Japan International Cooperation Agency (JICA)
Yangon Region Government

Project for
Comprehensive Urban Transport Plan
of the Greater Yangon (YUTRA)

Data Collection Survey for the Yangon Urban Mass Rapid Transit (YUMRT) Line 1 Project

Final Report

toward YUTRA 2035

January 2015

ALMEC Corporation
Oriental Consultants Co., Ltd.
Nippon Koei Co., Ltd.

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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

YANGON REGION GOVERNMENT

PROJECT FOR COMPREHENSIVE URBAN TRANSPORT PLAN OF THE GREATER YANGON (YUTRA)

DATA COLLECTION SURVEY FOR THE YANGON URBAN MASS RAPID TRANSIT (YUMRT) LINE 1 PROJECT

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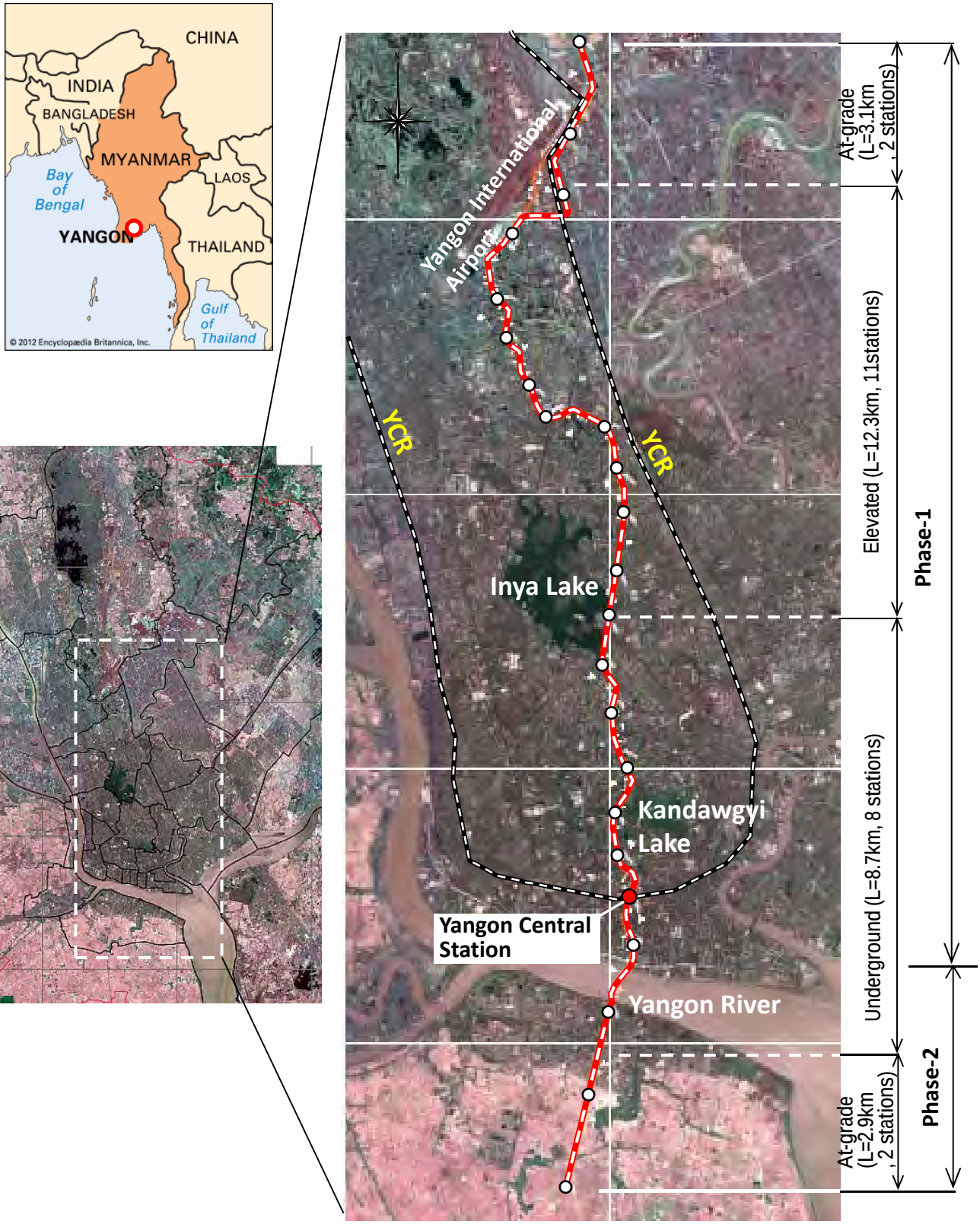

Location Map of the Project

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List of Abbreviation

AFC	:Automatic Fare Collection
ATO	:Automatic Train Operation
ATP	:Automatic Train Protection
ATS	:Automatic Train Stop (or Supervision)
BTN	:Backbone Transmission Network
CBD	:Central Business District
CBTC	:Communication Based Train Control
CCV	:Closed Circuit Television
CMMS	:Computerized Maintenance Management System
DTST	:Double Tube Single Track
FAM	:Fare Adjusting Machine
GOM	:Government of Myanmar
GRDP	:Gross Regional Domestic Product
HSR	:High Speed Railway
JICA	:Japan International Cooperation Agency
MR	:Myanmar Railway
MRT	:Ministry of Rail Transport
O&M	:Operation and Maintenance
OCC	:Operation Control Center
ODA	:Official Development Assistance
OEMs	:Original Equipment Manufacturers
PA	:Passenger Announcement
PIS	:Passenger Information System
PMO	:Project Management Office
PPP	:Public Private Partnership
PSD	:Platform Screen Door
ROW	:Right of Way

RS	:Rolling Stock
RSS	:Receiving Substation
SCADA	:Supervisory Control And Data Acquisition
STDT	:Single Tube Double Track
SUDP	:The Project for Strategic Urban Development Plan of the Greater Yangon
TOM	:Ticket Office Machine
TSS	:Traction Substation
TVM	:Ticket Vending Machine
UIC	:International Union of Railway
UMRT	:Urban Mass Rapid Transit
VAT	:Value Added Tax
YCDC	:Yangon City Development Committee
YCR	:Yangon Circular Railway
YGN	:Yangon
YUMRT	:Yangon Urban Mass Rapid Transit
YUMRTC	:Yangon Urban Mass Rapid Transit Company
YUTRA	:The Project for Comprehensive Urban Transportation Plan of the Greater Yangon

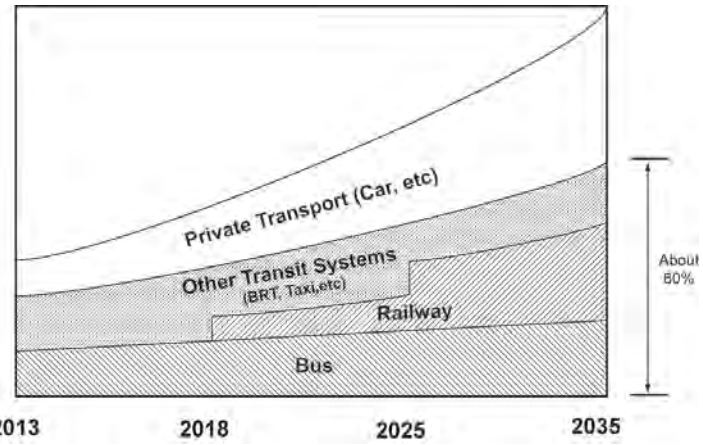
1 INTRODUCTION

1.1 Background and Objectives

Yangon city, the economic centre of the Republic of the Union of Myanmar, is currently suffering from serious traffic congestions as a consequence of a rapid increase of the number of private cars thanks to a recent economic recovery and relaxation of car-import regulations in 2011. The issue has already been recognized by the Yangon regional government as one of the most urgent and important issues to be solved. Under these circumstances, Yangon Regional Government and JICA have conducted “The project for Strategic Urban Development Plan of the Greater Yangon (SUDP)” in 2012 focusing mainly on the urban development and land use aspect of the city, and “The Project for Comprehensive Urban Transport Plan of the Greater Yangon (YUTRA)” in 2014 to prepare a comprehensive urban transport plan.

As a result of various studies in YUTRA including transport demand forecast, it is proposed as a indicative target that 60% share for the public transport be maintained in the future in the city (Figure 1.1-1), with the overall goal of transport set as follows;

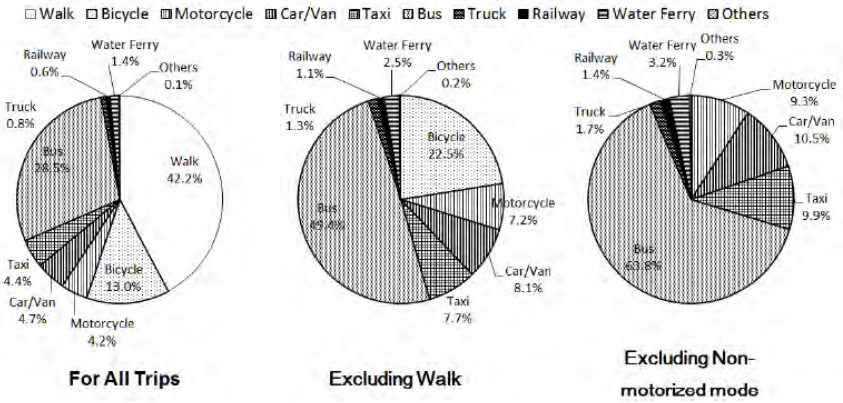
“Ensure mobility and accessibility to urban services that are vital for the people and the society, by providing a transport system characterized by safety, amenity, and equity and sustained by an efficient public transport system”



Indicative target in 2035

Source: YUTRA

Figure 1.1-1 The indicative target for Modal Share in 2035



Source: YUTRA

Figure 1.1-2 Current Modal Share

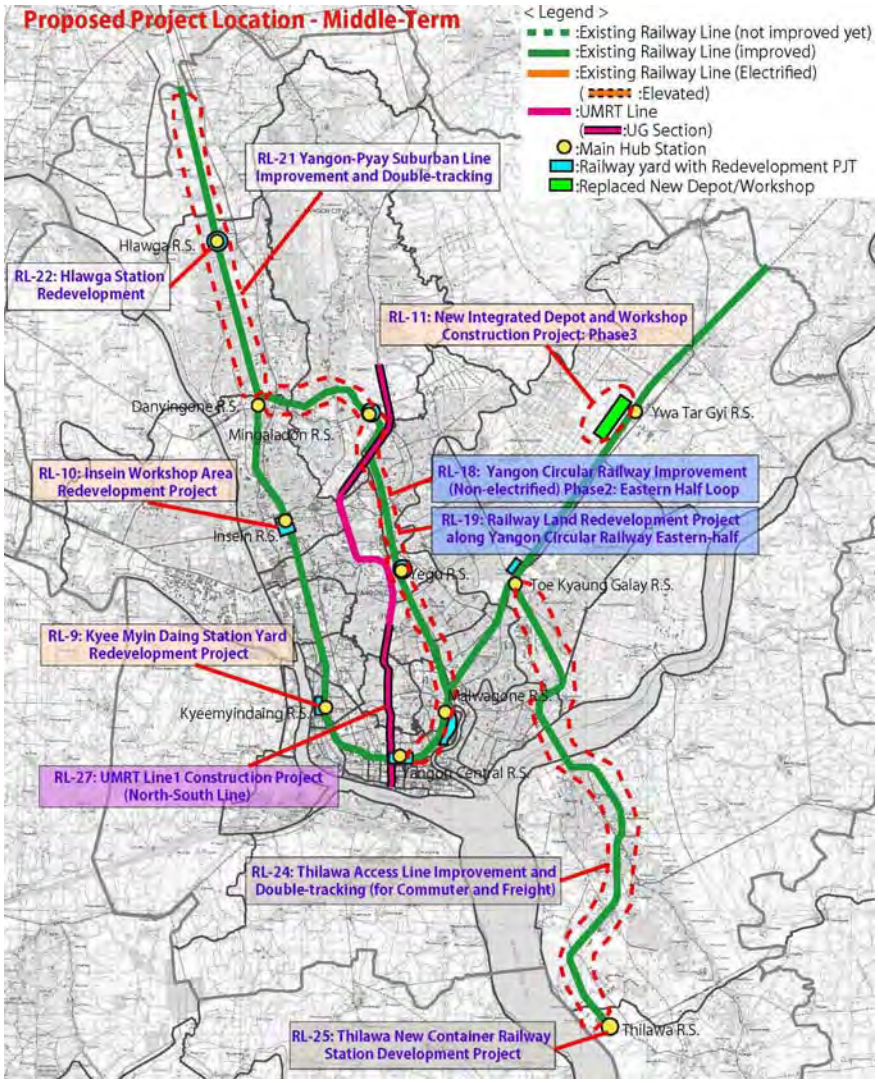
Following the decision of above strategy on the public transport, specific projects have been suggested in YUTRA for short-term, middle-term and long-term as a master plan for the public transport in the city. The major projects of each term are shown in Table 1.1-1.

