HO CHI MINH CITY PEOPLE'S COMMITTEE
MANAGEMENT AUTHORITY FOR URBAN RAILWAYS
SOCIALIST REPUBLIC OF VIETNAM

THE PREPARATORY SURVEY ON HO CHI MINH CITY URBAN RAILWAY CONSTRUCTION PROJECT (BEN THANH - MIEN TAY TERMINAL (LINE 3A PHASE 1))

FINAL REPORT

JANUARY 2018

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS GLOBAL CO., LTD.
TOKYO METRO CO., LTD.
TONICHI ENGINEERING CONSULTANT CO., LTD.
PACIFIC CONSULTANTS CO., LTD.
ALMEC CORPORATION

1R
JR（先）
18-002

HO CHI MINH CITY PEOPLE'S COMMITTEE
MANAGEMENT AUTHORITY FOR URBAN RAILWAYS
SOCIALIST REPUBLIC OF VIETNAM

THE PREPARATORY SURVEY ON HO CHI MINH CITY URBAN RAILWAY CONSTRUCTION PROJECT (BEN THANH - MIEN TAY TERMINAL (LINE 3A PHASE 1))

FINAL REPORT

JANUARY 2018

JAPAN INTERNATIONAL COOPERATION AGENCY

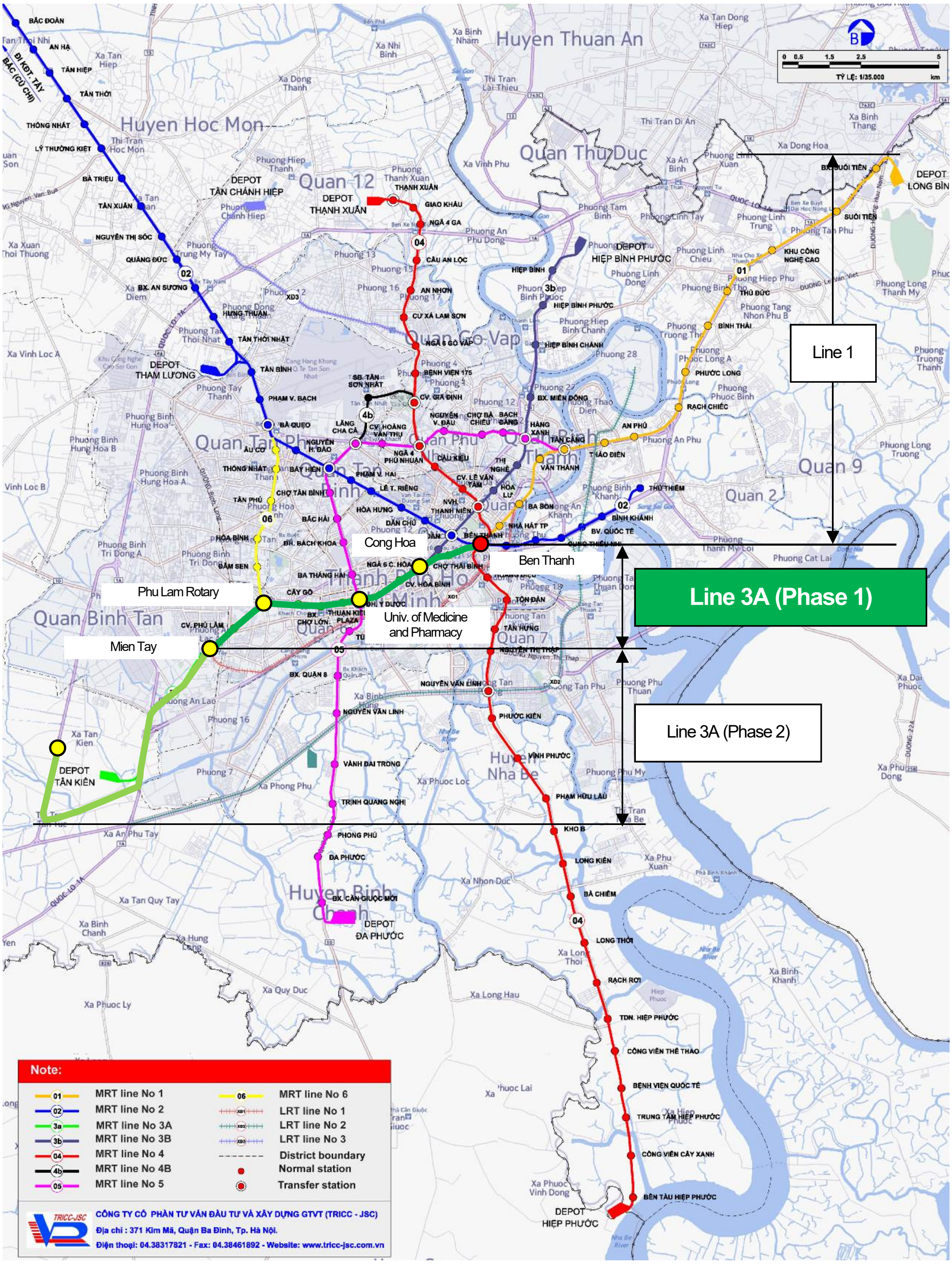
ORIENTAL CONSULTANTS GLOBAL CO., LTD.
TOKYO METRO CO., LTD.
TONICHI ENGINEERING CONSULTANT CO., LTD.
PACIFIC CONSULTANTS CO., LTD.
ALMEC CORPORATION

Exchange Rate Used in the Report

VND 1	= Yen	0.00461
USD$ 1.00	= Yen	101.3
USD$ 1.00	= VND	21,954

(As of November, 2016)

PROJECT LOCATION MAP



Note: Ben Thanh Station, which will be constructed under Line 1 Project, is not counted.

Source: 568/QD-TTg dated 08/04/2013, Decision of the Prime Minister

ABBREVIATIONS

ADB	Asian Development Bank
AFC	Automatic Fare Collection
ATC	Automatic Train Control
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATS	Automatic Train Stop
BAU	Business As Usual
BRT	Bus Rapid Transit
CAP	Corrective Action Plan
CBD	Central Business District
CBI	Computer Based Interlocking
CCB	Climate Change Board
C/P	Counterpart
CCTV	Closed-Circuit Television
CBTC	Communication Based Train Control
CDM	Clean Development Mechanism
DCSCC	District Compensation and Site Clearance Committee
DEG	Diesel Electric Generator
DMS	Detailed Measurement Survey
DOF	Department of Finance
DONRE	Department of Natural Resources and Environment
DOT	Department of Transport
DPA	Department of Planning and Architecture
DPC	District Peoples' Committee
DPI	Department of Planning and Investment
E&M	Electrical and Mechanical
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EIRR	Economic Internal Rate of Return
EMA	External Monitoring Agency
EMU	Electric Multiple-Unit
EVN	Electricity of Vietnam
FGM	Focus Group Meeting
FEED	Front End Engineering Design
FIRR	Financial Internal Rate of Return
F/S	Feasibility Study

GHG	Green House Gases
GIS	Gas Insulated Switchgear
GRM	Grievance Redress Mechanism
HAIMUD1	The Project for Studying the Implementation of Integrated UMRT and Urban Development for Hanoi
HAIMUD2	Project for Studying the Implementation of Integrated UMRT and Urban Development for Hanoi in Vietnam
HCMC	Ho Chi Minh City
HCMC-PC	Ho Chi Minh City Peoples' Committee
HDPE	High-density polyethylene
HOUTRANS	The Study on the Urban Transport Master Plan and Feasibility Study in HCM Metropolitan Area
ICR	Inception Report
IL	Interlocking
INV	Regenerative Inverter (INV)
IOL	Inventory of Losses Survey
IRP	Income Restoration Program
ITR	Interim Report
JCM	Joint Crediting Mechanism
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau
KOICA	Korea International Cooperation Agency
LEP	Law on Environmental Protection
LFDC	Land Fund Development Center
LRT	Light Rail Transit
MAUR	Management Authority for Urban Railways
M/D	Minutes of Discussion
METROS	Data Collection Survey on Railways in Major Cities in Vietnam
MOC	Ministry of Construction
MOCPT	Management and Operation Centre for Public Transport
MONRE	Ministry of Natural Resources and Environment
MOT	Ministry of Transport
MPI	Ministry of Planning and Investment
MRV	Measurement, Reporting, Verification
NAMA	Nationally Appropriate Mitigation Action
NGO	Non-Governmental Organization
O&M	Operation and Maintenance
OCC	Operation Control Center
OCR	Ordinary Capital Resources

OD	Origin-Destination
ODA	Official Development Assistance
PAP	Project Affected Person
PC	Pre-stressed Concrete
PHPDT	Peak Hour Peak Directional Traffic
PMSM	Permanent Magnet Synchronous Motor
PPID	Project / Program Investment Decision
PPIP	Project / Program Investment Policy
PPTA	Project Preparation Technical Assistance
PSD	Platform Screen Door
PTA	Public Transport Authority
RAMS	Reliability, Availability, Maintainability, Safety
RAP	Resettlement Action Plan
RCS	Replacement Cost Survey
ROW	Right of Way
RPF	Resettlement Policy Framework
RSS	Receiving Substation
SAH	Severely Affected Household
SCADA	Supervisory Control And Data Acquisition
SHM	Stakeholder Meeting
SIV	Static Inverter
SP-RCC	Support Program to Respond to Climate Change
SSS	Service Substation
SSTA	Short Scale Technical Assistance
STEP	Special Terms for Economic Partnership
SV	Stored Value (Card)
TBM	Tunnel Boring Machines
TOD	Transit Oriented Development
TOR	Terms of Reference
TSP	Total Suspended Particular
TSS	Traction Substation
UMRT	Urban Mass Rapid Transit
VCR	Volume Capacity Ratio
WB	World Bank
WG	Working Group

EXECUTIVE SUMMARY

NEED FOR PROJECT

Travel demand in HCMC has increased significantly during the last decade from 11.5 million person trips/day (excluding walking and intra-zonal trip1) in 2002 to 16.7 million in 2013. The trend is that people prefer private transport and are gradually shifting to the use of Car. This may lead to more serious traffic congestions.

HCMC Line 3A is located at south-western area of the city, which connects from Ben Thanh Station of the city center, where will be an intermodal station of Line1, 2 and 4, to the suburban area to the south-west. It is expected to contribute to expand public railway transport service between east and west areas of the City, and to increase ridership and convenience of Line1 passengers which the Japanese Government provide technical and financial assistance. For this, the HCMC Government prioritizes the Line 3A project for implementation.

In the approved plan, one of the major objectives is to develop urban railway network in the city which promote modal shift from private vehicle to public transport, and specific targets for urban railway project implementation are indicated. This project is to contribute to mitigate worsening traffic congestion and to reduce pollutions caused by traffic by construction of urban mass rapid transit system in place to road transport in the metropolitan of HCMC.

DEMAND FORECAST

The ridership of the line was estimated for years 2027, 2030, 2040 and 2050. The number of boarding passengers per day in 2027 is 244,700 and will become 404,800 in 2030 after extension of Phase 2 (C11-C17) section. In 2050, it will reach 561,300 passengers per day.

Many of the passengers come from Line 1 and directly go through Line3A as the entire operating line. The station with the highest number of two-way passengers per day in 2027, except for Ben Thanh Station, is C8 Phu Lam Rotary with over 25,000 passengers for each boarding and alighting. The second is C10 Hoa Binh with over 18,000 passengers per boarding and alighting likewise.

Table 1 Traffic Demand Forecast

Year		2026	2030	2040	2050
Section		C0-C10	C0-C17	C0-C17	C0-C17
No. of Boarding Passenger (Pax/day)	C0-C10	244,700	344,200	398,500	473,700
	C11-C17	-	60,600	77,000	87,600
	Total	244,700	404,800	475,500	561,300
PPHPD (Perk rate 12%) (Pax/Hour/Dir.)		13,500	19,300	22,100	25,000
Off Peak Hour Line Volume (5%) (Pax/Hour/Dir.)		5,600	8,000	9,200	10,400
Pax km (Pax km / day)		1,456,543	2,750,746	3,330,325	3,848,330
Ave. Travel Dist. (km)		5.7	6.8	7.0	6.9
Fare Revenue (million VND/day)		6,369	9,635	11,300	13,322

Source: JICA Study Team

ROUTE SELECTION

The selected route envisages underground structure at central and sub-central districts of HCMC, i.e. from Ben Thanh (beginning point) to C8 Station, with due considerations of resettlement, landscape, and other environment issues, while viaduct structure is proposed in the remaining section as no obstructions to build elevated structures are identified. With regard to construction cost, this Option possibly reduce about 15% of civil works cost, which derives from alterations from underground to elevated structures for 2km out of 10km in total length. The above alternatives of alignment and structures were thoroughly discussed with MAUR and agreed in principal.

In order to build the elevated section, power cables situated in the road median need relocation to underground level for about 3.6km from C8 to C10. The meeting with EVN concluded that power cables will be relocated to underground.

PROJECT DESIGNS

In the course of this study, the Study Team reviewed F/S and established project plans as summarized in the following table.

Table 2 Project Plans of F/S and This Study

Item	F/S	This study
Section	Starting point : Ben Thanh Station* Ending point : Mien Tay Terminal Station	
Total length**	Double track with about 9.9 km	Double track with about 9.9 km
Underground section	9.9km	8.2 km
Elevated section	-	1.7 km
Number of stations	10 stations	10 stations
Underground station	10 stations	8 stations
Elevated station	-	2 stations
Average interval	970 m	970 m
Demand forecast	In opening year of 2015	In opening year of 2027
Daily average ridership	127,000	244,700
PHPDT	5,800	13,500
Operation hours	5:00 - 23:00	5:00 - 23:30
Operation interval	In opening year of 2015	In opening year of 2027
Peak hour	11 trains/hour	14 trains/hour
Off peak	5 trains/hour	6 trains/hour
Location of Depot		
Phase 1	Common use of Suoi Tien Depot of Line 1	
Phase 2	Tan Kien Depot of Line 3A	

Source: Study team

DESING PARAMETERS AND SYSTEM FEATURES

Design Parameters and system features of the project are shown below.

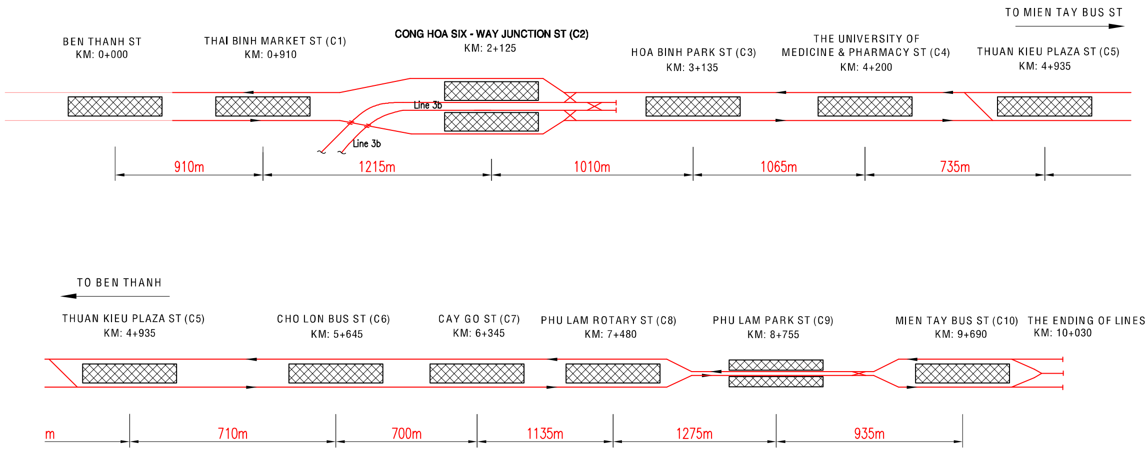
Table 3 Design Parameters and System Features

Item		Specifications
Operation	Designed maximum speed	Elevated section : 120km/h Underground section : 80km/h
	Operational direction	Right side
Construction standards	Gauge	1,435mm
	Rail	60kg/m
	Minimum horizontal curve radius	300m
	Minimum vertical curve radius	3,000m
	Maximum cant	150mm
	Maximum grade	3.5 %
	Minimum distance between tracks	3.7m
	Design axial load	14ton or 16ton
	Width of formation level	2,750mm
	Effective platform length	130m
Structures	Stations	Underground section: Two stories of cut and cover tunnel, Elevated section: Single pier and double piers
	Between stations	Underground section: Shield tunnel (single line - twin tubes), Transition section : Cut and cover tunnel and U-shape retaining wall, Elevated section: Viaduct with PC U-shape girder
Rolling stocks	Body dimensions	lengh:19.5m, width :2.95m
	Train consist	Maximum 6 cars
	Maximum output	190kW
	Capacity	942 passenger / trainset (6 car trainset, 3 pax/m^2)
Electric System	Electrification system	DC- electrification
	Current feeder system	DC1,500V
	Receiving substation	110/22 kV 25MVA x 2unit
	Catenary system	Overhead contact system
	Span Cycle	Underground section : 5m, Elevated section : 50m
Signaling	Signaling system	Automatic block system, train radio device
	Train control system	ATS (Automatic Train Stop), ATP (Automatic Train Protection), ATO (Automatic Train Operation)
Communication system	Communication system	Telephone system, dedicated telephone system, train radio, public address system, passenger information display system, CCTV, clock system and data transmission system

Source: Study team

TRAIN OPERATION PLAN

Track layout of Line 3A is proposed as follows.



Source: Study team

Figure 1 Track Layout

Year-wise transport plans are summarized in the following table, where Daily Line Volume in 2030 and beyond incorporates the ridership of Phase 2 section.

Table 4 Transport Plan

			Base Case (C0 - C10)	3A Extension Case (C0 - C17)	
			2027	2030	2040
C0 Ben Thanh~C1 Thai Binh		Daily Line Volume (Passengers)	244,700	404,800	475,500
	Peak time	Peak Hour Peak Direction Traffic	13,500	19,300	22,100
		Number of Trains/Hour	14	25	26
		Headway	0:04:20	0:02:25	0:02:20
		Transport Capacity (Passengers)	13,188	23,550	24,492
		Congestion rate (%)	102%	82%	90%
	Off-peak time	Peak Hour Peak Direction Traffic	5,600	8,000	9,200
		Number of Trains/Hour	6	12	12
		Headway	0:10:00	0:05:00	0:05:00
		Transport Capacity (Passengers)	5,652	11,304	11,304
		Congestion rate (%)	99%	71%	81%
Operating hours			5:00 ~ 23:30		

Source: Study team

Fleet requirements and timing of expansion to meet the transport plans are summarized as follows:

Table 5 Fleet Requirements

	2026	2030	2040
Fleet requirement (Number of train)	10	23	24
Fleet requirement (Number of cars)	60	138	144

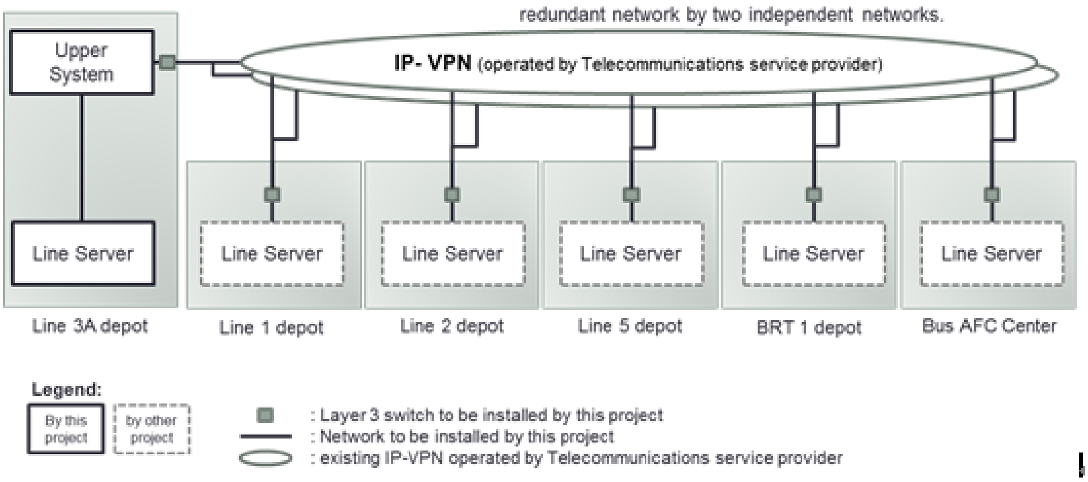
Source: Study team

RAILWAY SYSTEMS, ROLLING STOCK, DEPOT & WORKSHOP

Outline specifications of railway systems and rolling stock shall be based on those of Line 1 as interoperation between Line 3A and Line 1 is envisaged. Advantages of this standardization include avoidance of human errors due to difference in specifications, reduction in Maintenance and procurement costs, and others. Line 3A at the early years of operation will use the Line 1 depot, while additional depot will be developed for Line 3A upon extension of the line.

INTEGRATION OF FARE COLLECTION SYSTEMS

The study team assumes the services with two options: 1) MRT card issuing and ownership of fare are under MAUR, and 2) those are under MRT company. On those conditions, the functions to be covered by the AFC system at the upper level include Card Management, Blacklist Management, Revenue Management, Statistics management, and Clearing between entities. It is assumed that the servers for the upper system will be installed in the server room to be built in the Line 3A depot; and the network between the upper system and each transport modes will be realized via IP-VPN like Japanese system. The economic value mentioned above can be expected to be approximately 7 billion JPY after deducting the implementation and 5 year maintenance costs of the upper system.



Source: Study team

Figure 2 Network between Upper System and Each Transportation Mode

STATION AREA & INTERMODAL TRANSFER FACILITY DEVELOPMENT

Influenced areas along the corridor are divided into 3 levels including (i) cluster level including several station areas of homogenous characteristics, (ii) walking distance of each station (500m-1km radius from station), and (iii) at and around station.TOD will accelerate to convert balanced and mixed landuse, to promote urban redevelopment of built-up areas and to promote commercial and business activities.

If TOD concept is applied in line with Line3A development, new urban areas with mixed-use residential facilities will be developed by application of urban redevelopment of degraded low-rise and high dense residential areas and 30% of night population will be increased in 2030. In daytime, thanks to development of commercial and business districts and facilities between the city center and suburban areas, 70% of daytime population (employment) will be additionally increased.

Proposed regulations in TOD area are as follows:

Table 6 List of TOD Projects

Category	Coverage	Project	Contents
Transport improvement	Area within walking distance (500m-800m radius)	Road improvement	to improve carriageway and sidewalk condition of main trunk roads and distribution roads to ensure accessibility to the station
		Road development and widening	to develop new roads and/or widen existing roads in compliance with the Zone Plan to formulate road network around the station
		Access alley improvement	to improve condition of alleys (re-pavement, drainage, street light, road marking, etc.) to ensure accessibility from built-up areas to the station
		Intersection improvement	to improve intersection (signal, pedestrian crossing, road marking, etc.) to ensure pedestrian's safety for crossing and to manage traffic flow
	TOD Area	Priority road within TOD area	to develop roads at the station which are indispensable to access to the station
		Station plaza	to develop intermodal facilities and environmental space (pedestrian plaza, open space, etc.) in an integrated manner at the intermodal stations
		Bus terminal	to operate feeder buses including UMRT relay bus and circulating bus at the terminal stations and/ or intermodal stations
		Pedestrian crossing	to ensure safety, time-saving of pedestrian crossing of intersections
		Underground walkway	to ensure safety, time-saving of pedestrian crossing of intersections and transferring to other stations
		Underground parking facility	to develop underground parking facility where is difficult to secure at-ground space for parking in built-up areas
		Parking space	to ensure parking space for motorbikes and bicycles at the station plaza, space under the UMRT viaduct, public spaces such as roads, sidewalk space and parks
		Bus stop	to ensure smooth accessibility between UMRT station and buses near the station
		Traffic management	to install signals, pedestrian facilities, road marking, traffic signs, tactile for visually impaired person, designated lanes for motorbike, bus priority lane, etc.
Integrated urban development	Station and transport related facility	Development of space inside the station	To develop commercial and service facilities such as kiosk, café, bookstore, convenience store, etc. inside platform and concourse space mainly for UMRT users
		Development of space under the viaduct	To develop commercial and service facilities such as convenience store, supermarket, retail shops, nursery, parking, etc. under the viaduct of elevated railway mainly for UMRT users and local communities
		Development of station building	To develop the station building at and above the UMRT station to formulate a landmark of the station with distinguished urban facilities such as hotel, office, clinic, apartment, as well as public service facilities
		Development of underground facilities	To develop underground mall and parking space to promote subway use and to alleviate congestion around the station and to promote integrated development with neighboring facilities by connecting underground walkways
		Redevelopment of railway related lands	To develop VNR owned lands including depots and factories to promote integrated development to formulate a new CBD and regional center
		Redevelopment of bus terminal	To redevelop bus terminal land to improve connectivity between UMRT station and provide convenient services such as department store, hotel, etc.
	Area around the station	Redevelopment of public facilities and factories	To promote redevelopment of public facilities and factories which will be relocated to develop multi-purpose complex including apartments for resettlement and public facilities
		Redevelopment of high-dense residential areas, old apartment areas	To promote improvement and redevelopment of existing residential areas and apartments by providing new apartment flats inside the project area
		Development of new towns along UMRT railway	To develop new towns with urban facilities along railway in suburban areas, with business revenues generating a capital gain that covers the cost of construction of railway and new towns and promoting UMRT ridership

Source: Study team

TRAFFIC MANAGEMENT & SAFETY MANAGEMENT

The traffic management plan is proposed as follows:

- Road closing is planned for C1, C2 and C3 station, but important intersections is always maintained during the construction.
- The traffic diversion is planned for C4, C5, C6 and C7 using temporary deck.
- The traffic diversion is planned for C9 and C10 station in the elevated section ensuring traffic road and construction section on the same road.

With respect to the safety management, safety training for Line 3A by the Contractor needs to focus on three serious accidents, namely 1) falling accident, 2) construction machinery accident and 3) accident by flying and falling objects, and it should be held on a regular basis as duty. Safety management organization and system will be established in order to flow the information and communication properly using IT system. Also, the documents of “Safety manual” and “Safety Case Studies” issued by JICA and MOC of Vietnam in 2012, “The guidance for ODA construction work safety management” issued by JICA in 2014 will be included in bidding documents for the Contractor as reference to encourage compliance.

PROJECT IMPLEMENTATION PLAN

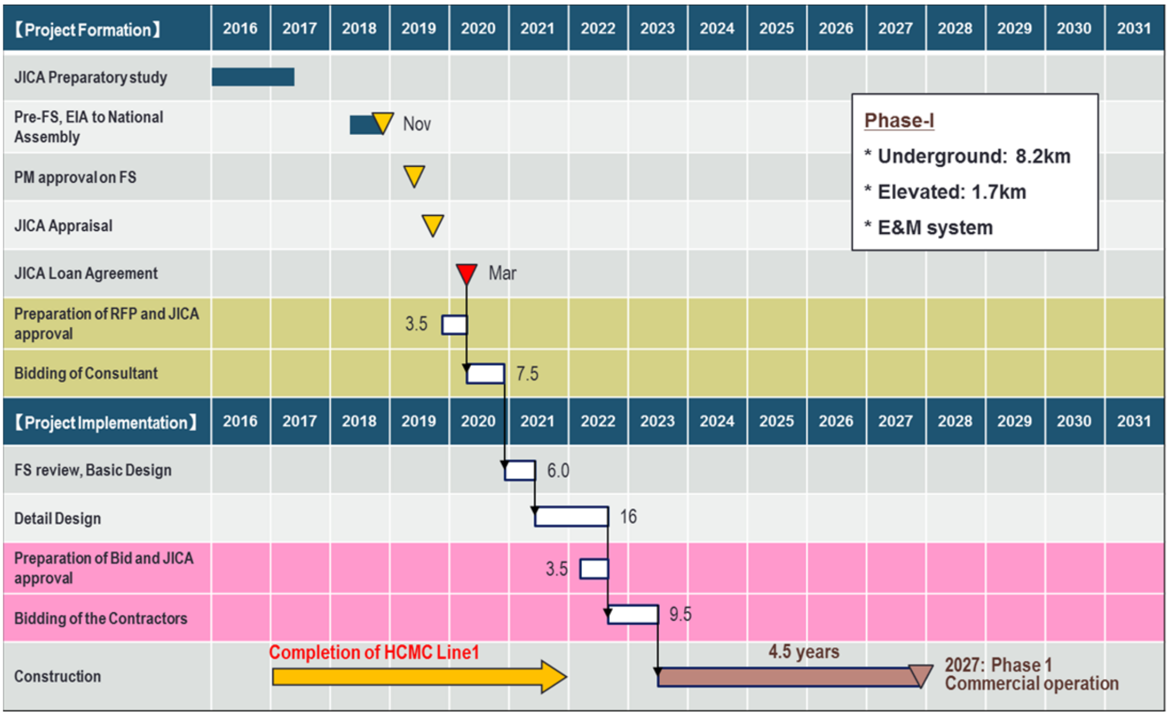
Contract packages

Non-Disclosure Information

Total Investment Cost

Non-Disclosure Information

The construction period for Line 3A phase 1, which is mainly underground civil works, seems to be 4.5 years including civil works (underground and elevated section), procurement for rolling stocks and the railway system (including the detailed design by the contractor, fabrication, installation, individual functional and performance test), whole system integration, commissioning and trial running before revenue operation.



Source: Study team

Figure 3 Project Implementation Schedule

PROJECT IMPLEMENTATION STRUCTURE

MAUR will be responsible for project implementation and official coordination with line departments, HCMC-PC and JICA as the implementing agency. Project management will be jointly carried out by MAUR and the consultant hired by MAUR. MAUR will be under the supervision of the Project Steering Committee with the leadership of HCMC-PC as the chairman. Day-to-day coordination with districts and community stakeholders will be handled by MAUR.

MAUR is increasing technical and construction / procurement supervision capacity through on-the-job training by way of implementation of Line 1, Line 2 and Line 5 projects. Also, MAUR deepens understandings of urban railway systems through various studies and technical assistance programs under JICA and ADB initiatives. Furthermore, majority of MAUR personnel experienced or start experiencing JICA ODA loans and ADB co-financing schemes through Line 1, Line 2 and Line 5 projects. Therefore, with the capacity gained, MAUR is expected to formulate and implement the Project in smooth and efficient manner.

Creation of the O&M Company under MAUR was decided in December 2015 as the result of past studies below. Preparatory works for opening to public are being handled by the preparation unit within MAUR. In this study, a manpower profile of Line 3A Phase 1 was estimated as 201 persons. With regard to the capacity building on operation and maintenance, JICA already provided technical assistance for establishment of the O&M Company and maintenance management. The assistance will be extended till the start of commercial operation. Therefore, MAUR will equip operational readiness at the time of implementing the Project.

