation, Sea Transport and Maritime Infrastructure, Land Transportation, Rail Systems and Infrastructure. It was established by virtue of Executive Order No.277 on January 30, 2004 to secure civil aviation safety. In response to the international mandate (i.e. ICAO and IMO guidelines) calling for a single authority for all modes of transportation security in the Philippines, E.O. 311 was issued on April 26, 2004.

(3) Philippines National Railways (PNR)

The PNR was established via legislation in June 1946, in order to provide a nation-wide railway transportation system. There are currently plans to develop new lines connecting the rapidly developing areas in Central Luzon and the South Tagalog region with Metro-Manila.

(4) Light Rail Transit Authority (LRTA)

The LRTA was established via Executive Order 603 on July 12, 1980, in order to oversee the construction and operation of the Light Rail Transit project extending from Baclaran in Pasay City, to Monumento in Caloocan. Since then, the LRTA's mandate has expanded to encompass other light rail projects in Metro-Manila.

(5) North Luzon Railways Corporation (NLRC / North Rail)

The North Luzon Railways Corporation (NLRC), or North Rail, was established to implement the North Rail Project, a major undertaking of the Philippine government which aims to build a fast, reliable, and efficient railway system in Central and Northern Luzon.

10.1.1.2 Budget and Financial Situation

As of 2012, the DOTC Operating Budget for Major Final Outputs (MFO) was PhP 34,574.48 million, of which 73.88% correspond to Infrastructure Development Services, 13.03% to Regulatory and Enforcement Services, 12.15% Operation and Management Services, and 0.94% Policy Plan Formulation Services.

Functions upon Railway Construction and O&M

There are three functions to implement a new railway project as shown in the following Table 10.1.1.2-1

Table 10.1.1.2-1 Functions upon Railway Construction and O&M

Function	Details	Responsibility
Regulator / Project Controller	• Planning • Budgeting • Bidding • Contract	Preparation for the Project • Planning new railway network plans • Railway construction planning Managing contract
Project Owner / Implementation Body	• Supervising • Training	Project Management Office • Supervision of construction and facilities installation • Preparation for the commencement of revenue operation • Staff training
O&M	• Operation • Maintenance • Outsourcing	• Operating and maintaining railway • Outsourcing of some maintenance works • Supervising contractors

Source: *JICA Study Team*

10.1.2 Philippine National Railway (PNR)

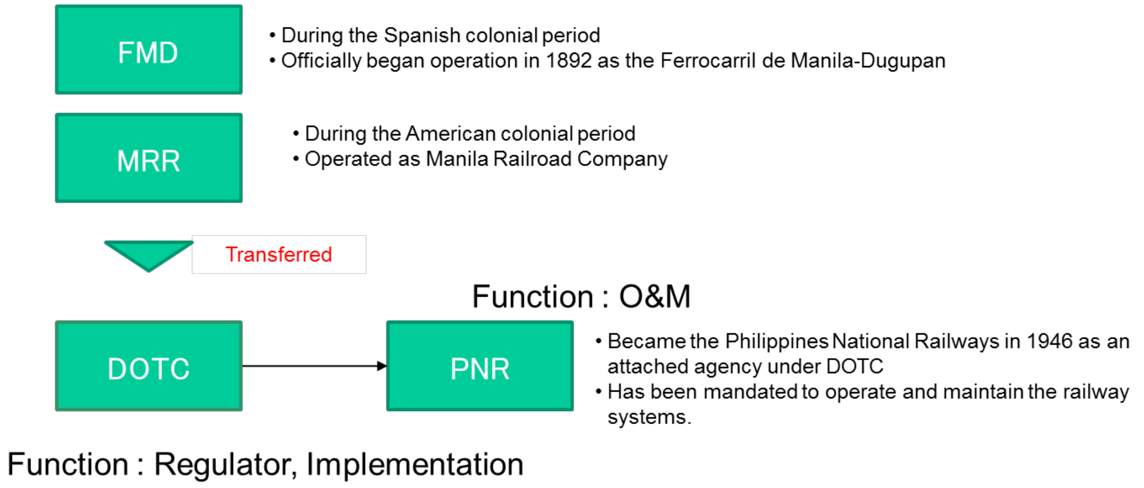
10.1.2.1 Organization Structure

The state-owned Philippine National Railways (or Pambansang Daangbakal ng Pilipinas in Filipino), commonly abbreviated as PNR, is the sole operator of the most extensive intra-island railway on Luzon, the largest island in the Philippines.

The PNR officially began operations on June 26, 1875 as the Ferrocarril de Manila-Dagupan, during the Spanish colonial period, and later renamed to the Manila Railroad Company (MRR) during the American colonial period. It became the Philippine National Railways on June 20, 1946 by virtue of Republic Act No. 4156. The PNR is an Attached Agency under the Department of Transportation and Communications.

It has two commuter rail services in Metro Manila and the Bicol Region. The Bicol service is currently under rehabilitation in preparation for the resumption of the Bicol Express run to Naga City in Camarines Sur province, and eventually to the southern terminal in Legazpi City in Albay. The existing and well-patronized commuter service in Metro Manila is part of the metropolitan transit system and is referred to as the Orange Line.

The PNR's function is O&M, and the DOTC plays roles as a regulator and an implementation body as shown in Figure 10.1.2.1-1



Source: *JICA Study Team*

Figure 10.1.2.1-1 Functions of PNR

Organization Chart of the PNR is shown in Figure 10.1.2.1-2. Staffing of the PNR as of December 2013 is shown in Table 10.1.2.1-1, separately indicating permanent staff and Job Order staffing