Table 1.1-1 Major Railway Projects proposed in YUTRA

Term	Major Projects
Short-term (2018)	- YCR Modernization (Phase-1) - Yangon Central Station Redevelopment project.
Middle-term (2025)	- Yangon Mandalay Line Improvement - YCR Modernization (Phase-2) - **UMRT Line 1 project (North-South Line)**
Long-term (2035)	-Yangon-Pyay Suburban Line Electrification - **UMRT Line 1 Extension Project.**

Source: YUTRA

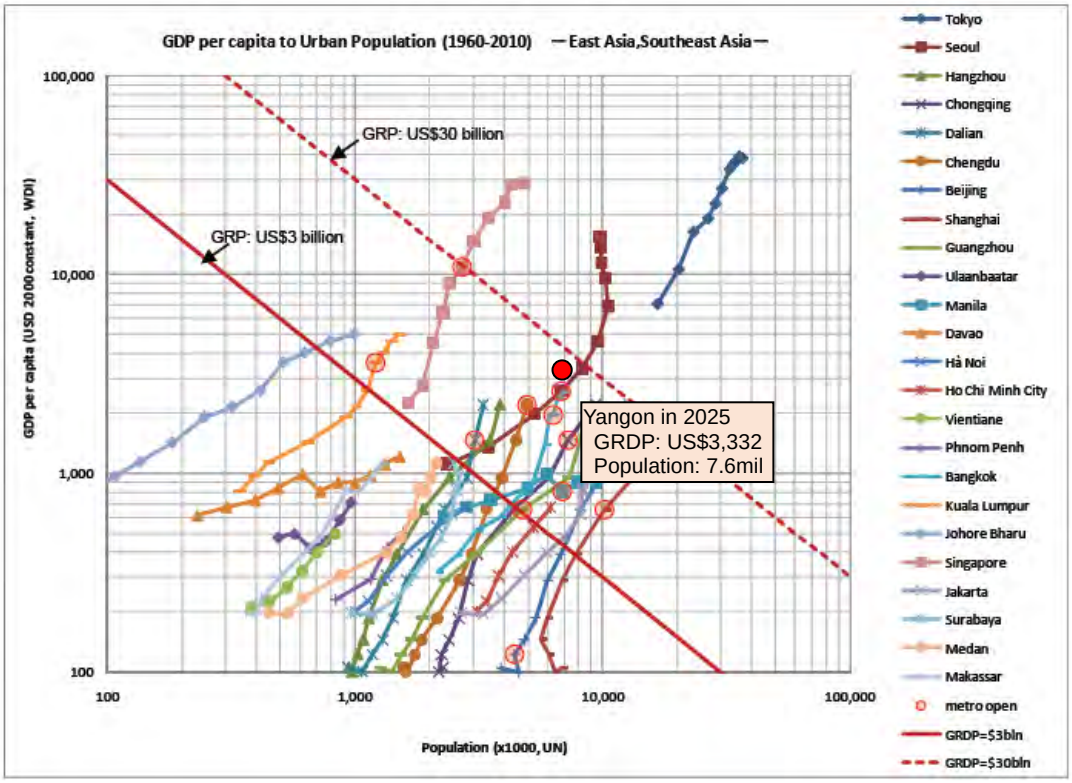
Although there is no clear definition of UMRT, it can be characterized as the highest capacity public transportation system which approximately carries more than 30,000phpdt. The first UMRT line is proposed to start operation in 2025 as one of the middle-term railway projects as shown in Figure 1.1-3.



Source: YUTRA

Figure 1.1-3 Proposed Project Location Map for Middle-term in YUTRA

As mentioned in YUTRA, one study shows that most of the first UMRTs in Asian countries started operation in between the GRDP band of US$3bil. and US$30bil. This indicates that UMRTs have been introduces in Asia in accordance with the scale and economic size of the cities. Yangon city is estimated to achieve GRDP of US$3,332 and population of 7.6 million in 2025, which is considered to be sufficient socio-economic level for sustainable operation of UMRT.



Source: The Research on Practical Approach for Urban Transport Planning, JICA, 2011

Figure 1.1-4 Yangon's Position in 2025 on Relation Figure UMRT Opening Year and GRDP in Asian Major Cities

This study is conducted within a framework of YUTRA to accelerate the implementation of the YUMRT Line 1 project (herein after referred to "the Project") and to provide preliminary studies for evaluating the Project as reference for the future feasibility study.

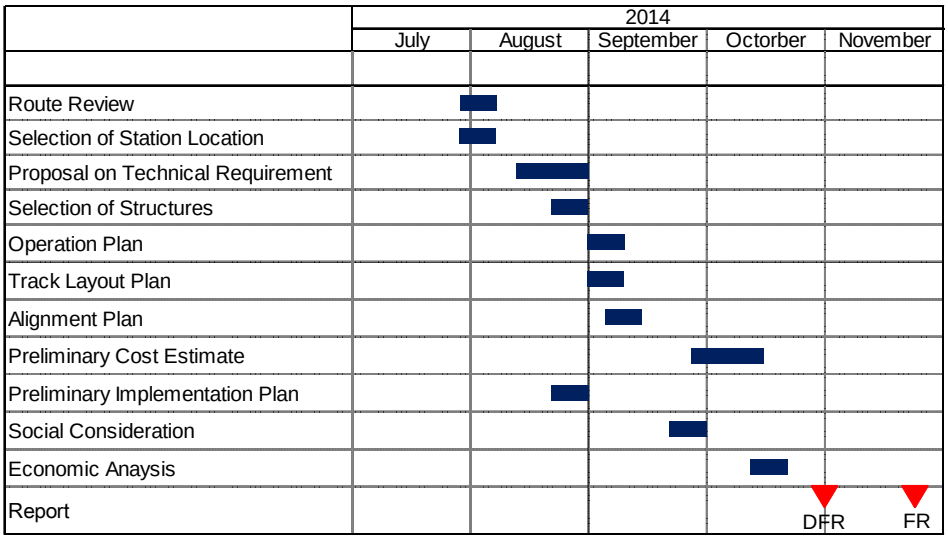
1.2 Scope and Schedule of the Study

The scope of this study is set as follows;

- Route and station location selection
- System Selection
- Proposal on desirable technical requirements for the Project
- Selection of structures (on-ground, elevated or underground)
- Operation plan, alignment plan
- Preliminary Cost Estimate
- Preliminary Project Implementation Plan and O&M Organization Plan

- Social Considerations
- Economic and Financial Analysis

The schedule of the study is shown as follows;



Source: Survey Team

Figure 1.2-1 Schedule of the study

2 Existing Conditions of the Proposed Candidate Route

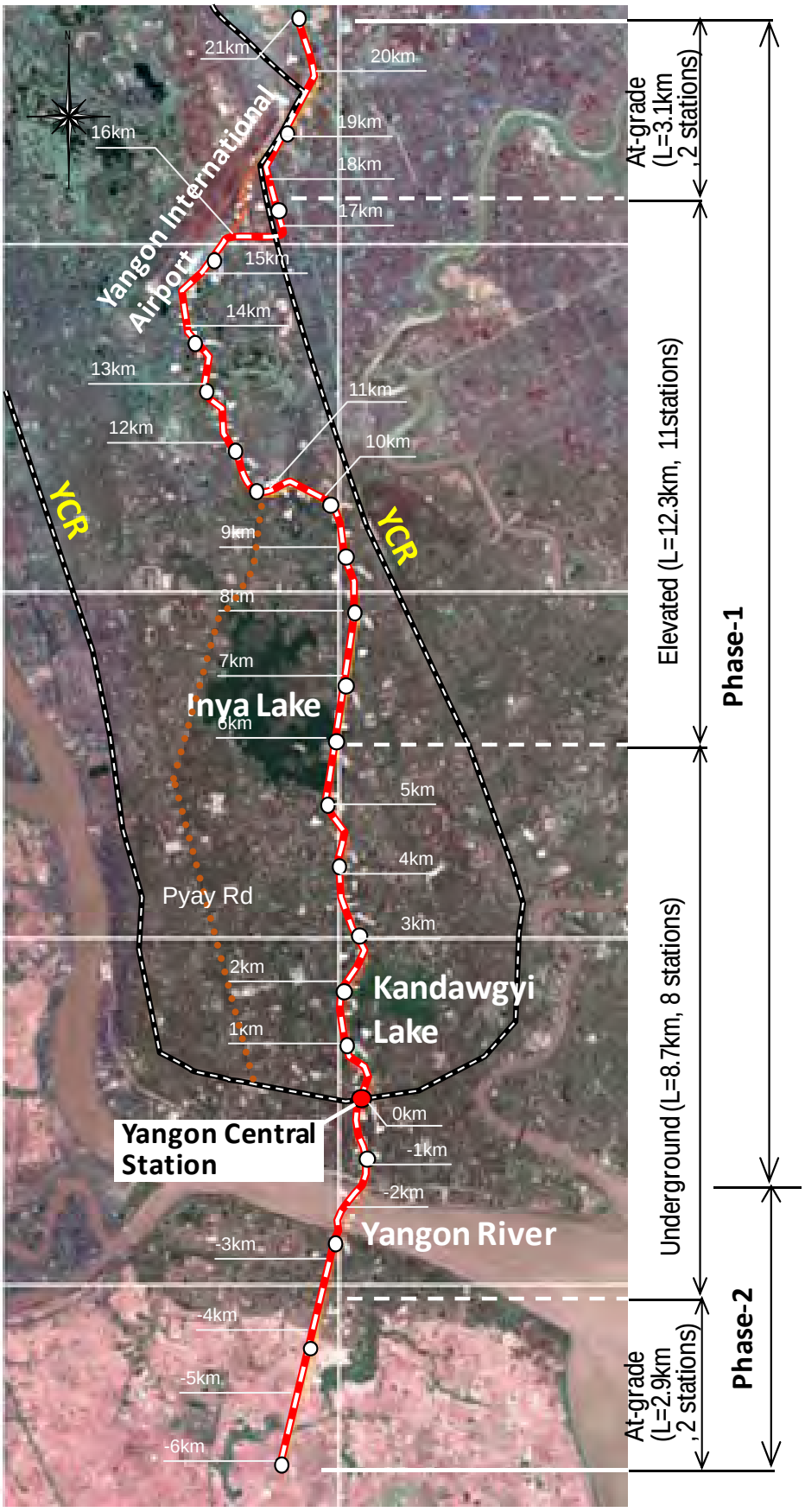
2.1 Background of the Route[1]

As a North-South public transport axis, there are only two possible candidate roads applicable as UMRT routes, which are namely Pyay Road running western side of Inya Lake, and Kaba Ayer Pagoda Road running eastern side of Inya Lake. Since there is a huge size of Inya Lake lying in the very centre of Yangon Urban region, there are not so many roads wide enough as UMRT route candidates. When it comes to South-half of the section, Pyay Road is too close to western section of YCR (See Figure 2.2-1 for reference) which will also serve as North-South public transport axis for western half of Yangon City. It is unreasonable to compete two public railway transport systems by setting two alignments very close and parallel. With regard to above, since Kaba Aye Pagoda Road can be deemed to take more demand than Pyay Road, Kabar Aye Pagoda Road has been selected as a candidate route for UMRT in YUTRA.

2.2 Summary of the Route

The proposed candidate route starts with just north of the Yangon International Airport. A candidate plot for Depot is located at the northern origin of the candidate route. The route extends southward partially running in parallel with existing Yangon circular line. Right after Wai Bar Gyi Station, the route shifts from at-grade to elevated and then goes over YCR and runs southward along Yangon Airport road. At the crossing point with Pyay Rd the route shifts to Pyay Rd westward. Proposed alignment runs in parallel with Pyay Rd to the crossing point with Kabar Aye Pagoda Rd and then turns west in parallel with Kabar Aye Pagoda Rd. It goes along with Kabar Aye Pagoda Rd from north to south, passing beside Kabar Aye Pagoda and Inya Lake. There is a wide green zone at a lakeside where the alignment goes underground. The alignment extends along with Kabar Aye Pagoda Rd just before the entrance of newly-built flyover, ant it strays from Kabar Aye Pagoda Rd and goes into residential area to avoid substructures of the flyover. It links to Bahan Rd near the Japanese Embassy and connects to Zoological Garden Rd. After passing Zoological Garden Rd, it goes under the Bogyke Aung San Stadium and Yangon Central Station and then extends southward along Sule Pagoda Rd. After passing between Sule Pagod and YCDC, the alignment crosses under Yangon River and then reaches to Dala on the opposite side of the river. Route outline with approximate chainage is shown in Figure 2.2-1. Starting point of chainage is set at Yangon Central Station.

[1] Refer to Figure 6.2.1.17 (page 6-35) of YUTRA main report.



Source: Survey Team

Figure 2.2-1 Route Outline and Chainage

2.3 Existing Conditions of the Proposed Candidate Route

Conditions of existing roads along the candidate route are summarized in Table 2.3-1.

Table 2.3-1 List of Roads and Conditions of the Proposed Candidate Route

Chainage	Ph	Road Name/ current status	No of Lane	Median	Remarks
21 000	Phase-1	Grassland	-	-	
19 + 700		In parallel to YCR	-	-	
17 + 200		Residential area	-	-	
16 + 500		(a road with no name)	1/1	Un-Divided	Very narrow
16 + 000		Yangon Airport Road	4/2	Un-Divided	Devious road
14 + 000		Pyay Rd	6/2	Un-Divided	Very devious
11 + 300		Kabar Aye Pagoda Rd.	6/2	Un-Divided	
9 500		Kabar Aye Pagoda Rd.	6/2	Divided (New jersey Type)	straight
8 + 000		Kabar Aye Pagoda Rd.	6/2	Un-Divided	straight
3 + 400		Under the residential area	-	-	Avoiding newly-built flyover
2 + 400		Inside Kandawgyi Lake Park	-	-	
1 + 800		Zoological Garden Rd.	6/2	Un-Divided	straight
0 + 900		Zoological Garden Rd.	3/1	Un-Divided	One way
0 + 500		Under Studiam and Yangon St	-	-	
-0 + 200		Sule Pagoda Rd.	6/2	Divided	with very wide side strip and frontage road.
-0 + 700		Maha Bandula Park St	3/1	Un-Divided	
-1 + 400		Under Yangon River	-	-	
-2 + 200	Phase-2	Dala-Twante Rd.	2/1	Un-Divided	
-2 + 600		In the middle of rice field	-	-	
-6 + 040					

Source: Survey Team

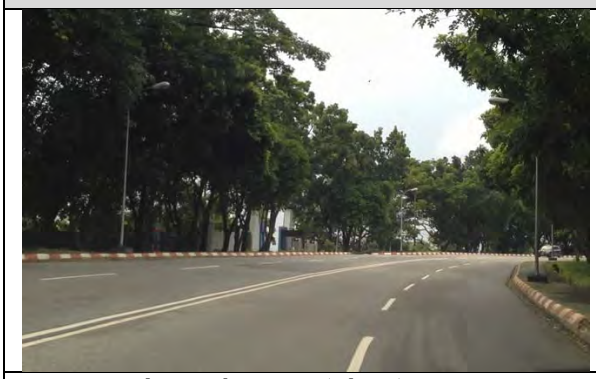
Note: 1) "/1" indicates one-way traffic, "/2" indicates two-way (inbound and outbound) traffic.

Photos of the existing conditions along the proposed candidate route are shown below;

Maha Bandula Park St	Sule Pagoda Road
	
- Narrow one way road without side strip and walkway. - Buildings/ houses stand side by side on both sides of the street.	- Wide side median with frontage road on both sides of the road. - Divided by fence.

Zoological Garden Road	Lakeside of Inya Lake
	
- One way section (3 lanes)..	- Very wide green zone on the lakeside. - Transition of structure (elevated to underground) planned on the green zone.

Kabar Aye Pagoda Road	Pyay Road
	
- Jersey barriers on the centre. (6 lanes) - Narrow walkway on both sides of the road.	- No median on the centre (6 lanes). - Successive steep curves.