ENVIRONMENTAL & SOCIAL CONSIDERATIONS

In the course of this study, 2 Stakeholder Meetings were carried out at the time of scoping and DF/R. Along with the results of environmental and social surveys and the stakeholder meetings, reports on Environmental Impact Assessment (EIA) and Resettlement Action Plan (RAP) were prepared.

PROJECT APPROVAL PROCEDURE

Necessary procedures for project approvals include "Program/Project Investment Policy" (PPIP) and "Program/Project Investment Decision" (PPID). Application for PPIP shall be made with pre-F/S, certification documents of EIA, and documents related to financial portfolio of the Project. "Decision on Application and Management of ODA Loan" specifies the period of RPF preparation and approval at "preparatory stage for PPID". RAP shall be prepared and approved by Vietnamese side at early stage of project preparation and disclose at the website of the donor.

GENDER CONCERNS AND PROTECTION OF DISADVANTAGED

With respect to gender concerns and protection of disadvantaged, the Gender Action Plan (GAP), Action plan for labour protection, poverty reduction and anti-infection, and Universal Design Action Plan (UDAP) proposed by this study shall be embodied in the project designs and monitoring frameworks.

CLIMATE CHANGE MITIGATION

The annual GHG emission reduction by the project is increased from 6,606 ton in the opening year to approximately triple at 20,185 ton in 2050 due to the increase in the number of annual passengers and the average distance travelled by a passenger. The total reduction by the Project for 25 years till 2050 is 388,671 ton, giving an annual average of 15,547 ton.

PROJECT EVALUATION

Based on the estimated revenues and costs, the FIRR and EIRR indicates 7.60% and 9.55%, respectively. The financial internal rate of return is a relatively low number in this project since the underground section is the majority . However, this project is an economic infrastructure development with a high public nature, and it is necessary to judge the projectability together with the economic internal rate of return.

The proposed Operation and Effect Indicators include availability ratio, mileage, number of trains per day, ridership, reduction in journey time, reduction of GHG emission, accident rate during construction, number of socially vulnerable and female passengers. For the quantitative indicator, we set the target value for the target year targeted at 2 years after completion, along with the reference value.

Qualitative effects include i) traffic alleviation, improvement of traffic conditions, relief of traffic pollution, ii) reduction in GHG emissions, mitigation of climate change, improvement of living environment by reducing air pollution and noise, iii) improvement of convenience by more efficient and punctual railway transportation in the area, iv) improvement of the city's investment climate, promotion of redevelopment along the corridor, development of peripheral regional economy, v) generation of employment opportunities (including promotion of gender equality), etc.

RISK MANAGEMENT

The Study Team summarized the points to note in the project implantation and prepared the Risk Control Sheet using the JICA format. The project stakeholders shall carefully manage the risks by use of this sheet throughout the project, beginning with project appraisal, during implementation and preparation for commercial operation, and at the operation stage. Once the Loan Agreement is reached, MAUR and consultants will be required to periodically update the sheet, share the observed potential risks with JICA as the donor agency, and take appropriate actions to manage the risks.

CAPACITY BUILDING AND TECHNICAL ASSISTANCE

At the time of implantation of the Project, ranges of capacity building and technical assistance for the Line 1 project had already completed. Therefore, programs for the Project should focus on the activities to enhance values of urban railway service and associated area development along the corridor, encompassing 3 pillars, namely "Establishment of integrated management structure for urban railway network", "Enhancement of the functions of station areas", and "Improvement of urban railway services".

WAY FORWARD

The expected project schedule after this report is as follows:

- Submission of documents for PPIP from HCHC-PC to the Central Government Feb. 2018
- Approval of PPIP Nov. 2018
- JICA Fact Finding Mission Aug. 2019
- JICA Appraisal Mission Oct. 2019
- ODA Loan Agreement Mar. 2020
- Approval of PPID During D/D

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

Page

CHAPTER 1 INTRODUCTION

1.1 General

1.1.1 Background and Objective of the Survey

Ho Chi Minh City (hereinafter referred to as "HCMC"), which is the largest city in Vietnam, predicts city's population from 5.3 million in 2000 to 7.43 million in 2013 including immigrations and visitors. It is also predicted that the city population will reach approximately 9.0 million in 2030.

Together with the population increase, the number of motorbike and car has increased dramatically in HCMC. Thereby, increasing traffic volumes in the roads have caused not only chronic traffic congestion but also air pollution. As a result, efficient economic and social activities are suffocated.

HCMC revised the urban transport master plan approved by Prime Minister in January, 2007 (Decision No. 101/QD-TTg). As a result, HCMC has been planning to construct 8 routes of urban railway. Now, there are 3 urban railways including Line 1, Line 2, and Line 5 under implementation.

Line 3A will run from Ben Thanh station, which is located in eastern part of HCMC and is a junction for Line 1 Line 2 and Line 4, to south west area passing through the city center. It is expected to expand railway network and to improve accessibility for citizens by connection with Line 1 directly. Thus, Line 3A is one of the top priority railway projects in HCMC.

Based on the feasibility study (hereinafter referred to as "F/S") conducted by Management Authority for Urban Railways (hereinafter referred to as "MAUR") in 2012, MAUR has been anticipating this project to be implemented as Japan’s ODA from Japanese government.

The purpose of the Preparatory Survey (hereinafter referred to as "the Survey") is to gather information for appraisal of the Project for Japan’s ODA Loan which requires "objective of the Project", "summary", "project cost", "implementation structure" "operation and maintenance", "environmental and social consideration", and "possibility of technical connection with other urban railways".

1.1.2 Project Goal

The objective of the Project is to alleviate serious traffic congestion in HCMC by constructing urban railway, thereby contributing not only for economic and social development but also vulnerabilities in the regions.

1.2 Scope of the Survey

1.2.1 Project Site

Project site to be surveyed is the proposed corridor for the Urban Railway Line 3A Phase 1, i.e. Ben Thanh to Mien Tay Terminal (approximately 9.7 km, underground, 10 stations[1]) in HCMC.

1.2.2 Counterpart and Other Concerned Agencies

Counterpart (hereinafter referred to as "C/P") and other concerned agencies are as follows.

C/P Agency

- Management Authority for Urban Railways (MAUR)

Other Concerned Agencies

- Ho Chi Minh City People's Committee (HCMC-PC)
- Department of Planning and Investment (DPI)
- Department of Finance (DOF)
- Department of Transport (DOT)
- Department of Planning and Architecture (DPA)
- Department of Natural Resources and Environment (DONRE)
- Ministry of Finance (MOF)
- Ministry of Planning and Investment (MPI)
- Ministry of Transport (MOT)
- Ministry of Construction (MOC)
- Ministry of Natural Resources and Environment (MONRE)

1.2.3 Objective of the Survey

The objective of the survey is gathering information for appraisal of the Project for Japan's ODA Loan which requires "objective of the Project", "summary", "project cost", "implementation structure" "operation and maintenance", "environmental and social consideration", and "possibility of technical connection with other urban railways".

1.2.4 Scope of Works

In light of the objectives of the Survey, scope of works is prescribed as follows.

[1] Ben Thanh Station, which will be constructed under Line 1 Project, is not counted. Scope of the Line 3A Project includes the works to provide physical connection to Line 1 system.

Table 1.2.1 Scope of Works

Task		Sub-Task	
0100	Preparation of Inception Report and initial coordination meetings		
0200	Confirmation of Rationale and Background of the Project		
0300	Confirmation of Route Alignment	0310 0320 0330 0340	Review of route alignment in F/S Traffic demand forecast Review of modal split model Development of evaluation criteria for route selection
0400	Preparation of Project Designs	0410 0420 0430 0440 0450 0460 0470 0480 0490	Route alignment and facility plan Civil infrastructure plan (tunnel, viaduct, station, trackwork) Train operation plan Review of rolling stock design specification Depot plan Electrical and mechanical facility plan Signalling and communication facility plan Automatic fare collection system and integration plan Station Area Development/ intermodal transfer facility plan
0500	Preparation of Interim Report		
0600	Preparation of Project Implementation Program	0610 0620 0630 0640 0650 0660 0670	Outline construction plan Traffic control plan and safety management plan Procurement plan and proposal of construction method Applicability assessment of Japanese technology Proposal of project implementation schedule Proposal of consulting service including TOR and manning plan Proposal of project implementation cost
0700	Examination of Project Implementation Structure	0710 0720 0730 0740	Review of financial condition, budget structure, and management skills of implementing agency Examination of O&M scheme and structure Project implementation structure Proposal of additional technical cooperation for implementing agency and O&M company
0800	Analysis of Environmental Impact	0810 0820 0830	Review and enhancement of EIA Report Assistance for stakeholder coordination meetings and JICA advisory committee meetings Conduct of supplemental EIA study
0900	Analysis of Social Impact	0910 0920 0930	Review and enhancement of resettlement plan Assistance for stakeholder coordination meetings and JICA advisory committee meetings Conduct of full RAP study
1000	Analysis of Gender Relations etc. for Inclusive Approach	1010 1020	Universal designs Needs analysis in terms of gender, poverty, labor, Project Affected Persons (PAPs), potential users, etc.
1100	Estimate of the Effect of Climate Change Mitigation Strategy	1110 1120 1130 1140	Data collection for quantitative analysis Estimate of reduction in Greenhouse Gas emission Examination of the applicability to Clean Development Mechanism (CDM) Study on Japan's past contribution to Climate Change Mitigation and its relation to the Project
1200	Estimate of Project Effect	1210 1220 1230 1240 1250 1260	Estimate of quantitative effects Estimate of qualitative effects Public Relations - Preparation of 3D animation movie Public Relations - Preparation of schematic views Public Relations - Preparation of project brochure Public Relations - Publicity to Japan's ODA

Task		Sub-Task	
1300	Works of Other Issues for Project Readiness	1310 1320 1330	Examination of issues on project implementation structure and organization Examination of issues on O&M structure and organization Assistance in preparation of F/S and EIA by the Vietnamese side
1400	Works of Miscellaneous Items	1410 1420 1430 1440 1450	Conduct of study program in Japan Preparation of explanatory materials on approving procedures of Japan's ODA loan projects in Vietnam Potential assessment of co-finance with ADB Assistance in preparation of explanatory meeting by JICA Study on the circumstances of system assurance (RAMS)
1500	Proposal of Human Resources Training (Technical Cooperation) Programs		
1600	Preparation of Draft Survey Report		
1700	Preparation of Final Survey Report		

1.2.5 Phase 2 (C11-C17) Section

During this study, HCMC-PC and C/P strongly requested Japan side to assist pre-F/S preparation of Phase 2 (Mien Tay-Tan Kien) section in addition to the thorough study on Phase 1 (Ben Than-Mien Tay Terminal), aiming the project approval of the both sections at the same time. In order to respond to their request, JICA and the Study Team entered into the revised contract.

With respect to the Phase 2 section, the Team carried out F/S review, study on demand forecast, route selection, train operation, structures, facility, depot, station area and intermodal transfer facilities, project cost, project implementation plan, etc. <u>with particular focuses on technical considerations which are necessary for the project approval by the National Assembly</u>. Meanwhile, Vietnam side was fully responsible for social and environmental studies.

These survey results were already incorporate to the application form of the National Assembly approval, i.e. pre-F/S and submitted to C/P. In this Final Report, only the technical subjects relevant to the integration with Phase 1 section are <u>provided at each chapter / section as the Appendix</u>.

In the event Phase 2 on top of Phase 1 section should be financed by the Japanese ODA Loan, conduct of additional preparatory survey for Phase 2 section will be necessary.

1.3 Report Contents

Objective of this report is to provide all the outputs of this Survey.

Chapter 2 prescribes background and "Need for Project" by making clear the status quo, issues, challenges, and consistency between the Project and transport sector policies.

Chapter 3 develops and evaluates route alternatives of the Project after review of the alignment designs of the past studies. Also, this chapter performed and analyzed traffic demand forecast for the selected route alignment.

Chapter 4 presents outline project designs and preliminary cost estimate thereof. The outline project designs include route alignment, civil works and infrastructure, train operation, rolling stock, depot and maintenance equipment, electrical and mechanical systems, signalling and communication systems, automatic fare collection system and smartcard integration.

Chapter 5 reports the progress of activities on station area development and intermodal transfer facilities with an aim to enhance the project performance. This includes site visit and recommendations by the JICA Advisory Group composed of Japanese railway operators.

Chapter 6 proposes project implementation plans including construction plan, traffic management plan, safety management plan, applicability of Japanese technologies, project implementation schedule, project cost estimate, and consulting services.

Chapter 7 evaluates the financial and technical capacity of implementing agency and operation & maintenance body, and describes needs for technical assistance.

Chapter 8 provides the studies on environmental considerations, including analysis of the areas along the route corridor, legal framework in Vietnam, environmental impact assessment, and the results of stakeholder coordination meetings.

Chapter 9 provides the studies on social considerations, including analysis of the areas along the route corridor, legal framework in Vietnam, resettlement action plans, and the results of stakeholder coordination meetings.

Chapter 10 reviewed the current circumstances and proposes action plans on gender concerns, protection of Disadvantaged, and universal designs.

Chapter 11 provides the studies on Green House Gas emission including estimate of reductions, development and registration of Clean Development Mechanism, track record of Japan's initiatives and directions for implementation of the Project.

Chapter 12 indicates the results of economic and financial analysis, operation and effect benchmarks, qualitative effects of the Project, etc.

Chapter 13 analyzes points to note for implementation of the Project, including the risks in terms of project implementation structure, operation & maintenance structure, and project approving procedures in Vietnam.

Chapter 14 reports miscellaneous items, including procedures for ODA project appraisal in Vietnam, possibility of co-financing with ADB, and analysis of system safety certification.

Chapter 15 proposes framework, objectives, implementing structure, and activities of capacity building and technical assistance programs along with the project implementation.

Chapter 16 presents the adjustments of the project designs and project implementation plans for the decision to delay the investment policy approval of the Project by the National Assembly from 2017 to 2018.

Chapter 17 provides conclusions and recommendations of this Survey.

CHAPTER 2 BACKGROUND AND NEED FOR PROJECT

2.1 Approved Plans and Past Studies

2.1.1 Urban Plan and Transport Plan of HCMC

Basic urban development orientation of the Ho Chi Minh Metropolitan Area is provided by "the Regional Planning of the Ho Chi Minh Metropolitan Area, Phase 2005-2020, Vision Up to 2050", which was prepared by the Ministry of Construction and approved by the Prime Minister in May 2008 (No.589/QD-TTg). This regional planning and vision shows the future urban structure, principal infrastructure arrangement plan, transport network, etc. In the basic urban development orientation, while the area within a 30 km radius of HCMC and its outskirts are positively urbanized as "the Nuclear Central Urban Zone and Surroundings".

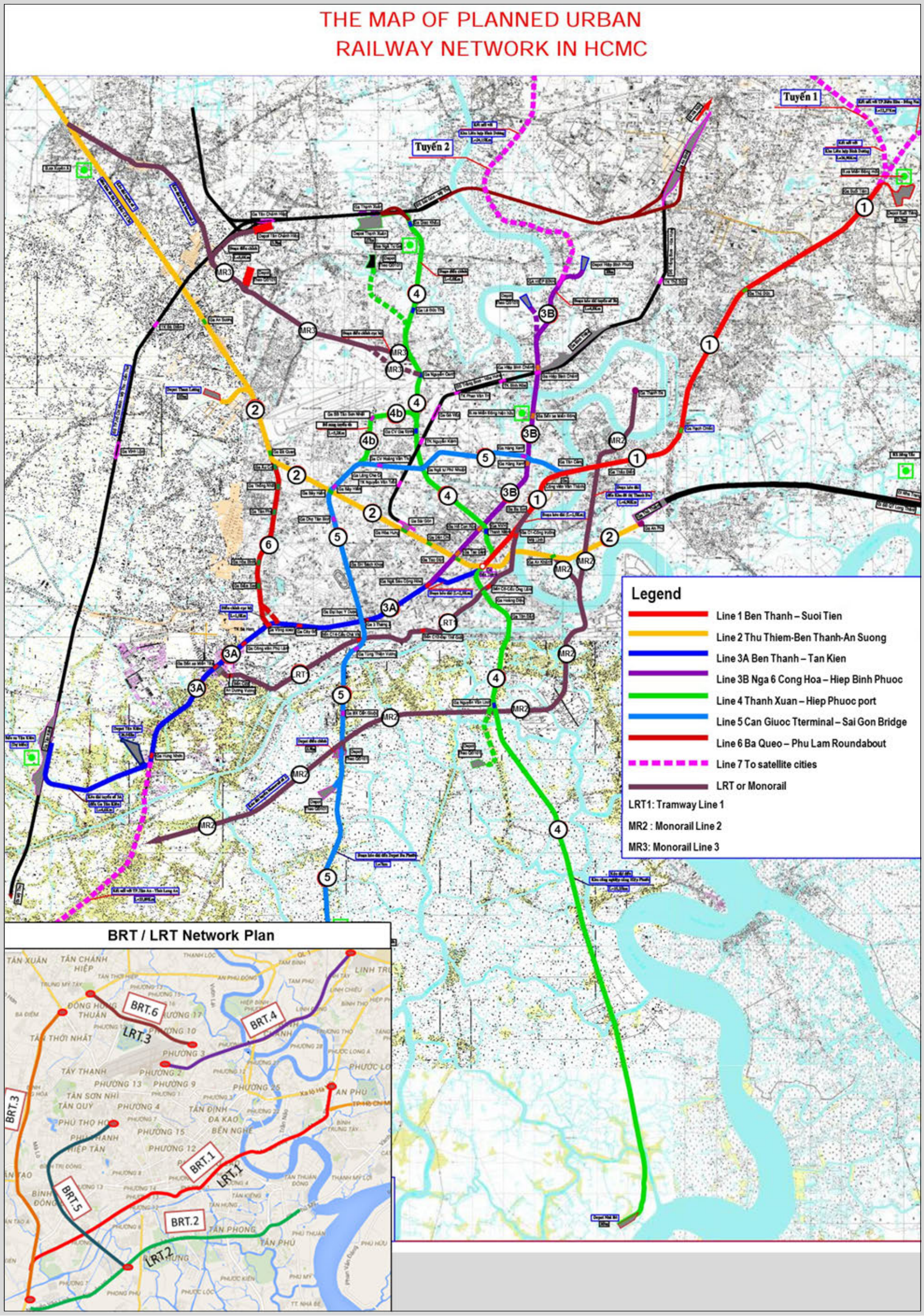
Urban development policies of HCMC itself are collectively given in "the General Construction Master Plan up to 2025 as approved by the Prime Minister in 2010" (No.24/QD-TTg). This master plan provides that multi-core urban structure should be formed by newly located satellite towns and sub-centers in the suburbs in order to mitigate the present overconcentration in the central area.

The planned UMRT network and alignments are stipulated in "the Decision No. 568/QD-TTg of the Prime Minister on Approval of the Adjustment for the Transportation Development Planning of Ho Chi Minh in 2020 and the Vision to 2020", which was approved on 8 April 2013. The plan for the UMRT covers the development of eight (8) metro lines with a total length of 159 km and six BRT/LRT lines with a total length of 98 km, of which the construction of UMRT Line 1, 2, 3A (FS of Phase 1 is ongoing) and 5, and BRT No. 1 is ongoing.

Table 2.1.1 Overview of Planned Urban Railway Lines in HCMC

UMRT Line				Length by Structure (km)			Estimated Cost (USD mil.)	
No.		Section	Length (km)	Viaduct	Under-ground	Transition	Total	per km
1		Ben Thanh - Suoi Tien	19.7	17.5	2.2	-	2,202	112
2	Stage 1	Ben Thanh - Tham Luong	11.3	0.78	9.32	1.23[2)]	1,375	121
	Stage 2	Ben Thanh - Thu Thiem	5.8	2.29	3.26	0.26	621	107
		Tham Luong-Tay Ninh (An Suong) Bus Terminal	3.2	3.2	0	0	195	61
	Stage 3	Tay Ninh Bus Terminal at Tay Bac Cu Chi Industrial Park	28.0	28	0	0	1,721	61
3A	Stage 1	Ben Thanh - New Mien Tay Bus Terminal	9.7	0	9.7	0	1,600	165
	Stage 2	New Mien Tay Bus Terminal-Tan Kien	10.1	10.1	0	0	n/a	n/a
3B		NH13 - Cong Hoa	12.1	9.1	3	0	1,700	140
4		Ben Cat Bridge - Nguyen Van Linh	36.2	18.2	16.2	1.8[2)]	3,324	93
4B		Gia Dinh Part - Lang Cha Ca	5.2	0	5.2	0	475	137
5	Stage 1	Nga Tu Bay Hien - Sai Gon Bridge	8.9	0.9	7.7	0.3	1,011	114
	Stage 2	New Can Giuoc Bus Terminal - Nga Tu Bay Hien	14.7	5.7	8.6	0.4	1,568	108
	Stage 3	Saigon River- Thu Thiem	3.1	3.1	0	0	n/a	n/a
6		Ba Queo - Phu Lam Roundabout	5.6	0	5.6	0	1,227	202
Total			**173.6**	**98.9**	**70.8**	**4.0**	**17,019**	**106**

Source: Decision No. 568/QD-TTg of the Prime Minister on Approval of Adjustment for the transportation development planning of Ho Chi Minh City in 2020 with a Vision to 2030



Source: Decision No. 568/QD-TTg of the Prime Minister on Approval of Adjustment for the transportation development planning of Ho Chi Minh City in 2020 with a Vision to 2030

Figure 2.1.1 Approved Urban Railway Network in HCMC

Line 3A Phase 1 having the proposed corridor from Ben Thanh to Mien Tay Terminal specifies as stage 1 of Line 3A as indicated in Table 2.1.1. In the same manner, Line 3A Phase 2 having Mien Tay Terminal to Tan Kien, which is extension after Phase 1 construction, states as stage 2 of Line 3A in the same table.

2.1.2 Urban Railway Studies and Projects

At present, UMRT Line1 construction project funded by JICA, UMRT Line2 construction project funded by ADB/ EIB/ KfW, the Feasibility Study of Line3A funded by JICA, UMRT Line5 Phase1 construction project funded by Spain/ ADB/ EIB, the FS of UMRT Line5 Phase2 funded by KOICA, and BRT Line1 construction project funded by WB have been conducted. Furthermore, Vietnam Government asked JICA to fund Line 3B, which will be conned with 3A line. Moreover, in parallel with these construction projects, following studies and projects have been or were conducted.

- "Special Assistance for Project Implementation (SAPI) for Ho Chi Minh City Urban Railway Project (Ben Thanh–Suoi Tien Section (Line1))"(JICA, 2014): To develop an implementation plan of a feeder bus network along the HCMC UMRT Line 1; to conduct a feasibility study and basic design of intermodal facilities in station areas of the HCMC UMRT Line 1; and to recommend policies and regulations for station area urban development.
- "Preparatory Study of Transit Oriented Development and BRT Project in Binh Duong Province"(JICA, 2016): PPP FS to conduct a preparatory study for BRT development and integrated urban development in Binh Duong Province, including station area development of Suoi Tien Terminal Station of UMRT Line1.
- "Project Preparatory Technical Assistance (PPTA) for the Sustainable Urban Transport for Ho Chi Minh City (HCMC) Metro Line 2" (ADB, 2013): To formulate of design concept, conceptual design and design of multi-modal interchange with other public transport or MRT lines for MRT2 stations
- "Data Collection Survey on Railways in Major Cities in Vietnam, METROS"(JICA, 2016): technical assistance project with following objectives: (a) to collect and review existing plans and data regarding transport and urban development, and especially those related to UMRT system, (b) to update urban traffic database by conducting necessary supplemental surveys, (c) to conduct demand analysis based on updated database on current UMRT network and individual lines which has been approved by the Prime Minister based on the updated data, (d) to review current UMRT network and lines from technical and engineering viewpoint; and (e) to make recommendations on the future development of UMRT systems based on the above.

Furthermore, Line 3A will connect with Line 3B at Cong Hoa Station (C2), Line 5 at The University of Medicine & Pharmacy Station (C4) and Line 6 at Phu Lam Rotary Staton. It should be noted that there is no funder for Line 6 until now.

2.1.3 Feasibility Study and Basic Design

Line 3A will run from Ben Thanh station, which is located in eastern part of HCMC and is a junction for Line 1 Line 2 and Line 4, to south west area passing through the city center. It is expected to expand railway network and to improve accessibility for citizens by connection with Line 1 directly. Thus, Line 3A is one of the top priority railway projects in HCMC.

Based on the feasibility study (hereinafter referred to as "F/S") conducted by MAUR in 2012, MAUR has been anticipating this project to be implemented as Japan's ODA from Japanese government.

2.2 Present Situation of Urban Transport Sector

2.2.1 Population and Growth Rate

The HCMC Metropolitan Area comprises HCMC and seven provinces, namely Binh Duong, Dong Nai, Ba Ria-Vung Tau (BR-VT), Long An, Tien Giang, Tay Ninh and Binh Phuoc with 12.1 million population in 2013. In the 2009-2013 period, population growth of HCMC has been slowing down at 0.9%, those of Binh Duong and Dong Nai has been increasing rapidly at 5.3%/year and 2.9%/year, respectively. In 2030, population of HCMC and surrounding area will achieve 9 million and 1.6 million respectively.

2.2.2 Urban Transport Sector

As the Study Area is the most significant economic hub in Vietnam including the largest urban area of HCMC, different types of transport activities concentrate in the area and create complex transportation and traffic problems and challenges for the Government.

The Transport network in the Study Area is mostly composed of various types of roads with different functions. During the last decade, the transport system has been greatly improved. Expressways and a number of primary roads and bridges were constructed and improved, some ports were relocated to outside of urban center, bus system was expanded, and traffic management was strengthened. Efforts of the Central and local governments are continuously being made, though the traffic situation is still degrading because of increasing demand.

In 2013, there are 7,089 managed roads, with total length of 4,478 km and a total surface area of 32.56 km^2. The ratio of road area per motor vehicle is 5.1 m^2. The road construction is still necessary. (According to Tokyo Metropolitan Government Bureau of Construction and Tokyo Statistical Yearbook, total length of the road in Tokyo in 2015 is 11,891 km with a total surface area of 102.52 km^2. The ratio of road area per motor vehicle is 52.1 m^2). The length of the road network grew 5.7 percent per year from 2006 to 2013, but from 2009 to the present, the growth slowed down at only 2.9 percent per year.

Fixed-route public transport services in HCMC are provided by buses. There is also a well-developed taxi system as well as an informal motorbike-taxi service (xe om) transporting passengers via motorcycles. Over the past ten years, the city has made efforts to raise bus ridership. According to the Department of Transportation, the number of passengers using public buses and taxis has increased significantly. However, public transport ridership still remains low. The city has invested in the development of the bus system, which includes a bus route network, bus fleet, bus stations, bus parking lots, bus stops, and bus shelters. The city also has subsidized with 1.39 trillion VND per year (2013) for their operating bus routes according to DOT. The quality of public transport services is still low.

At present, there is only the North–South railway line in the study area, and it passes through Sai Gon Station (Hoa Dung) and Binh Trieu Station in HCMC, Song Than Station (Binh Duong) and Bien Hoa Station in Dong Nai. This railway line was constructed more than 100 years ago, so its facilities along the line and at the stations have become old and obsolete.

Travel demand in HCMC has increased significantly during the last decade from 11.5 million person trips/day (excluding walking and intra-zonal trip1) in 2002 (HOUTRANS) to 16.7 million in 2013 (see table below). Main characteristics are as follows:

- Number of trips made by bicycles decreased and the modal share is now only 2.8% of the total demand in 2013.
- The share of trips made by motorcycles accounts for 83% of the total demand in 2013, and the number increased by 1.5 times between 2002 and 2013.
- The share of “Car” trips make up for 5.3% of total demand, and the number of trips made by cars increased by 4.2 times in the 2002-2013 period.
- Number of trips made by buses increased 2.2 times in the same period, but its modal share is still only 6.3%.

The trend is that people prefer private transport and are gradually shifting to the use of Car. This may lead to more serious traffic congestions.

Table 2.2.1 Modal Share

Mode	2002		2013		AGR (%/yr)
	000/day	%	000/day	%	
Bicycle	1,080	9.4	464	2.8	-6.8
Motorcycle	9,429	81.8	13,860	83.0	3.3
Car	214	1.9	890	5.3	12.6
Bus	485	4.2	1,050	6.3	6.7
Other	313	2.7	437	2.6	2.8
Total	11,521	100.0	16,702	100.0	3.1

Source: HOUTRANS, METROS

2.3 Need for Project

In the approved plan, one of the major objectives is to develop UMRT in the city which promote modal shift from private vehicle to public transport, and specific targets for UMRT project implementation are indicated. This UMRT Line3A project is to contribute to mitigate worsening traffic congestion and to reduce pollutions caused by traffic by construction of urban mass rapid transit system in place to road transport in the metropolitan of HCMC.

HCMC UMRT Line 3A is located at south-western area of the city, which connects from Ben Thanh Station of the city center, where will be an intermodal station of Line1, 2 and 4, to the suburban area to the south-west. It is expected to contribute to expand public railway transport service between east and west areas of the City, and to increase ridership and convenience of UMRT Line1 passengers which the Japanese Government provide technical and financial assistance. For this, the HCMC Government prioritizes the Line3A project for implementation.

In the METROS, it is indicated that “It is highly desirable that Line 3a and Line 1 operate as an integrated line to form a public transport backbone.” UMRT and integrated urban development along Line1 and Line3A is indispensable to formulate a urban backbone of north-eastern and south-western areas.