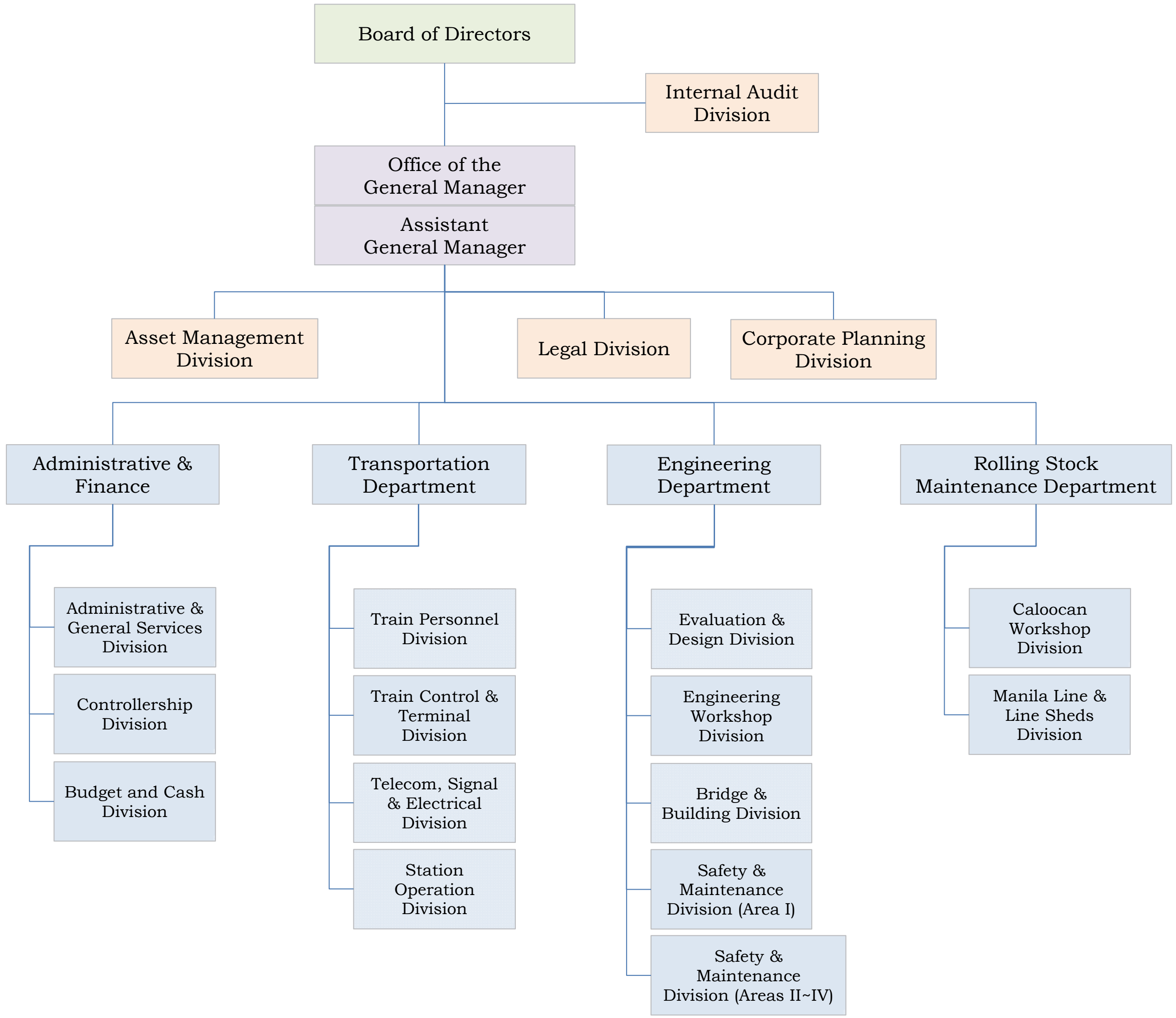


Figure 10.1.2.1-2 Organization Chart of PNR

Source: *JICA Study Team*

Table 10.1.2.1-1 PNR Staffing

Unit	Permanent Staff	Job Order Staff
Board of Directors	**7**	
Internal Audit Division	**3**	**3**
Office of General Manager	**28**	**86**
General Manager	8	86
Legal Division	8	
Asset Management Division	8	
Corporate Planning Division	4	
Administrative & Finance Department	**30**	**79**
Office of Department Manager	2	79
Administrative & General Services Division	12	
Controllership Division	6	
Budget and Cash Division	10	
Transport Department	**66**	**300**
Office of Department Manager	5	300
Train Personnel Division	28	
Train Control and Terminal Division	13	
Telecom, Signal & Electrical Division	4	
Station Operation Division	16	
Engineering Department	**86**	**623**
Office of Department Manager	6	623
Evaluation and Design Division	9	
Engineering Workshop Division	17	
Bridge and Building Division	27	
Safety and Maintenance Division (Area I)	8	
Safety and Maintenance Division (Areas I ~ IV)	19	
Rolling Stock Maintenance Department	**21**	**156**
Office of Department Manager	3	156
Caloocan Workshop Division	11	
Manila Yard and Line Sheds Division	7	
Grand Total	**241**	**1247**

Source: *JICA Study Team*

10.1.2.2 Budget and Financial Situation

According to the Commission of Audit (COA) Annual Audit Report of Fiscal Year (FY) 2013, issued on August 2014, the financial highlights are as shown in Table 10.1.2.2-1

Table 10.1.2.2-1 PNR Financial Highlights (in million pesos)

Comparative Financial Position

	2013	2012	Increase / (Decrease)	%
Assets	52,868.619	53,102.553	(233.934)	0.4
Liabilities	26,114.602	25,956.031	158.571	0.6
Equity/Capital Deficiency	26,754.017	27,146.522	(392.505)	1.4

Comparative Results of Operations

	2013	2012 As restated	Increase/ (Decrease)	%
Total rail and non-rail revenue	401.023	397.641	3.382	0.9
Personal Services	99.198	100.953	(1.755)	1.7
Maintenance & Other Operating Expenses	567.912	638.315	(70.403)	11.0
Financial Expenses	225.308	404.682	(179.374)	44.3
Total other income (expenses)	(25.670)	244.327	(269.997)	110.5
Subsidy from National Government	254.605	128.653	125.952	97.9
Net loss	262.459	373.329	(110.87)	29.7

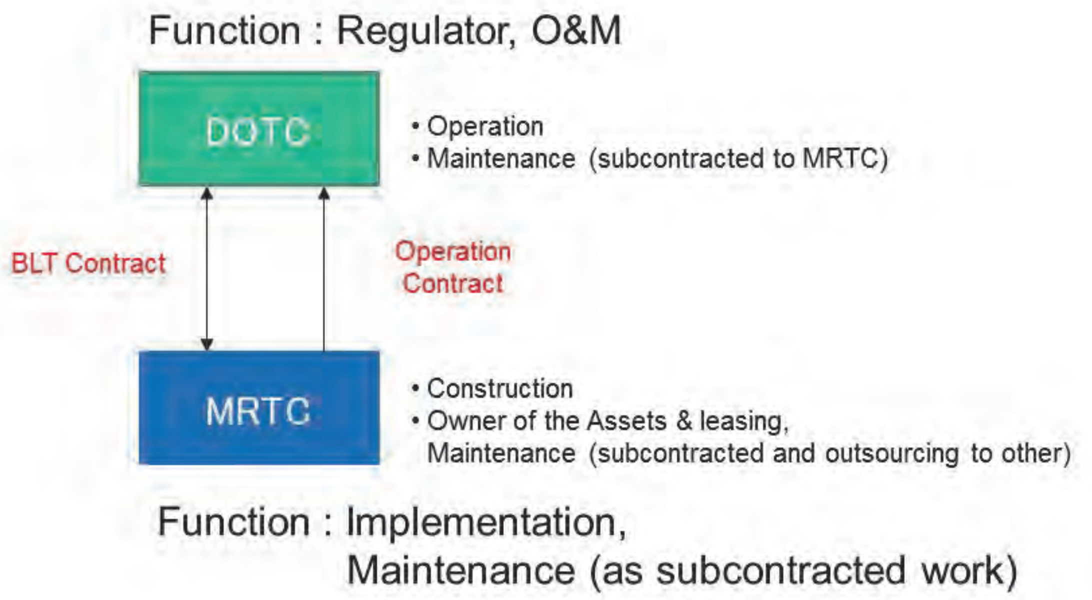
Source: *COA, Annual Audit Report, FY 2013*

10.1.3 Metro Rail Transit Corporation (MRTC)

MRT3 was implemented by the DOTC through a Build-Lease-Transfer contract with the privately owned Metro Rail Transit Corporation (MRTC). It has 13 stations on a 16.9 km rail system along EDSA from North Ave., Quezon City to Taft Ave., Pasay City. It became fully operational in 2000.