Yangon Airport Road	Wai Bar Gyi Station (Circular Railway)
	
- No median on the centre. (4 lanes) - Wide green zone on both sides of the road - Successive steep curves	- A YUMRT station is planed adjacent to the existing Wai Bar Gyi Station.

Source: Survey Team

Figure 2.3-1 Existing Conditions of the Route

There is no median on most of the existing roads along the proposed candidate route and outbound and inbound lines are just divided by white paint. In such sections, road widening may be necessary to guarantee the space for column of elevated structures in case that elevated structure is developed on the existing roads. In addition, some of the existing roads do not fit the railway alignment because of devious plane alignment. The railway alignment along such roads may not be able to set within right-of-way, requiring land acquisition of adjoining land.

Other existing conditions along the proposed candidate route are described by phase in the following sections.

1) Phase 1 Section

Phase-1 section starts with YCDC station which will be located at the Maha Bandoola Garden. The route goes through in between YCDC and Sule Pagoda. Two shield tunnels have to go through this limited space. Once the route turns off from Sule Pagda Road, it cannot be turn back to the road considering the railway alignment, thus the southern terminal station is proposed to be at the location of Maha Bandoola Garden.

Source: Survey Team

Photo 2.3-1 Clearance between YCDC and Sule Pagoda

After running through Yangon Central Station the route will be linked with Zoological Garden Road. There are two one-way roads Between Yangon Central Station and Zoological Garden road both of which are devious and not wide enough for underground UMRT structure. Because of these poor road conditions, the route runs under the existing Bogyoke Aung San Studium, since low-height structure does not seem to have any underground support structures such as piles.

Source: Survey Team

Photo 2.3-2 Scenery toward Stadium and Yangon Central Station from building top on north.

There is a newly-constructed flyover along Kaber Aye Pagoda road. This section has successive sharp curves where there is no choice at all for railway alignment to be applied along this road. Adding to the sharp-curved alignment, there is no space for UMRT elevated structures since tall buildings stand very close to the flyover. And there are substructures of the flyover including piles which interfere with YUMRT underground structures. In both cases; elevated and underground, this section is not suitable for YUMRT alignment.

Source: Survey Team

Photo 2.3-3 Substructure of New Flyover

Source: Survey Team

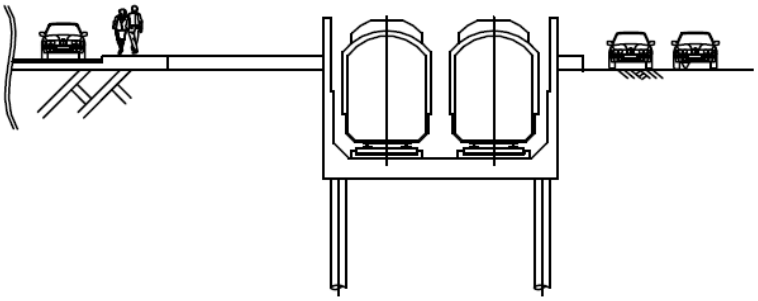
Photo 2.3-4 Conditions over New Flyover

For above reason, the route has to turn off from the existing road ROW and goes under the residential area. The candidate route passes the narrow alley where Japanese Embassy sits adjacent and goes under the residential area. The route avoids major buildings (high-story buildings) where there may be foundation piles underground in order not interfere with underground YUMRT tunnels.

Source: Survey Team

Photo 2.3-5 Narrow Alley where the Candidate Route runs beneath.

The route extends toward north all along with Kabar Aye Padoda road. Qiute wide space (approx 12m) is necessary for certain amount of length (approx 700m) to transit from underground as shown in Figure 2.3-2. It seems to be only one section is wide and long enough for transition section in the eastern bank of Inya Lake (see Photo 2.3-6). It is proposed to use this vacant plot for the YUMRT to transit from underground to elevated structures.



Source: Survey Team

Figure 2.3-2 Typical Section of Transition Section

Source: Survey Team

Photo 2.3-6 Candidate Site for Transition Section

After passing Inya Lake, the candidate route runs in parallel to the existing road within the ROW although part of the horizontal alignment cannot fall within the ROW of existing road along devious roads like Pyay Road and Airport Road.

In order not to interfere with the Airport Facility, the route turns its direction to the east where public roads are not developed wide enough and some of the part are not even paved. It is necessary for the YUMRT to run along this road to widen and develop this road in prior to the YUMRT project. After this section, since there is no existing road that allows to YUMRT to accommodate, the route has to cross residential area where small houses stand sparsely. The route goes over the YCR and turns its direction to the north and runs in parallel with YCR. A connection line will be installed near existing Wai Bar Gyi station.

Source: Survey Team

Photo 2.3-7 Narrow Alley where the Candidate Route runs beneath.

There has to be at least one depot within the phase-1 section where train cars stand by during the night time and undergo inspections and repairs for maintenance. Approximately ten hectors of land is required for depot though it depends on the figure of the plot. It is difficult to find such a wide-open area in the centre of Yangon City since it has densely developed. The only plot which seems wide enough for YUMRT depot can be observed at the northern side of Yangon International Airport where Mingalardon Industrial Park is being developed nearby. The phase-1 section has to be extended at this point to connect with depot. By extending phase-1 section at this point, connection with YCR can be possible from the early stage of the project; advantages of connecting YUMRT with YCR will be discussed late in this report.

2) Phase 2 Section

Phase-2 section of the project is planned to be developed in Dala District where the entire area is not at all developed as well as opposite side of Yangon River. There are no brick or concrete-made houses but are hut-like small houses standing sparsely. However, this area has a huge potential as a development target thanks to closeness to CBD of Yangon City once it's connected by YUMRT or other transport mode. Phase-2 section is premised that this area be developed dramatically in prior to the project. Although the candidate route ends in the middle of rice field, the southern terminal of phase-2 section depends on the extent of future development in this area.

Source: Survey Team

Photo 2.3-8 A Street in Dala.

3 Preliminary Project Plan

3.1 General

As described in YUTRA, first urban railway system in Yangon city is proposed to be Urban Mass Rapid Transit (UMRT). The demand of YUMRT in 2035 is expected to be 380,000 passengers although the figure should be reviewed and revised in the next study.

This chapter of the report describes the result of preliminary technical studies for future Yangon UMRT system. It should be noted that technical specifications and alignment etc, described under this section shall be reviewed in the next study and may be revised based on the further detailed studies.

3.2 Design Criteria

3.2.1 Design Criteria of Yangon Circular Railway

The following table shows the design criteria of Yangon Circular Railway Improvement project. Most of the figures in the table are similar with those of standard criteria of UMRT system in Japan, except for the maximum gradient of 5‰ which is far lower than the Japanese standard of 35‰.

Table 3.2-1 Design Criteria of YCR

YCR Criteria			Description/ Value
1	Gauge		1,000mm
2	Speed	Maximum	80km/h
		Schedule	30km/h
3	Minimum Horizontal Curvature	Main track	291m (6 degree)
		Platform	-
4	Gradient		5‰
5	Traction System	System	To be determined
		Voltage	To be determined

Source: Survey Team

3.2.2 Proposed Design Criteria of YUMRT

It is strongly recommended to set up design criteria in a way that YUMRT is compatible with other railway such as to-be-improved/electrified Yangon Circular Railway in view of possible mutual operation in the future. Connection with other lines improves expandability, maintainability and flexibility of YUMRT. The advantages of setting design criteria of YUMRT compatible with YCR are described as follows;

- Expandability Connecting YUMRT with YCR enables inter operation of YUMRT and existing Myanmar railway.
- Maintainability Depot and workshop can be shared by YUMRT and existing railways. By sharing these facilities, it is possible to avoid double investment on the various railway facilities and thus contribute to reduce maintenance cost.

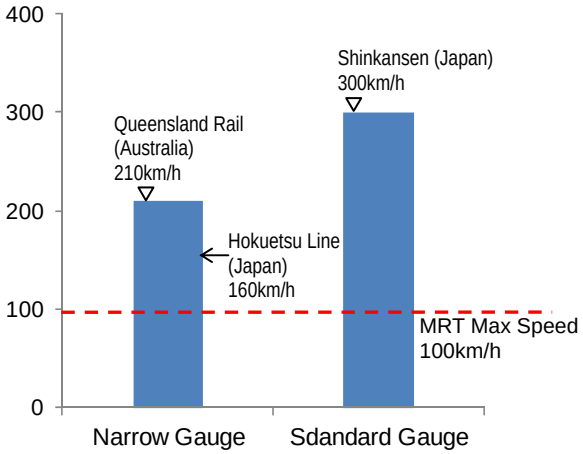
➢ Flexibility — Track structures and other systems (signalling, power supply etc,) shall be the same as those to be applied to YUC in the future. This enables to maintenance know-hows and human resources to be shared by YUMRT and YCR.

(1) Gauge

Railway gauge should be determined by considering the followings;

- Speed

Generally speaking, wider gauge allows trains to run faster as it is more stable. However, maximum speed of UMRT is usually determined not by the stability or performance of railway system but by stricter alignment. Alignment of UMRT is usually stricter than that of suburban railway. Distance between two stations is much shorter, curve is shaper and slope is steeper.



Source: Survey Team

Figure 3.2-1 Gauge and Max Speed

The figure on the right shows a relation between gauges and maximum speed. This figure shows that standard gauge ranked higher in the world highest maxmum speed record by gauges. It is clear from this figure that gauge does not affect the MRT maxmum speed since it is much lower than possible maximum speed of both gauges.

Applying existing meter gauge to YUMRT does not affect maximum speed of YUMRT.

- Capacity

Capacity of train is determined by the size of train cars. Although loading gauge of rolling stock is the most major factor for determining the size of rolling stock, there is no big difference in loading gauges between train cars running on narrow track gauge and on standard track gauge. International Union of Railway (UIC) specifies a width of 3.15m as a loading gauge, while Japan applies a width of 3.0m.

- Safety

Wider gauge seems to contribute stable, and thus, safe train operation. However, even though narrow gauge is applied, Japanese metro has proven the safest operation in the world. This shows that safety is not dependent only on the width of gauge.

- Maintainability

If 1,000m gauge is applied to YUMRT, it enables mutual operation with existing railways. In this case, maintenance facilities such as depot and workshop and maintenance

equipment can be shared by both parties. In addition, human resources like operators and dispatchers can also be shared since similar operation system should be applied to both railways for mutual extension operation.

- Expandability

YUTRA forecasts future traffic demand up to 2035. This demand is based on various conditions determined throughout the course of YUTRA study and is considered to be reasonable. However, it is sometimes the case that the reality is not what had been forecasted some decades ago. In preparation for such cases, it is important to be ready for the unexpected in the future. Once the gauge of YUMRT is fixed different from the existing gauge, it will never be mutually connected, considerably shrinking future expandability of transportation network. As mentioned above, since it seems that there is no advantage to apply standard gauge for YUMRT, applying the same gauge to YUMRT may allow unexpected needs of expanding transport network to be possible in the future.

- Availability

Narrow gauge is applied to some of the South Eastern Asian countries such as Thailand and Vietnam etc, while Standard gauge is applied most of the European countries. Manufacturers of rolling stock spread all over the world although world biggest manufacturers are mainly located on European and North American continent. Japan has some of the best-quality manufacturers in the world; recently China and Korea are emerging rapidly in the world railway market. Since it appears that demand of manufactures for standard gauge including rolling stock surpasses those for narrow gauge, manufactures for standard gauge seems to be more available in the market.

- Initial Cost

Initial cost does not dependent on the gauge if the same railway system such as power distribution system is applied.

Table 3.2-2 Comparison between 1,000mm gauge and standard gauge

	Gauge	
	1,000mm	1,435mm (Standard)
Speed	+	+
Capacity	+	+
Safety	+	+
Maintainability	+	-
Expandability	++	-
Availability	-	+
Cost	+	+
	+	-

Source: Survey Team

Judging from the preliminary comparison study shown above, the gauge width of 1,000mm is recommended for YUMRT Line 1 project.

(2) Railway System

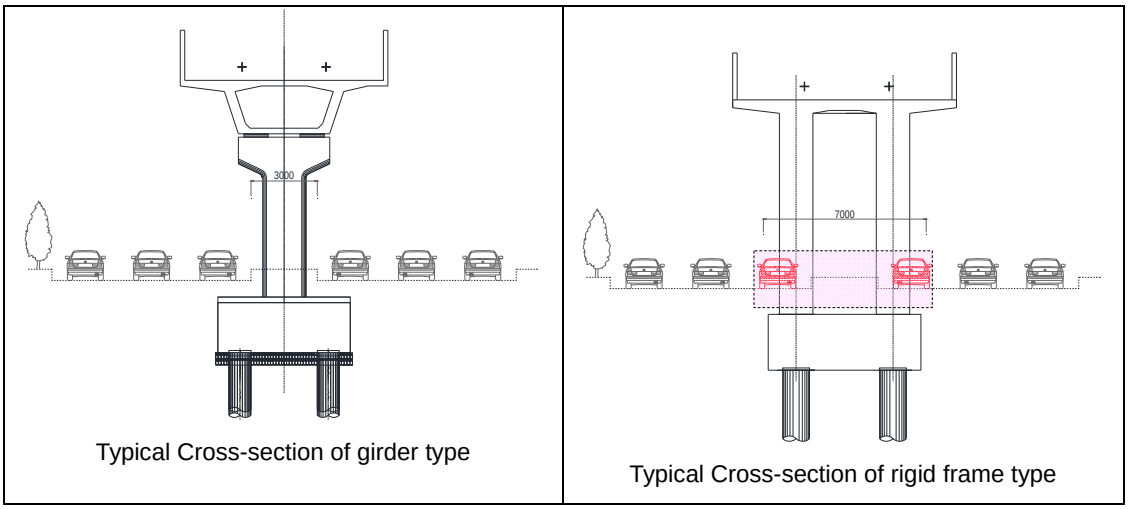
The basic policy for other railway system such as power distribution system, track structures etc, shall follow those of future-improved Yangon Circular Railway considering possible mutual operation in the future.

(3) Civil Structures

Preliminary comparison study for selection of civil structure is conducted. In the next study (feasibility study), soil investigation shall be carried out and preliminary design for civil structure shall be conducted considering the result of soil investigation.

Elevated Structure

Generally, elevated structure for MRT is selected from either a girder type structure or rigid frame structure. The typical cross section of both structures is illustrated in Figure 3.2-3.