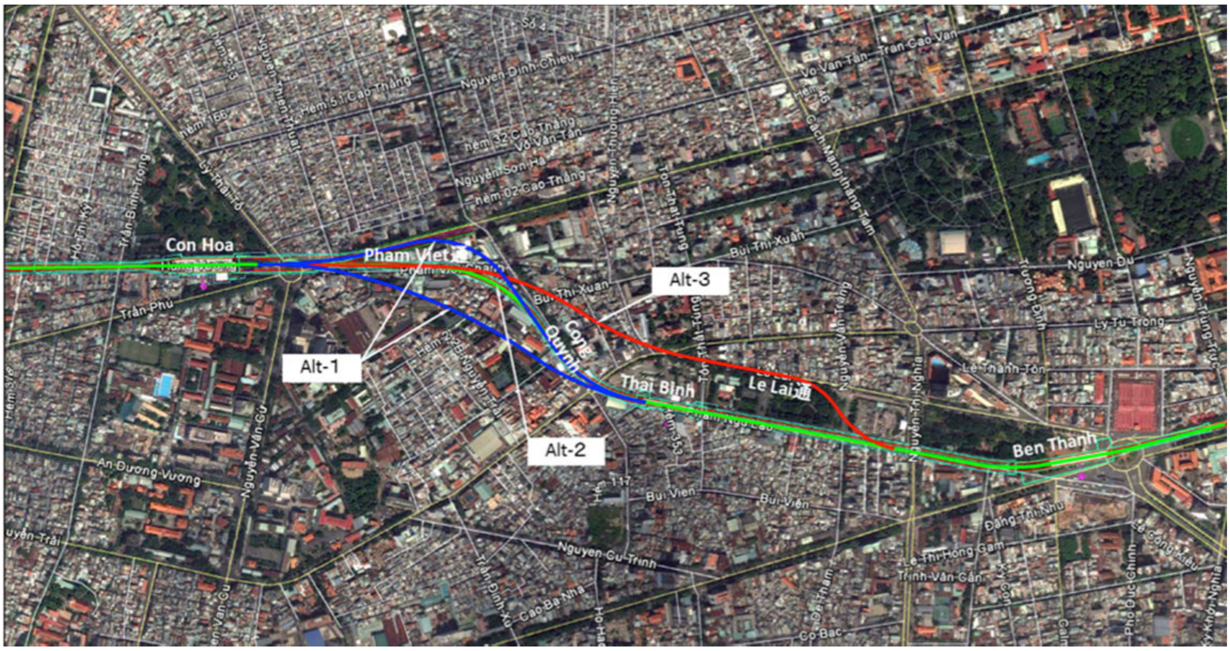
For this, UMRT construction project is in compliance with development issues and policies of HCMC Government, as well as in line with the ODA orientation of the Japanese Government and JICA. For this, it is necessary and reasonable to implement the Line3A project supported by JICA.

CHAPTER 3 ROUTE SELECTION

3.1 Review of Past Studies

3.1.1 Route Selection by Past Studies

Route alignment of urban railways on Traffic Development Plan in Ho Chi Minh City is basically designed within the right of way of existing roads in order to avoid or minimize the influence to ground and foundation structures. However, it is inevitable to pass underneath the residential area by tunnels in the section between Ban Thanh and Cong Hoa of Line 3A corridor because of the complicated existing road alignment. Therefore, the following alternatives of alignment are considered in order to minimize the influence to existing ground structures in past F/S.



Source: F/S

Figure 3.1.1 Route Selection by Past Feasibility Study

The salient features of alternatives for the alignment between Ben Thanh and Cong Hoa are shown below. The F/S selected Alt-2 and approval was made by HCMC PC taking into account construction easiness and minimum influence to the residential houses despite relatively higher cost of construction than Alt-1.

Table 3.1.1 Route Evaluation by Past Feasibility Study

Alternatives	Concept	Evaluation	Affected Households	Cost Estimate (Construction + Compensation)
Alt-1	Apply different alignments for two single tunnels and attempts to minimize total length of two tunnels	The alignment includes many reverse curves. Construction cost and compensation fee for land acquisition increased.	90	US$ 143 Mil.
Alt-2	Both tunnels pass through Cong Quynh and Pham Viet Street to minimize the influence to residential houses.	Construction is easy and the influence to the existing houses can be minimized.	62	US$ 151 Mil.
Alt-3	Both tunnels pass through Le Lai Street and the alignment passes underneath congested buildings up to Pham Viet Chanh Street.	Tunnels must be built underneath plenty of buildings, while the construction cost is not expensive.	91	US$ 167 Mil.

Source: F/S

3.1.2 Approach for Route Selection

Based on the review of past studies, comprehensive studies and alternative consideration of horizontal alignment have already been conducted taking into account traffic demand, city development plan, social and environmental impacts and interface with other UMRT lines and roads. Therefore, the Study Team focused on selection of vertical alignment and structure alternatives from the viewpoints of social and environmental impacts and project implementation. Detailed discussions and evaluations are made in Chapter 3.3.

3.2 Demand Forecast

3.2.1 Methodology

In this FS, the travel demand of Line 3A was estimated based on OD (Origin and Destination) matrices, socio-economic indicators, and network, which were prepared by METROS. The methodology to update OD matrices is briefly as follows.

- In METROS, a new Household interview survey (HIS) of 20,000 households (accounting for 1% of the total number of households in the study area) was conducted together with cordon and screen lines and other traffic surveys.
- The 2013 OD matrices was formulated, calibrated, and finalized using the latest data. On the basis of the latest HIS data, socio-economic data, and present transport network, the four-step models were used for travel demand forecast. The four-step models include trip generation/attraction, trip distribution and modal-choice, and traffic assignment.
- The estimated travel demand of Line 3A was determined through the use of future socio-economic data that includes population, employment, and school attendants as well as transport network.

3.2.2 Socio-Economic Framework

The socio-economic framework prepared by METROS was applied in this FS. The process of preparation is shown below. Since the latest population census data available is only for year 2009, the 2013 figure was obtained from the statistics of HCMC and adjoining provinces of Long An, Binh Duong, Dong Nai, and Ba Ria-Vung Tau.

The population in 2030 was estimated by taking into account of the following:

1) Growth trend between 2009 and 2013.
2) Projection of future population of related approval plans such Socio-Economic Development Plan (SEDP) and HCMC Construction General Plan.

The estimated future population by METROS is as follows:

Table 3.2.1 Future Population

City/Province	Population (000)		Annual Growth Rate (%/yr)	
	2013	2030	2009-2013	2013-2030
HCHC	7,431	8,982	0.9	1.1
Long An	1,107	1,389	0.6	1.3
Binh Duong	1,586	2,747	5.3	3.3
Dong Nai	1,878	2,710	2.9	2.2
BRVT	135	160	1.9	1.0
Total	12,136	15,988	1.7	1.6

Source: METROS

The employment at residence (nighttime) and employment at workplace (daytime) were estimated. The movement of workers between their residence and work places is the most significant type of urban travel or "to work" trips. Employment at residence is estimated by taking into account of the following factors:

1) Estimate of workforce (people ages 16 and above) based on the population data of General Statistical Office (GSO) and local authorities in 2013.
2) Estimate of employment by industry sector in 2013 based on the data of GSO and local authorities in 2013. The results of HIS conducted in METROS are also reflected.

The data of employment at workplace is not available in official statistics. Therefore, it was estimated in construction of followings:

1) Secondary sector (manufacturing and industry) activities will be relocated in outer areas in compliance with SEDP and future land use plan of HCMC and adjoining provinces.
2) Tertiary sector (commercial/business/service) activities will be mainly located in existing and emerging/ planned urban centers.

"To school" trips are also a major source of trip generation/attraction. The estimated number of students was based on two main assumptions: i) Attendance rates of future population by age group for different level of education, and ii) Locations of existing and planned schools especially colleges/universities.

Based on the future socio-economic indicators above, the future travel demand was estimated by traffic analysis zones. The total number of trips per day will increase from 29 million to 41 million in 2013 to 2030 with an average growth rate of 2%/year.

3.2.3 Split Model

The rail trip split model was developed based on a stated preference data, which was collected by HIS of METROS. A disaggregate model was developed. The model equation and estimated parameters are shown below.

$$P_{ijk}^{m} = \frac{e\left(V_{ijk}^{m}\right)}{\sum_{k'=1}^{K} e\left(V_{ijk'}^{m}\right)}$$

P_{ijk}^{m}: Choice probability of mode k and purpose m between i and j zones

V_{ijk}^{m}: Availability of mode k and purpose m between i and j zones

$$\mathrm{V}_{\mathrm{ijk}}^{\mathrm{m}} = \sum_{\mathrm{l}'=1}^{\mathrm{L}} \theta_{\mathrm{l}'} \cdot \mathrm{x}_{\mathrm{ijkl}'}^{\mathrm{m}}$$

$\mathrm{V}_{\mathrm{ijk}}^{\mathrm{m}}$: Availability of mode k and purpose m between i and j zones

$\mathrm{x}_{\mathrm{ijkl}'}^{\mathrm{m}}$: i characteristic availability value of mode k and purpose m between i and j zones

$\theta_{l'}$: Parameter

Table 3.2.2 Model Parameters

Item	MB/Metro		Car/Metro		Truck/Metro		Taxi/Metro		Bus/Metro	
	Coeff.	t-val.	Coeff.	t-val.	Coeff.	t-val.	Coeff.	t-val.	Coeff.	t-val.
Time (min)	-0.1344	-143.7	-0.0761	-7.5	-0.0457	-2.7	-0.1037	-7.0	-0.1015	-57.4
Cost (1,000VND)	-0.1684	-155.3	-0.0409	-8.7	-0.0069	-1.0	-0.0268	-11.1	-0.1496	-74.8
Constant	0.5500	67.2	1.5787	12.4	1.6696	9.5	2.0358	11.6	0.5285	29.4
No. of Samples	177,995		911		412		598		41,212	
Selection of Existing Mode	131,993		572		328		346		30,464	
Selection of Metro	46,002		339		84		252		10,748	
Likelihood	-79,5		-529		-204		-289		-19,1	
ρ2	0.218		0.120		0.020		0.290		0.195	
ρ	0.218		0.115		0.006		0.282		0.194	

Source: JICA Study Team

3.2.4 Assumptions

Preparation of future year OD matrices assigned to corresponding networks was updated on the precondition of new highway and rail networks. Ongoing railway projects were considered as a future committed network.

Table 3.2.3 Railway and Road Projects

Railway (MRT)	
MRT1	MRT2
MRT5	
Road	
HCMC–Long Thanh–Dau Giay Expressway	Bien Hoa–Vung Tau Expressway
Ben Luc–Long Thanh Expressway	HCMC–Moc Bai Expressway
HCMC–Thu Dau Mot–Chon Thanh Expressway	HCMC-Trung Luong
Ring Road No.1-4	Elevated route No.1 (Tan Phu – Binh Thanh) Elevated route No.2 (Tan Binh – Binh Tan) Elevated route No.3 (Tan Phu – Binh Chanh) Elevated route No.4 (Phu Nhuan – Quan 12) Elevated route No.5 (Thu Duc - Binh Tan)
Other local planned road	

Source: JICA Study Team

The rail service level affects the number of passengers. In this analysis, the service level of Line 3A is set as same level as METROS..

Table 3.2.4 Service Level

Fare (VND)	**Initial**	20,000
	per km	1,000
Headway (min)		2.4
Travel Speed (km/h)		40

Source: JICA Study Team

3.2.5 Travel Demand

(1) Traffic demand

The ridership estimated for years 2026, 2030, 2040 and 2050 are shown in the succeeding tables. The number of boarding passengers per day in 2026 is 218,500 and will become 404,800 in 2030 after extension of Phase 2 (C11-C17) section. In 2050, it will reach 561,300 passengers per day.

Table 3.2.5 Result of Demand Forecast

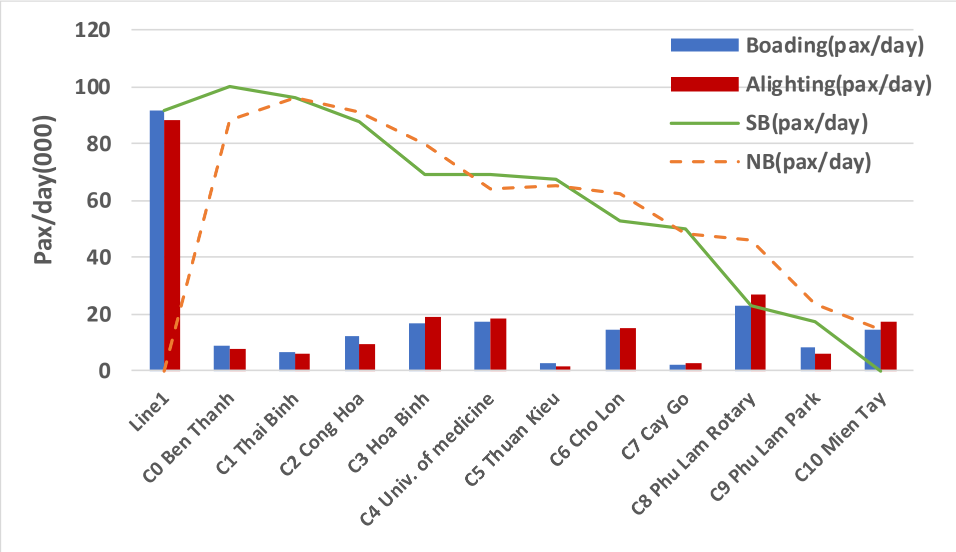
Year		2026	2030	2040	2050
Section		C0-C10	C0-C17	C0-C17	C0-C17
No. of Boarding Passenger (Pax/day)	C0-C10	218,500	344,200	398,500	473,700
	C11-C17	-	60,600	77,000	87,600
	Total	218,500	404,800	475,500	561,300
PPHPD (Perk rate 12%) (Pax/Hour/Dir.)		12,000	19,300	22,100	25,000
Off Peak Hour Line Volume (5%) (Pax/Hour/Dir.)		5,000	8,000	9,200	10,400
Pax km (Pax km / day)		1,178,368	2,750,746	3,330,325	3,848,330
Ave. Travel Dist. (km)		5.4	6.8	7.0	6.9
Fare Revenue (million VND/day)		5,548	9,635	11,300	13,322

Source: JICA Study Team

Moreover, the modal shift in each transportation modes in Vietnam is summarized follows:

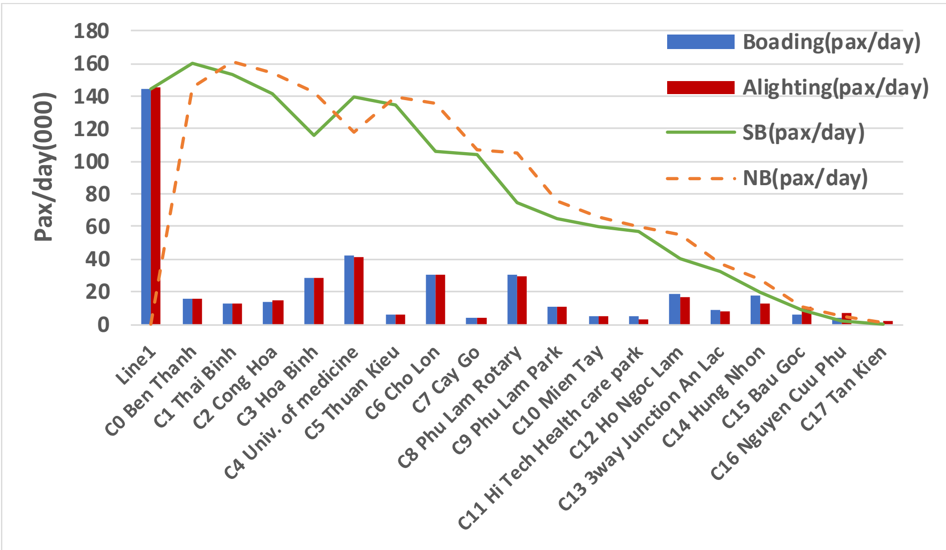
- In 2030, 2,329 buses will be reduced after HCMC3A operation. Because of this,11,645 thousand VND/day of bus fare revenue will be reduced. However, the value accounts only for 0.37% of HCMC bus business profit which considers not seriously reduced.
- In 2030, 178,143 motorbike vehicles will be reduced after HCMC3A operation. This will contribute to ease traffic congestion and mitigate negative environmental impact such as air pollution etc.
- In 2030, 48,211 car vehicles will be reduced after HCMC3A operation. This will also contribute to mitigate air pollution, etc.

The following figures show the number of boarding and alighting passengers in each station. Many of the passengers come from Line 1 and directly go through Line 3A as the entire operating line. The station with the highest number of two-way passengers per day in 2026, except for Ben Thanh Station, is C8 Phu Lam Rotary with roughly 25,000 passengers for each boarding and alighting. The second is C3 Hoa Binh with 17,900 passengers per boarding and alighting likewise. After extension of Phase 2 section, the number of passengers in every station will increase significantly. By 2050, there will be 69,000 passengers per boarding and alighting at C4 University of Medicine.



Source: JICA Study Team

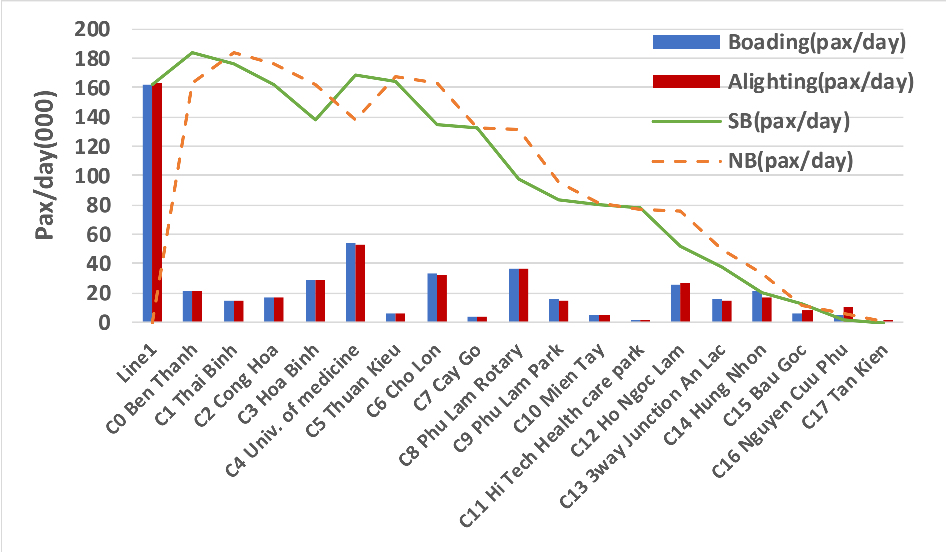
Figure 3.2.1 Number of Boarding and Alighting Passengers and Line Volume in 2026[2]



Source: JICA Study Team

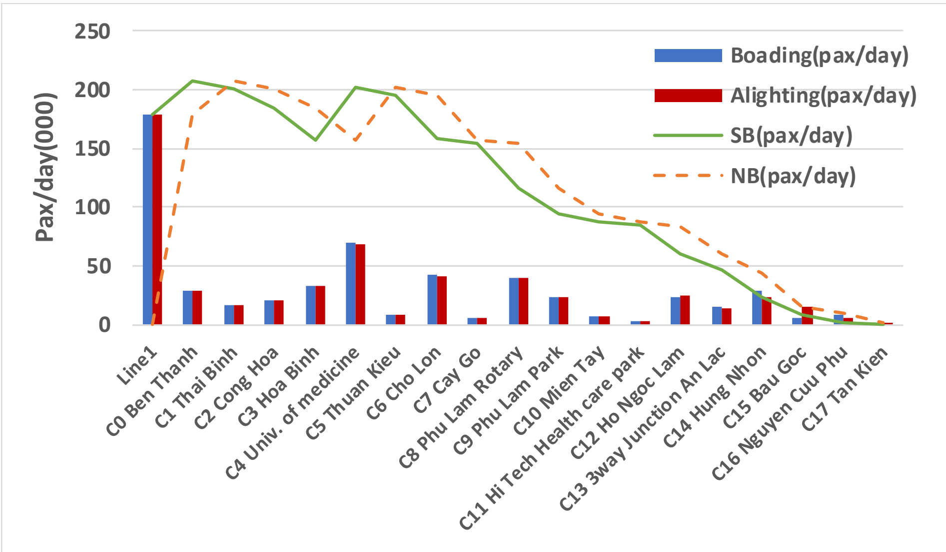
Figure 3.2.2 No. of Boarding and Alighting Passengers and Line Volume in 2030[2]

[2] SB : South Band, NB : North Band



Source: JICA Study Team

Figure 3.2.3 No. of Boarding and Alighting Passengers and Line Volume in 2040[2]

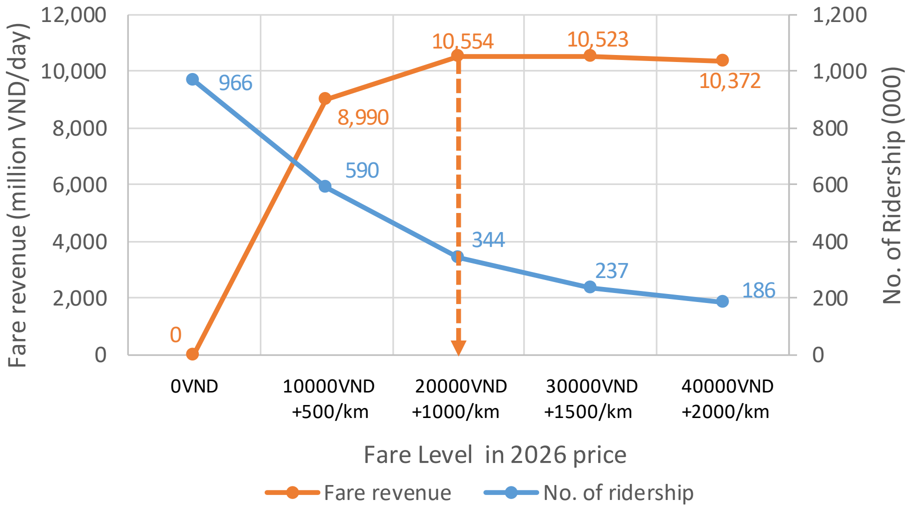


Source: JICA Study Team

Figure 3.2.4 No. of Boarding and Alighting Passengers and Line Volume in 2050[2]

(2) Sensitivity analysis

The result of sensitivity analysis shown below. The base case (20,000 VND+1,000VND/km) will generate the highest fare revenue, so this fare setting is the most appropriate.



Source: JICA Study Team

Figure 3.2.5 The result of sensitivity analysis in 2030

3.3 Route Selection

This section refers to the selection of vertical alignment and structural alternatives taking into account the previous study of horizontal alignment and about 1km of typical distance between stations as the control point. In order to select the best alternative, examinations and comparisons were made through quantitative assessments as appropriate in terms of economy, construction, social and environmental impacts.

3.3.1 Evaluation Criteria

The examinations and comparisons of alignment alternatives were made with respect to the following;

- Ensure safe and comfortable travelling with the urban railway service
- Ensure comfortable connection with other urban railway lines, cities and city roads.
- Avoid or minimize involuntary resettlement
- Optimize economy (duration, construction, cost, etc)
- Minimize the impacts on environment and social economic activities such as traffic congestion
- Ensure ease of maintenance during commercial operation
- Minimize environmental impacts in terms of landscape, noise and vibration
- Minimize the requirement of removing valuable trees on the road

Alternatives of vertical alignments were discussed with MAUR on 7th March 2016, where the Study Team proposed three alternatives as explained below.

3.3.2 Structure Alternatives

The following three structure alternatives were identified from the possible track level and station height:

- Elevated structure (viaduct)
- At-grade structure (such as box culvert and U-shape retaining wall)
- Underground structures (Tunnel, cut and cover tunnel)

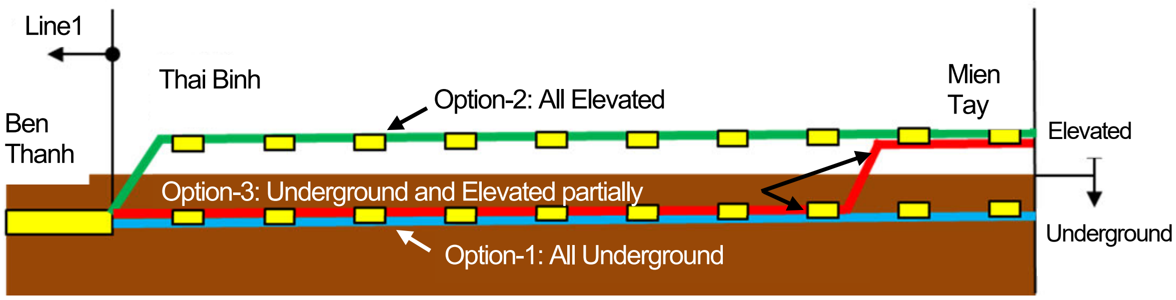
As at-grade structure has several disadvantages, particularly in relation to social and environmental issues, this alternative is no longer considered. Accordingly, the remaining alternatives including Zero-option (no construction option) are examined.

Table 3.3.1 Structure Options

Structure Alternatives	Content
Option-0 Zero-option	No construction
Option-1 All underground structures	All underground structures from the beginning to end point (Past study selected all underground on Phase-I and all elevated on Phase-II)
Option-2 All elevated structures	All elevated structures after Ben Thanh station to end point
Option-3 Underground and Elevated structures partially	Underground structures from the beginning point to C8: Phu Lam Rotary station and elevated structures after C8 station as sufficient road space can be secured after C8 station. (similarly, Line 1 builds 3 underground station in the city center and elevated structures after 3 underground stations)

Source: JICA Study Team

Figure 3.3.1 shows the schematic image of each option (except Option-0).



Source: JICA Study Team

Figure 3.3.1 Schematic Image of Alignment and Structure Options

3.3.3 Evaluation of Route Alternatives

Table 3.3.2 shows the results of evaluations on the route alternatives. In conclusion, Option-3 (a combination of underground and elevated structures) was selected as the best option taking into account the minimized social and environmental impacts and economy of project implementation.

Table 3.3.2 Evaluation of Vertical Alignment and Structure Alternatives

Option	Evaluation	Description
Option-0 No construction	×	No construction option can completely avoid land acquisition, resettlement and environmental impacts during construction such as noise and vibration. On the other hand, the increasing heavy traffic between Ben Thanh and Mien Tay and associated problems on urban environment will become even worse. Also, significant economic losses to other railway lines and social economic developments are anticipated through lowered effectiveness of urban railway network and urban developments under HCMC master plan. The road traffic speed, the ratio of travel time fluctuation and the ratio of running distance fluctuation were evaluated comparing with Line 3A case and without Line 3A case is carried out bus user encouragement. In the result, road traffic speed will be reduced 0.89km/h, volume capacity ratio will be increased 3.2%, travel time will be increased 18% and detour ratio will be increased 4%. The result is traffic volume will be increased and traffic congestion along line 3A will be estimated. For the reason, increased vibration, noise, greenhouse gas emissions, various occurrences of urban environmental problems, loss of synergies with other urban railroads and BRT / LRT routes, reduction of urban railway network and urban development effect, the social and economic development of each railway and related areas are assumed.
Option-1 All underground structures	○	Two single bored tunnels between underground stations can minimize the impact to above ground activities. Station are constructed by open excavation with retaining wall. Application of appropriate construction plans and technics to minimize noise and vibration, surface settlement and ground water drawdown during the construction is essential. Some land acquisition is required to provide the above ground structures such as station entrances and ancillary buildings. After commercial operation begins, the Option can enjoy advantages in comparison with elevated options in terms of landscape, sunshine, noise and vibration. Also there are high potentials for economic development including integrated development with underground commercial facilities. On the other hand, disadvantage of option is construction cost. The cost for underground section is about three times higher than the cost of elevated section.
Option-2 All elevated structures	△	This Option retains serious risks of social and environmental concerns as it requires expansion of the existing narrow street in order to accommodate elevated structures at the section between C1 and C3 station. Also, this option involves resettlement of number of houses between C2 and C3 station as the alignment goes out of the existing road at very narrow and steep curvatures. Besides, landscape, noise and vibration are significant where viaduct structures are built above the narrow road. After C4 station, the road width becomes wider, making construction of the viaduct structure easy by use of center medium of roads. Relocation of overhead high power cables into underground is, where applicable, mandatory , to build the viaduct structures. Other obstructions for the construction of viaduct structures are at C7 (existing steel flyover) and C8 (existing new Ong Buong bridge). Therefore building viaduct structures in coordination with these obstructions are considered not feasible. Landscape impact is an additional negative factor of this Option.
Option-3 Combination of Underground and Elevated structures (Recommended)	◎	This Option envisages underground structure at central and sub-central districts of HCMC, i.e. from Ben Thanh (beginning point) to C8 Station, with due considerations of resettlement, landscape, and other environment issues, while viaduct structure is proposed in the remaining section as no obstructions to build elevated structures are identified. Phase 2 section of Line 3A was designed with all elevated structures in the past study. This gives another reason to build transition from underground structures to elevated structures after C8 station. Landscape impact of viaduct structures to surrounding residential buildings becomes smaller after C8 station, where road width are much wider than the same in city center. Also, wider road ease diversion of high power cable to underground level. With regard to construction cost, this Option possibly reduce about 15% of civil works cost, which derives from alterations from underground to elevated structures for 2km out of 10km in total length. In addition, EVN agreed for high voltage relocation and MAUR also accept alignment revision including the high voltage relocation. Moreover, the cost for the high voltage relocation has been considered in total implementation cost.

Source: JICA Study Team

Table 3.3.3 Comparison and Evaluation of Vertical Alignment and Structure Alternatives

Evaluation ◎:most suitable among alternatives, ○:second suitable among alternatives, △:possible alternative in case of no other option, ×:not suitable

Items	Option-0 No construction	Option-1 All underground structures	Option-2 All elevated structures	Option-3 Combination of Underground and Elevated structures
Outline and purpose for alternative	Although a new infrastructure does not construct, the current traffic systems are improved as much as possible such as increasing bus numbers and routes and revising traffic plan etc.	This is an option that constructs HCM 3A Line by all underground sections using open cut method at station sections and single line-double tube of shield tunnel method at tunnel sections to reduce traffic congestion and to achieve urban and land developments along the railroads.	This is a construction option having all elevated sections, which consist of elevated two layer stations by concourse and platform floors and viaduct by u-shape girder to reduce traffic congestion and to achieve urban and land developments along the railroads.	This is an option that both underground section (C1 to C8 station) and elevated section (C9 and C10) are constructed to reduce traffic congestion and to achieve urban and land developments along the railroads.
Social impacts	◎	○	×	○
	Resettlement and new land acquisition are not required.	A partial resettlement is required at C1, C2 and C3 station to be constructed by open excavation method. Furthermore, it may be necessary to consider some compensation between C1 and C2 station where tunnel alignment runs just under existing houses.	A large land acquisition & resettlement and road widening are required from C1 to C3 station for construction of elevated structures.	It is the same impacts to option 1 from C1 to C8 station. From C9 station to C10 station, basically land acquisition and resettlement is not required since road is wide.
Environmental impacts	◎	○	○	○
	No impact because of no construction of the new infrastructure	It is possibility to have impacts to underground water by treatment of excavated soil and ground settlement by underground work.	It is possibility to have bentonite pollution by excavation work for piers. It may necessary to cut trees along streets.	It is the same impact with option -1 from C1 to C8 station and option -2 for C9 and C10 station.
Impact on the living environment/ Pollution	×	◎	△	◎
	It is difficult to reduce traffic congestion by only revising soft side aspects. Hence as a result, exhaust and greenhouse gas emissions are increased by reduction in the average traveling speed and increase in the number of stop start. Furthermore, noise of vehicles and traffic accidents involving motorbikes are also increased.	It assumes that open cut area may give negative impacts during construction.	It assumes that section from C1 to C4 station may have impacts to living environment such as noise and vibration during construction and operation since surrounding buildings are clustered. Furthermore, other negative impacts such as landscape and sunshine aspect may be incurred.	It is the same impact with option -1 from C1 to C8 station. Elevated section from C9 to C10 has wide road, and hence impacts by noise and vibration are reduced. However, there is possibility to have dust due to pier work.