The MRTC constructed the MRT3, and owns, maintains and leases it to the DOTC, which operates it.

Therefore, the function of the DOTC in MRT3 is mainly the operation. In addition, the DOTC has regulatory and O&M functions, where maintenance work is subcontracted to MRTC, as shown in Figure 10.1.3-1.



Source: *JICA Study Team*

Figure 10.1.3-1 Function of MRTC

10.1.4 Light Rail Transit Authority (LRTA)

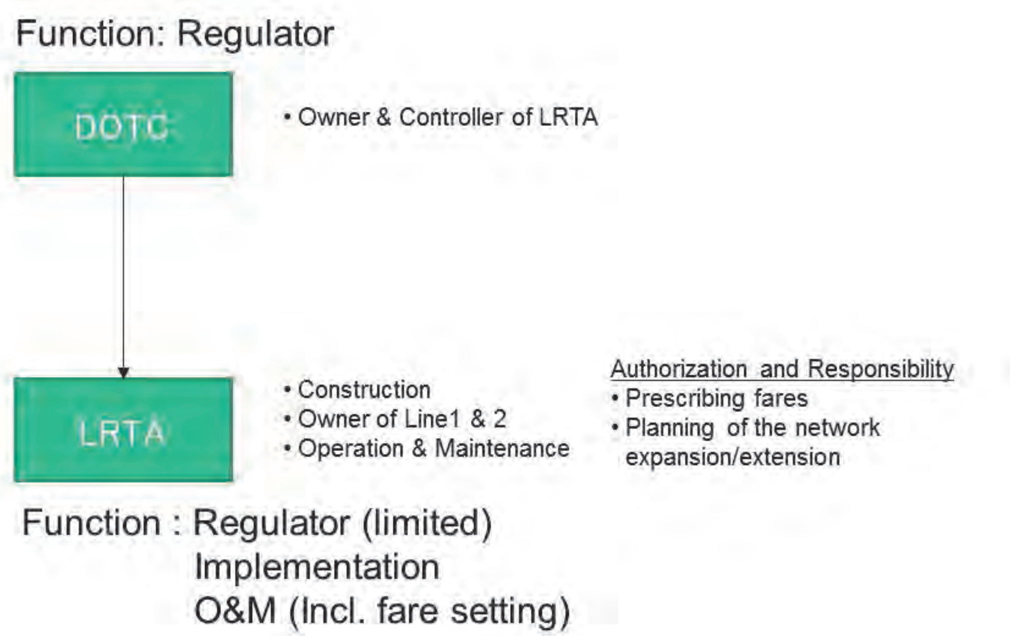
The Light Rail Transit Authority (LRTA) is a wholly government owned and controlled corporation attached to the DOTC.

By virtue of Executive Order No. 603 dated July 12 1980, as amended by EO No. 830 dated September 30 1982, and EO No. 210 dated July 7, 1987, the LRTA was established and mandated to be responsible primarily for the construction, operation, maintenance and/or lease of LRT systems in the Philippines.

LRTA owns the existing LRT Line 1 and LRT Line 2, and retains the power of prescribing the fares and planning of the network expansion/extension. The mission of LRTA is to provide safe, efficient, reliable and responsive mass transport services in the urbanized areas of the country, particularly in Metro Manila, and in conjunction with other existing modes of public transportation.

LRTA is responsible for all the light rail projects in Metro-manila as well as operation and maintenance of 2 urban railway lines. Therefore, it has three functions, i.e. as a regulator with limited function, as an implementation body of the project and as an O&M body as shown in Figure 10.1-4-1.

However, these 2 lines, which are currently being operated and maintained by the LRTA, are planned to be operated and maintained by private sectors in near future.

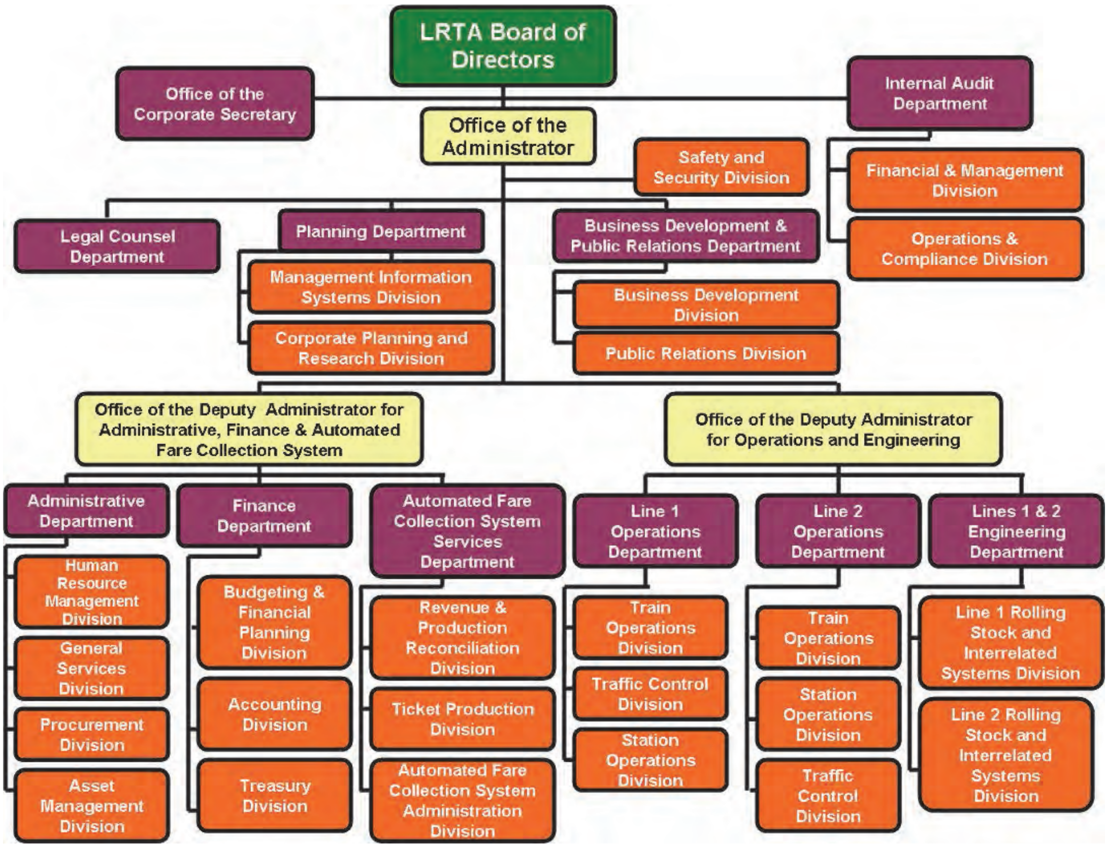


Source: *JICA Study Team*

Figure 10.1.4-1 Function of LRTA

Figure 10.1.4-2 shows the organizational structure of the LRTA, and Table 10.1.4-1 shows the staffing of the LRTA.