Typical Cross-section of girder type

Typical Cross-section of rigid frame type

Source: Survey Team

Figure 3.2-2 Typical Cross Section of Elevated Structure for MRT

The rigid frame structure has a wide dead space under the girders, and thus, it negatively affects the existing road traffic. In addition, in the section where there is no additional space such as wide median or green zone, it may be necessary to expand the existing road width, which will cause additional resettlement and land acquisition.

Comparison of these two structures is shown in Table 3.2-3 Even though initial cost of girder type structure is slightly higher, it is recommended to apply girder type structure for elevated section.

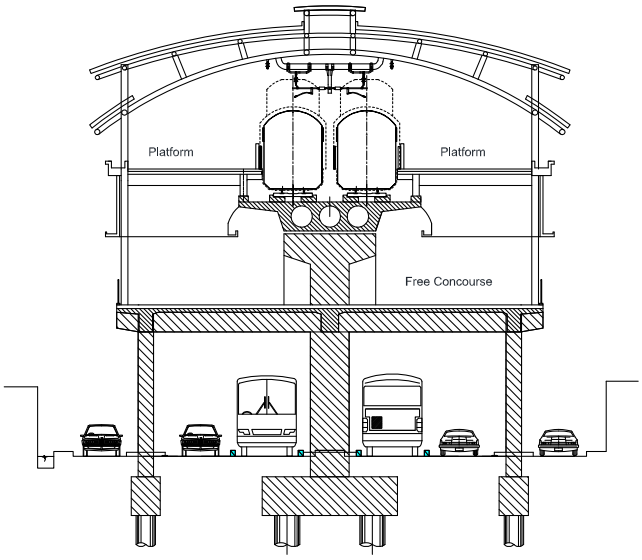
Table 3.2-3 Comparison Table of Elevated Structure

Description	Girder Type	Rigid Frame	Note
Economic Efficiency	△	○	Construction cost of girder type structure is approximately 1.3-1.5 times higher than that of the rigid frame type structure.
Constructability	○	×	Construction of rigid frame type structure occupies a wider area compared to that of the girder type structure.

Description	Girder Type	Rigid Frame	Note
Construction Duration	○	×	Construction of rigid frame takes two times longer than that of the girder type structure.
Landscape	○	×	Girder type structure is simpler and does not spoil the scenery.
Environmental Impact	○	×	Rigid frame structure occupies a wider area of existing roads during and after construction.

Source: Survey Team

Typical cross section of elevated station is shown in the following figure;

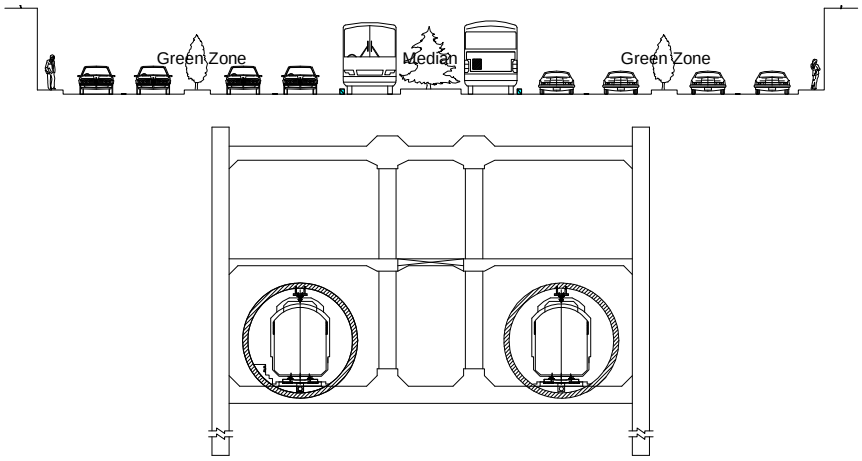


Source: Survey Team

Figure 3.2-3 Typical Cross Section of Elevated Station

Underground Structure

The only option for underground tunnelling method is shield tunnelling as it is generally the most low-cost construction method for UMRT tunnelling. It has also environmentally much less negative impact to the surface. Stations have to be constructed by cut-and-cover method, which is higher environmental impact. Following figures show typical cross sections of tunnel and station in underground section.



Source: Survey Team

Figure 3.2-4 Typical Cross Section of Underground Structure for UMRT.

(4) Proposed Design Criteria

Following Table shows the proposed design criteria for YUMRT Line 1 project. Further studies should be conducted for setting more detail technical criteria in the next stage of the project.

Table 3.2-4 Proposed Design Criteria for YUMRT

Criteria				Description/ Value
1	Gauge			1,000mm
2	Speed	Maximum		100km/h
		Schedule		30km/h
3	Maximum horizontal cavature	Main track		300m (Absolute minimum: 200m)
		Platform		400m
4	Gradient			35‰
5	Civil Structure	Elevated	Guide way	PC Box Girder
			Station	PC Box Girder (Hybrid structure)
		Tunnel	Guide way	Shield Tunnel (STDT: Single Tube Double Track)
			Station	Open Cut Method
	Train Frequency			4.0 min
	Traction System	System		Overhead Catenary
		Voltage		1500V DC
	Train Composition			6 cars

Source: Survey Team

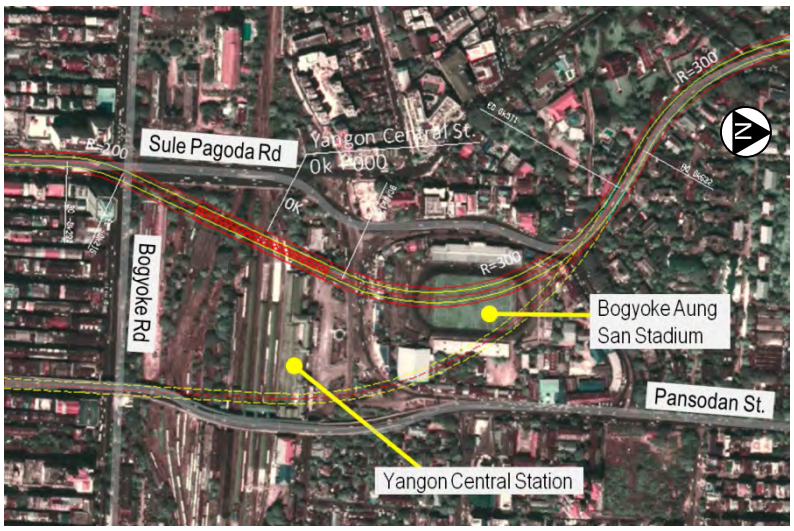
3.3 Alignment

The basic policy for planning alignment is as follows;

- The centre of alignment shall follow the road centre, if ROW allows, as much as possible.
- Horizontal alignment shall be designed in a way that all the UMRT structures can be constructed within ROW to minimize land acquisition and resettlement as much as possible
- By any chance UMRT structures cannot be constructed within ROW, at least alignment shall keep off from major buildings.
- It is desirable to set elevated section as long as possible instead of underground section in order to minimize the initial cost. However, in the centre of Yangon city, buildings and houses have been built so densely that there is no extra land left for elevated structure on the ground. Therefore, underground section has to be introduced accordingly, considering the location of transition section from elevated to underground.

Some of the control points in alignment plan are summarized as follows;

Location	Description	
12k ~ 14k		Due to successive steep curves along Yangon Airport Road and Pyay Road, railway alignment cannot catch up with the existing road alignment. In sections where railway alignment runs off from the existing alignment, land acquisition might be inevitable.
5k+100 ~5k+800		There is a quite wide area at the lakeside of Inya Lake. Since transition section from elevated to underground requires wide area (approx 10m) , this sections can be utilized as a transition area.
3k+500		Due to tight curves along existing road alignment and obstruction of newly-built flyover, UMRT alignment has to turn off from existing ROW and go into residential area.

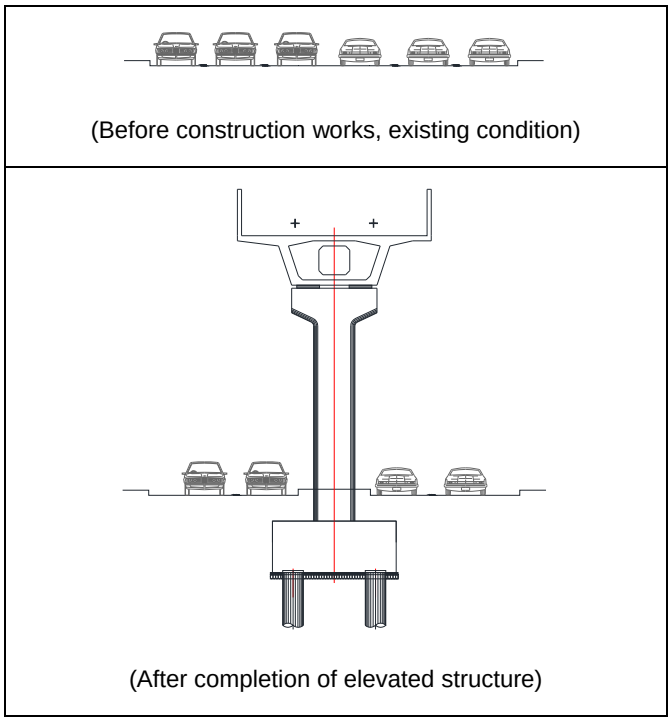
2k+000 ~2k+500		After under -residential sectionn, UMRT alignment (underground) passes beside Japanese Embassy, and goes through part of Kandawgyi lakepan side park area.
0k+000 ~0k+500		There is narrow, three-lane one way section along Zoological Garden Road where existing road runs with continuous steep curves. In order to go along with the existing road alignment, UMRT alignment has to go under the Bogyoke Aung San Stadium.
-0k+500 ~-1k+000		The proposed alignment averts Sule Pagoda and goes through in between YCDC and Sule Pagoda.

Source: Survey Team

Figure 3.3-1 Major Control Points in Alignment Plan

Although alignment plan has been made preliminarily in this study, topographic survey will have to be carried out in the next stage for further detail alignment study.

In elevated section, it is desirable for UMRT alignment to run along with existing road alignment in order to minimize land acquisition and resettlement. However, some of the sections along the route have continuous steep curves in a way that railway alignment cannot follow. In these sections, some land acquisition and resettlement may have to be inevitable although further studies are needed for confirmation. Although it is desirable to set the horizontal alignment along the centre line of the existing road considering land acquisition and resettlement, current number of traffic lanes cannot be sustained since columns of elevated structure requires approximately 2.0m. Reduction of traffic lane may be required; however, this should be confirmed by conducting the topographic survey in the feasibility stage.

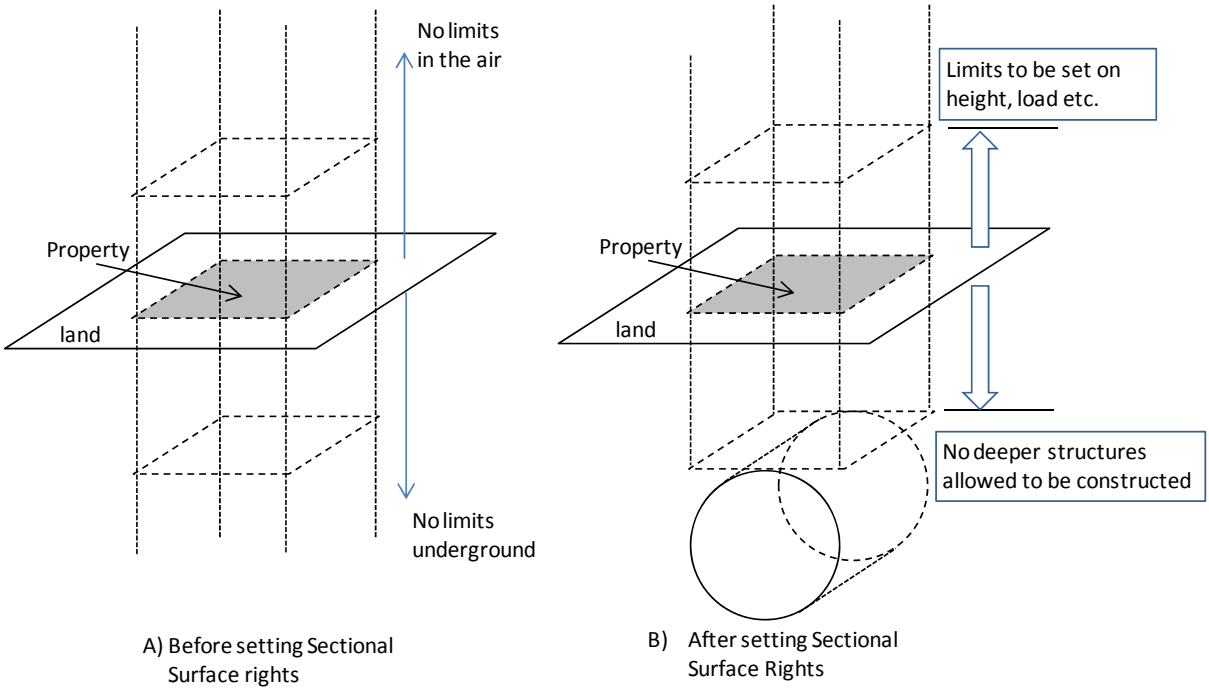


Source: Survey Team

Figure 3.3-2 Road Structure before and after the Construction of Elevated Structure

In underground section, alignment has planned in a way that UMRT alignment runs within ROW of existing road as much as possible. However, since there is a section along Kaber Aye Pagoda Road where existing alignment is so sharp for railway alignment to follow and a newly-built flyover interrupts railway alignment, part of the route has to go under the residential area. In Myanmar, there is no law or regulations that allow public structures to go under private property. It is strongly recommended that regulations like “Sectional Surface Rights” should be introduced since such cases are likely to be inevitable in YUMRT Line 1 project. A conceptual image of “Sectional Surface Rights” in Japan is shown in the Figure 3.3-3. When Land Rights is set in the form of property; it usually covers all the air above the property and all the soil under the property. However, once Sectional Surface Rights is registered, usable area in the air or underground will be limited and a variety of limits will be set on the property in order to avoid possible damages to the public structures. When setting Sectional Surface Rights to the property already owned by

private person, compensation for limiting the use of land shall be made.



Source: Survey Team

Figure 3.3-3 A Conceptual Image of "Sectional Surface Rights"

3.4 Alignment Alternatives

There are a few sections where further detail studies for alternative route might be required. Followings describe possible alternative routes which need to be reviewed and scrutinized in the next feasibility stage.