Items	Option-0 No construction	Option-1 All underground structures	Option-2 All elevated structures	Option-3 Combination of Underground and Elevated structures
Traffic function	×	◎	◎	◎
	The current traffic conjunction cannot be solved fundamentally and it is also difficult for urban and land developments along the railroads.	Traffic congestion can be solved and urban and land along the railroads can be developed promptly.	Traffic congestion can be solved and urban and land along the railroads can be developed promptly.	Traffic congestion can be solved and urban and land along the railroads can be developed promptly.
Impact on socio-economic activity and community development	×	○	○	○
	It is difficult to establish smooth and safe transportation by only revising traffic systems. As a result, it will be obstruction to social and economic activities and whole Ho Chi Minh city development.	Socio-economic activity and community development can be progressed by smooth and safe transportation. Furthermore, income of the region is increased by increasing employment opportunities of local workers and purchasing consumer goods during the construction. However, road traffic has trouble temporarily by partial road closing and detour for underground station construction.	Socio-economic activity and community development can be progressed by smooth and safe transportation. Furthermore, income of the region is increased by increasing employment opportunities of local workers and purchasing consumer goods during the construction. However, road traffic has trouble temporarily by partial road closing for viaduct construction.	It is the same impact with option -1 from C1 to C8 station. Elevated section from C9 to C10 has wide road, and therefore impacts to road traffic can be minimized.
Total Implementation cost	◎	×	○	△
	Although it is not required cost for land acquisition and construction, burden of bus company is increased. However, it is cheap compared to other three options.	Although construction cost for underground structures is about three times higher than that of elevated structures, large road widening and resettlement are not required.	Even though construction cost is the cheapest among three construction options, large road widening and resettlement are required from C1 to C4 station.	Although construction cost is higher compared with that of option 2, it is lower than option 1.
Maintenance cost	◎	×	○	△
	Even though maintenance cost for bus company increases, the cost is cheap compared with other three options.	Maintenance cost is slightly higher than option 2 since maintenance work for tunnel lighting & ventilation and fire prevention equipment is required.	It is cheap compared with option1.	It is cheap compared with option 1.

Items	Option-0 No construction	Option-1 All underground structures	Option-2 All elevated structures	Option-3 Combination of Underground and Elevated structures
Comprehensive evaluation	×	○	△	◎
	It can be say that only focusing soft side aspects cannot be solved for negative impacts to urban environment and social activities in Ho Chi Minh city which is progressing to urbanization. Therefore, it concludes that option-0 is unsuitable option.	While it is the option that structures and methods can be minimized environmental impacts compared to other construction options, in terms of economy and maintenance cost aspects, it is more expensive than option 2. Especially, this option is inferior in economic aspect in remote area where sufficient lands and spaces are available.	Although this option has advantages for economy and construction aspects, it can be judged as unsuitable alignment in urban areas where landscape and environmental and social factors such as land acquisition, trees along roads, sunshine obstacles etc. have been affected seriously.	This is the best option which has advantages to environmental impacts in the same manner with option 1 and economy and maintenance aspects in the same way with option 2.

Following table shows the changing ratio of average speed, VCR (volume by capacity ratio) and total travel time and total travel distance in the interior of 1km from the Line 3A aliment in zero option and with cases.

Table 3.3.4 The evaluation result comparing zero option and after in 2030

	Zero option	With case	Zero option – with case
Total travel time changing ratio (with case:100%)	118%	100%	18%
Total travel distance changing ratio (with case:100%)	104%	100%	4%
Average speed (km/h)	6.76	7.65	-0.89
Road volume capacity ratio (VCR)(%)	78.3%	75.2%	3.2%

Source: JICA Study Team

3.3.4 Consensus Building

The above alternatives of alignment and structures were thoroughly discussed with MAUR on 26th April 2016 and MAUR agreed in principal the Option-3 (combination of underground and Elevated structures). For two parties to sign an official agreement, the report titled “Report for Design Changes for Line 3A Phase 1” was submitted to MAUR both in English and Vietnamese on 10 May 2016 and MAUR issued no objection letter on 17 May 2016 (see Appendix 4.4.5).

Pre-F/S report for whole project was submitted to MAUR in late January 2017 and explanations to the related departments and authorities of HCMC-PC and the Central Government were made in the end of May 2017. Finally, it is expected that the Pre-F/S will be submitted to the National Assembly in June 2018 to get approval for investment policy (see 6.5).

CHAPTER 4 PROJECT DESIGNS

4.1 Project Summary

4.1.1 Project Outline

(1) Project Plans

In the course of this study, the Study Team reviewed F/S and established project plans as summarized in Table 4.1.1.

Table 4.1.1 Project Plans of F/S and This Study

Item	F/S	This study
Section	Starting point : Ben Thanh Station* Ending point : Mien Tay Terminal Station	
Total length**	Double track with about 9.9 km	Double track with about 9.9 km
Underground section	9.9km	8.2 km
Elevated section	-	1.7 km
Number of stations	10 stations	10 stations
Underground station	10 stations	8 stations
Elevated station	-	2 stations
Average interval	970 m	970 m
Demand forecast	In opening year of 2015	In opening year of 2026
Daily average ridership	127,000	218,500
PHPDT	5,800	12,000
Operation hours	5:00 - 23:00	5:00 - 23:30
Operation interval	In opening year of 2015	In opening year of 2026
Peak hour	11 trains/hour	14 trains/hour
Off peak	5 trains/hour	6 trains/hour
Location of Depot		
Phase 1	Common use of Suoi Tien Depot of Line 1	
Phase 2	Tan Kien Depot of Line 3A	

(Note)

* Ben Thanh Station, which will be constructed under Line 1 Project, is not counted. Scope of the Line 3A Project includes the works to provide physical connection to Line 1 system.

** The length is the distance between the beginning and the end of the Project.

Source: JICA Study team

(2) Design Parameters and System Features

Design Parameters and system features of the project are shown below.

Table 4.1.2 Design Parameters and System Features

Item		Specifications
Operation	Designed maximum speed	Elevated section : 120km/h Underground section : 80km/h
	Operational direction	Right side
Construction standards	Gauge	1,435mm
	Rail	60kg/m
	Minimum horizontal curve radius	300m
	Minimum vertical curve radius	3,000m
	Maximum cant	150mm
	Maximum grade	3.5 ‰
	Minimum distance between tracks	3.7m
	Design axial load	14ton or 16ton
	Width of formation level	2,750mm
	Effective platform length	130m
Structures	Stations	Underground section: Two stories of cut and cover tunnel, Elevated section: Single pier and double piers
	Between stations	Underground section: Shield tunnel (single line - twin tubes), Transition section : Cut and cover tunnel and U-shape retaining wall, Elevated section: Viaduct with PC U-shape girder and PC box girder
Rolling stocks	Body dimensions	lengh:19.5m, width :2.95m
	Train consist	Maximum 6 cars
	Maximum output	190kW
	Capacity	942 passenger / trainset (6 car trainset, 3 pax/m^2)
Electric System	Electrification system	DC- electrification
	Current feeder system	DC1,500V
	Receiving substation	110/22 kV 25MVA x 2unit
	Catenary system	Overhead contact system
	Span Cycle	Underground section : 5m, Elevated section : 50m
Signaling	Signaling system	Automatic block system, train radio device
	Train control system	ATS (Automatic Train Stop), ATP (Automatic Train Protection), ATO (Automatic Train Operation)
Communication system	Communication system	Telephone system, dedicated telephone system, train radio, public address system, passenger information display system, CCTV, clock system and data transmission system

Source: JICA Study team

4.2 Natural Conditions

4.2.1 Topographic Survey

A range of topographic surveys including the following 4 items was carried out to obtain base information for alignment designs and preliminary designs of civil infrastructure.

(1) Topographic survey at 10 stations with the scale of 1/500

- To understand the existing structures within station areas such as buildings, roads, road facilities and electric facilities, etc.

(2) Topographic survey with the scale of 1/2,000 from Km 1+150 to Km 1+600 and building survey

- To get updated the data between C1 and C2, where TBM runs under existing buildings.

(3) Topographic survey at junction stations with the scale of 1/500

- To collect the topographic information at interchange stations (C2, C4 and C8) which will be connected to the stations of other lines (see 2.1.1 and Table 4.3.3).
- To gather foundation information under existing buildings

(4) Topographic survey on adjacent structures

- To collect accurate information about Ong Buong bridge and Cay Go flyover, which are adjacent to the route alignment.

As the results of the building survey, it was clear that all house foundations above the tunnel alignment are direct foundations or wooden piles, which are not interfered with tunnel construction.

Please note that topographic survey drawings, the results of the building survey and drawings for adjacent structures are indicated in “TOPOGRAPHOCAL SUVEY REPORT”.

4.2.2 Geological Survey

In order to supplement the geological information in the F/S, an additional geological survey at ten locations was performed to collect base information for alignment designs and preliminary designs of civil structures, facilities and equipment, etc. Our evaluations of the result are:

- Although water level is high, which is from GL-1.2m to -7.0m and average is GL-3.9m and soft clay and silty sand is deposited, soil is relatively stiff, which N value is about more than 30 in average in more than 40m depth and rock layer does not exist at underground section. Hence ground condition is stable and suitable for construction (see Table 4.2.1).

- Very soft layer was found at elevated section. N value ranges from 1 to 2 with 70% of natural water content (yet still within liquid limit). This will not affect to the tunnel excavation. Diameter and length for foundation piles were designed considering this very soft layer.
- As a result of consolidation test, preconsolidation stress (pc) at GL -4.0m is only about 50Kpa. However, it concludes that this value is not reliable, since it does not increase corresponding to depth as theoretically calculated. It assumes that disturbed specimens were used for the consolidation test because sampling for undisturbed specimens is difficult in Ho Chi Minh City due to containing silt in clay. Therefore, the soft layer cannot be judged as normal consolidation in this survey. Hence, it proposes that the consolidation test should be carried out using undisturbed specimens with paying close attention during the detailed design and if the layer is confirmed as normal consolidation, enough pile length considering negative friction is secured. Soil test results for elevated section are summarized in Table 4.2.2.

Moreover, Figure 4.2.1 shows boring log of BH1 to BH10 and Figure 4.2.2 indicates each location carried out field tests.

Please note that the detailed results of geological survey are indicated in "GEOLOGICAL SUVEY REPORT".

Table 4.2.1 Summary for Soil Layers and N Value

Layer No.	Description of soil	Boring Log No.	Depth (thickness)	N value Min.to Max. (Average)
K	Fill	BH1 BH2 BH3 BH4 BH5 BH6 BH7 BH8 BH9 BH10	1.8m 1.8m 1.3m 0.5m 0.7m 0.9m 1.0m 3.0m 3.5m 2.2m	- - - - - - - - - 9
1a	Clay, green grey, soft	BH1 BH2 BH3 BH8 BH9 BH10	1.8 to 2.7 m (0.9m) 1.8 to 2.7 m (0.9m) 1.3-2.5m (1.2m) 3.0-5.5m (2.5m) 3.5-17.0m (13.5m) 2.2-19.2m (17m)	1 (1) 1 (1) 3 (3) 1-2 (2) 1-2 (2) 9 (9)
1b	Silty Sand, loose	BH8	5.5-11.7m (6.2m)	7-14 (10)
2	Sandy Clay, brown grey	BH3 BH5 BH8	2.5-3.8m (1.3m) 0.7-3.2m (2.5m) 11.7-15.8m (4.1m)	18 (18) 12 (12) 6-8 (7)
3	Sandy Clay, medium stiff	LC-P50 LC-P51 BH8	0.0 to 4.5m(4.5m) 0.6 to 4.2m(3.6m) 15.8-19.5m (3.7m)	4 - 4(4) 5 - 9(7) 15-21 (18)
4a	Clay with sand, green grey, stiff to very stiff	BH1 BH2 BH3 BH4 BH5 BH6 BH7 BH8 BH9 BH10	2.7-8.9m (6.2m) 2.7-5.0m (2.3m) 3.8-6.0m (2.2m) 0.5-8.7m (8.2m) 3.2-7.9m (2.4m) 0.9-7.6m (6.7m) 1.0-3.5m (2.5m) 19.5-25.0m (5.5m) 22.5-27.5m (5.1m) 19.2-22.7m (3.5m)	6-15 (10) 5-10 (8) 11-14 (13) 7-14 (10) 22-26 (24) 12-20 (16) 9-12 (11) 20-39 (30) 16-21(18) 13-20 (17)
4b	Clay with sand, green grey, firm	BH3 BH5 BH7 BH8	6.0-8.6m (2.6m) 7.9-10.3m (2.4m) 3.5-6.5m (3.0m) 25.0-28.0m (3.0m)	6-8 (7) 18-20 (19) 10-15 (13) 32-34 (33)
L5	Sand, medium dense	BH1	8.9-11.4m (3.1m)	20-22 (21)
5a	Sand, loose to medium dense	BH1 BH2 BH3 BH4 BH5 BH6 BH7	11.4-14.5m (3.1m) 5.0-16.7m (11.7m) 8.6-13.5m (4.9m) 8.7-19.7m (11.0m) 12.8-18.0m (5.2m) 7.6-15.5m (7.9m) 6.5-12.0m (5.5m)	9-11 (10) 6-11 (8) 5-9 (7) 8-16 (12) 10-15 (12) 7-11 (9) 7-11 (9)
5b	Sand, brown, medium dense	BH1 BH2 BH3 BH4 BH5 BH6 BH7 BH8 BH9 BH10	14.5-41.5m (27m) 16.7-44.4m (27.7m) 13.5-45.4m (31.9m) 19.7-41.0m (21.3m) 18.0-37.3m (19.3m) 15.5-40.4m (24.9m) 12.0-38.1m (8.4m) 28.0-40.8m (12.8m) 27.5-40.3m (12.8m) 22.7-44.5m (21.8m)	9-36 (23) 6-28 (17) 13-29 (21) 8-31 (20) 10-36 (23) 7-29 (18) 11-29 (20) 13-20 (17) 11-38 (25) 18-28 (23)

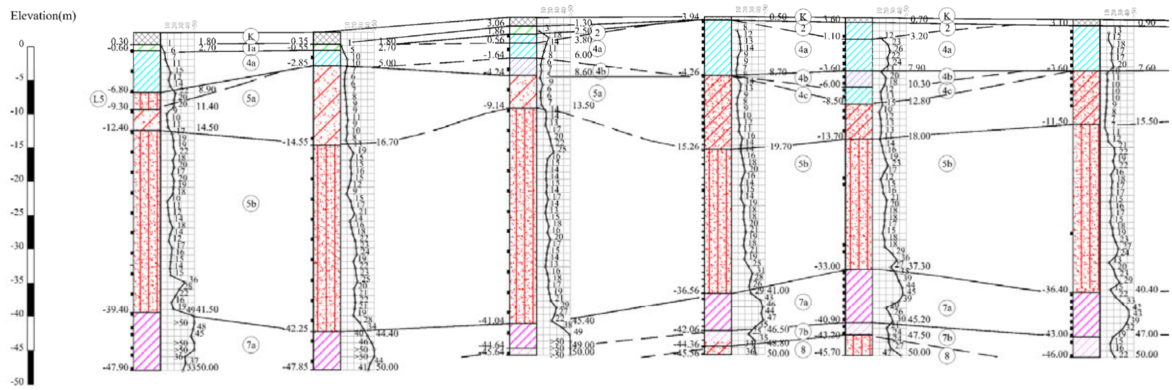
Layer No.	Description of soil	Boring Log No.	Depth (thickness)	N value Min.to Max. (Average)
7a	CLAY, yellow, brown grey, hard	BH1 BH2 BH3 BH4 BH5 BH6 BH7 BH8 BH9 BH10	41.5-50.0m (8.5m) 44.4-50.0m (5.6m) 45.4-49.0m (3.6m) 41.0-46.5m (5.5m) 37.3-45.2m (7.9m) 40.4-47.0m (6.6m) 38.1-46.5m (8.4m) 40.8-50.0m (9.2m) 40.3-51.0m (10.7m) 44.5-49.1m (4.6m)	35-55 (45) 40-51 (46) 38-52 (45) 29-47 (38) 20-45 (33) 22-43 (33) 25-45 (35) 31-37 (34) 23-50 (37) 31-38 (35)
7b	CLAY, light grey, yellow grey, hard	BH3 BH4 BH5 BH6 BH7	49.0-50.0m (1.0m) 46.5-48.8m (2.3m) 45.2-47.5m (2.3m) 47.0-50.0m (3.0m) 46.5-50.0m (3.5m)	54 (54) 25-35 (30) 21-24 (23) 15-22 (19) 23-30 (27)
8	SAND, brown grey, dense	BH4 BH5 BH10	48.8-50.0m (1.2m) 47.5-50.0m (2.5m) 49.1-51m (1.9m)	34 24-50 (37) >50

Source: JICA Study team

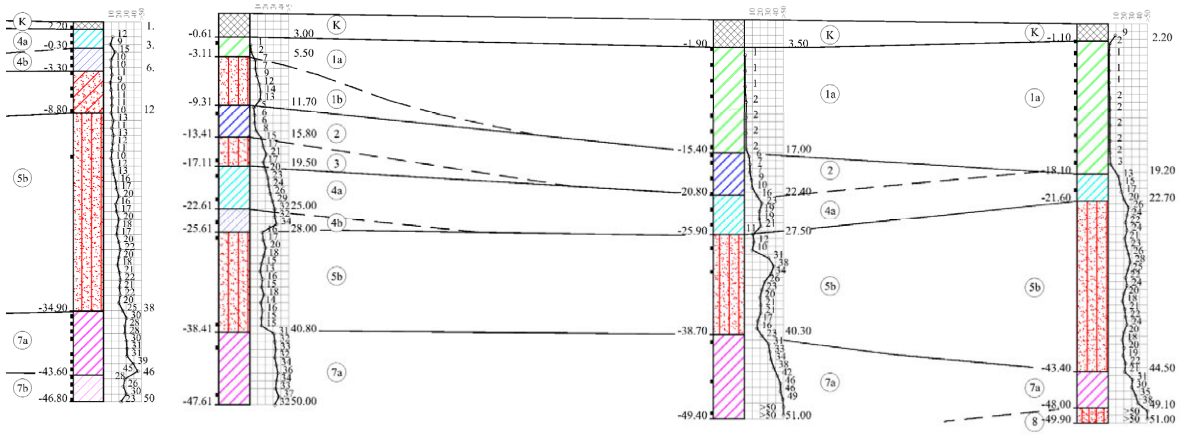
Table 4.2.2 Summary for Soil Parameters at Elevated Section (BH9)

Properties of layers	Sign	Unit	Layers				
			1a	2	4a	5b	7a
Percentage of Gravel		%				0.8	
Percentage of Sand		%	3.4	16.5	36.2	78.7	11.4
Percentage of Silt and Clay		%	96.6	83.5	63.8	20.5	88.6
Moisture content	W	%	70.1	24.1	22.1	17.9	19.8
Unit weight	ρ	g/cm^3	1.54			2.08	2.11
Specific gravity	ρ_s		2.69	2.73	2.71	2.67	2.74
Void ratio	e		1.973			0.516	0.559
Unsoaked angle of repose	α_d	degree				33	
Soaked angle of repose	α_w	degree				25	
Max void ratio	e_{max}					1.075	
Min void ratio	e_{min}					0.524	
Liquid limit	LL	%	85.7	40.2	35.6	20.2	45.8
Plastic limit	Ll	%	30.9	19.3	18.1	14.0	19.2
Plasticity index	PI	%	54.9	20.9	17.5	6.3	26.6
Liquidity index	LI		0.71				
Internal friction angle	□	degree	4°39'				16°53'
Cohesion	C	kg/cm^2	0.073				0.67
N value of SPT (blows/30cm)			1-2	6-10	16-21	11-38	23->50

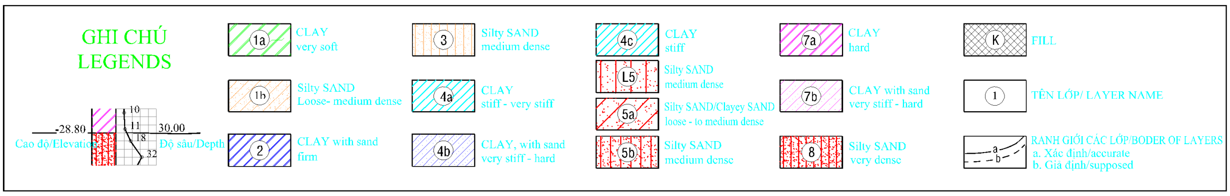
Source: JICA Study team



a) BH1 to BH6

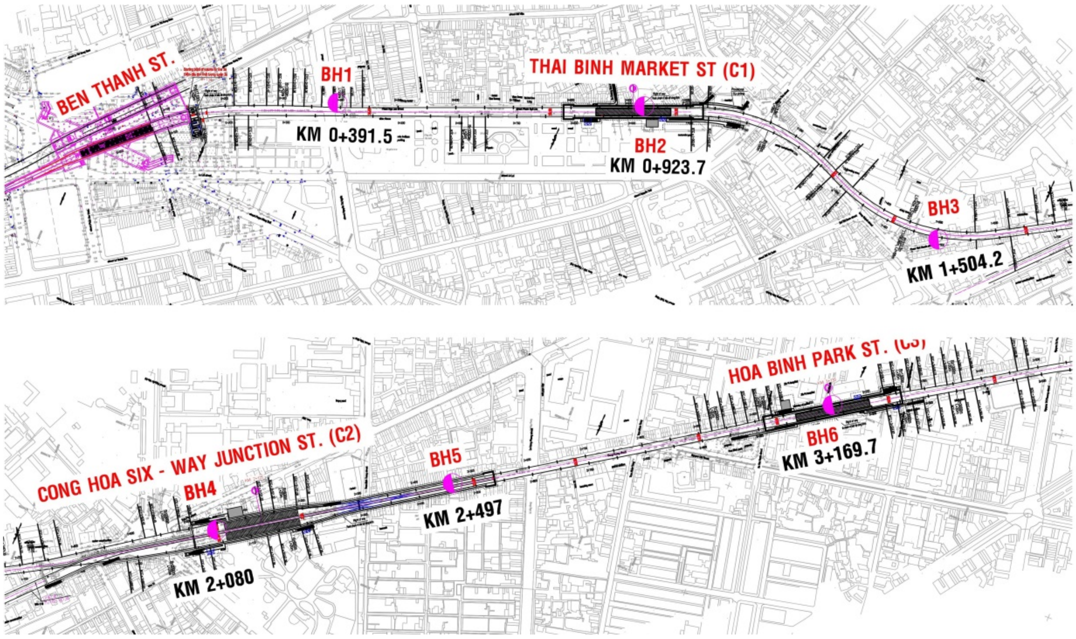


b) BH7 to BH10

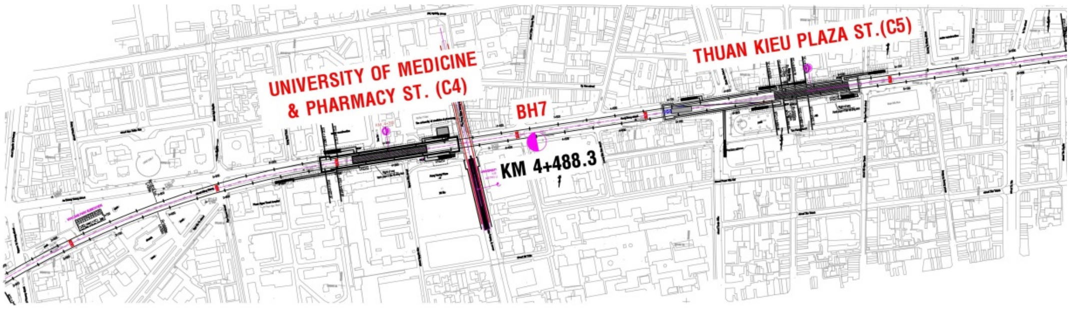


Source: JICA Study team

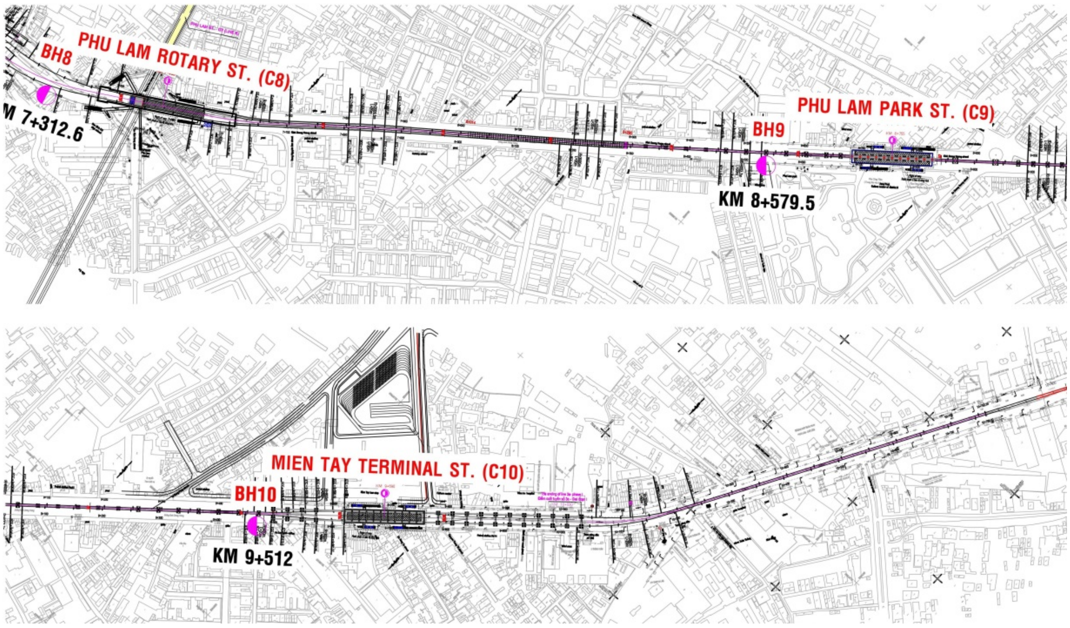
Figure 4.2.1 Boring Log of BH1 to BH10



a) BH1 to BH6



b) BH7



c) BH8 to BH10

Source: JICA Study team

Figure 4.2.2 Borehole Locations from BH1to BH10

4.3 Route Alignment

4.3.1 Route Alignment Plan

(1) Horizontal Alignment

The route of Line 3A Phase 1 remains unchanged from the F/S i.e. the Line begins at Ben Thanh Station and ends at Mien Tay Terminal Station (C10), running along Pham Ngu Lao St., Pham Viet Chanh St., Hung Vuong St., Hong Bang St. and Kinh Duong Vuong St..

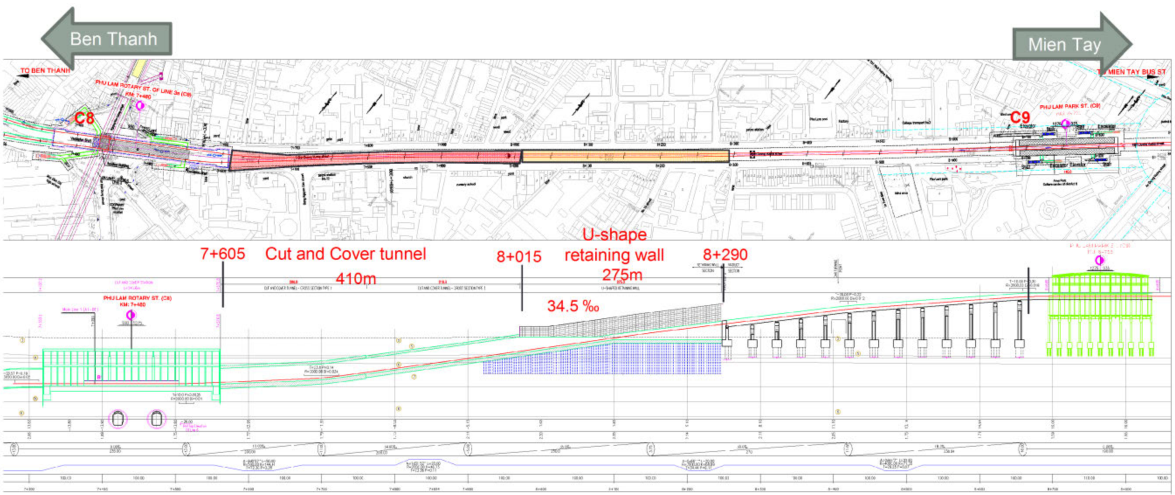
(2) Vertical Alignment

Notwithstanding the alignment designs of F/S where the entire alignment from Ben Than Station of Line to Mien Thai Terminal Station (C10) runs underground level, the Study Team and MAUR agreed on the following option among 3 alternatives specified in Chapter 3 in consideration of environmental impact and continuity with the elevated section of phase 2 (see Table 2.1.1).

- Underground section is from Ben Than Station to Phu Lam Rotary Station (C8)
- Elevated stations are Phu Lam Park Station (C9) and Mien Tay Terminal Station (C10)

(3) Transition Section from Underground to Elevated Structure

As illustrated in Table 2.1.1, the approved master plan envisages viaduct structure for 10.1 km of Phase 2, Line 3A. In particular, the F/S carried out by TEDI SOUTH proposed the transition section between C10 and Hi-Tech-Healthcare Park Station (C11) of Phase 2, whereas the Study Team determined the transition section in between C8 and C9 .