The Board of Directors is composed of eight (8) ex-officio cabinet members, such as the Secretary of the DOTC, as Chairman, the Secretaries of the DPWH, Department of Budget and Management (DBM), Department of Finance (DOF) and NEDA, the Chairman of the MMDA and the Land Transportation Franchising and Regulatory Board (LTFRB), the Administrator of the LRTA and one (1) representative from the private sector. The Board is tasked to issue, prescribe, and adopt policies, programs, plans, standards, guidelines, procedures, rules and regulations for implementation, enforcement, and application by the LRTA Management. The Board also convenes to resolve operations-related issues and concerns as well as other matters requiring immediate attention and resolution.



Source: *JICA Study Team*

Figure 10.1.4-2 Organizational Structure of LRTA

Table 10.1.4-1 LRTA Staffing

Section	Number of Staff		
	Regular	Contractual	Total
Administration	52	53	105
Finance	67	156	223
Engineering	38	28	66
Internal Audit	12	1	13
AFCS	21	60	81
BDU	6	4	10
planning	2	34	36
Operations	70	-	70
Office of Administrator	5	-	5
Office of Corporate Secretary	2	-	2
Safety & Security	10	-	10
Legal	6	-	6
MIS	20	-	20
Public Relations	6	-	6
Office of DA Finance	4	-	4
Office of DA Eng.	4	-	4
Station Teller			
Line 1	-	647	647
Line 2	-	123	123
Train Operators			
Line 1	-	187	187
Line 2	-	97	97
Total Filled Positions	325	1,390	1,715

Source: *JICA Study Team*

10.1.5 Review of Functions of Each Agency regarding Railway Projects

There are some types of function sharing upon railway construction and O&M among concerned agencies, where each type has its own pros and cons. Table 10.1.5-1 shows the current function sharing of railway projects from implementation to O&M in the Philippines:

Table 10.1.5-1 Overview of Function Sharing

Lines \ Function	Regulator / Project Controller	Project Owner / Implementation Body	O&M
PNR	DOTC	DOTC	PNR
MRT3	DOTC	MRTC	DOTC/MRTC
LRT 1&2	DOTC / LRTA	LRTA	LRTA

Source: *JICA Study Team*

As it can be observed from the above table, every railway has different function sharing type in the Philippines, which might cause inefficient placement and/or allocation of staff and also confuse staff regarding the demarcation of roles and responsibilities of each authority and other problems. Taking it into consideration, recommendation for the project implementation structure for the Mega Manila Subway is described in the following chapter, which can be also referred to the re-arrangement of function sharing of other railways in the Philippines.

10.2 Recommendation for Project Implementation Structure

10.2.1 Long Term vision

10.2.1.1 Creation of Manila Metro Vision

As a philosophy or basic policy for the future railway network in Mega Manila, creation of “Manila Metro Vision” is recommended. In order to be chosen and used by more and more people and to be a sustainable transport mode, railway systems should become safe, reliable, reasonable, convenient, and comfortable, which needs to be acknowledged by potential railway users.

The basic concept of the recommended “Manila Metro Vision” is;

(1) Safe: The most basic value for railway systems and railway business. Safety upon construction, operation and maintenance are both indispensable.

(2) Reliable: Reliability, such as punctual service and transparent fare collection, is the second basic value.

(3) Reasonable: Fare setting is the key for acquiring the most appropriate demand of passengers and bring about the highest profit. Both Construction costs and O&M costs have to be reduced as much as possible. The increase of income by non-rail business or the synergy of railway business and non-rail business have to be considered, which will then a benefit to railway users by lower fare.

(4) Convenient: High frequency, universal design, convenient non-rail service and easy access from other transport modes attract passengers.

(5) Comfortable: If passengers feel comfortable while riding, they can be the repeaters of the railway.

This vision in principle shows the direction upon network planning, construction project and operation and maintenance of any railway system.

10.2.1.2 Creation of New Business Model in the Philippines

To reduce burdens on both government and railway operators, railway projects should be created as a new business model. It will be difficult to achieve this in a short period, but definitely ideal for a railway operator to be financially independent from the government.

The major issues for such new model are;

(1) Reasonable risk sharing between government and operator

Enforcement system on land acquisition, subsidy scheme, contract scheme, regulation on public and private transport modes

(2) Financially and technically reducing costs upon construction, operation and maintenance

Reducing initial costs by proper subsidy scheme and adopting new technologies through consultation with experienced consultants or railway operators in other countries

(3) Providing high quality railway service

Analyzing customers' direct opinions and big data from IC ticket system to respond to demands of passengers

(4) Developing non-rail business and synergizing it with railway business

Taking the space to develop non-rail business into consideration upon designing stations and synergy of rail and non-rail businesses, such as giving fare discounts to those who purchase products in station stores

(5) Total planning for sustainable business

10.2.1.3 Establishment of "PRA"

The considerations mentioned 10.2.1.1 and 10.2.12 should be conducted by proper local sector, though they need support from experienced consultants or railway operators in other countries, because these policies have to be maintained and revised by themselves if needed. Therefore, to conduct these considerations and to avoid problems mentioned in Chapter 10.1.5, the establishment of an autonomous lower branch of the DOTC, temporally called the "Philippine Railway Agency" (PRA) is suggested for the long-term vision of the railway administration in the Philippines.

The PRA shall play a role as the Project Owner upon railway construction projects, and as the regulator after commencement; Transport Policy, Planning and Budgeting, Regulatory Function, Land Acquisition etc., as shown in Figure 10.2.1.4-1

The tasks of the PRA are expected to be as described below;

- Transport Policy Setting (like Metro Manila Vision)
- Planning and Budgeting (Regulator / Project Controller)
  - New railway projects
  - Extension or improvement of existing railway systems.
  - Maintenance of infrastructure
- Regulation
  - Transport Safety
    - Operator licensing
    - Train driving licensing

- ✧ Technical standard
- ✧ Inspections and audits
- ✧ Accident and incident investigations

- ➢ Workers' safety and health
- ➢ Market access
  - ✧ Competition and Bidding
- Land acquisition

The PRA is expected to contribute to:

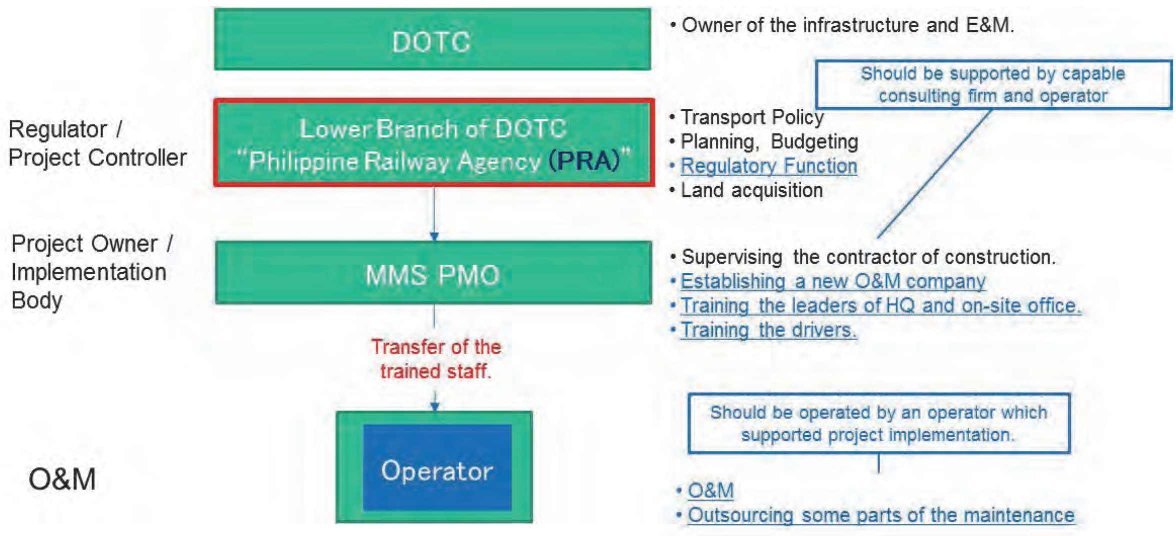
- Smooth implementation of railway projects, while securing consistency and clear demarcation of the roles and responsibilities.
- Accumulation of know-how of railway projects by supervising all the railway projects, including both implementation and O&M.
- Reliable regulatory functions with sufficient power and know-how as the only one agency which manages railway projects and regulates railway operators in the Philippines.

10.2.1.4 Establishment of PMO

During the implementation of the project, a Project Management Office (PMO) should be established as the organization to be in charge of the implementation of the project and to contact with the consultants, contractors and other third parties concerned. This PMO will be called "MMS PMO".

The MMS PMO shall be also responsible for training train drivers and other staff in charge of operation and maintenance. After completion of the construction, the staff will be transferred to the operation and maintenance agency.

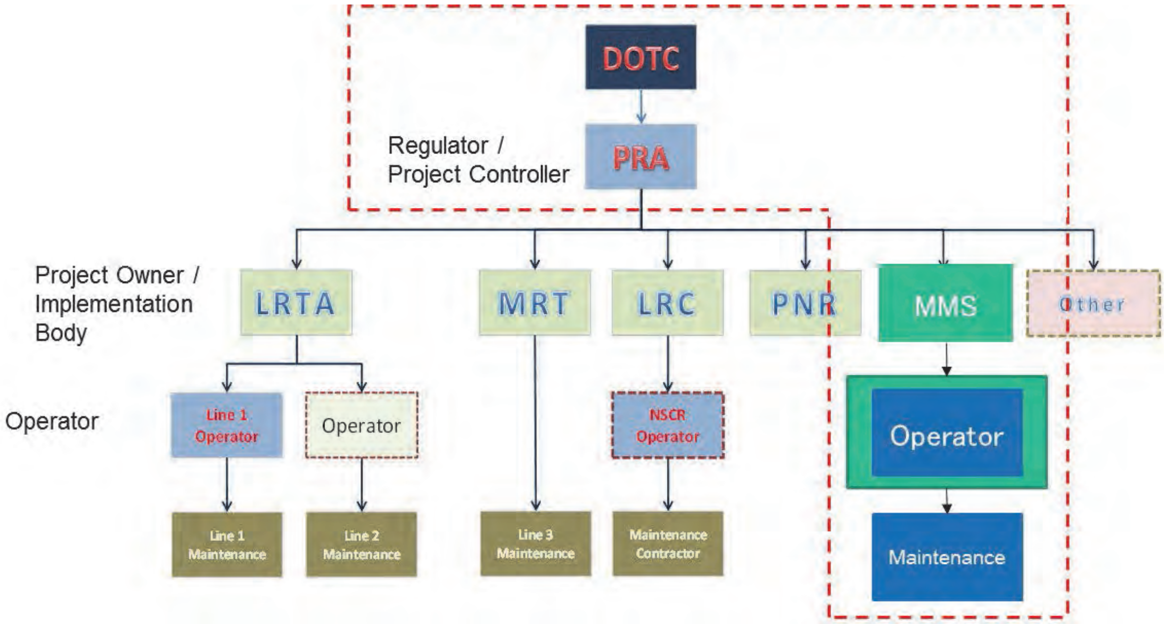
The proposed organization structure for the Mega Manila Subway Project in the long term is as shown in Figure 10.2.1.4-1.



Source: *JICA Study Team*

Figure 10.2.1.4-1 Proposed Organizational Structure for MMS Project (Long Term)

Figure 10.2.1.4-2 shows the overall organization structure for the implementation of all railway projects in the Philippines as the long term vision.



Source: *JICA Study Team*

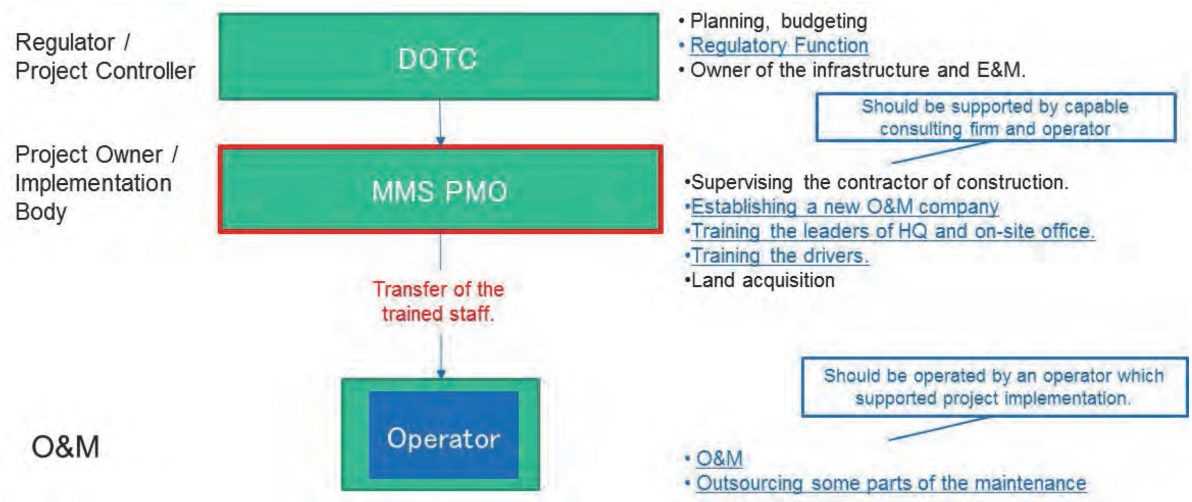
Figure 10.2.1.4-2 Proposed Overall Organization Structure for Railway Projects (Long Term)

10.2.2 Short Term Vision

From the long-term viewpoint, the establishment of the PRA is recommended. However, it might take a long time to establish a permanent agency, thus the establishment of a temporally agency which will manage the Mega Manila Subway project is suggested from the short-term view point.