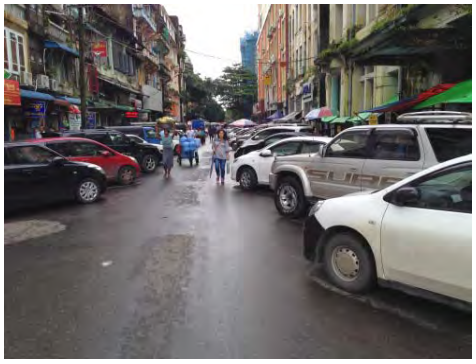
(1) Alignment under Sule Pagoda

Present alignment runs between Sule Pagoda and YCDC building in order for the alignment to avoid going just beneath Sule Pagoda. However, because of this "detour", alignment of Phase-2 has to go along Maha Bandula Park Street which is very narrow one way street. Since buildings along this street are quite high and they seem to have approximately five stories, there should be foundation piles under the building. If single track double tube is applied in this section, tunnel may interfere with those foundation piles. In order to avoid this to happen, there are two possible solutions.

Source: Survey Team

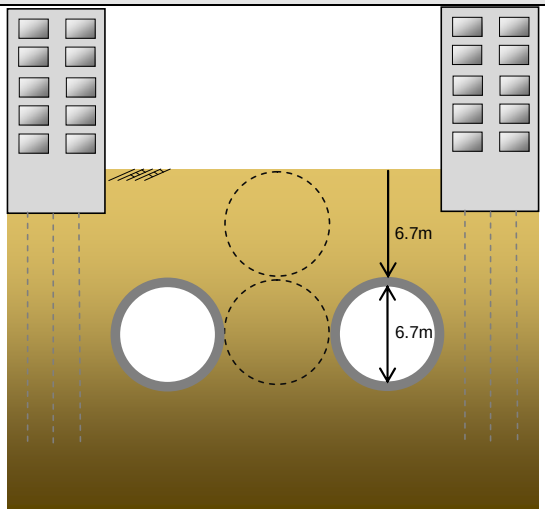
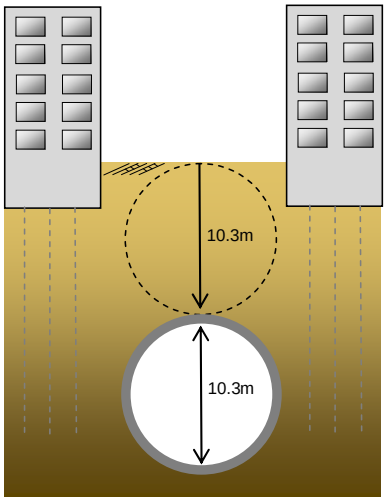
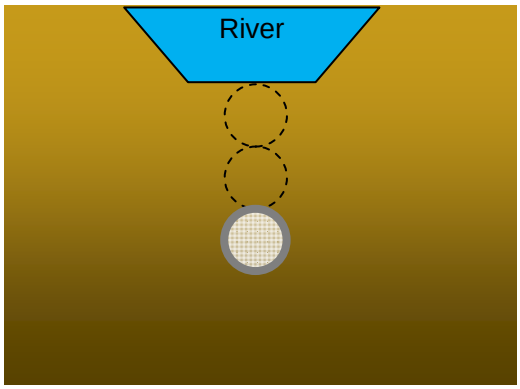
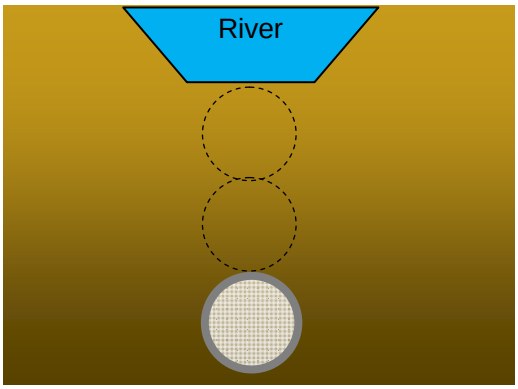
Figure 3.4-1 Alignment near Sule Pagoda

First possible solution is to apply double track single tube shield method in this section. This can minimize the negative influence of tunnel construction to the surrounding area although tunnelling cost will be much higher than double track single tube tunnel. The difficulty in this option is vertical alignment under Yangon River. As can be seen in Figure 3.4-2, DTST tunnel has to be deeper than STWT. Since earth covering of under-river section in shield tunnel shall usually be more than twice as thick as tunnel outer diameter. This means that stations on both side of Yangon River, YCDC station in Phase-1 and Dala Station in Phase-2, are required to be constructed in very deep underground. Further alignment studies including confirmation of planning river bed of Yangon River shall be carried out in the feasibility study.



Source: Survey Team

Photo 3.4-1 Maha Bandula Park St.

	(A) Single Track Double Tube (STDT)	(B) Double Track Single Tube (DTST)
Cross-section of tunnel		
Depth under the river		

Source: Survey Team

Figure 3.4-2 Comparison between STDT and DTST

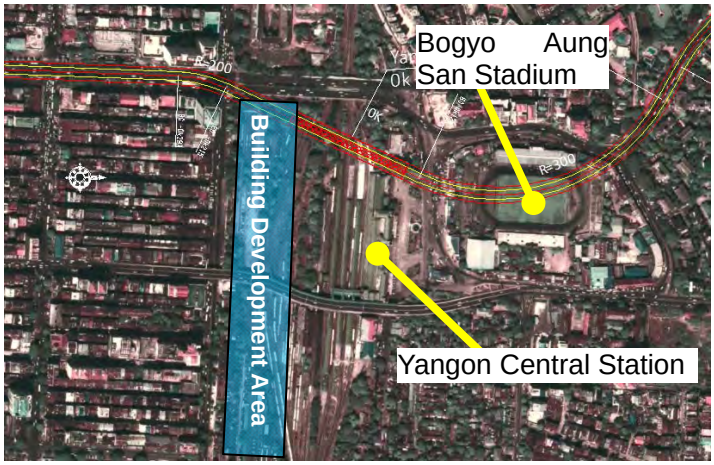
Second possible solution is to put the alignment under Sule Pagoda. Although this seems to be the simple option, it has to be verified and confirmed from as many aspects as possible if tunnelling just under the very popular religious Buddhist stupa is feasible or not.

Source: Survey Team

Figure 3.4-3 Alternative Route around Sule Pagoda

(2) Alignment around Yangon Central Station

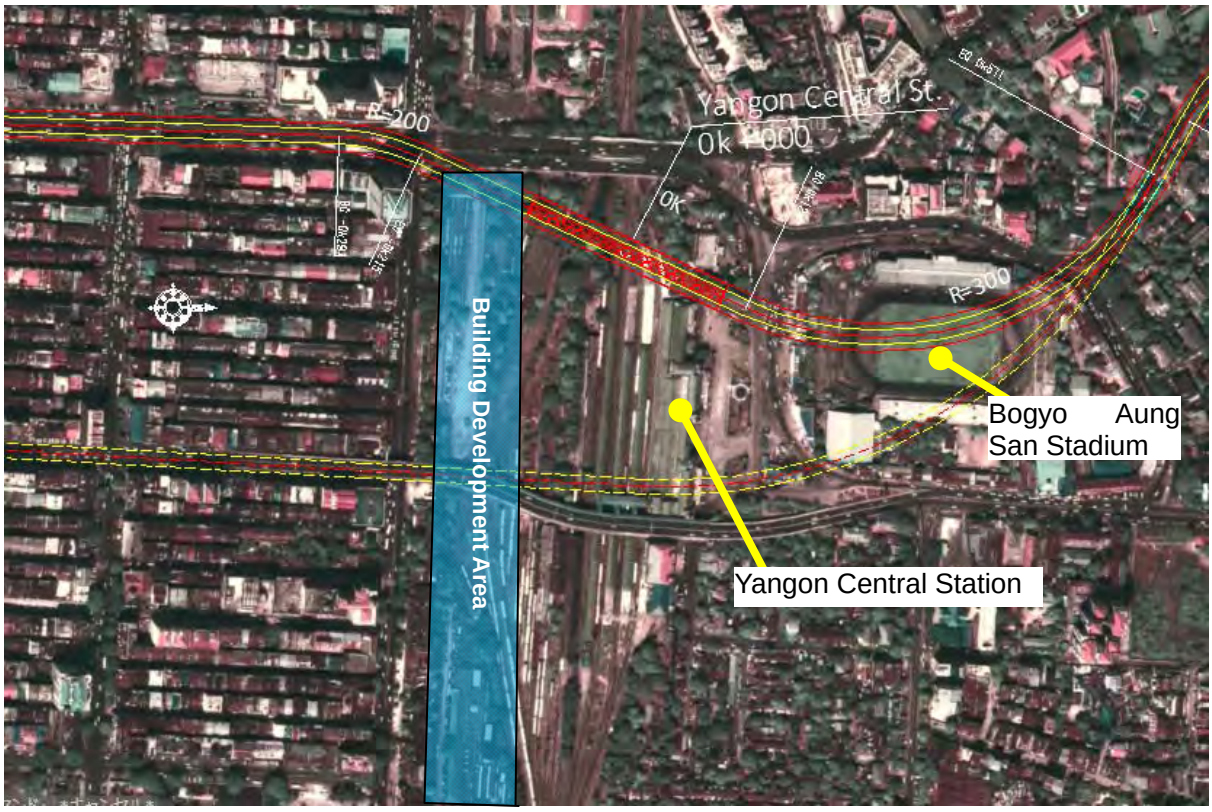
There is an ongoing station development project in Yangon Central Station. The bidding process has already begun and bidding will be held soon. In this project, commercial buildings are planned to be developed on the north side of the Yangon Central Station. As a matter of course, the alignment set in this study is just a first draft of YUMRT and has to be discussed with relevant authorities and the contractor of the development project who will conduct design works of entire development project. Considering the entire schedule, completion of station development is supposed to be earlier than completion of YUMRT project. If YUMRT alignment will be crossing part of building development area, YUMRT structures have to be considered in the design works of station development project and, if necessary, have to be constructed in synchronization with development project in prior to YUMRT construction works. The alignment set in this study is crossing the edge of building-planned location, which may decrease the value of the property as a whole.



Source: Survey Team

Figure 3.4-4 Location of Building Development Project

Although the final alignment in this area should be studied and determined through the discussions with relevant authorities, the contractor and other stake holders, Figure 3.4-5 shows one of the possible alternatives in this area. The alignment of this alternative crosses in the middle of building development area and later goes along Pansodan Street. By crossing in the middle of building development area, passengers' accessibility to/from the buildings will increase. This is beneficial both for development project and YUMRT project and passengers will receive the benefit the most.

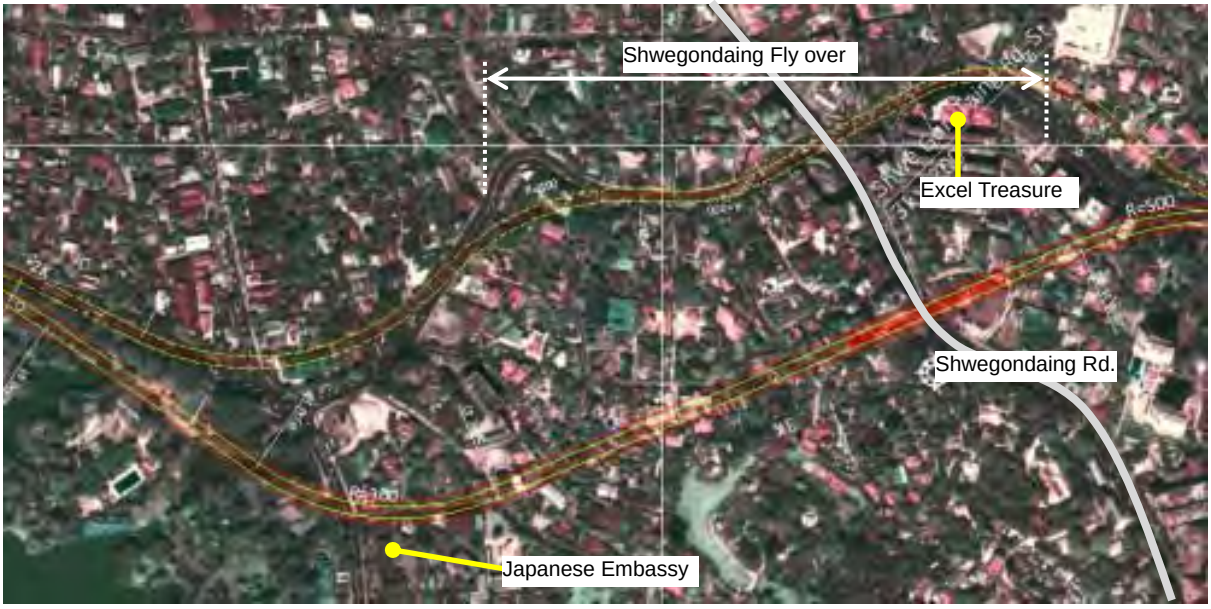


Source: Survey Team

Figure 3.4-5 Alternative route in Yangon Central Station Development Area.

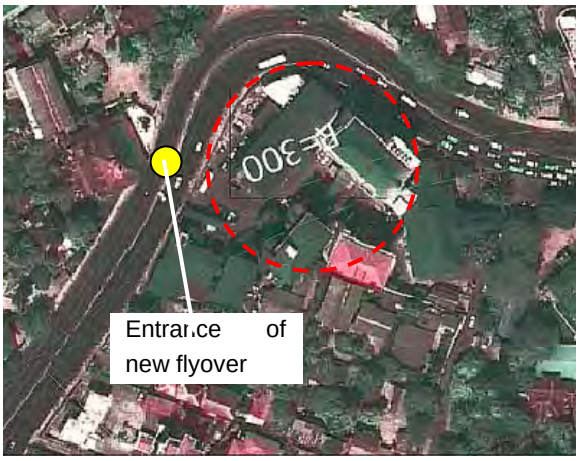
(3) Alignment under residential area

As described earlier, there is a section where the alignment runs just under the residential area near the newly-built flyover along the Kaye Pagoda Rd, due to successive steep curves and interference with foundation piles of new flyover. Although legal development to allow underground public transport possible, there may be a case where such a legal development cannot be achieved. For such a case, an alternative route plan is indicated as shown in Figure 3.4-6. However, even in this alternative which avoids major buildings and houses as much as possible, the alignment has to go beneath some of the private land and houses. It is notable that there is a hospital at the entrance of the new flyover and this building cannot be avoided because of a very sharp curve just before the entrance of the new flyover. Since the alternative route plan partially runs under the new flyover, a special construction method has to be applied in the section where foundation piles interfere with tunnel, which is called "underpinning" method. The outline of underpinning construction method is shown in Figure 3.4-8.