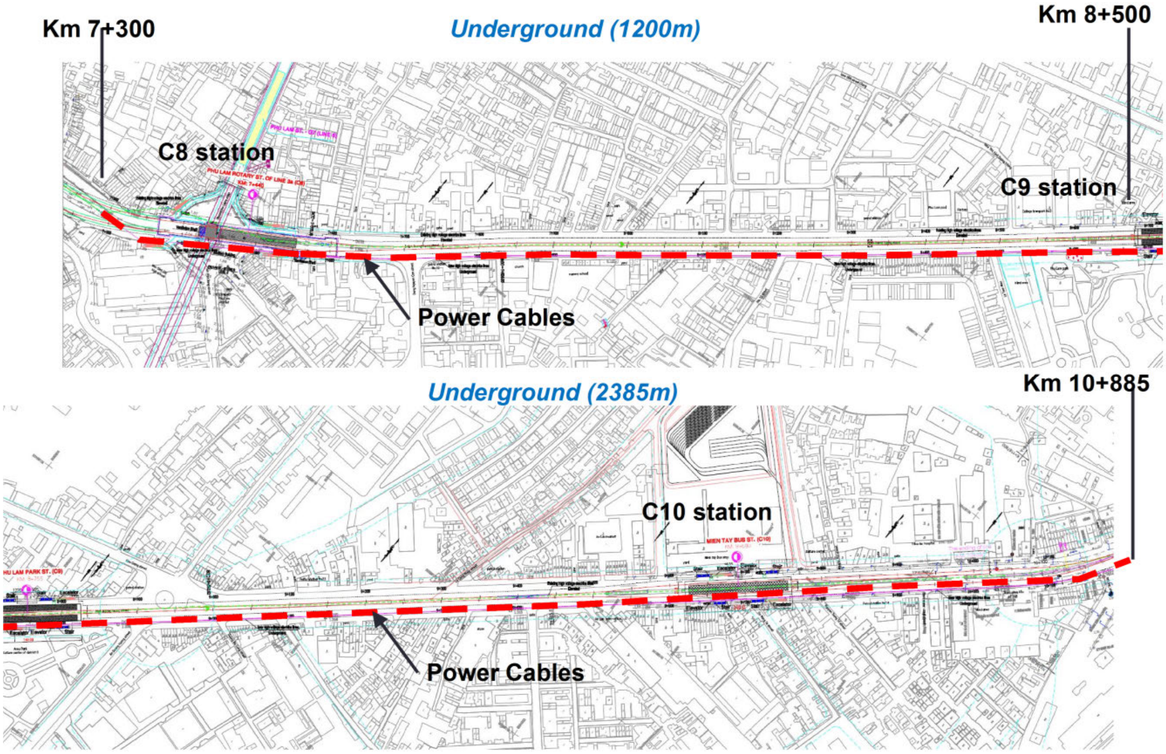


Source: JICA Study team

Figure 4.3.1 Transition Section from Underground to Elevated Structure

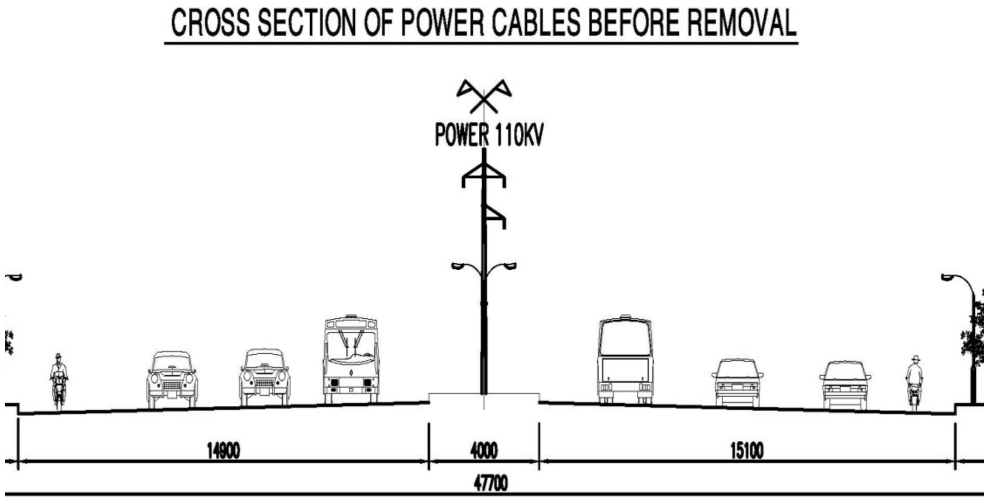
(4) Relocation of Power Cables

In order to build the elevated section, power cables situated in the road median need relocation to underground level for about 3.6km from C8 to C10. The meeting with EVN held on 21 April 2016 concluded that power cables will be relocated to underground using High-density polyethylene (HDPE) pipes and protected by concrete slab referring to other projects carried out by EVN as indicated in the following Figure.



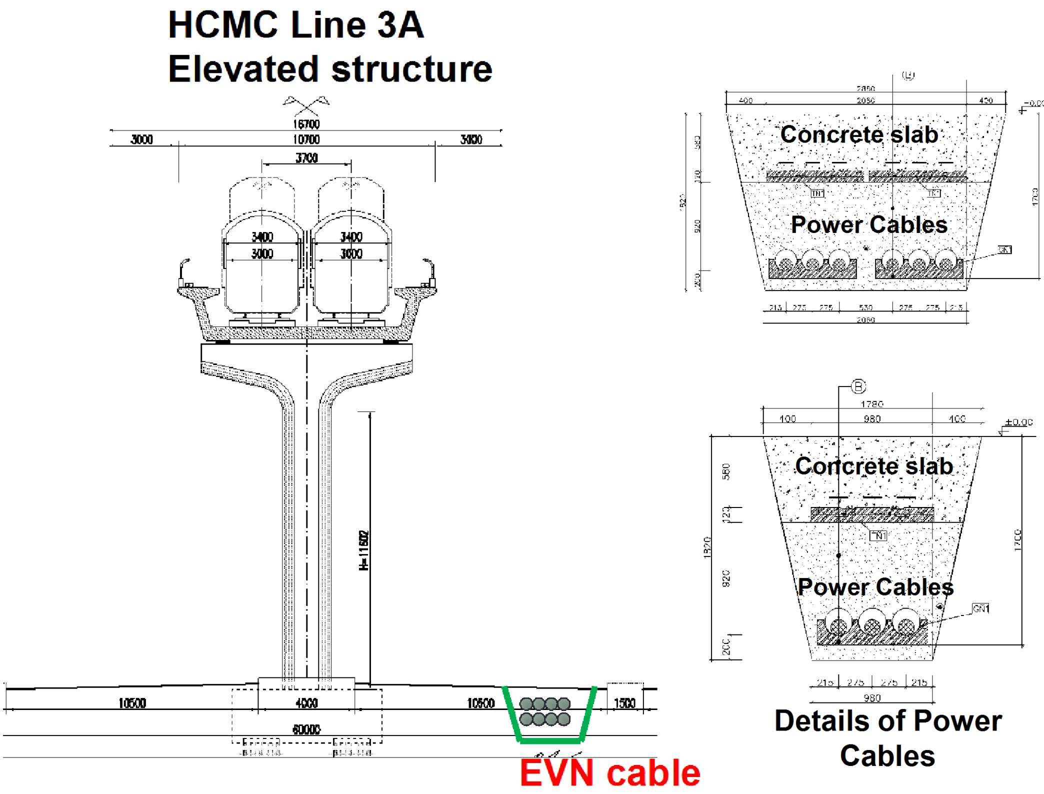
Source: JICA Study team

Figure 4.3.2 Relocation of Power Cables – Plan



Source: JICA Study team

Figure 4.3.3 Cross Section before Relocation of Power Cables (Existing Condition)



Source: JICA Study team

Figure 4.3.4 Relocation of Power Cables - Cross Section

(5) Alignment Geometry

Based on the above studies, the Study Team prepared alignment designs with the following alignment geometry.

Table 4.3.1 Alignment Geometry

Station	Chainage	Curve L/R	Curve		Grade	
			Radius (m)	Length (m)	‰	Length (m)
C0: Ben Thanh (East End)	Km 0+ 000				0	0
	Km 0+153	R	417	199		
	Km 0+ 170				0	170
	Km 0+ 303	R	1,500	85		
	Km 0+ 352				-20	182
	Km 0+ 402	L	1,500	91		
	Km 0+ 555				-5.2	203
	Km 0+ 785				20	230
C1 : Thai Binh Market	Km 0+ 910					
	Km 0+ 995				0	210
	Km 1+ 100				-10	105
	Km 1+ 148	R	313	314		
	Km 1+ 400				-25	300
	Km 1+ 457	L	300	436		
	Km 1+ 650				8	250

Station	Chainage	Curve L/R	Curve		Grade	
			Radius (m)	Length (m)	‰	Length (m)
	Km 1+ 724	L	800	130		
	Km 1+ 895				32	245
	Km 1+ 963	L	2,500	102		
	Km 2+ 015				10	120
C2 : Cong Hoa Six-Way Junction	Km 2+ 125					
	Km 2+ 171	L	600	100		
	Km 2+ 250				0	235
	Km 2+ 600				2	350
	Km 2+ 763				-20	163
	Km 2+ 935	L	2,000	83		
	Km 3+ 019	R	2,000	83		
	Km 3+ 020				10	257
C3: Hoa Binh Park	Km 3+ 135					
	Km 3+ 260				0	240
	Km 3+ 262	R	1,300	86		
	Km 3+ 352	L	1,300	86		
	Km 3+ 410				-10	150
	Km 3+ 650				-30	240
	Km 3+ 788	R	1,615	668		
	Km 3+ 810				4	160
	Km 4+ 036				32	227
C4 : University of Medicine & Pharmacy	Km 4+ 200					
	Km 4+ 320				0	283
	Km 4+ 504				-18	184
	Km 4+ 660				15	156
	Km 4+ 820				-2	160
	Km 4+ 905	L	3,015	83		
C5: Thuan Kieu Plaza	Km 4+ 935					
	Km 5+ 060				0	240
	Km 5+ 240				-30	180
	Km 5+ 347				3	107
	Km 5+ 520				30	173
	Km 5+ 537	R	915	314		
C6: Cho Lon Bus	Km 5+ 645					
	Km 5+ 770				0	250
	Km 6+ 088				5	139
	Km 6+ 220				32	131
C7: Cay Go	Km 6+ 345					
	Km 6+ 470				0	250
	Km 6+ 700				-32	230
	Km 6+ 890				-20	190
	Km 7+ 030				12	140
	Km 7+ 031	L	600	188		
	Km 7+ 285	L	350	277		
	Km 7+ 300				32	270
	Km 7+ 405				8	105

Station	Chainage	Curve L/R	Curve		Grade	
			Radius (m)	Length (m)	‰	Length (m)
C8: Phu Lam Rotary	Km 7+ 480					
	Km 7+ 585				0	180
	Km 7+ 650	L	400	135		
	Km 7+ 730				9	145
	Km 7+ 845	R	2,004	103		
	Km 8+ 422				34.5	692
	Km 8+ 489	L	4,000	91		
	Km 8+ 665				19	243
C9: Phu Lam Park	Km 8+ 755					
	Km 8+ 845				0	180
	Km 9+ 023	L	6,000	88		
	Km 9+ 094				-18	249
	Km 9+ 350				7	256
	Km 9+ 490				0	140
	Km 9+ 495	L	700	89		
	Km 9+ 584	L	800	87		
	Km 9+ 590				9	100
C10: Mien Tay Terminal	Km 9+ 690					
	Km 10+ 030				0	440

Note: A boundary between underground and elevated section is Km 8+290m, which is including U-shape retaining wall of transition section.

Source: JICA Study team

4.3.2 Station Location

(1) Design Parameter

Design parameters of stations are summarized in the following table.

Table 4.3.2 Design Parameters of Stations

Item	Parameter	Item	Parameter
Platform length	130m	Minimum radius of horizontal curve for platform	400m
Distance from platform edge to track centerline	1.55m	Gradient at platform	0‰
Platform width	12m	Turnout	10# for main line 8# for side line
Platform Type	Island (C1, C3-C8, C10), Siding (C2, C9) (see Figure 4.5.1)		

Source: JICA Study team

(2) Station Location

Station locations are specified as follows.

Table 4.3.3 Station Location

No	Station name	Chainage	Distance	Connecting line	Structure Type	Function*
C1	Thai Binh Market	0+910	910m	-	Underground	Intermediate station
C2	Cong Hoa Six –Way Junction	2+125	1,215m	Line 3B	Underground	Hub station
C3	Hoa Binh Park	3+135	1,010m	-	Underground	Intermediate station
C4	University of Medicine & Pharmacy	4+200	1,065m	Line 5	Underground	Transit station
C5	Thuan Kieu Plaza	4+935	735m	-	Underground	Intermediate station
C6	Cho Lon Bus Station	5+645	710m	-	Underground	Intermediate station
C7	Cay Go	6+345	700m	-	Underground	Intermediate station
C8	Phu Lam Rotary	7+480	1,135m	Line 6	Underground	Transit station
C9	Phu Lam Park	8+755	1,275m	-	Elevated	Intermediate station
C10	Mien Tay Terminal	9+690	935m	LRT Line1	Elevated	Terminal Station

Note)

Intermediate Station : station situated between terminal stations of Line 3A. Transit Station : station where passengers can change trains to other lines , Terminal station : station situated at the end of Line 3A, Hub Station : Intermediate Station -cum- Transit Station.

Source: JICA Study team

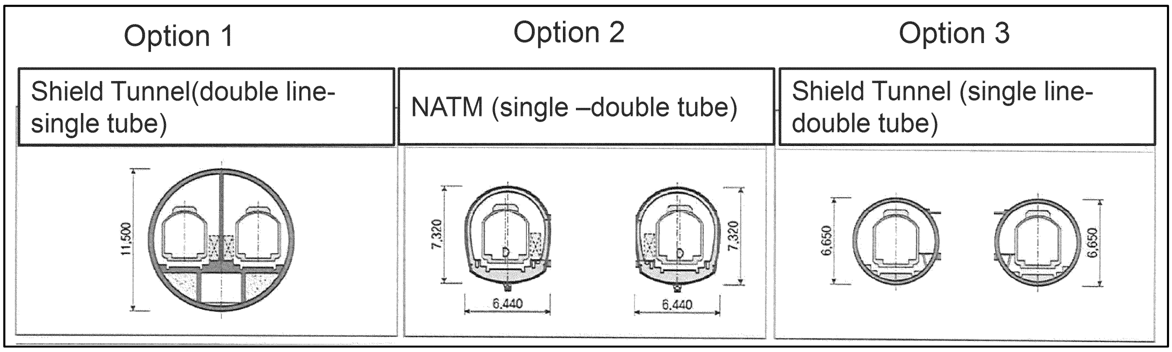
4.4 Civil Infrastructure

4.4.1 Civil Structure

(1) Underground Structure

1) Shield Tunnel

Three alternatives were compared, i.e. Option 1: double lines of single tube by Shield Tunneling, Option 2: single line of double tubes by New Austrian Tunneling method (NATM) and Option 3: Single line of double tubes by Shield Tunneling, from the viewpoint of construction cost, schedule and impact to the vicinity area. The Study Team selected option 3 as the most suitable method in any of the evaluation criteria. HCM Line 1 also adopted Option 3 for the same reasons.



Source: JICA Study team

Figure 4.4.1 Alternatives for Tunneling Method

Table 4.4.1 Station Location

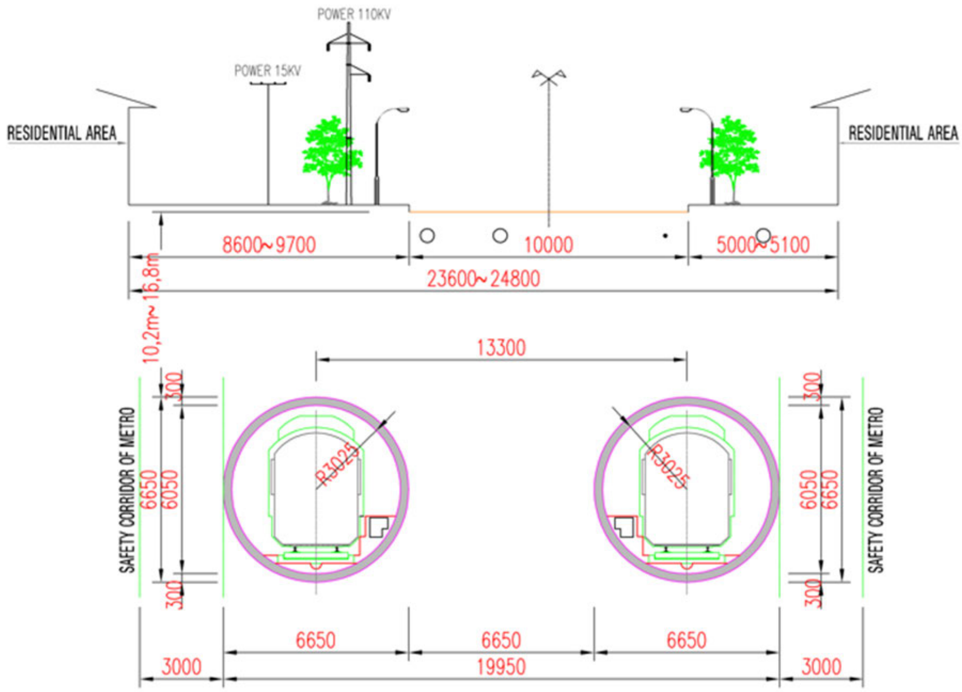
Option	Construction Cost	Construction Schedule	Impact to Neighborhood	
Option 1	* Maximum	Medium	Medium Impact	
Option 2	** Medium	Longest	*** Max. Impact	
Option 3	Minimum	Shortest	Min. Impact	Recommended

Note:
* : Larger amount of excavation
** : Requiring tunnel supportive
*** :Particularly difficult to reduce the impact under soft ground condition

Source: JICA Study team

It should be noted that the minimum earth covering was decided as 1.5 D (6.65 x 1.5m =10.0m) referring to "Standard Specifications for Railway Structure: Shield Tunnels", which mentions that earth covering should be planned securing at least 1 D. However, 2D of the minimum earth covering was adopted between C1 to C2 station where the shield tunnel is constructed under existing buildings to minimize building impacts.

Typical cross section of tunnel structure is shown as follows.



Source: JICA Study team

Figure 4.4.2 Typical Cross Section of Tunnel Structure

2) Cut and Cover Station

Construction of cut and cover stations, consisting of concourse and platform layers, employs "Top Down Method" using temporary earth retaining wall (diaphragm wall) as the permanent structure.

Inside length of station was revised from the original 160m in the F/S to 240m. Also, inside station width was revised from the original 20.5m to 22.9m to meet the following requirements:

- The platform width was enlarged from 10m to 12m.
- The thickness of diaphragm wall was expanded from 1.0m to 1.2m considering the impact to the vicinity areas, since the deflection of diaphragm wall may lead to the ground settlement.
- 400mm drainage and 200mm brick wall were adopted for leakage control.

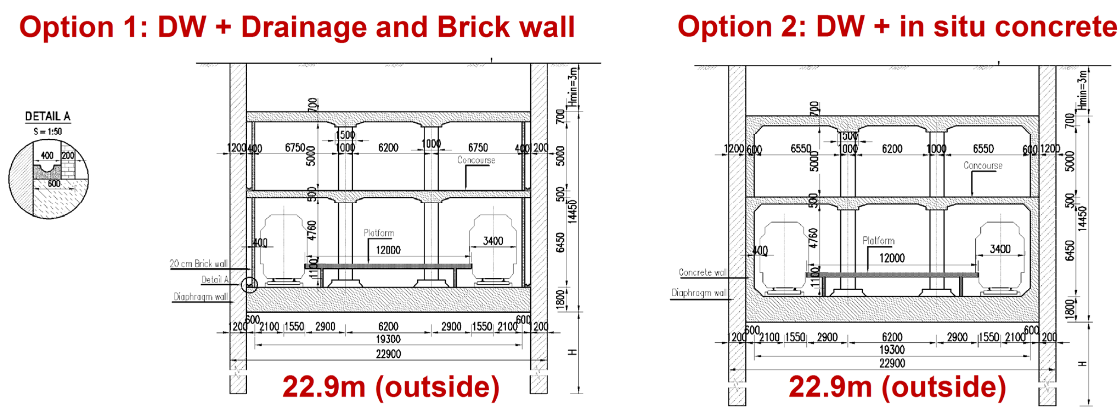
The minimum earth covering above station box is 3m, which was decided refereeing to similar projects having 2.5m to 3.0m earth covering such as HCM Line 1 and Hanoi Line 2 although there is no regulation regarding the minimum earth covering in Vietnam. Depth of station is about 17.5m from ground level (see below Figure).

Since GL -3.9m of the underground water average is relatively high, leakage countermeasure is required. For instance, it considers that waterproof sheet may be used at the location where structure is directly contacted with soil such as top and bottom slab and penetrating waterproof material may be sprayed at the diaphragm wall surface inside of the cut cover station.

Whilst the design of the F/S and HCM Line 1 adopted double walls, namely in situ concrete plus diaphragm wall to cater for the leakage control, the Study Team proposed a combination of diaphragm wall, drainage and brick wall for the following reasons.

- Although the leakage is controlled within the range of project specifications, the said leakage control may be insufficient.
- Public appearance is negative if the leakage occurs.
- The proposal by the Study team (Option 1) is superior to Option 2 (see below Figure) in terms of construction cost, safety, stability, ease of construction work and maintenance.

However, Option 2, which follows the same design concept with the F/S and HCM Line 1, will remain the alternative option as far as having same dimension with Option 1. The decision may be made during the detailed designs considering the leakage condition of Line 1.



Source: JICA Study team

Figure 4.4.3 Typical Cross Section of Underground Station

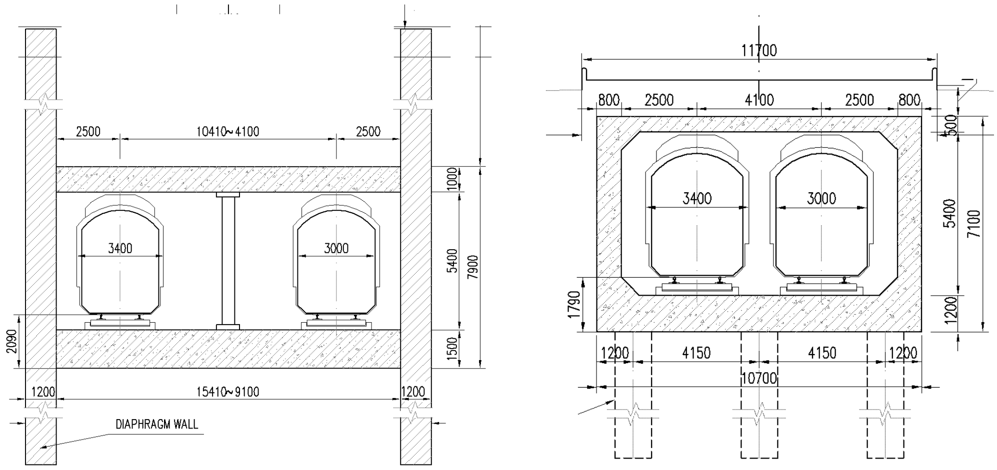
3) Cut and Cover Tunnel

Cut and cover tunnel is located in front and behind of C2 station and in front of C5 station (Ben Thanh side) to secure crossing railway (see Figure 4.5.1), which is second layer of box culvert and consists of crossing floor and concourse floor for station development and same with the station section.

Furthermore, the cut and cover tunnel is also located at transition section from underground to elevated section with having 410m length (see Figure 4.3.1). In the same manner with the station section, it has diaphragm wall section to be used for permanent structure and pile foundation section for shallow excavation where earth covering is less than 3.0m. Each section is shown in Figure 4.4.4.

Even though there is no regulation regarding necessary clearance (depth) under road for future utility work, it was decided that temporary diaphragm wall would be removed 2.5m from the ground level considering similar project conditions that have 2.5m to 3.0m earth covering, workability, influence to the top slab etc. In the same manner, temporary sheet piles and H piles used for pile foundation section are cut 2.5m from the ground level if they cannot be extracted.

For the diaphragm wall section, it is also required for leakage countermeasure in the same manner with the cut and cover station. For the pile foundation section, waterproof sheet and/or penetrating waterproof material may be required at the location where structure is directly contacted with soil.



a) Diaphragm Wall Section b) Pile Foundation Section

Source: JICA Study team

Figure 4.4.4 Cut and Cover Tunnel Section at Transition Section

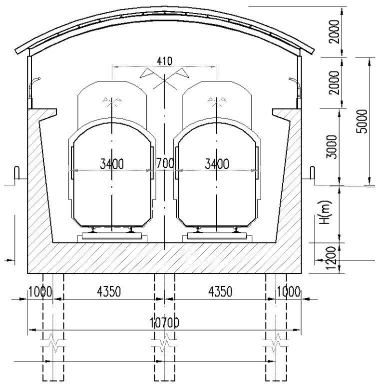
4) U-shape Retaining Wall

U-shape retaining wall is located at part of transition section from underground to elevated section, which is next to the cut and cover tunnel with having 275m (see Figure 4.3.1). U-shape retaining wall structure consists of u-shape retaining wall and pile foundations (see Figure 4.4.5).

Roof on the U-shape retaining wall is planned to prevent rainwater (see Figure 4.4.5) since although rainwater drainage pipe can be installed on the pier of the elevated section, pump drainage system is required in the tunnel section. The other purpose of the roof installation is to prevent the throwing of garbage.

It should be noted that wall height of U-shape retaining wall is decided by flood level and the roof is also installed as mentioned above and therefore flood gate may be not required in tunnel entrance.

In the same manner with pile foundation section of cut and cover tunnel, leakage countermeasure is necessary for the location where structure is directly contacted with soil by waterproof sheet and/or penetrating waterproof material.



Source: JICA Study team

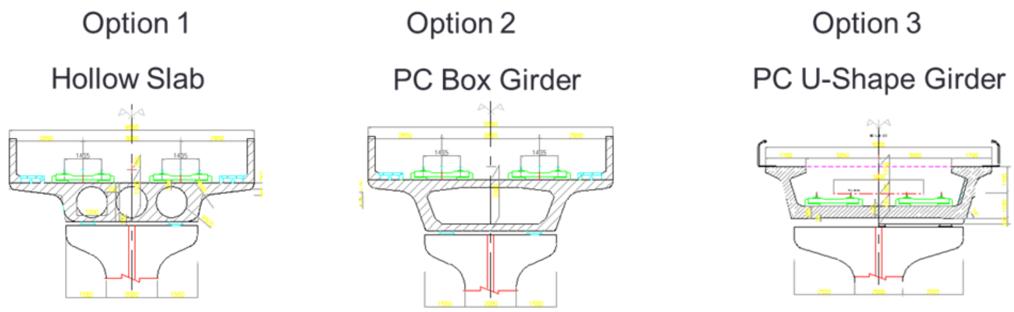
Figure 4.4.5 U-shape Retaining Wall Section at Transition Section

(2) Elevated Structure

1) Viaduct

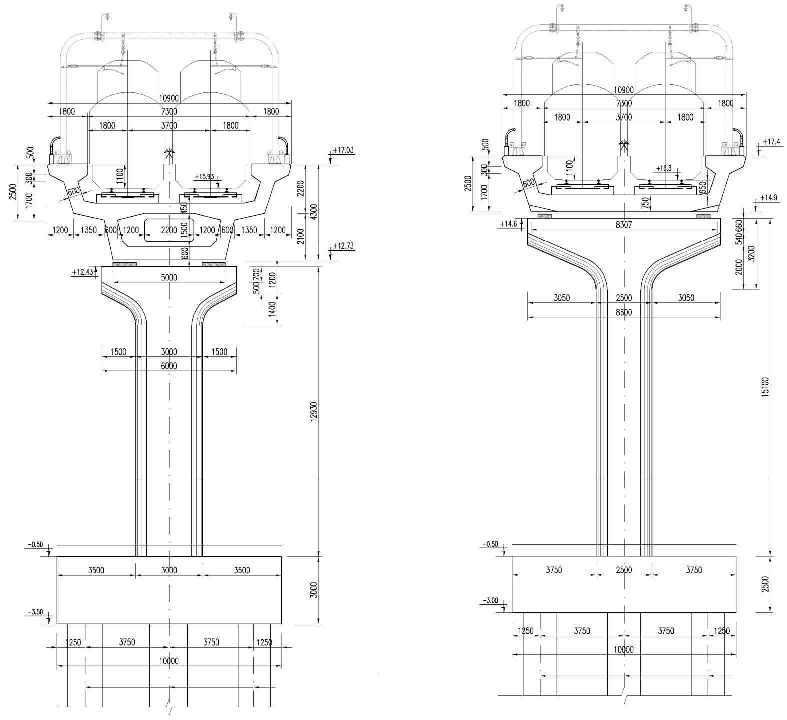
Three options of elevated structures were compared, i.e. hollow slab, PC box girder and PC U-shape girder for the superstructure of elevated section. The Study Team selected PC U-shape girder since it has advantages that lowest height of noise barrier and rail level under the same vertical clearance of girder are required compared to other two options (see Figure 4.4.6), moreover the F/S recommended and HCM line 1 also adopted it.

Although main viaduct is a simple bridge with having 35m span, PC box girder continuous viaduct having 70m maximum span is planned for the rotary for Hau Giang Street and An Duong Vuong Street in order not to disturb the traffic. The viaduct section is illustrated in Figure 4.4.7.