Fortunately, the MMS PMO will be anyway needed whether PRA is established or not. Therefore, the functions which will belong to the PRA in the future could be shared by the DOTC and the MMS PMO.

DOTC will be responsible for planning, bidding and regulating, on the other hand MMS will be responsible for Land acquisition as shown in Figure 10.2.2-1.



Source: *JICA Study Team*

Figure 10.2.2-1 Proposed Organization Structure for MMS Project (Short term)

There are two options how such MMS PMO can be established.

One is to be established under the DOTC as an Attached Agency, whereas the other is within the LRTA as one of the departments, which is the existing agency most familiar to the implementation of railway projects.

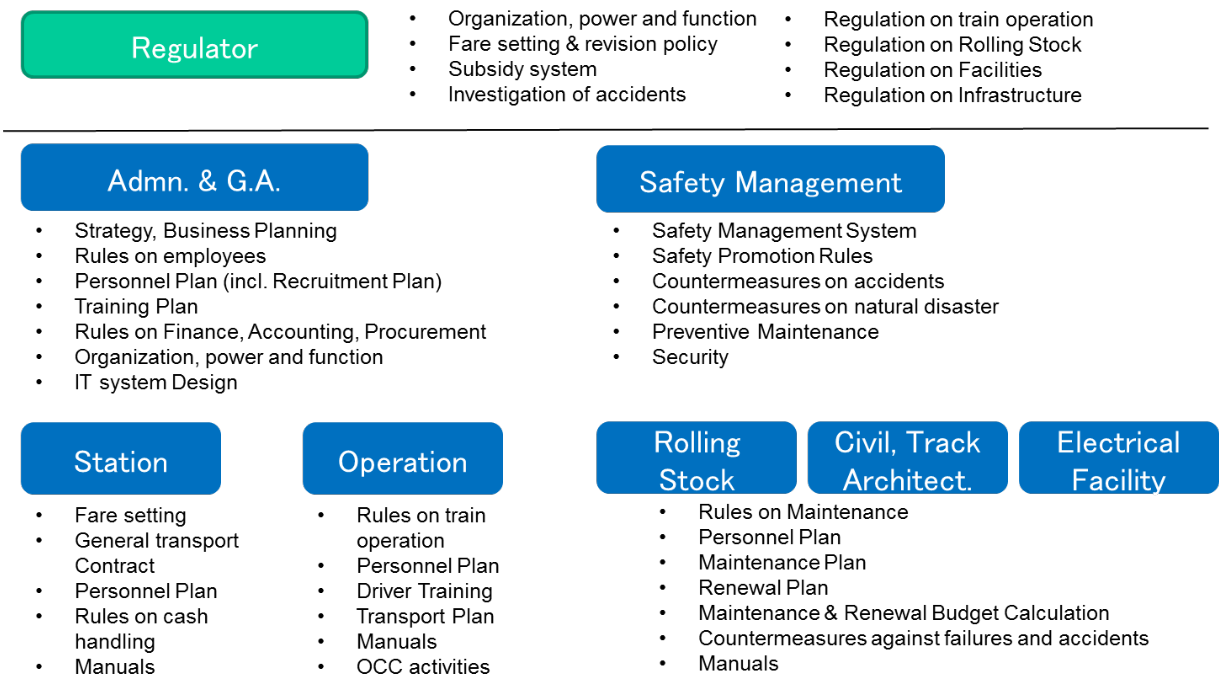
Though one of the Attached Agencies under the DOTC will have less experiences and know-how about urban railway systems at the beginning of the project, compared with as one of the departments of LRTA, it is recommended that the agency should be one of the Attached Agencies under the DOTC from the point of the governance. In order to fasten the decision-making, the relevant agencies within the DOTC should be reduced.

In any case, railway projects should be supported by experienced consultants and railway operators in other countries as suggested above.

Upon the implementation of the railway projects, staff training is indispensable.

Generally speaking, there are two targets. One is those in the regulator, and another is those in the operator. Both shall be trained through on-the-job-training. Training for those in the regulator shall consist of organization, fare policy, accident investigation, and regulation. Training for those in the operator training shall consist of all functions which a railway company should have.

The proposed contents of the trainings are shown in Figure 10.2.2-2



Source: *JICA Study Team*

Figure 10.2.2-2 Contents of Staff Training

10.3 Recommendation for O&M Structure

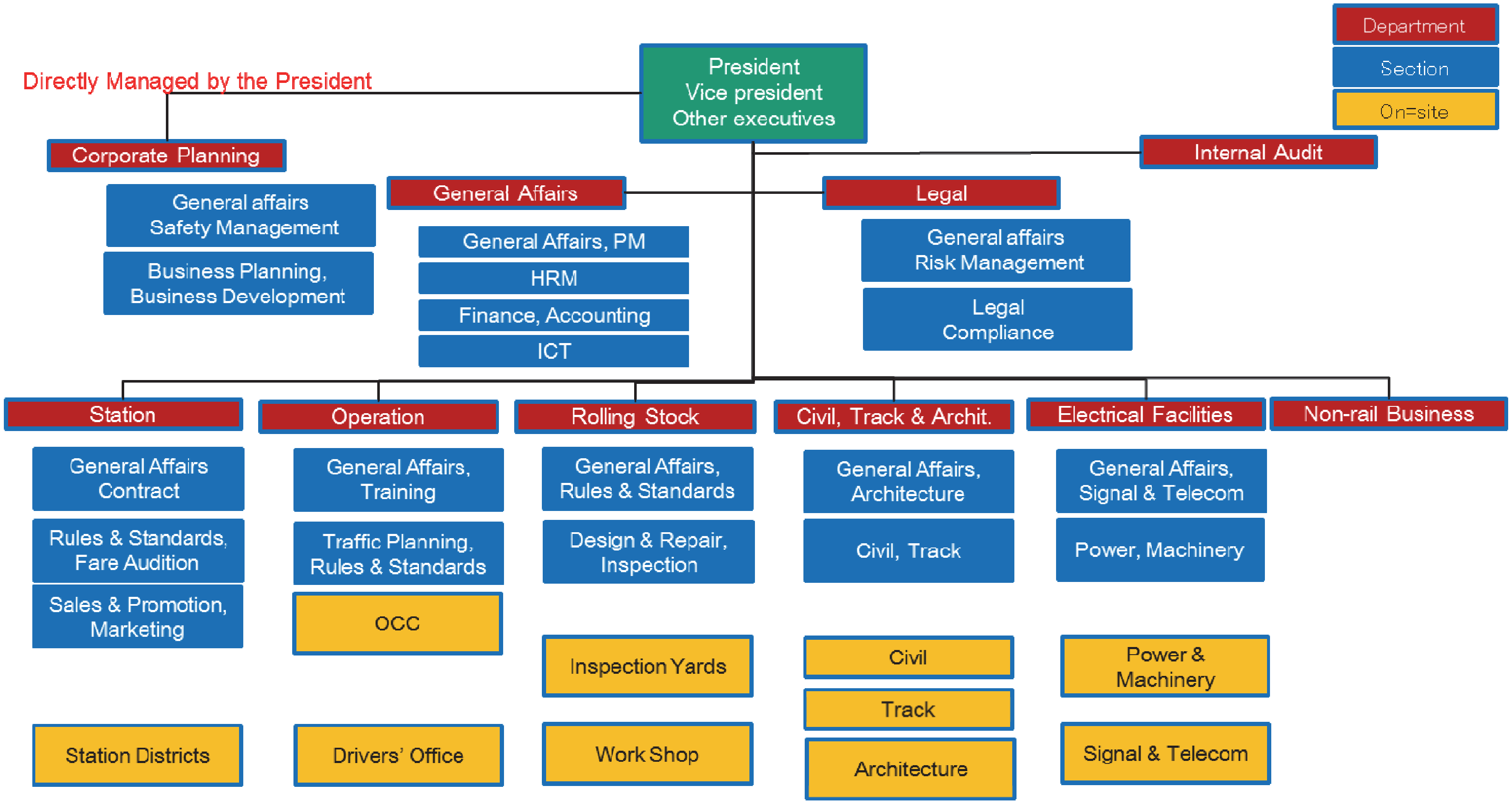
10.3.1 Organizations Structure of O&M Company