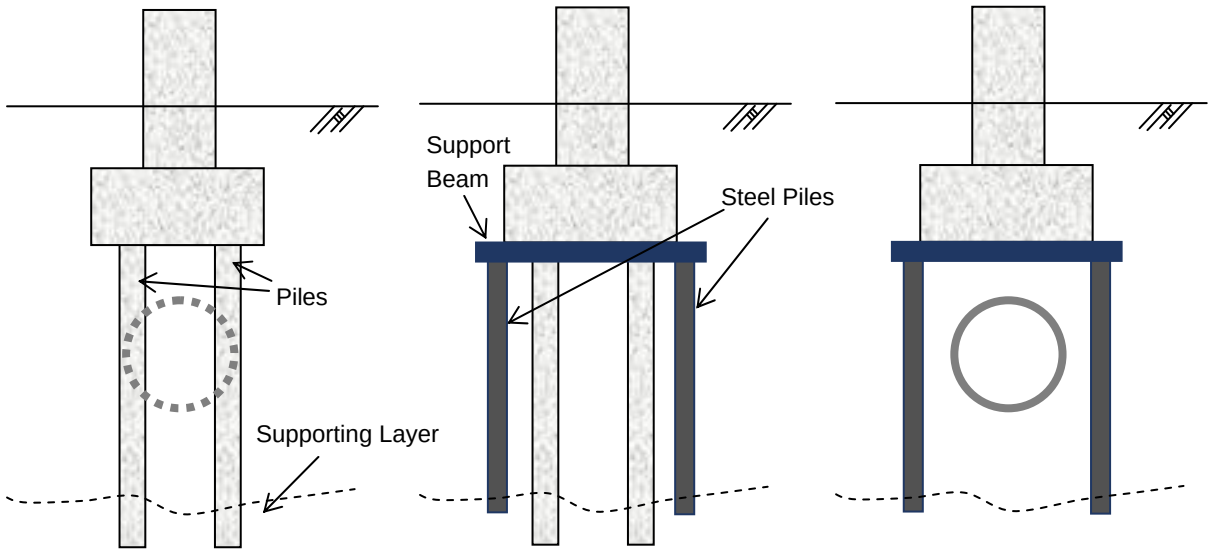
Source: Survey Team

Figure 3.4-6 Alternative Route along Kabar Aye Pagoda Rd.



Source: Survey Team

Figure 3.4-7 Location of Hospital which Interferes with the Alternative Alignment



Source: Survey Team

Figure 3.4-8 Underpinning Method

3.5 Station Location

Station locations are proposed as shown in Table 3.5-1, considering connectivity with other transportation, alignment, development plan around the area and so on. In the UMRT project, the distance between stations usually tends to be set around 1.0km in consideration of walking sphere.

The chainage of stations are summarized in Table 3.5-1 with brief explanations of connectivity and accessibilities with other adjacent facilities and other transportation modes.

Table 3.5-1 Station Locations

	Ph	Station		Chainage	Remark
1	Ph-1	Mingaladon	At-grade	21k +000	Northern terminal of the project. Access to Mingalardon Industrial Park
2		Wai Bar Gyi		19k +090	Connectivity with existing YCR Wai Bar Gyi Station
3		Okkalapa	Elevated	17k +400	Connectivity with existing YCR Wai Bar Gi Station
4		YGN Airport		15k +440	Access to Yangon International Airport
5		Airport Entrance		13k +860	Access to Lanthit Rd, and Yangon – Mandalay Hwy.
6		9th Mile		13k +080	Access to Taw Win Rd, and North Point Shopping Mall
7		Mayagone		11k +840	Connectivity with existing Bus stop

8		Myaing Hai Wun		11k +100	− Possible development project around this area − Connectivity with Kyaik Waing Pagoda Rd, and Pyay Rd.
9		Nawaday		9k +835	Connectivity with existing bus stop and Wai Za Yan Tar Rd.
10		Kabar Aye Pagoda		8k +885	Access to Kabar Aye Pagoda
11		Parami Rd		8k +085	Connectivity with existing bus stop and Parami Rd.
12		Yeik Than		6k +880	Connectivity with existing bus stop and hotels around the area
13		Inya Lake		5k +880	− Access to Inya Lake Park and Sedona Hotel − Connectivity with No1 Industrial Rd
14		Sedona		5k +080	Connectivity with University Rd.
15		Pearl		4k +270	Access to Pearl Condominium
16		Shwe Gon Taing		3k +200	Connectivity with Shwegondaing Rd.
17		Bahan		1k +800	− Connectivity with U Htaung Bo Rd. And Kan Yeik Tha Rd. − Access to Yangon Zoo.
18		Zoological Garden	Underground	1k +040	Connectivity with Bo Min Kaung St.
19		Yangon Central Station		0k +000	− Connectivity with Myanmar National Railways including YCR. − Connectivity with Bus Terminal.
20		YCDC		-0k +920	Access to CBD including YCDC.
21	Ph-2	Dala		-2k +420	Connectivity with Bus Terminal and Ferry Port.
22		Dala Central	Elevated	-4k +170	(Connectivity with possible future development.)
23		Twan Tay		-6k +040	(Connectivity with possible future development.)

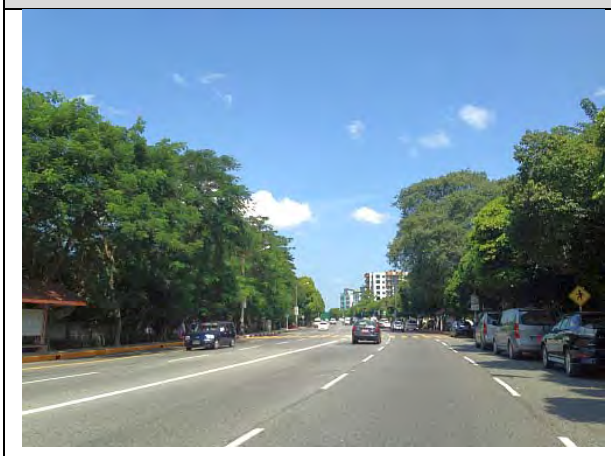
Source: Survey Team

Photos that show existing conditions of proposed station locations are summarized below;

No. 1 - Mingaladon Station	No. 2 - Wai Bar Gyi Station
	
Mingaladon Station will be located in the middle of rice field.	Existing YCR Wai Bar Gyi station stands at an isolated area.

No. 3 – Okkalapa Station	No. 4 – Yangon International Airport Station
	
Existing YCR Okkalapa station stands at an isolated area.	Airport building renovation works are ongoing.

No. 5 – Airport Entrance Station	No. 6 – 9th Mile Station
	
A busy intersection with four raoads crossing.	There is a big shopping mall called North Point Shopping Mall just in fromt of the proposed station.

No. 7 – Miyagone Station	No.8 – Myain Hai Wun Station
	
There is a bus stop called Mahar Si.	Possibly-abandoned playground equipment can be seen everywhere. It's still used as a amusement park but few customers.

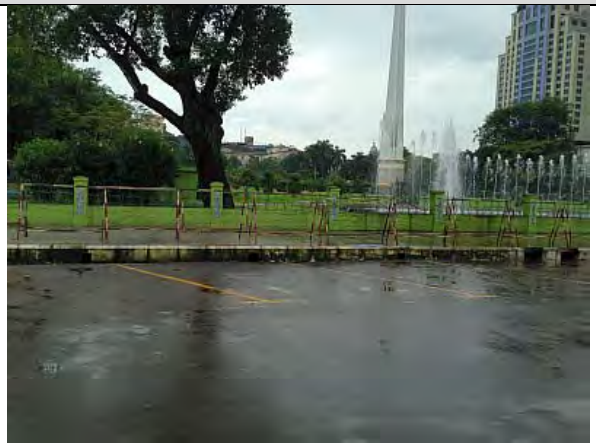
No. 9 – Nawaday Station	No. 10 – Kabar Aye Pagoda Station
	
Nawaday Cinema is located close to the station and good access to Wai Za Yan Tar Rd through connecting road.	Entrance of Kabar Aye Pagoda stands just in front of the station.

No. 11 – Parami Rd. Station	No. 12 Yeik Than Station
	
A very busy intersection with Parami Road and Kabar Aye Pagoda Road.	Micasa Hotel and Marina residents condominium stand close to the station.

No. 13 – Inya Lake Station	No. 14 – Sedona Station
	
Entrance to Inya Lake Park, close to the station stands Sedona Hotel. New development project is ongoing close to the station.	Intersection with University road.

No. 15 – Pearl Station	No. 16 - Shwe Gon Taing Station
	
Pearl condominum stands just in front of the station.	There are houses on the proposed station location. Land acquisition is inevitable.

No. 17 – Bahan Station	No. 18 – Zoological Garden Station
	
An accessing station to Shwedagon Pagoda, Yangon Zoo. Intersection with U Htaung Bo Road.	Station stands under the intersection with Bo Min Kaung Street.

No. 19 – Yangon Central Station	No. 20 – YCDC Station
	
A to-be-huge-transportation-hub. Detail station location has to determined in coordination with station development project.	Station locates at part of present Maha Bandoola Garden. Good access to the CBD.

No. 21 – Dala Station	No. 22 (23) – Far South from Dala Central Station
	

Source: Survey Team

Photo 3.5-1 Existing Condition of Proposed Station Location

3.6 Train Operation Plan

(1) Track Layout

Track layout of YUMRT project is shown in Figure 3.6-2. Generally, island platform is applied to the underground stations considering the offset distance between the two shield machines of 1.0 D (“D” represents diameter of the tunnel). On the other hand, separate type platform is applied to the elevated stations considering the continuity with the viaduct structure.

Since it is proposed that the same track gauge as YCR be applied to YUMRT, track shall be connected to YCR in the section where YUMRT alignment runs in parallel with YCR, which is namely near Wai Bar Gyi station.

- Turn back facility

  Turn back facility is proposed to be installed on the north side of Mingaladon station (North terminal) and YCDC station (South terminal). As YCDC station is an underground station, a turn back facility is installed right before or after this station by applying cut and cover method, instead of shield tunnelling. It is convenient for the cars to turn back more quickly if a turn back facility is installed after the station. However, more cut & cover section has to be considered since scissor crossing length plus train length will be required as cut & cover section. This makes construction much higher as cut & cover method is usually more costly than shield tunnel method. In addition, YCDC station has to be constructed in deeper underground if turn back facility is installed after YCDC station, since route has to go under Yangon River. For these reasons, a turn back facility at the south terminal station is proposed to be installed before YCDC station although it takes more time for trains to turn back.

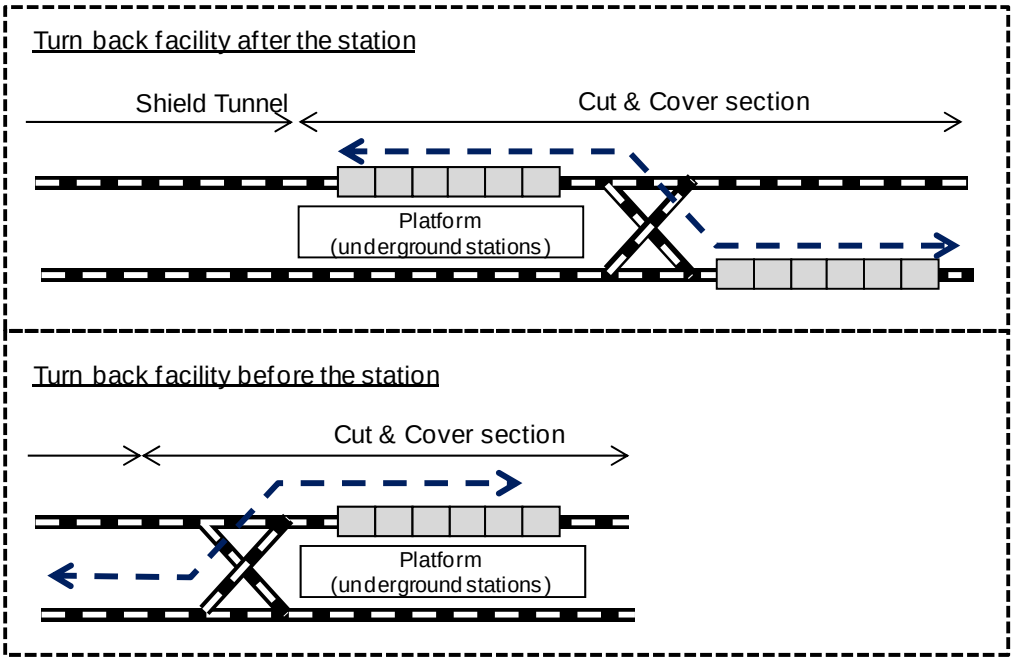
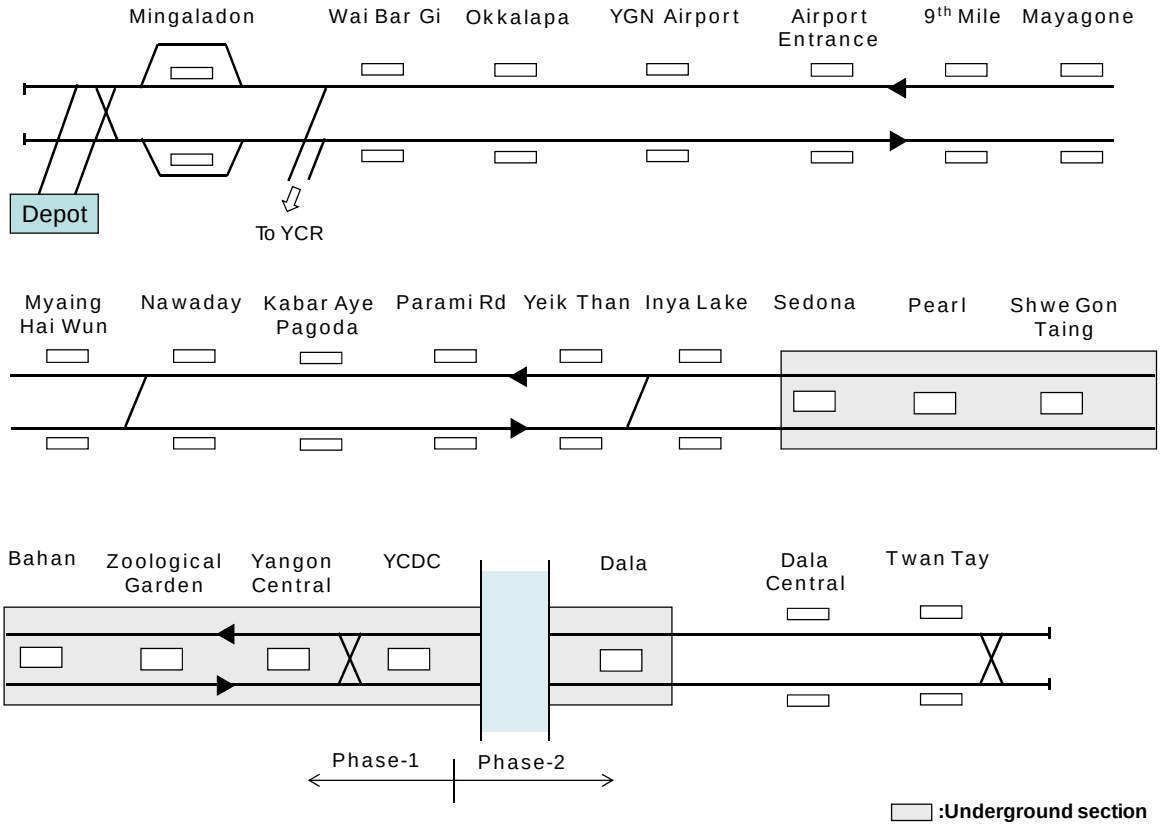


Figure 3.6-1 Position of Turn Back Facility

- Milagadon

  Milagadon station is the northern terminal of the project and through this station train cars are shipped to mail line from depot. This station is 2-platform 4-track station, which makes train cars shipment from/ to depot much easier without interference with actual operation.