Source: JICA Study team

Figure 4.4.6 Alternative Options for Viaduct



a) PC Box Girder Continuous Viaduct b) PC U-Shape Girder Simple Viaduct

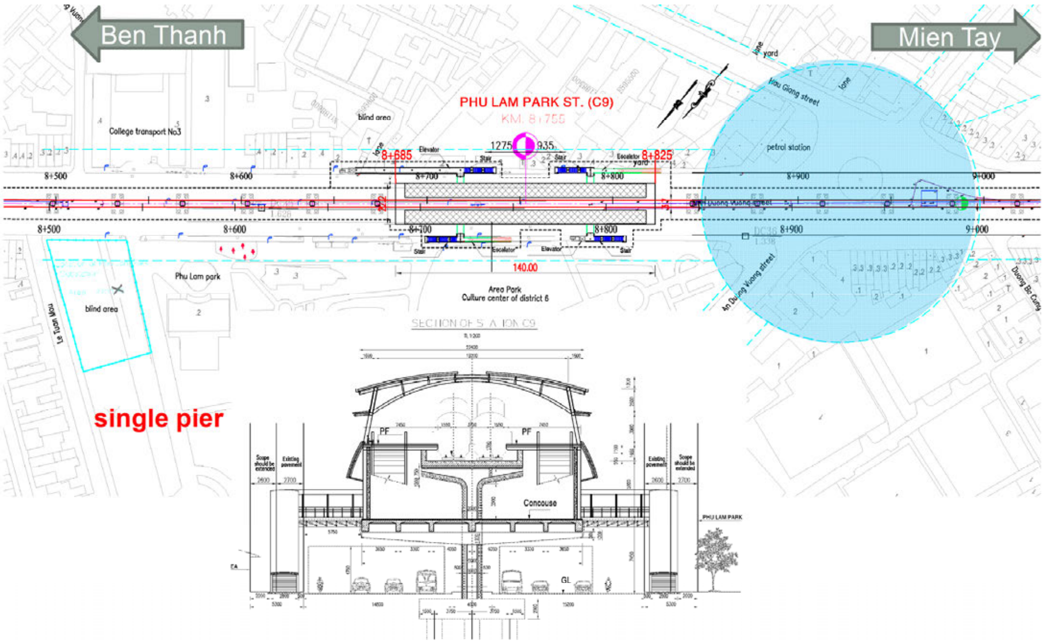
Source: JICA Study team

Figure 4.4.7 Viaduct Section

2) Elevated Station

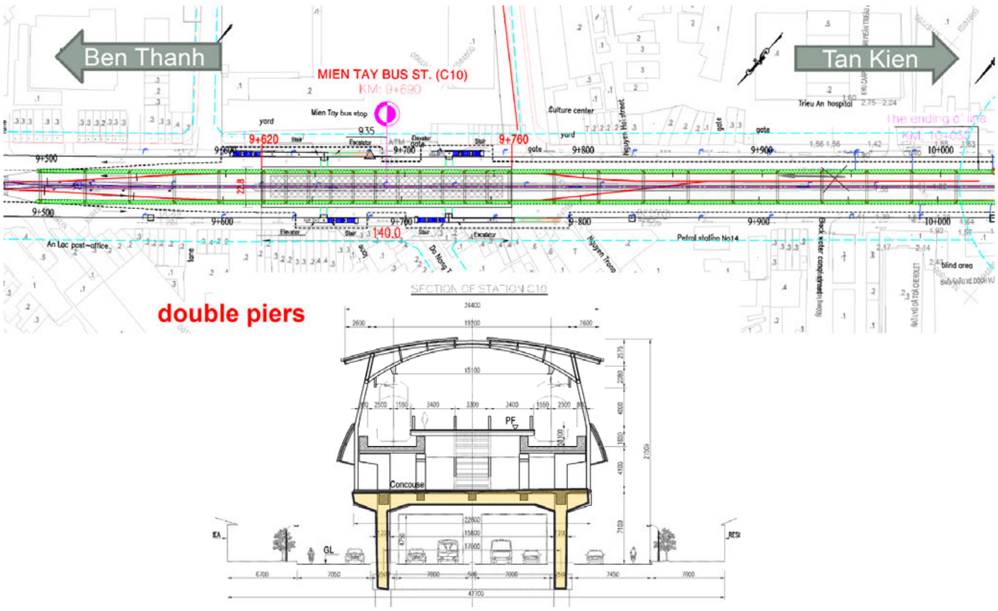
With the change in vertical alignment, C9 and C10 station became elevated stations. Whilst C9 structure can be supported with single pier, C10 structure, having an island platform with three tracks, should be placed on double piers considering deflection of super structure and stability of whole structure.

Side platforms may be supported with single pier. In the meantime, there is no past example of urban railways using single pier for one island platform with three tracks.



Source: JICA Study team

Figure 4.4.8 Elevated Station (C9)



Source: JICA Study team

Figure 4.4.9 Elevated Station (C10)

3) Foundations of Elevated Structure

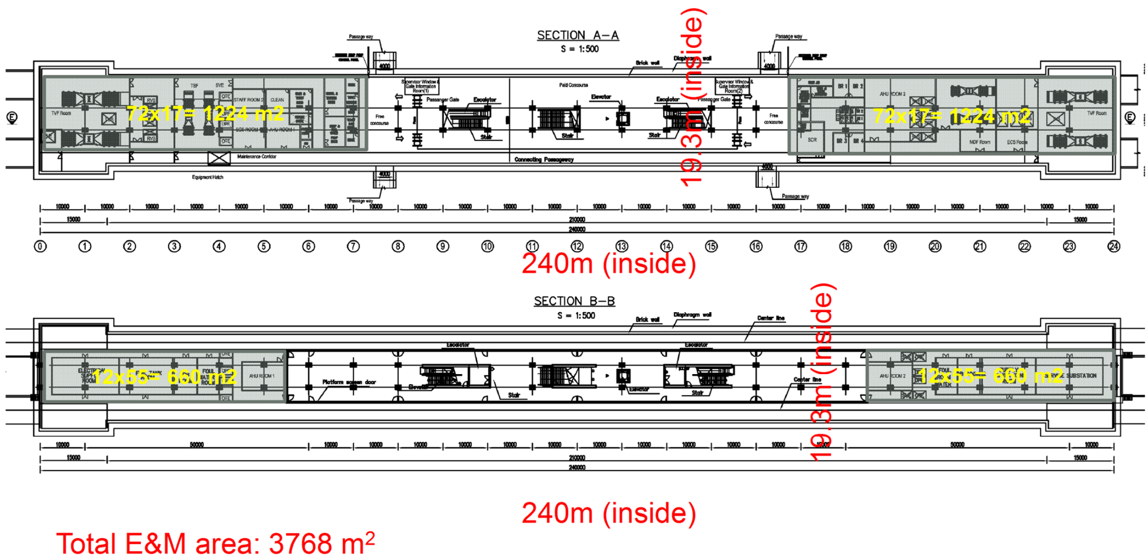
Very soft layer namely N value ranges from 1 to 2 was observed at elevated section. Therefore, this very soft layer was considered for the design of footings and foundation piles which support elevated structure loads by adjusting dimensions and lengths. However, the soft layer cannot be judged as normal consolidation in this survey. Hence, it proposes that the consolidation test should be carried out again during the detailed design and if the layer is confirmed as normal consolidation, enough pile length considering negative friction is secured.

4.4.2 Station Layout and M&E System

The F/S specified station inside length of 160m and station inside width of 17.3m. In the course of this Survey, the Study Team revised the inside length from 160m to 240m and the inside wide from 17.3 m to 19.3m. As the result, the Study Team proposed to increase the area for E&M system from 1,048m^2 to 3,768m^2 for the following reasons.

- Typical metro stations have 200 to 240m in length with a similar train configuration as Line 3A. The length proposed by the F/S is extremely tight to accommodate both passengers and equipment.
- The proposed area by the F/S is significantly insufficient to accommodate necessary facilities for underground stations, such as Tunnel Ventilation and Environmental Control System.

The above proposal was made with reference to the drawing for E&M system at Ba Son Station of Line 1.



Source: JICA Study team

Figure 4.4.10 E&M Systems Layout

4.4.3 Auxiliary Facilities and Equipment

The following facilities and equipment are installed at concourse and platform floors. In addition, auxiliary buildings, which have mechanical room, generator room and cooling tower, etc., are built separately within station area.

(1) Concourse floor

- Passenger facilities (ticket vending machines, automatic fare collecting gates, toilets, stairs, escalators and elevators, etc.)
- Station staff facilities (meeting rooms, stationmaster's office, toilets and rest area, etc.)

- E&M facilities (tunnel ventilation room, track exhaust fan room, environmental control system room and air handling unit, etc.)

(2) Platform floor

- Passenger facilities (stairs, escalators and elevators, etc.)
- E&M facilities (power supply room, service substation room, fire water room and air handling unit room, etc.)

4.4.4 Trackwork

In this study, slab track or direct fastened track, which having an excellent maintenability, is adopted in the main lines, while ballast track is adopted at depot area where travel speed of trains is restricted and separated from commercial line. Key specifications are;

- Rail for main line：heat-treated rail (equivalent to UIC 60kg)
- Turnout (10# for main line, 8# for siding tracks)
- Pre-stressed concrete sleeper
- Anti vibration box

4.4.5 Approval for Design Change from the F/S

In the meeting held on 26 April 2016 between MAUR and the Study team, a basic agreement was made on the revised vertical alignment which requires relocation of power cables, changes in station locations and design concepts of stations such as detailed arrangements of diaphragm wall and revision of station length and width, furthermore, removal and reconstruction of Cay Go flyover for C7 station construction. For two parties to sign an official agreement, the draft letter with a report, titled as "Report for Design Changes for Line 3A Phase 1", was submitted to MAUR both in English and Vietnamese on 10 May 2016 (see Appendix 4.1).

MAUR issued no objection letter ref. no. 1350/BQLDSDT-QLDA1 dated 17 May 2016 (see Appendix 4.2).

In addition, in terms of power cables relocation, the letter which mentions terms of agreement was issued to EVN in accordance with MAUR's suggestion.

4.5 Train Operation

4.5.1 Track Layout

Track layout of Line 3A shall meet the following train operation plans.

(1) Interoperability with Line 1

According to the track layout of Cong Hoa Six-Way Junction (C2) Station in the F/S, level crossing between main line, Ben Thanh - Mien Tay Terminal, and Line 3B, which turn over at this station, could hinder punctual operations of Line 3A. For this reason, track layout of C2 should be revised to avoid level crossings to prioritize interoperation between Line 1 and Line 3A.

(2) Turn Over at Intermediate Station

Traffic demand forecast shows gradual decrease from Ben Thanh Station in city center to the terminal stations in suburban area. Some trains should turn over at an intermediate station to ensure efficient transportation. Therefore, Mien Tay Terminal (C10) Station should allow turn over of trains even after opening of Phase 2 section.

Also, an intermediate station, possibly at Thuan Kien Plaza (C5) Station, should be provided with a simple turnout to allow turn over in the event of accidents and failures.

(3) Track Layouts of Stations for Depot Access

Line 3A Depot will be situated between C14 and C15 station of Phase 2 section. Track layouts of these stations for depot access require the following considerations:

1) Trains can access to and egress from depot in short period to serve peak hour traffic

- According to the estimate by the Study Team, maximum 12-15 trains depart from the depot for peak hour traffic in 2030 and beyond, when the headway becomes less than 3 minutes. Although it is desirable that depot access has double track based on the above circumstances, single track is proposed considering reducing occupied area by piers and construction cost. However, bidirectional signaling system is adopted to allow direction operation.

Furthermore, multi-level crossing is planned for main line and depot access, since trains from the depot and main line for C15 station are crossing.

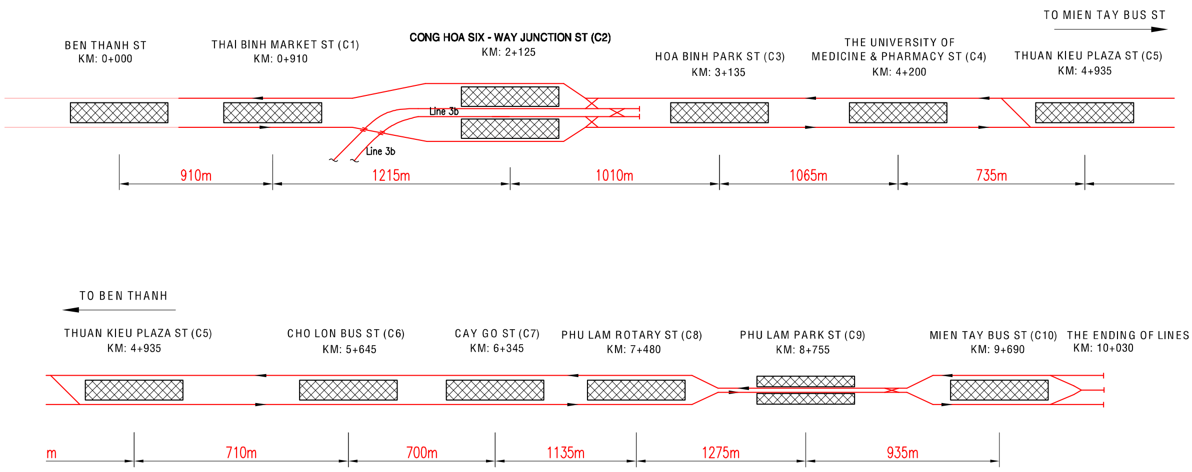
2) Trains require no change of direction for depot access and egress

- Track layout of F/S allows depot access and egress with both C14 and C15 station. However, the layout needs to reverse train direction in some cases, while specifications of Line 1, particularly signaling facilities, do not allow bidirectional operation. Therefore, depot access and egress should be made only with C14 station.

(4) Stabling of Accident Trains

Track layout of Line 3A should have a provision of stabling trains in the event of critical failures in order to make immediate evacuation from the main line possible. Use of side tracks at each station for this purpose can help reduce the development cost.

In light of the above, track layout of Phase 1, Line 3A is proposed as follows:



Source: JICA Study team

Figure 4.5.1 Track Layout

4.5.2 Travel Time

(1) Travel Time of Phase 1 Section

The Study Team developed transport plans based on the run curve information in F/S. The Run Curve provides travel time between stations by second. Meanwhile, the time in the table is rounded up by 5 seconds to secure some allowance for delays, which accounts for 4 - 5% and similar to the case in Japan.

Table 4.5.1 Travel Time (Phase 1 Section)

Travel Time (Westbound)	Dwell Time	Station	Dwell Time	Travel Time (Eastbound)
0:01:25	(0:00:30)	Mien Tay Terminal (C10)	(0:00:30)	–
0:01:25	0:00:30	Phu Lam Park (C9)	0:00:30	0:01:20
0:01:40	0:00:30	Phu Lam Rotary (C8)	0:00:30	0:01:35
0:01:10	0:00:30	Cay Go (C7)	0:00:30	0:01:30
0:01:00	0:00:30	Cho Lon Bus (C6)	0:00:30	0:01:10
0:01:20	0:00:30	Thuan kieu Plaza (C5)	0:00:30	0:01:10
0:01:35	0:00:30	University of Medicine & Pharmacy(C4)	0:00:30	0:01:10
0:01:25	0:00:30	Hoa Binh Park(C3)	0:00:30	0:01:35
0:01:50	0:00:30	Cong Hoa Six-Way Junction(C2)	0:00:30	0:01:30
0:01:25	0:00:30	Thai Binh Market(C1)	0:00:30	0:01:45
–	(0:00:30)	Ben Thanh(C0)	(0:00:30)	0:01:35
0:18:45		Total Time	0:18:50	

Note: Dwell times at Ben Thanh Station and Mien Tay Bus Station are not included in the total.

Source: JICA Study team

(2) Travel Time beyond Phase 1

Travel time beyond Phase 1 which is necessary for transport plans of Phase 1 is assumed as follows:

- Phase 2 Section : 0:18:00
- Line 1 Section : 0:29:00

4.5.3 Transport Plan

(1) Premise

- Reference was made to F/S for operation concept and specifications of Line 1 for signaling facilities
- Interoperation between Line 3A and Line 1
- Train operation diagram of Line 1 is assumed by the Study Team based on the demand forecast and specifications of Line 1 systems.
- Demand forecast of Line 1 is incorporated in the designed number of trains of Line 3A, i.e. number of trains per hour is determined based on the section loading between Opera House and Ben Thanh Station of Line 1, which has higher demand than any section loading of Line 3A.
- Maximum congestion rate per one peak hour is set within 125% to maintain riding comfort and safety of passengers.

(2) Summary of Transport Plan

Year-wise transport plans are summarized in the following table, where Daily Line Volume in 2030 and beyond incorporates the ridership of Phase 2 section.

Table 4.5.2 Summary of Transport Plan

			Base Case (C0 - C10)		3A Extension Case (C0 - C17)	
			2026	2028*2	2030	2040
C0 Ben Thanh - C1 Thai Binh	Daily Line Volume (Passengers)		218,500	311,700	404,800	475,500
	Peak time*1	Peak Hour Peak Direction Traffic	12,000	15,700	19,300	22,100
		Number of Trains/Hour	14	19	25	26
		Headway	0:04:20	0:03:10	0:02:25	0:02:20
		Transport Capacity (Passengers)	13,188	17,898	23,550	24,492
		Congestion rate (%)	91%	88%	82%	90%
	Off-peak time	Peak Hour Peak Direction Traffic	5,000	6,500	8,000	9,200
		Number of Trains/Hour	6	8	12	12
		Headway	0:10:00	0:07:30	0:05:00	0:05:00
		Transport Capacity (Passengers)	5,652	7,536	11,304	11,304
		Congestion rate (%)	88%	86%	71%	81%
Operating hours*3			5:00～23:30			

Note:

*1) Peak hour peak direction traffic, number of trains/hour, headway, transport capacity (passengers) and congestion rate for peak time are data of the direction having higher number of trains compared to the other direction. In more details, the data shows westbound (to the suburbs) at peak time in the morning and eastbound (to the downtown) in afternoon since although it is opposite to the main direction of transportation in HCM Line 3A, it can be clarify the time to be reached the limit of the signal system by indicating data that is shorter operation interval. For number of trains and congestion rate for the main direction, it is shown in Table 4.5.3.

*2) Numeric values are average of data in 2026 and 2030 because there is no demand forecast data in 2028.

*3) Operating hours are for reference only. This should be equivalent to the operating hours of Line 1 once determined.

Source: JICA Study team

(3) Number of Trains

All trains run through between Ben Thanh Station and C10 station without any turn overs at intermediate station in the early years of Phase 1 operation.

Meanwhile, some trains will turn over at C10 station after 2030 when the Phase 2 section becomes operational in order to reduce number of trains in the Phase 2 section with lower traffic.

(4) Number of Trains in Peak Hours

Demand forecast shows a gap of 30 - 40% of traffic between Line 1 and Line 3A. If Line 3A is provided with the same number of trains as Line 1, capacity becomes far beyond the actual traffic volume with significant increase in operations cost. For this reason, the Study Team determined number of trains in the morning and evening peak by direction and thereby remove unnecessary train operations.

In more details, the main direction of transportation in HCM Line 3A is opposite to that of HCM Line 1 and therefore number of trains is planned as shown in the following Table securing transportation capacity which does not impair amenity and safety.

Table 4.5.3 Number of Trains in Peak Hours by Direction

Year	Time Zone	Line-3A (Ben Thanh - Thai Binh Market)
2026	Morning Peak	14 train/hour 91% (Inbound)
	Evening Peak	14 train/hour 91% (Outbound)
2028	Morning Peak	16 train/hour 104% (Inbound)
	Evening Peak	16 train/hour 104% (Outbound)
2030	Morning Peak	18 train/hour 114% (Inbound)
	Evening Peak	18 train/hour 114% (Outbound)
2040	Morning Peak	20 train/hour 117% (Inbound)
	Evening Peak	20 train/hour 117% (Outbound)

Source: JICA Study team

(5) Number of Trains in Off-Peak Hours

Gap of traffic volume between Line 1 and Line 3A is observed in off-peak hours, too. Unlike peak hours, same numbers of trains are provided to secure convenience of the passengers through frequent service as comparable to the cases in overseas including Tokyo.

(6) Interoperation with Line 3B

The Study Team suggests that trains of Line 3B should turn over at C2 station in the early years after opening of Line 3B system. Justifications for this arrangement are:

- Mixed traffic of Line 1, 3A and 3B should hinder punctual operations as operational delays spread to the entire network. This is obvious from the experience of urban railways in Japan.
- Inbound trains departing from C10 station have two destinations including Ben Thanh Station and Line 3B, which will confuse passengers and give negative impressions. This should be avoided to promote the use of urban railways.

The above issues may be addressed through development of operational skills and accumulated experience of passengers. The decision should be made in the appropriate time.

4.5.4 Fleet Requirements

(1) Fleet Requirements and Timing of Expansion

Fleet requirements and timing of expansion to meet the transport plans are summarized as follows:

Table 4.5.4 Fleet Requirements

	2026	2028	2030	2040
Fleet requirement (Number of train)	10	14	23	24
Fleet requirement (Number of cars)	60	84	138	144

Source: JICA Study team

Key assumptions of the above are:

- Integrated operation with Line 1
- Train operation diagrams of Line 1 are prepared by the Study Team
- 1 spare train for response to maintenance and failures

(2) Operating Rate

Operating rate of Line 3A cars are summarized as follows. The rates in weekends / holidays are remarkably lower than weekdays simply because less number of trains is in operation due to absence of peak hours, which are comparable to the case in Tokyo Metro.

Table 4.5.5 Operating Rate

Type / Year	Weekday			Weekend / Holiday		
	Number of Trains	# of Trains in Operation	Operating Rate	Number of Trains	# of Trains in Operation	Operating Rate
2026	10	10	100%	10	5	50%
2028	14	13	93%	14	9	64%
2030	23	22	96%	23	13	57%
2040	24	23	96%	24	13	54%
Tokyo Metro (example)	53	50	94%	53	25	47%

Note: Operation rate of Tokyo Metro is based on the record of Marunouchi Line as of December 2013.

Source: JICA Study team

4.6 Rolling Stock

4.6.1 Review of Past Studies

Specifications of rolling stock in F/S are prescribed as follows. Except route conditions and particulars, these specifications are consistent with typical commuter trains in Japan.

Table 4.6.1 Outlines of Rolling Stock Specifications

Item		Specification
Train Consist (M: Motor Car, Mc: Motor Car with Driving Cabin, T: Trailer Car)		Mc -T- M - M - T - Mc or Mc -T- T - M - T - Mc
Dimensions	Length (Mc)	20,250mm
	Length (T)	19,500mm
	Width	2,950mm
Passenger Capacity*	Capacity (Mc)	147 passengers
	Capacity (T)	162 passengers
Body Material		Stainless / Aluminum alloy
Maximum Speed		Elevated Section120km/h, Underground Section 80km/h
Driving Performance	Acceleration	3.3 km/h/s (0.92 m/s^2)
	Deceleration (Ordinary/Emergency)	3.6 km/h/s (1.0 m/s^2), 4.5 km/h/s (1.25 m/s^2)
Traction System	Power Collection	DC 1500V/AC 25kV
	Control System	VVVF IGBT Inverter
	Main Motor	380V 3-phase DC motor
Brake System		Air-pressure brake, regenerative brake
Bogie		Bolsterless type

Note*: Passenger capacity defines as “seating plus standing capacity”. The standing capacity is calculated using the value of 3.3person/m^2 that shows ratio for standing space of floor area in Japan.

Source: JICA Study team

4.6.2 Preliminary Outline Specifications

(1) Considerations for Interoperation with Line 1

Outline specifications of rolling stock shall be based on those of Line 1 as interoperation between Line 3A and Line 1 is envisaged. Advantages of this standardization include:

- Human errors due to difference in specifications will be avoided as handling by train operation and maintenance personnel will be standardized.
- Maintenance and procurement costs will be reduced by maintenance standardization.
- Total number of rolling stock will be reduced by common use of spare trains between Line 1 and Line 3A
- Response to system failures will become faster with unified maintenance system

(2) Necessary Considerations for Standardization

According to the train operation plan based on traffic demand forecast, the Operator is supposed to own a total of 50 train-sets (300 cars) for Line 1 and Line 3A in 2040. In the event completely same specifications are introduced to all trains/cars, a trade-off between "efficiency" and "risks" must be properly understood. In fact, Tokyo Metro experience the following issues in the past.

Table 4.6.2 Issues of Standardization - Case of Tokyo Metro

Issue	Impact	Remarks
Failures due to structural defects of on-board device / equipment	Simultaneous and epidemic occurrence of failures	In the worst case, part of operations will be cancelled due to lack in functional trains
	Need for inspections and repairs of every products of same suppliers	
Hit of Disaster to manufacturing factories of maintenance parts	Became unable to procure spare parts from the supplier and had trouble in finding alternative products	

Source: JICA Study team

Being aware of the above risks, important parts for train drive, such as control systems, motors and braking systems, should have several supply sources even if contracted with one supplier.

4.6.3 Next Step

(1) Incorporate of the Latest Technologies

The following table summarizes major developments of technologies which were recently introduced to commuter trains in Japan. Taking into account the need and cost for introduction, the Study Team will consider the applicability of these technology to the Project.

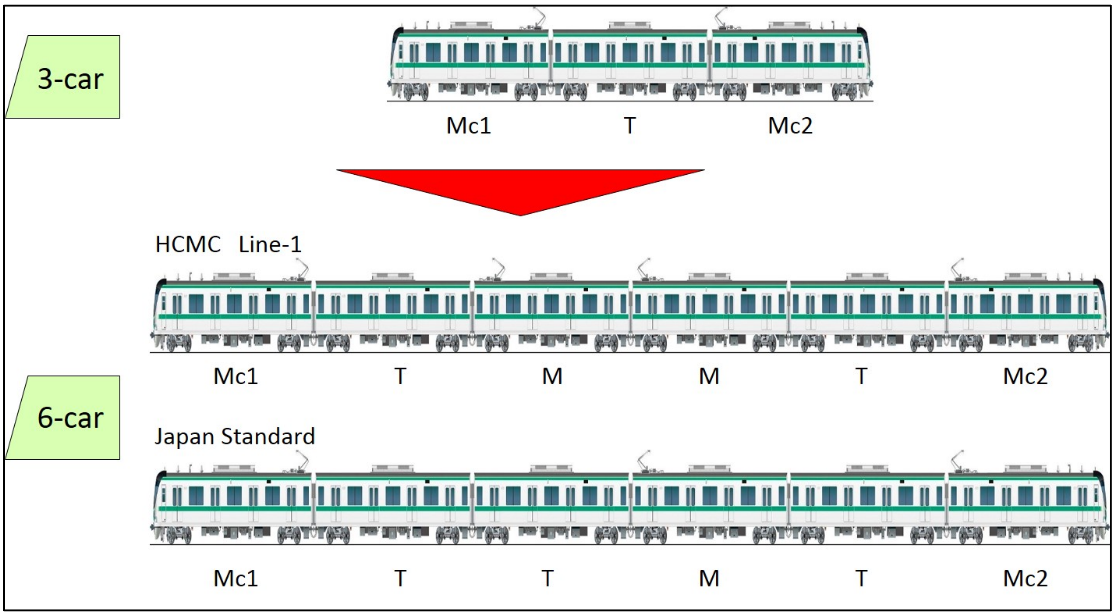
Table 4.6.3 Latest Rolling Stock Technologies

Latest Rolling Stock Technology	Advantage of Japanese Technology
Permanent Magnet Synchronous Motor (PMSM)	• Optimized system designs for particular route conditions • Reduction in failure ratio and maintenance cost by fully enclosed type traction motor, fan-less cooling devise, undegrated and bearing-changeable structure (plus highly proven with track records) • Cost saving by smaller and lighter control systems • Reduction in noise level • Cost reduction by less number of motor cars per trainset • Enhanced running efficiency by optimized control of idling and gliding • High energy saving
Fully closed high efficiency induction motor (Undegrated and bearing-changeable type)	• Reduction in power consumption by expanded range of regenerating brake and avoidance of motor loss • Say 15% of reduction in traction power according to the cases in Japan • High energy saving
SiC Element (Export opportunity is limited as of this reporting period)	• Significant reduction in size and weight • Making possible regenerative brakes at high speed of travel • Reduction in loss at power conversion • Significant energy saving
Parallel sync of auxiliary power Saving of auxiliary power during off-peak hours	• Reduction in power loss with operation of less auxiliary power during off-peak hours • High energy saving
Other Records	**Advantage of Japanese Technology**
Records of failure ratio and requirement in Rolling Stock specification	• Possibly lower the requirement of failure ratio from Line 1 • High reliability and steady transportation service

Source: JICA Study team

(2) Particular Requirements in Design

6 car-trainset is assumed as the train consist of Line 3A since day one of its commercial operation, while Line 1 begins operation with 3 car-trainset. With respect to the ratio of motor cars per trainset is larger, i.e. 4M2T, in comparison with 3M3T which is typically introduced in commuter trains in Japan.



Source: JICA Study Team

Figure 4.6.1 Train Consist

3M3T formation should be considered as it can reduce initial cost as far as same driving performance with Line 1 trains can be secured.

4.7 Depot and Maintenance Facilities

4.7.1 Approach

Depot requires maintenance facilities and equipment necessary for periodical inspections as specified in the regulations and repairs in the event of failures. With the assumptions of having one depot each for Line 1 and Line 3A, facilities and equipment for inspections and repairs as required by car maintenance plans are not necessary to be duplicated at two depots.

This section aims to develop maintenance facilities and equipment plans that can achieve efficiency and cost minimum, taking into account integrated operations of Line 1 and Line 3A in accordance with the fleet requirements estimated from traffic demand forecast.

4.7.2 Depot Location and Layout

(1) Outlines of Line 1 Depot

Line 1 Depot at Suoi Tien equips a range of maintenance facilities and equipment for all necessary inspections and repairs of rolling stock, having a maximum capacity of 32 trainsets (192 cars).

Table 4.7.1 Outlines of Line 1 Depot

Capacity	Description	Remarks
Stabling Capacity	Maximum 30 trainsets of 6 cars	
Inspections and Repairs Capacity	• Overhaul (every 8 years) & critical parts inspections (every 4 years) – A total of 32 trainsets per 4 years • Monthly inspections (every 3 months) – 32 trainsets per 3 years • Inspections of trains (at least every 10 days) – 3 trainsets per day • Daily inspections (before departure from depot to operational lines) – All trainsets except spare trains every day	• Having a capacity of 31 trainsets per day for daily inspections, which is equivalent to maximum number of trains to be owned by Line 1 (32 trainsets) minus 1 spare trains

Source: Hitachi and Inspection Period as per Japanese Regulation

(2) Inspections and Repairs Capacity

A total number of trainsets for Line 1 and Line 3A will grow as shown in the following table according to the estimate of the Study Team based on traffic demand forecast. This indicates that inspections and repairs requirements will reach beyond the capacity of Line 1 depot in 2030. It means development of additional depot upon extension of Phase 2 of Line 3A, which is not covered by this project, must be completed by this period.

Table 4.7.2 Inspections and Repairs Capacity

Year	Line-1	Line-3A	Total	Remarks
2026	16	11	27	Number of trainsets excludes 1 spare train each. Number of cars = number of trainsets x 6
2028	18	14	32	
2030	23	23	46	
2040	25	24	49	

Note: Number of trainsets of Line 1 is estimated from the train operation diagram with assumed traffic forecast by the Study Team. Time to reach the capacity limit is, therefore, subject to change depending on the actual transport plans of Line 1.