After the commencement of the revenue service of the railway, the railway system will be operated and maintained by an O&M company.

In order to manage the company and the railway systems efficiently, the organization of the company should be a functional structure with more specialized departments than the existing operators in the Philippines. The department for engineering should be subdivided in accordance with the similarity of the technologies to fulfill the responsibilities. It would be difficult to manage fields which require different specialties, for example trackwork and signal.

The department for engineering should have on-site offices to inspect their facilities, conduct light repair and supervise the maintenance contractors, assuming some maintenance activities are outsourced. If all the on-site activities would be outsourced, it would be very difficult to manage the maintenance contractors and also they lose opportunities to obtain know-how of maintenance activities.

The proposed organization structure of the O&M Company is shown in Figure 10.3.1-1.



Source: *JICA Study Team*

Figure 10.3.1-1 Proposed Organization Structure of O&M Company

10.3.2 Functions of Each Department

There are two major features on the functions.

First, both Corporate Planning and General Affairs departments shall have comprehensive power and responsibility to lead and support business departments. Especially, Corporate Planning Department is expected to be responsible for the establishment and management of the business plan and the safety issues, which are the most important issues of the railway company.

Since this organization structure is a functional structure, the possibility of problems caused by sectionalism will be still high. However, by being directly managed by the president, Corporate Planning Department is expected to adjust opinions from other departments. The department shall have a power to adjust opinions (at meetings and other opportunities) and to impose and manage KPI (Key Performance Indicator) of all departments in the O&M Company.

Second, Operation Control Center (OCC) department shall have strong leadership against on-site divisions to secure the operational safety as the highest priority. OCC department is expected to strongly lead other on-site divisions at all times. All on-site divisions have to follow orders and instructions of OCC department in terms of railway operation and maintenance.

Proposed major functions of each department are as described in Table 10.3.2-1

Table 10.3.2-1 Major Functions of Each Department

Department	Major Functions
Corporate Planning	• Safety Management • Corporate Vision, Strategy, Business Planning, Business Development • Supervising the other departments (except Internal Audit Dept.)
General Affairs	• General affairs, Document Management, Property Management, Human Resource Management, Finance, Accounting, ICT planning & implementation
Legal	• Legal Consultation, Lawsuits, Compliance Activity • Risk Management, Business Continuity Plan
Internal Audit	• Financial Audit • Safety & Operation Audit
HQs of O&M	• Managing on-site offices, Setting rules and standards, Managing Contracts • Staff training, Other unique activities
OCC	• Controlling and supervising operational & maintenance activities.
On-site offices (Operational)	• Operational Activities • Supervising Contractors (Security, cleaning etc.)
On-site offices (Maintenance)	• Inspection • Supervising maintenance contractors • Parts replacement, light repair, depend on offices (These activities will consider to be outsourced in the future.)

Source: *JICA Study Team*

As mentioned above, it is recommended that the O&M Company has engineering on-site offices which conduct inspections and so on to ensure the safety of railway operation by accumulating their special know-how with responsibilities. Table 10.3.2-2 shows the expected functions of each engineering on-site office.

Table 10.3.2-2 Functions of Engineering On-site Offices

Functions / Offices	Inspection	Maintenance Incl. part replacement	Light Repair	Heavy Repair	Renewal
Rolling Stock	X	X	X	-	-
Civil	X	-		-	-
Track	X	X	X	-	-
Architect.	X	-	-	-	-
Power & Machinery	X	X	X	-	-
Signal & Telecom	X	X	X	-	-

X: Insourcing, -: Outsourcing and supervising

Source: *JICA Study Team*

To conduct activities mentioned above, the estimated number of employees required will be approximately 2,300 in 2045 as shown in Table 10.3.2-3

Table 10.3.2-3 Staffing of O&M Company (Route: A1) as of 2045

Department	Headquarters	On-site Offices
Exclusives	7	
Auditors	3	
Corporate Planning	17	
Internal Audit	9	
Legal	17	
General Affairs	33	
Station	25	1107
Operation	17	OCC 47
		Drivers' Office 198
Rolling Stock	17	211
Civil, Track & Architecture	17	201
Electrical	17	333
Non-rail Business	25	
Total	**204**	**2,097**
		2,301

Source: *JICA Study Team*

10.4 Preliminary Operation and Maintenance Cost

Operation and Maintenance Costs are estimated from two elements, i.e. Personnel Costs and Other Costs (Expenses except personnel costs). As a reference of the estimation, some of similar subway operators in Japan, shown with yellow highlight, were picked up as indicated in Table 10.4-1.

There are ten subway operators in nine cities in Japan (two operators in Tokyo). Out of them, Tokyo Metro, Tokyo Gove., Nagoya and Osaka are too large to be the reference, therefore, other six operators, i.e. Sapporo, Sendai, Yokohama, Kyoto, Kobe and Fukuoka, were chosen as the reference. Their data was quoted from the report as of 2012 edited by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) of Japan.

Table 10.4-1 No. of Lines, Distance and No. of Stations of Japanese Subway Operators

City / Operator	No. of Lines	Operating Kilometrage (km)	No. of Stations
Tokyo Metro	9	195	179
Sapporo	3	48	49
Sendai	1	15	17
Tokyo Gov.	4	109	106
Yokohama	3	53	42
Nagoya	6	93	100
Kyoto	2	31	32
Osaka	8	130	123
Kobe	3	31	26
Fukuoka	3	30	36
Total	42	735	710

Source: *MLIT Report*

10.4.1 Personnel Costs

Personnel costs were estimated by multiplying the number of staff devised as the personnel plan and the average labor costs reported by the LRTA.

10.4.1.1 Personnel Plan

As a basis of estimation of the personnel costs, the personnel plan should be planned as shown in Table 10.3.2-3. The personnel plan was planned under the precondition as shown in Chapter 10.3.

The number of staff of each department was estimated in the following way;

(1) Headquarters

Within the average rate of the chosen Japanese subway operators' headquarters (HQ) employee occupancy rate out of the total employees. The number of the HQ staff will be fixed from the beginning because a part of them will be working on activities related to the extension of the railway and they will be responsible for the management of the whole railway systems after the commencement.