Source: Survey Team

Figure 3.6-2 Track Layout of YUMRT

A list of station is shown in Table 3.6-1 below;

Table 3.6-1 A List of Stations

No	Station Name	Chainage	Type	Platform
1	Mingaladon	21 + 000	At-Grade	Separated
2	New Wai Bar Gyi	19 + 090	At-Grade	Separated
3	Okkalapa	17 + 400	Elevated	Separated
4	YNG Airport	15 + 440	Elevaed	Separated
5	YNG Airport Entrance	13 + 860	Elevaed	Separated
6	9th Mile	13 + 080	Elevaed	Separated
7	Mayangone	11 + 840	Elevaed	Separated
8	Myaing Hai Wun	11 + 100	Elevaed	Separated
9	Nawaday	9 + 835	Elevaed	Separated
10	Kabar Aye Pagoda	8 + 885	Elevaed	Separated
11	Parami Rd.	8 + 085	Elevaed	Separated

No	Station Name	Chainage	Type	Platform
12	Yeik Than	6 + 880	Elevaed	Separated
13	Inya Lake	5 + 880	Elevaed	Separated
14	Sedona	5 + 080	Underground	Island
15	Pearl	4 + 270	Underground	Island
16	Shwe Gon Taing Rd.	3 + 200	Underground	Island
17	Bahan	1 + 800	Underground	Island
18	Zoological Garden	1 + 040	Underground	Island
19	YNG Central	0 + 0	Underground	Island
20	YCDC	-0 + 920	Underground	Island
21	Dala	-2 + 420	Underground	Island
22	Dala Central	-4 + 170	At-Grade	Separated
23	Twan Tay	-6 + 040	At-Grade	Separated

Source: Survey Team

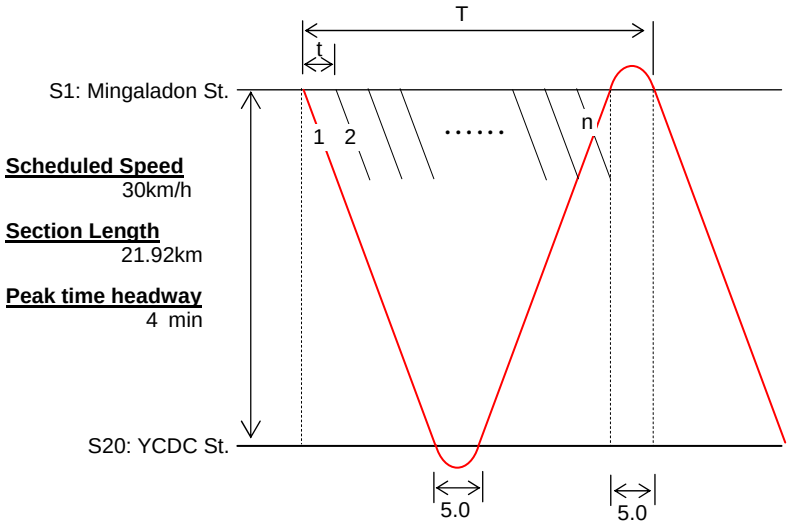
(2) Preliminary Operation Plan

The required number of train set is calculated by a simplified operation plan to estimate procurement cost of rolling stock. The calculation methodology is as mentioned below;

Table 3.6-2 Figures necessary to calculate required number of train (Phase-1)

Route Length L (km)	21.92 km
Scheduled Speed V (km/h)	30 km/h
Headway T_h (min)	4 min
Time for turn back Tb(time)	5 min

Source: Survey Team



Source: Survey Team

Figure 3.6-3 Image of variables necessary to calculate the number of train set

Required time of round trip (T_{round} min): $T_{round} = (\frac{2 \times L}{V} \times 60 + 2 \times Tb$ min

Required number of train in peak hour: $T_{round}/T_h \times 110\%$ (110% for backup)

By applying the above estimation methodologies, 28 sets of train will be required in peak hour for phase-1. Since one train consists of 6 cars, 168 cars should be procured for phase-1.

In the same way, the numbers of train car can be calculated for phase-2 by using the figures below with the calculation result.

Table 3.6-3 Figures necessary to calculate required number of train (Phase-2

Route Length L (km)	27.04 km
Scheduled Speed V (km/h)	30 km/h
Headway T_h (min)	4 min
Time for turn back Tb(time)	5 min
Nos of Trains (Nos)	33 (5 trains to be newly procured)
Nos of Train Cars (Nos)	198 (30 cars to be newly procured)

Source: Survey Team

3.7 Depot

A depot for UMRT usually consists of stabling tracks, inspection facility, washing facility, wheel turning track and many other buildings and facilities including workshop and it often includes Operation Control Center (OCC) as well. It requires as wide as approximately ten (10) hectors. A depot candidate plot is searched by observing the satellite image along the proposed candidate route and has been identified on the northern side of the Yangon International Station. Since route side area has been developed already, any plot that meets the width and figure requirement and connectivity to the route cannot be identified. The depot candicate plot identified is shown in Figure 3.7-1. It is advised that availability

of this plot should be confirmed by checking land use plan and special plan etc in the future studies.

Source: Survey Team

Figure 3.7-1 Depot Candidate Plot

3.8 Railway System

Even though railway system will follow those of future-electrified YCR's system, there are two options that seem to be applicable to YUMRT Line 1. The options are summarized in the Table below;

Table 3.8-1 Options for Railway Sytem

Option	System	Electricity System
1	Overhead Catenary	1500 VDC
2	Third rail	750 VDC

Source: Survey Team

Overhead catenary system makes tunnel diameter wider because of the pantograph height of the rolling stock, causing construction cost of tunnel section higher than the case of third rail tunnel. However, considering the benefit of possible mutual operation in the future and possible sharing of maintenance facility and equipment with those owned by Myanmar Railway, life cycle cost of catenary system is supposed to be lower.

On the other hand, although tunnel diameter of third rail is smaller, it cannot be applied to the railway that runs at-grade. Considering possible mutual operation with other Myanmar Railway lines, third rail is not suitable for the railway that runs at-grade because of its safety problem. Thus, it is proposed that overhead catenary system should be applied to YUMRT.

3.9 Other Technical Component

There are some technical components of UMRT, in addition to those described in this chapter, which should be discussed and determined in the future engineering studies. Those are summarized as follows;

(1) Signalling and Telecommunication

Signal and telecommunication system shall be those appropriate for UMRT system, ensuring safety, punctuality, reliability and capacity etc. The main functions of signalling system of UMRT are enumerated below;

- Control the distance between two trains (ATP, CBTC etc)
- Detect train locations (track circuit system)
- Control the turnouts in stations and depot.
- Supervise the train operation on the entire line (ATS, ATO etc)

Telecommunication system shall be an integrated system with fibre optic transmission and train radio, centralized clock system, Closed Circuit Television (CCV), PA (Passenger Announcement) system, clock system, Passenger Information System (PIS) and Backbone Transmission Network (BTN) system and so on.

(2) Automatic Fare Collection System (AFC)

AFC system enables not only the efficient management of fare collection, but also acquiring OD data and the numbers of passengers which can be useful for improving the operation services. There are several types of gate type such as flap-door type, retractable-door type and so on. Studies on other equipment like TVM (Ticket Vending Machine), Ticket Office Machine (TOM), Fare Adjusting Machine (FAM) etc shall be made in detail in the next study.

Source: Survey Team

Photo 3.9-1 an AFC Gate (Toei Oedo Line, Tokyo, Japan)

(3) Platform Screen Door (PSD)

For safety and cost-saving purpose (staff reduction and air-condition energy), PSD shall be introduced in each station. Half-height door type is proposed to be installed for elevated stations and Full-height type is proposed to be installed for underground station.

Half-height type in China (elevated station)

Full-height type in Bangkok (underground station)

Source: Survey Team

Photo 3.9-2 Photos of PSDs

(4) Station E&M

Station E & M (Electric and Mechanic) facilities shall include ascending facilities (elevators and escalators), air conditioner, ventilation system, smoke exhaust system, water supply and fire protection system and so on. Spaces or rooms for these facilities shall be carefully studied and considered in the design of elevated/ underground stations.

(5) Power Supply

Planning on power supply system in the next stage shall include transmission line plan, traction power feeding system plan, contact line system plan and utility power supply plan etc.

(6) Rolling Stock

Vehicle gauge and construction gauges are recommended to follow those of future improved-YCRs' considering the possible mutual operation. Seat arrangement, the numbers of doors, bogie type and traction control etc, shall be studied and considered in the design stage.

4 Preliminary Project Implementation Plan

4.1 Railway Operation and Maintenance Management Systems

This section would aim to propose an organization scheme for the implementation of Yangon Urban Mass Rapid Transit (YUMRT) and later its corresponding Operation and Maintenance (O&M). The proposed organization scheme in this section is one of the typical organization schemes seen in many urban cities around the world. However, it should be noted that other options may be preferable to this project since many other schemes have also been applied to the world urban railway projects as well.

4.1.1 Implementation

(1) Organization Structure

There are three possible levels that could be created and applied to implement of new mass transit projects, to wit:

- Supervisory and regulatory agency
- Implementation and Operation(O&M) agency
- Maintenance Provider

1) The Supervisory and Regulatory Agency

A supervisory and regulatory agency in central government is necessary as a governing body for setting transport policy, regulatory parameters, and for implementing all Urban Railway Programs.

The main objectives are to secure delivery by the industry of its regulatory obligations, assure satisfaction levels of passengers, equivalent to the best in railways and other forms of transport.

The key tasks of the agency are to provide for:

- Changes in the regulation of public transport operations for Government-owned operator as well as in joint venture with the private sector and, private operator,
- Health and safety regulation
  - Accident and incident investigation
  - Regulation and certification

    Safety approvals; Safety Directive; Interoperability; Train driving licences and certificates; Rail vehicle accessibility;
  - Inspections and audits

    Conduct inspections and audits to check that the rail industry has the management systems in place effectively controlling health and safety risks.
  - Enforcement of health and safety legislation
  - Safety guidance and research

Provide on-site and written advice and guidance on how to comply with the law.

- Worker and Infrastructure safety
- Occupational health - Moving the health agenda forward

- Land acquisition power,
- Setting up a transparent, consistent, efficient administrative mechanism to create a level playing field for all participants and protect the interests of all stakeholders,
- To prepare a projects list to be implemented under Government funds, ODA, or to be offered for PPP and take them forward, after approval from Planning Agency, with assistance of the highly qualified staff through a transparent selection process.
- Putting in place an effective and efficient institutional mechanism for speedy clearance of the projects.

Figure 4.1-1 shows proposed organizational chart of the agency.

2) The Implementation and Operating Agency (Owner/Concessionaire)

The YUMRT would be the first suburban mass transit project in the Yangon City, and even in the entire Myanmar. The operating organization will be newly established under the umbrella of the future MRA, also supported by GOM.

This section describes the organization plan of Yangon Urban Mass Rapid Transit Company (YUMRTC) in terms of its positioning, role and responsibility as Railway Supervisory/Operator & Implementing Agency, and indicates those responsibilities and tasks that could be given in concession according to the type of PPP scheme.

3) Maintenance Provider (PMO)

During the implementation of the project, a Project Management Office (PMO) should be created as the organization to be in charge of the actual implementation of the project and liaison with the Consultant, Contractor, and other concerned stakeholders. As the formal establishment of the YUMRTC would take time, an interim PMO shall be set up.