Source: JICA Study Team

4.7.3 Train Stabling

(1) Planning Concept

Concept of train stabling plans of Line 3A is as follows:

Table 4.7.3 Inspections and Repairs Capacity

Classification	Concept	Remarks
Phase1 (Covered by this project)	As many trains as possible to be stabling at stations, while remaining trains at Line 1 depot	Traffic demand forecast shows directionally asymmetric volume of traffic, i.e. Line 1 to 3A direction in the morning peak and Line 3A to 1 direction in the evening peak shows larger volume. To better meet this traffic asymmetry, several trains should be stabled at Line 1 depot.
Phase2 (Not covered by this project)	Stabling at 3A depot. Part of trains may be stabling at stations as appropriate in accordance with the operation plans of the first and last train of the day.	

Source: JICA Study Team

(2) Overnight Train Stabling

Based on the train operation plans, overnight train stabling of the rolling stock of Line 3A is designed as follows. According to the train operation diagram prepared by the Study Team, Line 1 Depot will accommodate 21 sets of Line 1 trains. Stabling capacity of Line 1 Depot is unlikely to reach maximum capacity in 2040 even though additional trains of Line 3A, say 3 trainsets, are to be stabled there.

Table 4.7.4 Overnight Train Stabling

Station / Year	Line-1 Depot	Line-3 Depot	Ben Thanh	Cong Hoa	Mien Tay Terminal	Total
2026	5		(1)	2	4	11
2028	8		(1)	2	4	14
2030	3	17	(1)	2	1	23
2040	3	18	(1)	2	1	24

Note: Unit: Number of trains, Stabled trains at Ben Thanh are counted as part of Line 1 operation. Trainsets in the table include 1 spare train.

Source: JICA Study Team

(3) Daytime Train Stabling

Daytime train stabling plans are summarized in the following table, where Line 3A Depot accommodates 3 trainsets of Line 1 after morning peak, while 1 trainset among these are returned to Line 1 operation in the evening time. This means Line 3A Depot receives additional 3 trains from the numbers in the table.

Table 4.7.5 Daytime Train Stabling

Station / Year	Line-1 Depot	Line-3 Depot	Ben Thanh	Cong Hoa	Mien Tay Bus	Total
2026	3		0	0	2	5
2028	5		0	0	2	7
2030	0	9	0	0	0	9
2040	0	10	0	0	0	10

Note: Unit: Number of Trains

Source: JICA Study Team

(4) Maintenance while Stabling

Maintenance and cleaning works can be undertaken in the daytime when the Depot accommodates 5 - 10 trainsets. No maintenance works are carried out overnight in Japan. If this is the case in Vietnam, satisfying stabling capacity at depot is the sole requirement.

4.7.4 Line 3A Depot

(1) Need for Line 3A Depot

As explained the above, Line 1 Depot will be shared with Line 3A in this project. However, Line 3A Depot is necessary in 2030, which is opening of Phase 2 (not covered by this project). Reasons for the need for Line 3A Depot are:

- Number of train operation and car ownership will increase upon opening of Phase 2 and capacity expansion of Line 1.
- Stabling capacity of Line 1 and Line 3A at stations will reach beyond maximum capacity.
- Insufficiency in inspections and repairs capacity of Line 1 Depot will make maintenance of rolling stock to ensure safe transportation incapable.

(2) Functions of Line 3A Depot

Line 3A Depot will require functions to supplement insufficiency in inspections and repairs capacity of Line 1 Depot. The following table explains two approaches for Line 3A Depot.

Table 4.7.6 Functions of Line 3A Depot

№	Approach	Description	Remarks
1	Line 1 Depot performs general overhauls and critical parts inspections, while Line 3A Depot serves for light maintenance such as monthly inspections.	Expand "car repair shop" of Line 1 Depot by 2030 with a capacity of general overhaul and critical parts inspection for around 50 trainsets every 4 years	Reasonable approach taking work efficiency and cost of inspections and repairs into consideration
2	Both Line 1 and 3A Depot equip all functions for necessary maintenance.	No expansion of Line 1 Depot, while Line 3A Depot equips all functions for maintenance works, i.e. same facilities and equipment as Line 1 Depot	Requiring higher cost for development, yet able to design flexible maintenance plans

Source: JICA Study Team

In fact, most of Japanese railway operators including Tokyo Metro integrate car repair shops. In the event of expanding the shop in Line 1 Depot, spatial requirements and availability must carefully be assessed. If the first alternative is not feasible for physical reasons, Line 3A Depot will be developed with the second alternative.

4.7.5 Next Step

Project implementation plan for Depot will be reflected in Pre-F/S for national assembly submission.

4.8 Electrical Systems

4.8.1 Review of Past Studies

Specifications of electrical systems of Line 1 are summarized as follows:

Table 4.8.1 Specifications of Electrical Systems (Line 1)

Facility	Specification	Location / outdoor or indoor
Receiving Substation (RSS)	2-GIS (Gas Insulated Switchgear) 110/22kV 25MVA×2 Transformers	Tan Cang and Binh Thai / outdoor
Traction Substation (TSS)	5-22kV/DC1500V x 3 x 3,000kW rectifier	Ben Thanh, Tan Cang, Rach Chiec, Binh Thai and Suoi Tien / indoor

Source: JICA Study Team

2 locations out of 5 TSS are combined with RSS. TSS equips the following facilities:

- TSSs at Ben Thanh, Tan Cang and Binh Thai equip regenerative electric power absorption Inverters (INV).
- Each TSS equips 22/6.6kV power supply transformers to supply electric power for station and tunnel facilities via Service Substation (SSS) at each station.

The F/S describes the following electrical facilities.

Table 4.8.2 Specifications of Electrical Systems (Line 3A F/S)

Facility	Specification	Location / outdoor or indoor
Receiving Substation (RSS)	1-110/22kV 2 x 20MVA Transformer	Newly established at Phu Lam Park(C9), outdoor
	1-110/22kV 1× 20MVA Transformer	Added to Tan Cang RSS of Line 1
Traction Substation (TSS)	2-22kV/DC1500V x 3 x 3,000kW rectifier	Newly established at Van Lang Park and Phu Lam Park (2 nos.), indoor

Source: JICA Study Team

Both RSS and TSS are proposed at Phu Lam Park.

4.8.2 Preliminary Outline Specifications

As the results of reviewing the F/S, preliminary outline specifications for Line 3A phase 1 are proposed as follows.

(1) Receiving Substation (RSS)

- According to the F/S, 110/22kV 1x20 MVA transformer will be added at Tan Cang RSS and 22kv cables will be pulled along the railway, especially in the tunnel via Ben Thanh Station to Van Lang Park TSS. This work should be carried out in the night after business hours since operation from Tan Cang to Ben Thanh station may be started at that time. In addition, there is no space for installation of additional 110/22kV 1x20 MVA transformer at Tan Cang RSS. Having considered these situations and following employer's requirement of Line 1 that even though one RSS cannot be operated due to power failure, train operation should be maintained, two RSSs are installed along Line 3A.

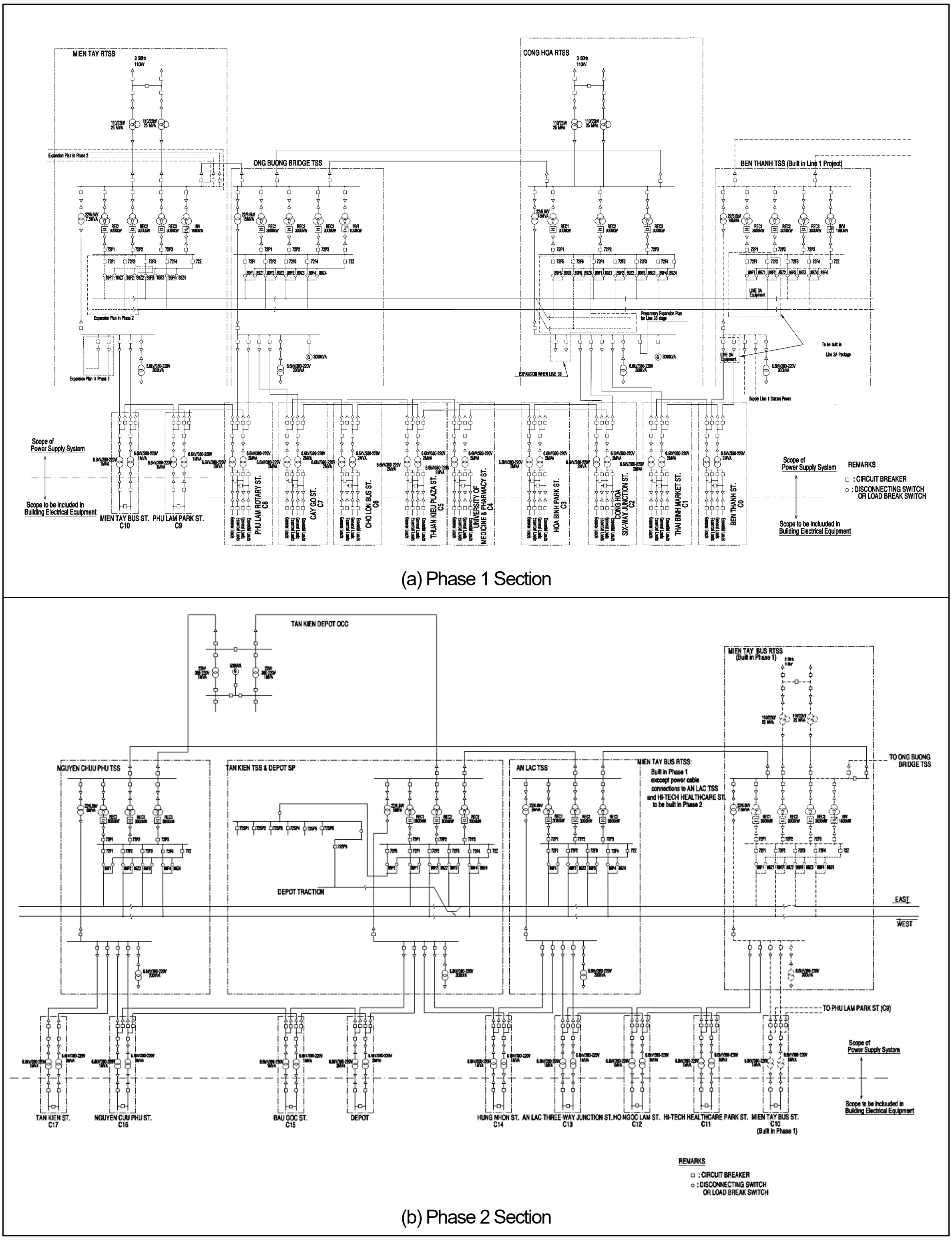
- Two RSSs are installed at Phu Lam Park and Van Lang Park respectively and those transformer capacities are 2sets-110/22kV 25MVA.
- Although RSS can be installed at outdoor, building for RTU for RSS, relay board and battery is required at Phu Lam Park and Van Lang Park respectively.

(2) Traction Substation (TSS)

- TSS should meet requirements such as 1) no influence to train operation against any troubles at substation and 2) pantograph point voltage is 1200V at normal time and more than 1000 V at abnormal time.
- As the results of power simulation, three TSSs are required.
- One TSS among three TSSs is planned at C10 station, which is end of Phase 1 section, to prevent voltage drop of pantograph point voltage. For TSS of C2 station, the space for additional two feeder lines of DC 1500V is required for future use of Line 3B. Furthermore, one TSS is installed at Ong Buong Bridge.
- TSS is indoor use.
- INV is indispensable equipment for position stopping, which will be installed at two locations of TSS in order to prevent one TSS failure. The install location of INV should be in front and behind of long slope, and therefore it is installed at C10 and Ong Buong Bridge respectively.
- Existing Ben Thanh TSS is required for additional two lines of DC1500V and 6.6kV including renovation for these additional lines. However, since Ben Thanh TSS is not considered these extensions, there is no space for extension of DC1500V switchgear and 6.6kV switchgear. Hence other space should be secured for extension.
- One 22/6.6kV transformer is installed each TSS respectively for power transmission to SSS, which capacity is indicated in Table 4.8.4.
- 2-6.6kV/380-220V transformer and 6.6kV switchgear for power receiving are installed at SSS. The transformer capacity is the same as that of Line1, i.e. 2MVA for underground station and IMVA for elevated station.
- It seems that emergency generator is installed at one location and supplying power to eight stations is impossible considering inrush current to transformer and system structure. Therefore, the emergency generator of 3000 kVA is installed at Cong Hoa TSS and Ong Buong TSS respectively and each generator supplies power for four underground stations. Furthermore, automatic control by power SCADA is adopted, since generator control cannot be started unless the total condition is grasped. This can be done one station substation by one station substation sequentially considering inrush current to transformer

of station substation. For this purpose, voltage condition on the secondary side of transformer at station substation, main switch and bus contact switch are integrated into RTU of station substation side for control.

- In terms of station substation, monitoring range at electrical side is shown in Figure 4.8.1.



(a) Phase 1 Section

(b) Phase 2 Section

Source: JICA Study Team

Figure 4.8.1 Power System Diagram

- Station substation where generator is installed cannot be established interlock with each station and hence start-up of the generator can be done by manual. However, other operation can be performed in accordance with power instructions
- Ong Buong Bridge TSS has three floors and the generator is installed at first floor.

The substation location and electrical equipment are shown in Table 4.8.3. Major equipment of substation and station substation (service substation) are indicated in Table 4.8.4 and 4.8.5 respectively.

Table 4.8.3 The Substation Location and Electrical Equipment

Location	Electrical Equipment
Mien Tay Terminal (C10) Station Substation	TSS
Phu Lam Park Substation	RSS
Van Lang Park Substation	RSS＋TSS＋INV
Ong Buong Bridge Substation	TSS＋INV
Cong Hoa Six-Way Junction(C2) Station Substation	TSS

Source: JICA Study Team

Table 4.8.4 Major Equipment of Receiving and Traction Substation

No.	Substation	Major Equipment
1	Cong Hoa TSS	1set-22kV Switchgear, 3 set-3000kW Rectifier equipment, 1set-1500V Switchgear, 1set-RTU for TSS, 1set-6.6kV Switchgear, 1set-15MVA 22/6.6kV Transformer, 1set -200kVA 6.6kV/380-220V STR, 1set-DC Battery Charger 1set-3000kVA Emergency Diesel Generator (All of the above indoor specification)
2	Van Lang Park RSS	1set-110V GIS, 2 set-25MVA 110/22kV Transformer (All of the above outdoor specification) 1set-Relay board for 110kV Receiving, 1set-RTU for RSS, 1set-6.6kV Switchgear, 1set -200kVA 6.6kV/380-220V STR, 1set-DC Battery Charger (All of the above indoor specification)
3	Ong Buong Bridge TSS	1set-22kV Switchgear, 3 set -3000kW Rectifier equipment, 1set-1000kW Regenerative inverter, 1set-1500V Switchgear, 1set -15MVA 22/6.6kV Transformer, 1set-6.6kV Switchgear, 1set-RTU for TSS, 1set -200kVA 6.6kV/380-220V STR, 1set-DC Battery Charger 1set-3000kVA Emergency Diesel Generator (All of the above indoor specification)
4	Phu Lam Park RSS	1set-110V GIS, 2 set -25MVA 110/22kV Transformer (All of the above outdoor specification) 1set-Relay board for 110kV Receiving, 1set-RTU for RSS, 1set-6.6kV Switchgear, 1 set -200kVA 6.6kV/380-220V STR, 1set-DC Battery Charger (All of the above indoor specification)
5	Mien Tay TSS	1set-22kV Switchgear, 3 set -3000kW Rectifier equipment, 1set-1000kW Regenerative inverter, 1set-1500V Switchgear, 1set-RTU for TSS, 1set-6.6kV Switchgear, 1set -7.5MVA 22/6.6kV Transformer, 1set -200kVA 6.6kV/380-220V STR, 1set-DC Battery Charger (All of the above indoor specification)

Source: JICA Study Team

Table 4.8.5 Major Equipment of Station Substation

No.	Station Equipment	Major Equipment
1	- Thai Bin Market ST. SSS - Cong Hoa Six-Way Junction ST. SSS - Hoa Binh Park ST. SSS - Univ. of Medicine & Pharmacy ST. SSS - Thuan Kieu Plaza ST. SSS - Cho Lon Bus ST. SSS - Cay Go ST. SSS - Phu Lam Rotary ST. SSS	1set-6.6kV Switchgear, 2 set -2MVA 6.6kV/380-220V TR 1set-RTU for SSS, 1set-DC Battery Charger
2	- Phu Lam Park ST. SSS - Mien Tay Terminal ST. SSS	1set-6.6kV Switchgear, 2 set-1MVA 6.6kV/380-220V TR 1set-RTU for SSS, 1set-DC Battery Charger

Source: JICA Study Team

4.8.3 Next Step

(1) Storage Battery

Storage battery is lead-acid battery since while output of nickel-cadmium battery is suddenly stopped, voltage of lead-acid battery gradually decreases when battery is deteriorated, and therefore it is easy to maintain.

(2) Employer's Requirement

For Line 1, rectifier is installed for harmonic suppression on the condition that two sets are equivalent to 24- pulse, namely it will be 12- pulse if one set is broken, moreover, it will be unbalance by phase due to third transformer. Railway operators who adopt the equivalent 24- pulse rectifier are not available in Japan and any problems by harmonic do not occur due to using 12- pulse rectifier. Therefore using 12- pulse rectifier is proposed, since it satisfies the specification that total harmonic voltage distortion is less than 3% even using 12- pulse rectifier.

(3) Revision of Receiving Substation

In the early stage of this study, RSSs are installed at two locations i.e. Van Lang Park and Phu Lam Park according to discussions with MAUR. However, substations are required at five locations because TSS and RSS are planned separately. Hence, it is proposed that each RSS will be integrated at Cong Hoa TSS and Mien Tay TSS, namely substations are installed at total three locations, since this proposal can be reduced sites and buildings for substations and maintenance days for all facilities of substations, which will be studied in the future design. In addition, MAUR commented this proposal as "no objection" as a result of meeting.

(4) Requirements of Station Load

In terms of station load, although capacity calculation was carried out for underground and elevated stations following the standard station of Line 1 and considering 20% of extra value, receiving capacity is beyond 50MVA if considering Phase 2, since requirement is huge. Hence, revision of station load and reduction of required capacity are issues for the next step.

4.9 Mechanical Systems

4.9.1 Review of Past Studies

The F/S proposed mechanical systems inside stations including elevators, escalators, platform screen doors, water supply system & drainage system and tunnel ventilation system, etc., while there is no description about depot and workshop equipment for Line 3A as these are the scope of Phase 2 project.

Depot and Workshop facilities to be constructed / installed in Phase 2 include stabling tracks, train washing plant, wheel reprofiling facilities, etc. for depot and wheel inspection and repair facilities, bogie inspection and repair facilities, traction motor testing facility, break maintenance equipment, train air-conditioner maintenance equipment, pantograph maintenance equipment, battery maintenance equipment, etc. for workshop.

With respect to station facilities, the latest specifications of Line 1 should be adopted taking into account interoperation between Line 1 and Line 3A.

4.9.2 Preliminary Outline Specifications

(1) Structure of Station Mechanical Systems

For the following station mechanical systems, the latest specifications of Line 1 should be adopted considering the interoperation between Line 1 and Line 3A.

Table 4.9.1 Structure of Station Mechanical Systems (Underground Station)

Air Conditioning Facilities	Tunnel Ventilation	Plumbing Systems
Air conditioning equipment, Cooling tower Refrigerating machine, Pump set relating air conditioner Air conditioner, Automatic control indoor radiator relating air conditioner Air condenser Duct (outlet/inlet/ intake/ exhaust port) Ventilation Duct, Piping Air supply and exhaust fan	Air supply and exhaust fan Noise control equipment Exhaust fan (for station railway side) Duct	Water tank with accessories Feed pump Sanitary equipment Piping Sewage pit with pump Drainage pump Sewage treatment unit
Fire Prevention Facilities	**Electrical Facilities**	**Lift**
Fire prevention water tank Pump for firefighting water Fire hydrant facilities Piping for firefighting water Inert gas injection equipment Kitchen gas facilities Portable fire extinguisher	Power supply equipment Switch boards for low voltage Power distribution equipment Uninterruptible Power Supply Room lighting device and electrical outlet Ground fault equipment protector Fire alarm equipment Automated facility for building	Elevator Escalator

Source: JICA Study Team

Table 4.9.2 Structure of Station Mechanical Systems (Elevated Station)

Air Conditioning Equipment	Plumbing System	
Air conditioner (including plumbing) Exhaust fan Duct (outlet/inlet/ intake/ exhaust port)	Portable fire extinguisher Feed pump Sanitary equipment Piping	
Fire‐Prevention Equipment	**Electrical Facilities**	**Lift**
Fire prevention water tank Pump for firefighting water Fire hydrant facilities Piping for firefighting water Inert gas injection equipment Portable fire extinguisher	Power supply equipment Power distribution equipment Uninterruptible Power Supply Room lighting device and electrical outlet Ground fault equipment protector Fire alarm equipment Automated facility for building	Elevator Escalator

Source: JICA Study Team

(2) Arrangement of Station Mechanical Systems

1) Typical Underground Station (Except for C2 and C5 Station)

Typical underground station is two stories of cut and cover tunnel with 240 m length having an island platform. Station mechanical systems are installed at the concourse floor which is the second floor of the station and enough space for the installation in the present plan.

2) C2 Station (See Appendix 4.3)

C2 station is a junction with Line 3B which track layout is planned to intersect the lower side of Line 3A at underground section and rise gradually until the same level at the end of platform and stop at the same level of leading track.

Furthermore, although main station length is 290m, the platform length is 130m and it is two stories of cut and cover tunnel except for intersection section with Line 3B. Moreover, since large structure space with two island platforms is planned, sufficient space for the installation of station mechanical systems is secured in the same manner with the typical underground station.

3) C5 Station (See Appendix 4.3)

C5 station has 340m length since it has crossover at Ben Thanh station side. Platform position is biased to C6 station side compared with structure position, and therefore clearance between platform and station structure is short compared to the opposite side. However, enough space for the systems installation is secured in the present plan because of long structure length.

(3) Ventilating Facilities in Ben Thanh Station for Line 3A

The design of Line 1 has not considered connection with Line 3A at Ben Thanh station, and hence tunnel ventilation for Line 3A has also not been considered at the design of ventilation equipment at Ben Thanh station. Therefore, additional ventilation equipment for Line 3A is required at Ben Thanh station.

For the additional ventilation equipment for Line 3A, tunnel intake and exhaust duct is required at Line 3A side of Ben Thanh station. If existing duct has some margin or space for expansion is available, the existing duct can be used, however, in case that there is no room for capacity expansion, the additional duct is installed using TBM shaft (see appendix 4.3).

It should be noted that in the case that the tunnel intake and exhaust duct is installed additionally, it is required to confirm whether the design of ventilation system for Line 1 at Ben Thanh station is suitable or not using the existing design.

4.10 Signaling Systems

Line 3A is planned to be built for connecting to Line 1 which is currently under construction and for enabling trains of both Lines to bilaterally operate interconnected through service between Line 1 and Line 3A.

In the event that signaling systems of Line 3A are built with non-compatible system with Line 1 signaling systems, train of Line 3A is required to equip another on-board equipment compatible with Line 1 signaling systems for travelling into zones under control of Line 1 signaling systems and vice versa in train of Line 1 mounting additionally on-board equipment compatible with Line 3A signaling systems. So that means both trains necessitate equipping double on-board equipment of signaling.

Consequently, in the interests of avoidance of overlapping investment for on-board equipment of signaling systems and bringing the complexity in outfit of double equipment on-board in a train, it is quite advisable to adopt, as Line 3A signaling systems (CBTC system), compatible systems with Line 1. The most optimal solution for assuring complete compatibility is to implement Line 3A signaling systems with exactly same system in configuration, structures, functions and performance with Line 1 systems.

Such implementation can be attained by one of two ways as follows:

(1) One is to additionally install signaling system equipment required in stations and wayside along Line 3A as part of unified signaling system for Line 1 and Line 3A and refurbish main equipment of Line 1 signaling systems in order to house equipment additionally installed along Line 3A and to construct integrated Line 1 and Line 3A signaling systems.

(2) The other is to construct Line 3A signaling systems independently with the shape similar to Line 1 signaling systems and share the control of train operation falling in own control zones under exchange of train tracking information bilaterally for hand-over of control at Ben Thanh Station.

It is however indicated that Line 1 signaling systems are under construction at the concept closed to Line 1 and adaptability for refurbishment is unclear. Therefore, in this study, Line 1 signaling systems are checked over and reviewed the applicability of the systems to Line 3A which are to be constructed independently from Line 1 signaling systems.

4.10.1 Review of Past Studies

Signaling **s**ystems of Line 1 are composed of Automatic Train Protection (ATP) System, Automatic Train Supervision (ATS) System, Interlock (IL) System and Automatic Train Operation (ATO) System. ATP adopts Computer-Based Train Control (CBTC) technology, in which data transmission between on-board ATP Equipment and Wayside (Ground) Station is conducted by wireless communication using 2.4GHz band. The performance of CBTC makes the advanced train operation control, as exemplified in the below, by the handling of relatively large volume of control data using relatively higher carrier frequency in wireless communication:

- On-board ATP Equipment always transmit own train's location data obtained from the fixed Balise (Transponder) passed by own Train to Wayside Station, which is, from time to time, corrected by the number of revolutions of on-board Tachogenerator.
- Wayside ATP Equipment figures out required signal indications and route control and calculates Limit of Movement Authority (LMA) of each Train based on received location information of each Train and transmit respective LMA information to each train.
- Each on-board ATP Equipment of each Train develops Train Speed Control pattern which enables the train to make complete stop at the LMA and controls, in continuous manner, the signals so that own Train runs at the running curve below the Train Speed Control pattern.
- As the succeeding Train approaches the preceding Train, the succeeding Train is controlled to the permissible speed to enabling complete stop at LMA. The train running is overseen in continuous manner by on-board ATP to immediately enable brakeage in the event that over-speed beyond the permissible speed is once detected so that the train makes complete stop before or at LMA.

In addition, as the way to encounter the ATP failure due to interruption of radio connection, the train operation is kept under one block section control reliant on control of IL and Departure Signal light of each station. Further, Track Circuit is provided to achieve the purpose of rail broken detection.

The data and information of signaling systems is transmitted among varied sites over network with Ethernet standard, dedicated for signaling systems to be built by using optical fibers.

According to the F/S, it appears that ATP, ATO and ATS are defined as constituent of CBTC System, and Computer-based Interlocking (CBI) System, Automatic Train Control (ATC) System, Signal lights, Transmission Network and Disaster Prevention System are defined as their subsystem. It is, however, judged that the main composition of presented signaling systems, except the ATC and Disaster Prevention System, adheres fundamentally to the signaling system composition planned to be implemented in Line 1. However, care should be taken to the descriptions and interfaces related to

Signal Monitoring System and SCADA. In such descriptions, functions of F-SCADA and ATS come to be mixed in with functions of signal systems. Therefore, such descriptions are to be realigned in the manner to distinguish functions of Signal Monitoring System, ATS, P-SCADA, F-SCADA and Disaster Prevention System. Meanwhile, Emergency Button and Platform Screen Door (PSD) System are defined as relative system of signaling systems.

4.10.2 Preliminary Outline Specifications

(1) System configuration

System configuration of Line 3A is required to follow the configuration of Line 1 signaling systems. Namely, the system is composed of following sub-systems and equipment:

1) Automatic Train Protection system (ATP)
2) Interlocking system (IL)
3) Automatic Train Operation system (ATO)
4) Train Detection system (TD)
5) Data Transmission System;
6) Automatic Traffic Supervision system (ATS)
7) Uninterruptible Power Supply System (UPS);
8) Point machine; and
9) Other necessary equipment.

(2) Operation Control Center (OCC)

Function of OCC in Line 3A is to follow Line 1's function to supervise operations of Line 3A trains and also Line 1 trains coming into Line 3A zones in the same manner to be implemented in Line 1, in a sense to make it possible to adopt unified train operation control in Line 1 and Line 3A.

System components of Line 3 are to follow exactly formation of Line 1 OCC.

Namely,

1) Data Transmission System
2) ATS Central Equipment
3) ATS Console
4) ATS MIMIC Display
5) Time Table Generation Equipment
6) Central Equipment of ATP/ATO Wayside Equipment

7) Signalling Monitor Terminal
8) Interlocking system Central Equipment for Main Line and Depot
9) Operation console with chairs for controllers/Dispatchers
9) Color laser printers
10) Power supply system including Uninterruptible Power Supply System (UPS)
11) Other necessary equipment

(3) Depot

Since it is not planned to build new Depot in the stage of Line 3A Phase 1, no function is created because no system components is deployed. In the stage of Phase 2, it is planned to build new Depot for handling train stabling and works of vehicle inspection and repair which exceed the stabling and work capability of Line 1 Depot.

Needless to add, function of and system components to be given to new Depot train operation supervision are to follow the same figure as Line 1 for the same reason stated in above OCC.

(4) Back-up Control Center (BCC)

Some controversy exists over the necessity to construct newly BCC for Line 3A. Focus is the financial efficiency in the aspect of balance with required function and the possibility of upgrading Line 1 BCC to cover Line 3A operation from standpoints of technical and economic. BCC has two objectives, one is back up function of OCC operation console and the other is for dispatcher training. For the latter purpose, Line 1 OCC is able to be upgradable with relative ease by adding line data of Line 3A signaling system equipment. However, the complexity is brought in case of upgrading work for the former because online train operation supervision work is required to be made available newly for Line 3A train operation and seamlessly for Line 1 train operation supervision without interruption to it.

Accordingly, it is required to make cautious evaluation of network connection of signaling systems for Line 1 and Line 3A from technical standpoint and required cost to upgrade Line 1 BCC for enabling it to perform backup operation respectively of OCC operation console of Line 1 and Line 3A.

(5) Maintenance Base

Since new Depot is not planned to be built in the stage of the Line 3A Phase 1, it is not supposed that maintenance base is then established in the Line 3A zones. In the reasoning that Maintenance Base is established in the stage that new Depot is established, signaling monitor is required for the Maintenance Base to cover monitoring at least status of signaling systems on Line 3A and, depending on work responsibility assigned to the Maintenance Base, to cover whole line of Line 1 and Line 3A. In the latter situation, the network connection of signaling systems involves as with BCC.

(6) Signaling System Capability

1) Minimum Headway of Train Operation to be satisfied

2 minutes and 10 seconds is required in Line 1. The headway mainly follows the braking distance to ensure the safety in CBTC system and calculates using the following formula:

$$T_{headway} = \frac{D_{mDist}}{V_{avg}}$$

Where $T_{headway}: headway$
$D_{mDist}: minimum\ safety\ distance\ between\ trains$
$V_{avg}: \quad average\ train\ speed\ in\ the\ safety\ distance$

Therefore, in theory, the expansion of minimum headway permits the expansion of minimum safety distance between trains in addition to relaxing the requirement of signaling system reaction time.