(2) Station Staff

On the basis of the number of gates, ticket office counters, platforms

(3) Drivers

On the basis of the number of train trips

(4) Inspection yard and workshop engineers

On the basis of the required staff for the regular inspection and other works, and the number of cars

(5) Other on-site engineers

In proportion to the operating car kilometrage and the number of staff of the chosen Japanese subway operators

The personnel plan for each route option is shown on Table 10.4.1.1-1

Table 10.4.1.1-1 Personnel Plan for Each Route Option

Route: A1 Unit: persons

	2025	2035	2045
Headquarters	204	204	204
On-site Offices	988	1,999	2,097
Total	1,192	2,203	2,301

Route: A2 Unit: persons

	2025	2035	2045
Headquarters	204	204	204
On-site Offices	995	2,003	2,104
Total	1,199	2,207	2,308

Route: A3 Unit: persons

	2025	2035	2045
Headquarters	204	204	204
On-site Offices	1,124	2,084	2,193
Total	1,328	2,288	2,397

Route: B1 Unit: persons

	2025	2035	2045
Headquarters	204	204	204
On-site Offices	988	1,994	2,093
Total	1,192	2,198	2,295

Route: B2 Unit: persons

	2025	2035	2045
Headquarters	204	204	204
On-site Offices	995	2,206	2,106
Total	1,199	2,206	2,310

Route: B3 Unit: persons

	2025	2035	2045
Headquarters	204	204	204
On-site Offices	1,124	2,079	2,193
Total	1,328	2,283	2,397

Source: *JICA Study Team*

Note: The above figures in 2035 and 2045 include the entire section of the MMS, covering north, central and south zones.

10.4.1.2 Personnel costs of each Route

As a result, the personnel costs of each alignment route option are as shown in Table 10.4.1.2-1.

Table 10.4.1.2-1 Personnel Cost of Each Route Option

Route: A1 Unit: 1,000 USD

	2025	2035	2045
Headquarters	2,239	2,239	2,239
On-site Offices	10,908	20,989	22,223
Total	13,148	23,228	24,462

Route: A2 Unit: 1,000 USD

	2025	2035	2045
Headquarters	2,239	2,239	2,239
On-site Offices	11,000	21,081	22,315
Total	13,239	23,320	24,554

Route: A3 Unit: 1,000 USD

	2025	2035	2045
Headquarters	2,239	2,239	2,239
On-site Offices	12,198	21,167	23,082
Total	14,438	23,936	25,321

Route: B1 Unit: 1,000 USD

	2025	2035	2045
Headquarters	2,239	2,239	2,239
On-site Offices	10,908	20,943	22,092
Total	13,148	23,182	24,331

Route: B2 Unit: 1,000 USD

	2025	2035	2045
Headquarters	2,239	2,239	2,239
On-site Offices	11,000	21,081	22,328
Total	13,239	23,320	24,567

Route: B3 Unit: 1,000 USD

	2025	2035	2045
Headquarters	2,239	2,239	2,239
On-site Offices	12,198	21,697	23,095
Total	14,438	23,936	25,334

Source: *JICA Study Team*

Note: The above figures in 2035 and 2045 include the entire section of the MMS, covering north, central and south zones.

10.4.2 Other Costs (Expenses except Personnel Costs)

10.4.2.1 Unit Costs

As a basis of the estimation of the operation and maintenance expenses except personnel costs, annual unit costs were calculated from the data of these six Japanese subway operators. Unit costs, which mean how much it costs per unit to operate or maintain the railway systems, were subdivided into several costs as shown in Table 10.4.2.1-1.

Table 10.4.2.1-1 Unit Costs

Unit: USD

Item	Costs	Unit /
Overhead	25,800	/ person (Administrations)
Advertising & Public Relations	4	/ 1000 passengers
Welfare	24	/ person (All the employees)
On-site Management	77,300	/ person (Related HQ staff)
Station Operation	487,940	/ station
(Train) Operation	279	/ 1000 operating kilometrage / car
Rolling Stock Maintenance	312	/ 1000 operating kilometrage / car

Track Maintenance (Incl. Civil & Architect.)	407	/ 1000 operating kilometrage / car
Electrical Facilities Maintenance	292	/ 1000 operating kilometrage / car

Source: *JICA Study Team*

10.4.2.2 Other Costs (Expenses except Personnel Costs) of Each Route Alignment Option

They are estimated as shown below,

- Overhead costs (estimated in proportion to)
  The number of the staff in Administrations
- Advertising & Public Relations costs
  The number of passengers
- Welfare costs
  The number of the staff
- On-site management costs (for headquarters)
  The number of the HQ staff who manage each on-site office
- Station operation costs
  The number of the stations
- (Train) operation costs
  Operating car kilometrage
- Rolling Stock maintenance costs
  Operating car kilometrage
- Track maintenance costs
  Operating car kilometrage
- Electrical Facilities maintenance costs
  Operating car kilometrage

The results of the estimation are shown in Table 10.4.2.2-1.

Table 10.4.2.2-1 Other Costs (Expenses except Personnel Costs)

Route: A1 Unit: 1,000 USD

	2025	2035	2045
Headquarters	9,659	10,203	10,498
On-site Offices	13,712	55,634	68,280
Total	23,371	65,837	78,778

Route: A2 Unit: 1,000 USD

	2025	2035	2045
Headquarters	9,641	10,206	10,504
On-site Offices	14,234	56,532	69,402
Total	23,875	66,738	79,906

Route: A3 Unit: 1,000 USD

	2025	2035	2045
Headquarters	9,689	10,253	10,579
On-site Offices	16,245	59,722	73,296
Total	25,934	69,975	83,875

Route: B1 Unit: 1,000 USD

	2025	2035	2045
Headquarters	9,659	10,296	10,568
On-site Offices	13,712	55,397	67,984
Total	23,371	65,693	78,552

Route: B2 Unit: 1,000 USD

	2025	2035	2045
Headquarters	9,641	10,302	10,604
On-site Offices	14,234	56,295	69,106
Total	23,875	66,597	79,710

Route: B3 Unit: 1,000 USD

	2025	2035	2045
Headquarters	96,89	10,360	10,671
On-site Offices	16,245	59,485	73,000
Total	25,934	69,845	83,671

Source: *JICA Study Team*

Note: The above figures in 2035 and 2045 include the entire section of the MMS, covering north, central and south zones.

10.4.2.3 Total Operation & Maintenance Costs

The total operation and maintenance costs are shown in Table 10.4.2.3-1.

Table 10.4.2.3-1 Total Operation & Maintenance Costs

Unit: 1,000 USD

	2025	2035	2045
A1	36,518	89,065	103,241
A2	37,114	90,057	104,460
A3	40,372	93,911	109,196
B1	36,518	88,875	102,883
B2	37,114	89,917	104,278
B3	40,372	93,780	109,005

Source: *JICA Study Team*

Note: The above figures in 2035 and 2045 include the entire section of the MMS, covering north, central and south zones.