As long as same signaling systems are introduced in Line 3A even from standpoint that no design changes are required from Line 1 systems which realize cost saving, the expansion of minimum headway requirement causes no effects on signaling systems.

2) Operation Mode

Following operation modes as realized in Line 1 are adopted directly to Line 3A including mode indication on Mode Indicator of Cab.

a) ATO/ATP Mode

b) ATP Mode in normal mode

c) Wayside signal mode

d) ATP in Emergency Operation Mode (upon system failure and/or incident)

e) ATP in Cut-off Mode (upon system failure and/or incident)

(7) Train Detection System

Train detection system exactly same as Line 1 design is adopted.

(8) Interlocking System

Computerized interlocking system with the same system concept and performance is constituted in the manner to be controlled in centralized arrangement to Line 3A OCC to cover Line 3A line.

(9) ATP System

CBTC system using bidirectional digital transmission of signal/data by radio/transponder without track circuit in intermediate section of main line, in combination with track circuits installed in station area, turnout locations and in Depot area is exactly adopted to cover protection in whole line of Line 3A, in which ground ATP system is workable with those of on-board ATP system even on Line 1 train.

(10) ATO System

Function, concept, performance and composition of ATO system is required to be exactly identical with those of Line 1 in order to assure safe train operation of Line 3A train even on Line 1 line and vice versa of Line 1 train on Line 3A line, subject to the provision of line conditions of Line 1 and Line 3A to respective on-board ATO equipment in mutually complementary manner.

(11) ATS System

Function, concept, performance and composition of ATS system is constituted to exclusively cover train operation of Line 3A in common with Line 1 system.

Nonetheless, ATS system of Line 1 and Line 3A is required to bilateral handover of data of train tracking, route setting and other data such as train number depending on framework arrangement of train operation between Line 1 and Line 3A, which is expected to be established in later stage, in Ben Thanh Station relative to interconnected through service of train.

(12) Miscellaneous Signaling System

Following miscellaneous signaling systems are set up in Line 3A in the same function, performance, configuration and manner mounted in Line 1.

a) Train Number system
b) Train Describer system (TDS)
c) Signaling Monitor
d) Substitution Signal
e) Wayside Signal
f) Point machine
g) Overrun Protection system (ORP)
h) Power Supply system (supplement supply to Signaling System)
i) Temporary Speed Restriction System (TSR)
~~j) Emergency Push Button~~ (This item is not required as deleted from the Line 1 contract.)

Signaling system construction is illustrated in Appendix 4.3.

4.11 Telecommunication Systems

Line 3A is planned to be built for connecting to Line 1 which is currently under construction and for enabling trains of both Lines to bilaterally provide consistent passenger transportation service under train's interconnected through service between Line 1 and Line 3A. In Line 3A construction, it is quite evident that most of continent sub-systems are, as corollary, led to the same ground with Line 1 systems in system configuration, structure and contents.

Therefore, this study primarily checks over Line 1 telecommunication systems and seeks the applicability of such specification to Line 3A telecommunication systems unless apparent inexpedience is discovered in the applicability of Line 1 telecommunication systems to Line 3A telecommunication systems.

4.11.1 Review of Past Studies

Communication system of Line 1 is composed of Backbone Network consisting of optical fibers, Phone System consisting of Internal Business PABX Telephone, Direct phone system for Traffic Control, Power Control and Wayside telephone, and their Voice Recording System, Video Surveillance System covering Station, Depot and On-board (during station stopping) premises and their Video Recording System, Public Address System covering respectively Station, Depot and OCC premises Clock System based on GPS Master Clock at OCC, Train Radio System based on TETRA technology (TDMA using π/4 DQPSK in 25kHz bandwidth), Disaster Prevention System, and Un-interruptible Power Supply System for those of Communication System elements.

Data and information transmission among those ground equipment of communication system in varied sites is made via Backbone Network using Ethernet standard.

According to the F/S, transmission facilities for communications system is composed of transmission line on the ground, Radio Communication Equipment and Mobile Radio Communication Equipment, and core Telecommunication System is composed of Auto Exchange Telephone System, Direct Line Telephone System, Radio System, Public Address System, Passenger Information Display System, CCTV, Clock System and Network System.

Optical fibers (48 cores are assumed) are laid down ranging over the both track sides of over-all Line 3 length, and become the part of the network system of communications system and is also offered to data transmission network of signaling systems. Business PABX Telephone System is connected to whole UMRT telephone network.

The Dispatcher Telephones are provided for each of Traffic Controller, Power Controller and Facility Operation Supervisor respectively, and such Dispatcher Telephones are dedicatedly provided for communications from OCC to relevant Station, Depot and Maintenance Crew Offices. Telephone Equipment of Wayside Telephone System is installed in every 500m interval in viaduct area and every 200m interval in tunnel area for the use of emergency case and maintenance work.

4.11.2 Specifications of Line 1 and Recommendations for Line 3A

The following shows key elements of telecommunication specs of Line 1.

(1) Train Radio and Frequency

- Train radio is based on TETRA system. Frequency is 400MHz band.
- Propagation by LCX (Leaky Coaxial Cable) or SR (Space Radio)
- Duplex Mode

(2) Onboard CCTV

- The transmission of onboard CCTV is planned to adopt a wireless method with 13GHz band.
- Assignment of frequency band is yet to be confirmed as acquisition of licence carries a cost according to the local regulation.

(3) Balise

- EuroBalise method is employed.
- The transmission of Balise drive is palnned to use 27.5MHz band (telewave) and 4.2MHz (telegram).
- Assignment of frequency band is yet to be confirmed as acquisition of licence carries a cost according to the local regulation.

(4) CBTC

- Line 1 adopts CBTC method by use of own protocol of the supplier.
- The transmission of CBTC communication is planned to use in the range of 2,400MHz to 2,483.5MHz (ISM frequency).

Recommendations for telecommunication systems for Line 3A are as follows:

(5) Avoidance of Double Mount of Onboard Equipment

With particularly regard to train radio system, it is led to the conclusion from standpoint of convenience and cost effectiveness that on-board train radio equipment is commonly usable on both lines to avoid double mount of on-board equipment serviceable independently for Line 1 telecommunication systems and Line 3A telecommunication systems. Therefore, train radios system in Line 3A will be recommended to follow Line 1 systems (including frequency and method).

(6) No Physical Integration

The interface between telecommunication systems of Line 1 and Line 3A shall be made and managed for inter-operation, while the two should be physically separated systems for the following reasons.

- Designs of Line 3A will be carried out long after the designs of Line 1.
- Up-to-date technologies should be incorporated to the designs of Line 3A. Standardization with Line 1 telecommunication system will miss an occasion to upgrade the system.

4.11.3 Preliminary Outline Specifications

(1) Data Transmission System (DTS)

DTS of Line 3A is built as the communications backbone between OCC, stations and other sites of Line 3A with high-integrity software and highly reliable components, in common with DTS of Line 1, servicing for data transmission of a number of other operationally critical systems such as signaling system, other constituent sub-systems of telecommunication system, power SCADA and automatic fare collection system etc.

Under the assumption that Line 3A OCC shares the location in Line 1 OCC Building, DTS is built in the form of Main line DTS to be installed alongside the Line 3A in the manner to cover all sites except Line 3A OCC and Extended DTS to be established along Line 1 to link Line 3A OCC with Main line DTS by connecting two DTS at Ben Thanh Station. The latter may be structured by using spare cores of Optical Fiber Network of Line 1 DTS rather than newly laying optical fiber cable, if cores required for extended DTS are allocable from Line 1 DTS.

Line 3 DTS shall be structured, in all aspects of following elements, essentially pursuant to the specification compatible with specification applied to Line 1 DTS in consideration of this study's assessment result that Line 1 is structured in effective, efficient and sound way and convenient for possible exchange of train and/or passenger information between Line 3A and Line 1which may be required if both lines operation is integrated into unified form.

1) Optical Fiber Network of Main line DTS
2) Data Transmission Service
3) Fast Ethernet Network
4) Network Management System (NMS)

(2) Telephone System

Following sub-systems are built for Line 3A (configuration, function and specification) as Line 1 system independently from Line 1 system. It is however required, in PABX service and DLT service, to interconnect Line 1 system and Line 3A system between their main switches for enabling to make direct voice communication between business phones of Line 3A system and Line 1 system.

1) Private Access Branch Exchange (PABX) Service (Business telephone)
2) Direct Line Telephone Service (DLT)
3) Interphone
4) Central Voice Recorder System (CVRS)

(3) Closed Circuit Television (CCTV) System

CCTV system is built (configuration, function and specification) as Line 1 system in Line 3A OCC and stations independently from Line 1 system.

1) Station CCTV Service
2) On-board CCTV Service

(4) Public Address (PA) System

PA system is built in same manner (configuration, function and specification) as Line 1 system to cover Line 3A OCC and stations independently from Line 1 system.

1) Main Equipment in OCC PA System:

a) Audio and Selection Panel (ASP) at OCC
b) PA Control Module at OCC Equipment Room
c) Digital Voice Announcement System (DVAS) at OCC Equipment Room
d) Amplifiers, stand-by amplifiers, and automatic noise control at OCC

2) Main Equipment in Station PA System:

a) Audio and Selection Panel (ASP) at Station Control Room (SCR)
b) PA Control Module comprised of PC controlled Digital Voice at SCR for controlling audio sources to various announcement zone groups selected by the operators.
c) Digital Voice Announcement System (DVAS) at SCR for pre-recorded message announcement.
d) Amplifiers, stand-by amplifiers, and automatic noise control at SCR and sensing devices.
e) Loudspeakers

(5) Clock System

Clock system is built in the same manner (configuration, function and specification) as Line 1 system to cover Line 3A OCC and stations independently from Line 1 system.

1) Equipment

a) Antenna system on the roof of OCC Building

b) Central Master Clock System in OCC Equipment Room which includes GPS Receiver, Oscillator for enabling accurate time maintenance for normal duration of loss of time, network time server to provide NTP timing for other interface systems, measures for power outage and local time display

c) Station/Depot Master Clock in Station Equipment Room/Depot Equipment Room which includes own oscillator and local display

d) Slave Clocks in various spaces and rooms of Stations and Depot including OCC Building, workshop and other buildings.

(6) Train Radio System

It is apparently economical and convenient that Train Cab Communications Panel with handset onboard Line 1 train is accessible to Line 3A radio system for maintaining radio communication with Line 3A OCC during running Line 3A line. In addition, in Line 1 radio system, shared use of communication line by Police and Firefighter is required under TETRA system. Therefore, it is presumed that Line 3A radio system is required to be built in compatible way to provide communication link service to Mobile Transceivers of Police and Firefighter. Consequently, Line 3A Radio system is to be built in the same manner (technology, configuration, function and specification) as Line 1 system to provide data and voice communication between OCC and all trains in Line 3A.

The following equipment is required in case that the same system with Line 1 is adopted.

a) OCC Equipment Room:

   (i) Central Control Equipment networked with all RBS

   (ii) Maintenance Terminal

b) OCC

   (i) Radio Dispatcher Workstation (RDW) for use of the Traffic Dispatcher

   (ii) Radio Control Panel (RCP) in preparation for failure of RDW

c) Station: Radio Base Station (RBS)

d) Underground Section: LCX networked with RBS

e) Viaduct Section: Antenna networked with RBS

f) On-board

(i) Train Cab Communications Panel with handset

(ii) Antenna

(iii) Mobile Transceiver (liked to train-borne Public Address System and train-borne Passenger Information Display System)

(7) Disaster Prevention System

The disaster prevention system is able to be built by either (i) new equipment in Line 3A territory for own disaster data collection or (ii) data acquisition from Line 1 disaster prevention system because no significant difference on disaster data is expected within relatively small region, which is easily achievable by linking DTS between Line 3A and Line 1.

In case of construction by new equipment, the following equipment is required.

a) OCC:

Central equipment consisting of the management equipment, display equipment and data accumulating equipment with alarm indication on the display equipment

b) Weather Station:

(i) Rain gauge

(ii) Vane anemometer

(8) Passenger Information System

The Passenger Information System (PIS) is recommended to be built in the manner to be able to provide passenger information substantially as specified in Line 1 system at the station display locations.

The following equipment is required when the same configuration with Line 1 is adopted.

a) Station:

(i) Station PIS Controller

(ii) PIS Workstation with information composing function

b) OCC:

(i) Central PIS Controller

(ii) PIS Workstation with information composing function

c) Staff Room:

Information Composing Equipment (Information is transmitted out via Central PIS Controller)

(9) Power Supply System

Same requirements on UPS minimum back up time for telecommunication systems in main power down as Line 1 system are consequent.

a) Data Transmission System, Telephone System, PAS, PIS, CASS and Radio System: two (2) hours by battery; and

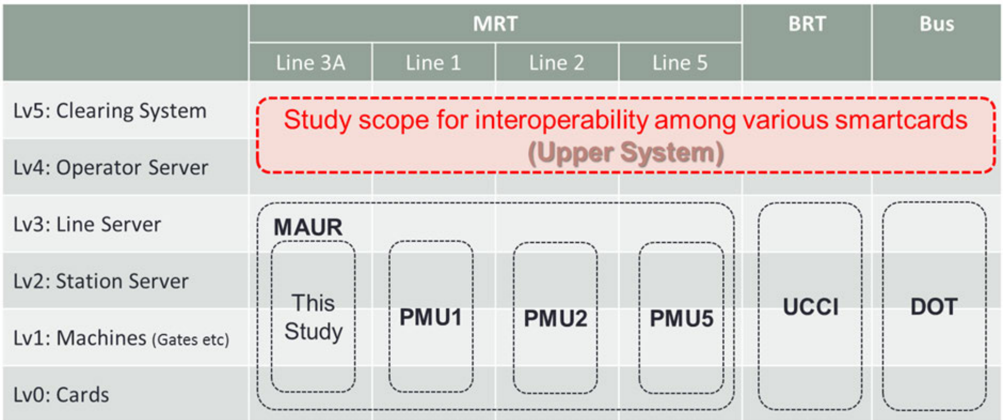
b) Others: thirty (30) minutes by battery

Telecommunication system configuration and wiring diagram in Line 3A are shown in Appendix 4.3.

4.12 Integration Plan of Automatic Fare Collection System

This section describes how the AFC (Automatic Fare Collection) system at upper level should be developed for realizing interoperability of the transport smartcards which are currently being introduced by each transport construction project in Ho Chi Minh City. In this study, the AFC system at upper level means the system exists at the higher level than the levels implemented by each transport construction projects. (Figure 4.12.1)

This study has been conducted to shape the AFC system at upper level based on its required functions extracted through reviewing the technical specification and business scheme of each transport construction project.



Source: JICA Study Team

Figure 4.12.1 AFC System at upper area reviewed by this study

4.12.1 Progress of Each Project

The latest information, as of March 2016, related to the smartcards being implemented to MRT line 1 and other lines, BRT and existing bus, such as communication standard and business scheme, were collected from each transport construction project and summarized into Table 4.12.1.

While all modes other than MRT line 1 will apply ISO14443 type A or B to the communication standard for its card media, multi-R/W devices3 are taken into their consideration in order to secure data-communication with other standards applied by other transport modes and lines. However, security key and data-format necessary for reading/writing data have not been discussed among the parties. Therefore, it is easily anticipated that Ho Chi Minh transport card will not have interoperability even though they are on same communication standard, like Bangkok MRTs faced this problem.4 Ticket types also have no coordination among the parties. Its specification which proposed by contractors and /or consultants are simply applied. Therefore, it is required to arrange also software aspect, not only hardware. It should be noted that different smartcard communication standards can be used on same device. Bangkok metro uses two standards on one gate: type A for stored value card, and type C for one-time token.

Regarding the card issuing organization and the fare revenue ownership, BRT and existing bus will follow existing road transport scheme, i.e. MOCPT will be in charge, while MRTs have not yet started to discuss this issue.

Table 4.12.1 Smartcard Related Information of Each Transport Mode

	MRT			BRT	Bus
	Line 1	Line 2	Line 5		
Financial Source	ODA (Japan)	ODA (German/ADB)	ODA (Spain/ADB)	ODA (World Bank)	Local Private *1
Opening Year	2020	2024	2023	2019	2017(*2)
Ridership [pax/day]	190,000 @2020	481,700 @2025	133,746 @2023	46,345 @2030	958,900 @2014
Communication. Std. of Smartcard	Type C	Type A/B	Type A/B	Type A/B	Depending on bidder *3
Ticket types	1month pass 3days pass 1day pass 1time SV*4	1monht pass 1week pass 1day pass 1time SV*4 Special (Employees etc)	1month pass 1week pass 1day pass Round trip 1time SV*4 Special (Employees etc)	Pass 1time SV*4	SV*4 *cash is also acceptable
Issuer	Not yet considered			MOCPT*5	
Ownership of Fare	Ditto			Ditto	

*1: Reportedly, BOO (Build-Own-Operate) scheme will be applied.
(https://www.vietnambreakingnews.com/2016/04/hcm-city-to-issue-electronic-bus-ticket-cards/)
*2: Planned year of Smartcard implementation
*3: Interoperability with other transport modes is mentioned in the People Committee's Decision No. 2898/QD-UBND
*4: SV (Stored Value: Prepaid type smartcards)
*5: Although a legal issuing entity is MOCPT, bus ticketing operation is planning to be outsourced to a private entity.

Source: This is produced based on each transport construction project's answer to the study team's questionnaire.

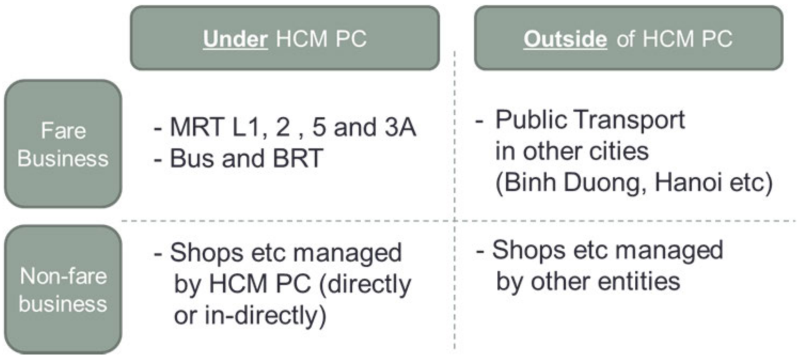
3 It is hardware device which enables to read data from and write it to card media via several communication standards. (Software modification is required separately)

4 ADB pointed out in their report in 2008 that Bangkok MRTs do not have interoperability between them due to lack of coordination, even though they, subway and elevated line, use same ISO14443 Mifare smartcard.

4.12.2 Range of Integration

In Vietnam, SBV (State Bank of Vietnam) Circular 19 (19/2016/TT-MHMM) becomes one of important conditions for studying a range of card services. SBV Circular 19 (SBV19) intents “when a card issued by entity A is used for the services rendered by entity other than A, the card must be categorized into a bank card.” Cover range of card affects its legal position.

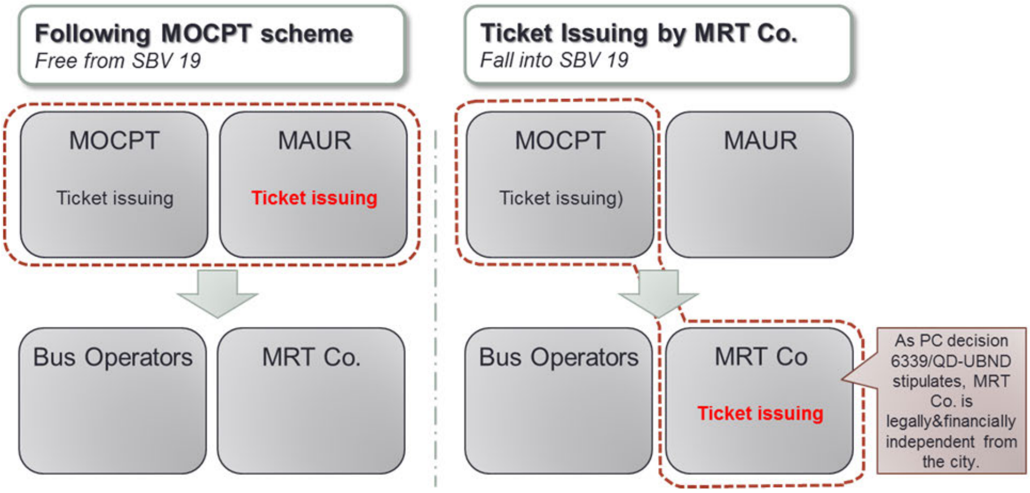
Figure 4.12.2 shows cover range of transport smartcard using 4 quadrants. When MAUR becomes a MRT card issuer and retains fare-ownership same as existing bus system, cash handled by card transaction falls into the city’s account as MOCPT does. In this case, transport smartcard in Ho Chi Minh city can be categorized as a house card, and 2nd & 3rd quadrants are out of SBV 19. The services at the 1st and 4th quadrants, strictly speaking, fall into the SBV 19, since those services are rendered by other entities.



Source: JICA Study Team

Figure 4.12.2 Range of Transport Smartcard’s Services

The 2nd and 3rd quadrants’ legal position, whether under SBV 19 or not, is also depending on a card issuer and fare-ownership. When MAUR becomes a MRT card issuer and retains fare-ownership same as existing bus system, cash handled by card transaction falls into the city’s account as MOCPT does. In this case, transport smartcard in Ho Chi Minh city can be categorized as a house card, and it is out of SBV 19. When MRT company becomes a MRT card issuer and retains fare-ownership, cash handled by MRT card transaction are related with two financially and legally separate entities: the company’s account and city’s account. In this case, transport smartcard in Ho Chi Minh city is most likely to be under SBV 19.



Source: JICA Study Team

Figure 4.12.3 Legal Differences between MRT Ticket Issuing Schemes

From the situation above, in consulting with its C/P (MAUR), the study team assumes that the study focuses on the services at the 2nd quadrant with two options: 1) MRT card issuing and ownership of fare are under MAUR, and 2) those are under MRT company. On those conditions, the functions to be covered by the AFC system at the upper level are summarized in Table 4.12.2. It should be noted that 6th function "clearing between entities" is needed only when MRT company act as MRT card issuer.

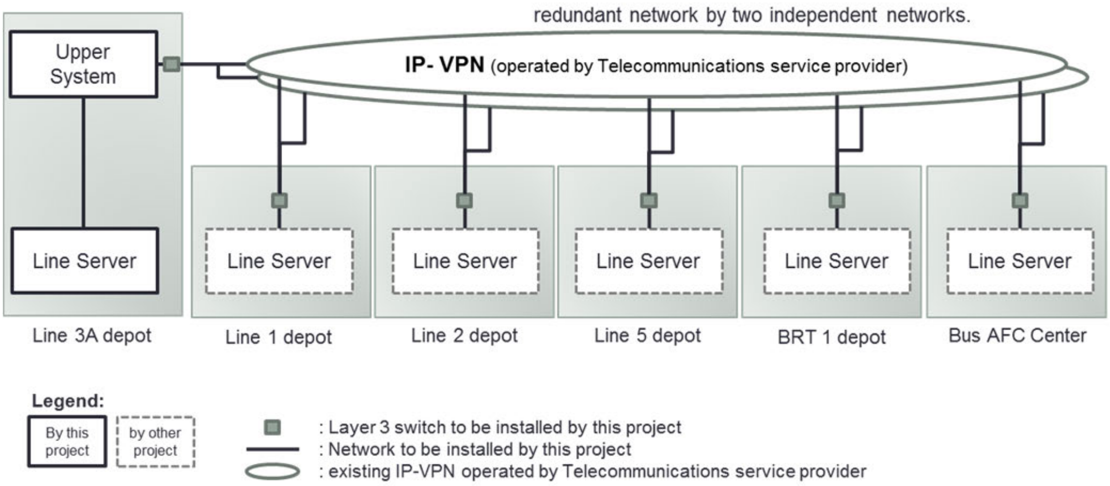
Table 4.12.2 Functions to be Provided by the Upper System

NO.	Function Name	Description
1	Card management	Managing issued cards' status in order to respond card user's queries in a timely manner.
2	Blacklist management	It is required to generate a negative-list for issued cards upon receiving card user's request. (ex. In case of lost card call)
3	Revenue management	Revenue management based on card transaction data (daily basis, monthly basis, yearly basis and per station etc)
4	Statistics management	Statistics analysis using card transaction data (The number of passengers per station, time-slot, gender, age etc)
5	Clearing between entities (*1)	Revenue and deposit management in case of more than one fare owner

*1: It is required in case that MRT company is an issuer for MRT ticket

Source: JICA Study Team

It is assumed that the servers for the upper system will be installed in the server room to be built in the Line 3A depot; and the network between the upper system and each transport modes will be realized via IP-VPN like Japanese system. Addition to those items, redundant-network realized by contracts with two-servicers, popular methods in Vietnam, is assumed due to low network availability in Vietnam.



Note: Upper system configuration and Data-transaction (examples) are shown in Appendix 4.6.

Source: JICA Study Team

Figure 4.12.4 Network between Upper System and Each Transportation Mode

4.12.3 Economic Analysis

This subsection explains the economic values which can be expected during 5 years from the introduction of the upper-system described above. It is possible to realize the interoperability for taking more than one line and mode by single SV ticket, just by modifying the AFC system without the upper-system.[5] Therefore the values are estimated based on the baseline where interoperability on AFC system is already realized just by modifying existing system.

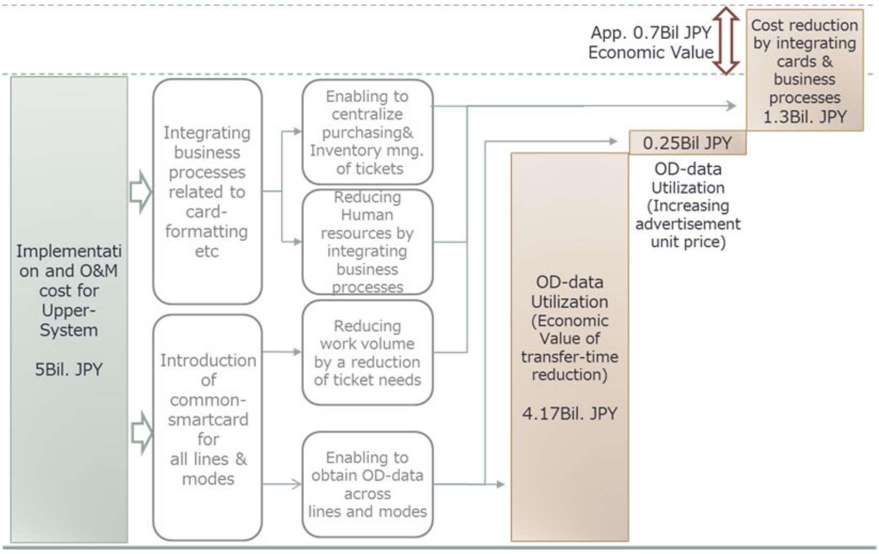
One of benefits derived from the upper-system is a work volume reduction. Since it provides easiness on data linkage between lines and modes, works performed individually can be integrated easily. For example, centralized purchasing and inventory control can be expected by integrating card-formatting work etc. It brings a reduction in cost of procurement, human-power and associated equipment. It is worth approximately 13 billion JPY.

2nd benefit is common tickets available at all lines and modes. The upper system lowers the barrier for the introduction of the common card. It makes to acquire OD-data across lines and modes easier, as a result, time-table revision for reducing transit-time can be considered with more quantitative data. If 100,000 pax/day can reduce 2-minutes each in transition time[6], time-value worth 4.17 billion JPY can be expected. Moreover, if OD-data is utilized for advertisement location and contents, an increase in unit price can be expected.

The economic value mentioned above can be expected to be approximately 7 billion JPY after deducting the implementation and 5 year maintenance costs of the upper system.[7]

---

5 This interoperability includes a value reduction only. Blacklist management and statistics management for all lines and modes are excluded.
6 It is assumed that 1 mill. people use city's public transport a day and a time reduction effect is expected on 10% of them.
7 Since the system-go-live will be 2025 as earliest, the figure may fluctuate up/down depending on VN's economic growth.



Note: For simplifying, 0,6 and 0.4 million JPY are respectively applied to the salaries of transport staff and passenger as of 2025.

Source: JICA Study Team

Figure 4.12.5 Economic Value expected by the Introduction of Upper System

4.12.4 Implementation Plan

Bid for IC card business operator for the public bus service was called and implemented in 2017 under public-private partnership, while the upper system will become functional in 2027 at the earliest if the introduction is as part of the Line 3A project. Alternatively, the upper system may be introduced by an independent project for earlier implementation.

Table 4.12.3 Options for Introduction of Upper System

	Option 1 As part of Line 3A Project	Option 2a Independent Project (1)	Option 2b Independent Project (2)
Budget	JICA ODA Loan	JICA Grant Aid	Local private fund
Executing Agency	MAUR	MAUR or MOCPT	Private Entity
Start of Operation	2027	2023(*1)	
Pros	• Easier to introduce upper system as part of railway construction project	• Earlier implementation	• Earlier implementation • Better sustainability of smartcard business by granting authority of IC card issuer to private entity
Cons	• Late implementation • Need for maintenance organization and technicians by the public	• Need for maintenance organization and technicians by the public	• Need to secure financial soundness and sustainability of the business operation

*1: It took 2 years since F/S completion till bid for the business operator of IC card for public bus service. With the assumption of same timeline, F/S completion in 2019, bid in 2021, commissioning in 2023

Source: JICA Study Team

Table 4.12.4 Roadmap toward Introduction of Upper System

Year	Introduction of IC card at each mode			Task for development of upper system	
	Bus	BRT Line 1 MRT Line 1	MRT Line 2	Grant	PPP
2018	Design, Build-out, Test	Design, Build-out		Technical assistance by use of private sector technologies: Business Scheme (Input of technical specifications to bus project)	(Same as the Left)
2019	**Start of Operation**	Design, Build-out		Preparatory Survey	PPP Study (Preliminary) Business Scheme Financing Plan Assistance for Project Formulation and Bids
2020		**Start of Operation**		(Evaluation)	PPP Study (Main) Detailed surveys (legal, financial and technical) Assistance for Project Formulation and Bids
2021				Bidding	(Same as the Left)
2022			Design, Build-out	Design, Build-out, Test (Input of technical specifications to MRT Line 2)	(Same as the Left)
2023			Design, Build-out	**Start of Operation**	(Same as the Left)
2024			**Start of Operation**		

Source: JICA Study Team