In case of an interim PMO, it should take responsibility for the initial duties until the formal establishment of the PMO within the YUMRTC. The staff of the former should be absorbed by the latter. The staff of this PMO will be critical for the success of the project and the YUMRTC

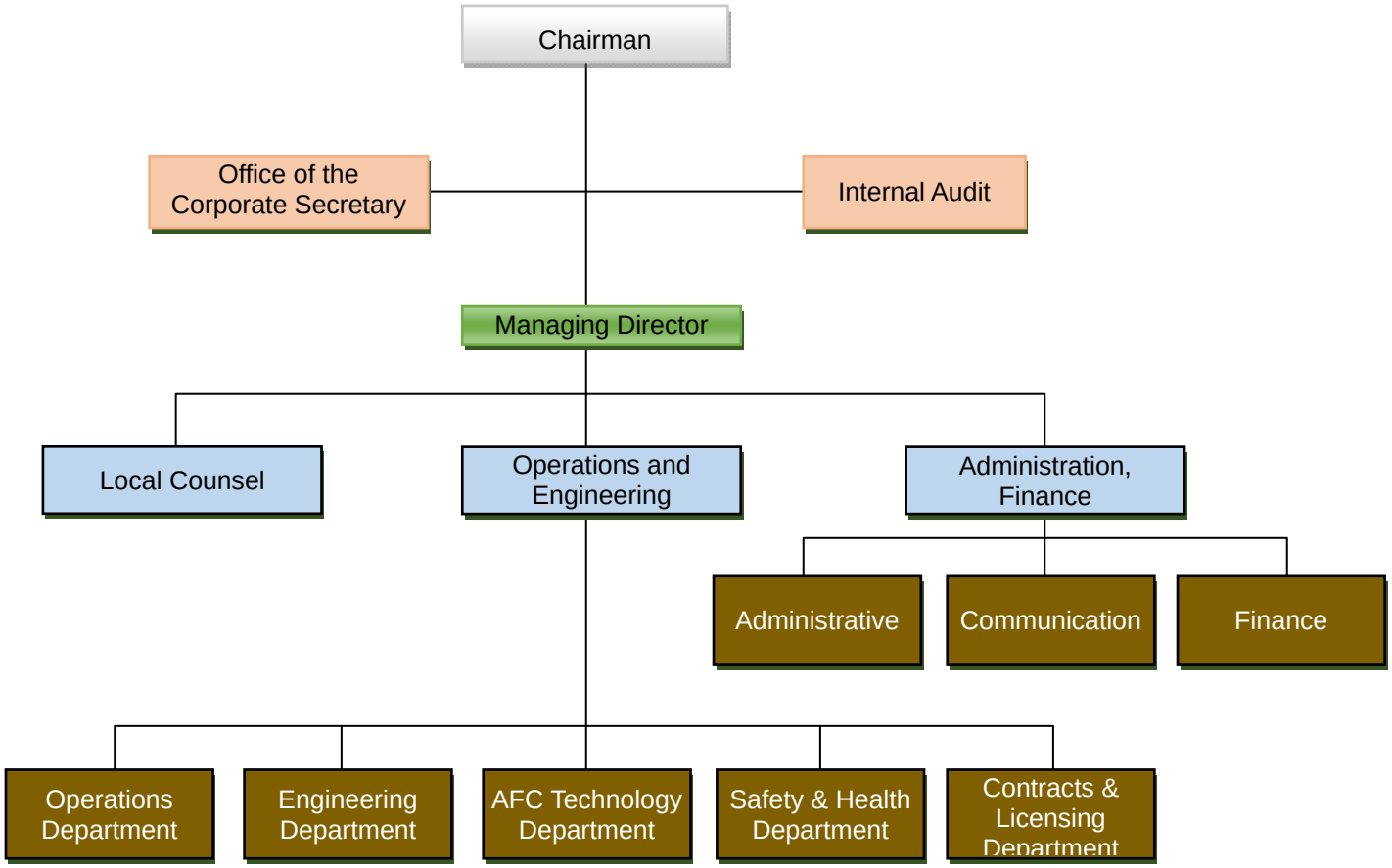
The main scope of works of the PMO is summarized below:

<u>Operation and Engineering Division</u>

- Reviews the Consultants design methods, standards and criteria used in the preparation of the design (Engineering Dept);
- Assures that the Contractor’s work complies with the plans and specifications of the contract by conducting regular site inspections (Engineering Dept).
- Monitors work accomplishment of the contractors (Engineering Dept).
- Responsible for the safekeeping of all project records and correspondence (Safety Dept).

Administration and Finance Division

- Analyzes and interprets financial statements/reports (Finance Dept);
- Responsible for all matters relating to taxes and transactions related to the Bureau of Internal Revenue (Finance Dept);
- Coordinates with YUMRTC Accounting Division and Commission on Audit regarding financial transactions of the PMO (Communication Dept).
- Coordinates with the ODA Bank's Representatives regarding the PMO's disbursements financed from ODA loans, if any (Communication Dept).
- Prepares all financial reports other than the PMO's financial statements as may be required by YUMRTC and fiscal authorities/other agencies (Finance Dept).
- Monitors and assists in the verifications of disbursements that are financed under the ODA loans (Finance Dept)



Source: Survey Team

Figure 4.1-1 Proposed Organizational Chart for a Supervisory Agency

(2) Scope of Work

The following Table 4.1-1 shows the list of tasks which YUMRTC is responsible for in the service operation and maintenance. This is the key to which tasks an individual party can access, review, handle and ultimately how a task is routed and approved.

Among the tasks and duties mentioned in Table 4.1-1 below, the Operations (III) and Maintenance (IV) are the tasks that could be given in concession to a private party in case such party has entered into a PPP with YUMRTC and requires return on investment

Table 4.1-1 YUMRTC Tasks and Duties

No.	Task Category	Description of the Task Category
I.	Management	To formulate policies, prescribe and promulgate the rules and regulations for the attainment of the objectives of the supervisory and regulation agency. Implements, enforces, and applies the policies, plans, standards, guidelines, procedures, decisions, rules and regulations issues, legal affairs, and public relations.
II.	Administration	The administration-related departments and section shall advise and assist the Management in the formulation and implementation of rules and regulations necessary to carry out the objectives and policies of the authority concerning administrative, finance, accounting, budget, human resources, etc.
III.	Operation	To ensure the safe, reliable and efficient operating of the railway and satisfactory service to the passengers on a day-to-day basis.
IV.	Maintenance	To perform the daily and the long term planning and execution of scheduled and unscheduled, preventive and corrective maintenance actions to ensure overall systems are ready for required operation at all times.
V.	Engineering & Construction	Advise and assist the Management in the formulation and implementation of rules and regulations necessary to carry out the objectives and policies of the YUMRTC concerning engineering. Monitor and be counterpart of Consultants and supervise Contractors.

Source: Survey Team

(3) Organization Structure and Staffing of YUMRTC

1) Organization Structure

Consistency of responsibility and autonomy will facilitate integration of the O&M perspective into system design, which will reduce lifecycle costs and achieve long-term sustainability. Such a system would also make it possible to identify future YUMRTC leaders (technical managers required for the O&M phase) during the E/S and construction phases. Early identification of future leaders from the PMO organization will lead to early capability-building activities in the organization, as they develop competency and acquire a holistic understanding of the integrated systems.

The YUMRTC organization shall start with a core team (i.e. PMO), and it will gradually evolve into its full form before start of the O&M phase. With the YUMRTC in charge of all phases, the engineers, supervisors, technicians, and operators (required for O&M phase) can be trained during the construction phase by the system contractors and Original Equipment Manufacturers (OEMs) to equip them with necessary knowledge and skills to handle supervisory tasks for the O&M activities effectively. The technical training should be done by visiting successful cases overseas and by inviting contractors and OEMs to Yangon. There should also be independent training on management and operational skill development, such as financial and business planning, maintenance auditing and service operations and general problem-solving.

All successful overseas metro systems, such as the Tokyo and Delhi Metros, share four key principles in their organizational design:

- The rail business unit is designed as a function-based organization. This is necessary to achieve the required level of competency in each railway system function, which needs to have specialized functional areas.
- The non-rail business unit (non-core) is designed differently from the rail business unit (core). This is important because the culture, skills, recruitment process, and business unit basis differ for the two businesses. Railway businesses require rigid adherence to technical standards to ensure safety and achieve specific operating standards, while non-rail businesses need creativity and flexibility to enhance non-fare box revenue.
- All decision-making authority is delegated to the board. Complete empowerment of the YUMRTC Board of Directors can achieve transparent corporate governance, faster decision-making, and rapid project implementation.
- An internal independent safety monitoring unit is important for controlling the system's safety and security by monitoring daily O&M activities. Since a railway system involves running trains through narrow passages with a high density passenger load, it is critical to ensure safe and secure operations.

2) Staffing

Steps in Establishing the Operations and Maintenance System

- Planning/Basic Design Stage

The hardware plan for the railway is essentially something that must be decided based on

what sort of system will implement a certain kind of operation. Therefore a person who mainly carries out that operation is required when planning a railway.

Generally, in an urban railway, a local government authority will, based on urban transport policies, independently carry out facility planning based on an operations structure and a standard of provided services.

In order to implement this, the YUMRTC must be established prior to the planning stage of Yangon, or the main planning body is set up and a system is put into place for possible discussion by the members who can fulfil the primary role of the YUMRTC in the future.

Therefore, if it is firmly suggested to develop the YUMRT, the YUMRTC or the YUMRTC preparatory organization (collectively referred to as the “PMO”) must be established as soon as possible

- Construction Bidding/Construction Management Stage

After the completion of basic planning and procurement of the necessary capital for construction, implementation of bidding and ordering and construction management will be conducted by the YUMRTC. At this stage, it is also necessary to procure the needed personnel in order to implement outsourcing of construction management as well as bidding.

Therefore, it is necessary to start the recruitment of personnel six months before the completion of basic planning, and when the basic planning is completed, it will only be necessary to secure the suitable personnel to transfer for bidding works

- System Expansion towards the Start of Business

Prior to the start of business operations, it will be necessary to train the personnel, particularly for the drivers for the start of operation. Due to the large numbers of required drivers, it is proposed that employment of a number of instructors shall be carried out at the stage when on-site training is possible in order to avoid last minute training.

Personnel who will be trained overseas require compliance for the acceptance by the concerned parties abroad, the objective is to obtain driving licensees that will undergo real-vehicle training.

To this end, 10 Myanmar personnel will be required beforehand. After one year of training in Japan with proper education to become instructors, the personnel will conduct training to the driver including test drives at the start of operations for part or a section of the completed area. In case the period of training in the Myanmar will take one year and the test drive will take six months to complete, training in Japan for the driving instructors will have to take place two and half years before the start of operations. Since it will take a long time to train everyone, recruitment will have to start more than three years before the start of operations.

It will not be a problem if the training period in other areas is short compared to drivers, but train control centre personnel require six months training before the start of test driving.

There are 10 personnel, so a Japanese person will conduct training at the actual site. In order to be able to start training, recruitment will need to be done one year before starting operations. Furthermore, two people are required to undergo an instructional course in Japan to become leaders.

The training period for station employees should take half a year from the start of test driving. However, the number of personnel is very large, and because it will not be cost-effective to have Japanese instructors, 20 local personnel (1 in 10 out of more than 200 people) will be recruited as instructors and will undergo an instructional course in Japan for one month.

Therefore, employment to secure the necessary number of station personnel will be carried out half a year before the start of operations. However, two persons per area should be employed before that to undergo training in Japan.

Furthermore, regarding maintenance, it is necessary to decide what to do regarding the division of outsourcing and self-production as well as the assignment of outsourcing. In order to address this at the start of test driving, it is necessary to proceed with preparations for each

4.1.2 Operation

(1) Proposed Operation & Maintenance Scheme

Given a proper setting of YUMRTC as mentioned above, YUMRTC should engage in the task of implementing the YUMRT. As the operation scheme will be decided in a later stage, this subsection introduces our proposed maintenance scheme, which is a general description of the most appropriate scheme for this project, and it is independent from the mode of implementation that would be finally selected, whether a fully ODA, PPP with two-tiered, Net or Gross Cost, etc., thus, suitable to any funding scheme.

The Study Team, taking in consideration all available information, site conditions, potential technical and financial capabilities of future YUMRTC, is suggesting the following maintenance scheme for the YUMRT: The Concessionaire/Operator shall outsource the maintenance activities, preferably to a contractor closely linked or associated to the main OEM (Rolling Stock). The Concessionaire/Operator shall outsource to a Maintenance Contractor all the maintenance activities, including, among others, light & heavy maintenance, troubleshooting, and procurement of capital and consumable spare parts.

The reasons to choose this scheme are that up to date, the implementing and supervisory agency YUMRTC has not yet being established. Then, it is not baseless to say that the required technical level of knowledge and capability to have a direct control of the O&M activities would not be achieved by its in-house staff by the time of the opening for revenue of the first line.

Due also to the complexity and difficulty of the maintenance of the E&M systems, and the condition of having a Warranty period in effect right after the opening for commercial revenue, it is recommendable to subcontract (outsource) all maintenance activities to a well experienced and capable contractor, preferably to the rolling stock OEM, as it is one of the critical and more complex railway subsystems that should be properly maintained

(2) Scope of Work

We first suggest the outline of the responsibilities to be addressed by and between the YUMRTC, which is represented as the owner/Authority (A), the Concessionaire/Operator (O), if any, otherwise its responsibilities lay on YUMRTC, and the Maintenance Contractor (C). A basic matrix of tasks and duties for the three stakeholders is shown in Table 4.1-2.

The basic concept of sharing of duties is that the Owner approves, the Operators monitor, and the Contactor implements the Maintenance Plan, which is prepared based on policies and guidelines for maintenance, and the OEM maintenance guidelines. They all should be bound by two contracts: a Concession Agreement between YUMRTC and the Operator (in case of Net Cost Scheme) or Service Agreement (in case of Gross Cost Scheme), and a Maintenance Contract between the Operator and Contractor for a period between 3 to 5 years.

Table 4.1-2 Tasks & Duties Matrix for Maintenance

	Task	Responsibility		
	Maintenance	A	O	C
1	• Formulate policies and guidelines in the maintenance of rolling stock, E&M subsystems, and civil works		☑	
2	• Approve policies and guidelines in the maintenance of rolling stock, E&M subsystems, and civil works	☑		
3	• Implement policies and guidelines in the maintenance of rolling stock, E&M subsystems, and civil works			☑
4	• Inspect repair maintenance activities of the maintenance contractor		☑	
5	• Implement of all maintenance activities related to rolling stock, E&M subsystems, and civil works			☑
6	• Approval of special repairs and corrective maintenance activities		☑	
7	• Approval of large rehabilitation programs of capital equipment	☑		
8	• Monitor Maintenance progress implementation of all maintenance activities by using CMMS		☑	
9	• Monitors the performance of the contractor and oversee the proper implementation of Quality Assurance/Quality Control of all maintenance/repair works.		☑	
10	• Audit/approve status reports of the maintenance of the tools and equipment;		☑	
11	• Supervise and monitor the Contractor to plan and procure local and foreign spare parts, material, tools and equipment;		☑	
12	• Plan and procure local and foreign spare parts, material, tools and equipment;			☑
13	• Supervise the control of inventories and the issuance of spare parts;		☑	
14	• Responsible for the control of inventories and the issuance of spare parts;			☑
15	• Prepare annual materials/spare parts budget (local and imported) for the operation and maintenance of the system;			☑
16	• Assist in managing the procurement process;		☑	

Source: Survey Team

The monitoring and supervision of the maintenance activities should be done using a Computerized Maintenance Management System (CMMS).

Capital equipment (rolling stock, subsystems, etc.) replacement due to end of life cycle or new acquisition due to capacity expansion is the responsibility of the Owner or Concessionaire depending of the type of contract, if any.

Accordingly, all parties (the Owner, Operator, and Maintenance Contractor) should adopt the concept of fully integrated teams. The recommended functional organization structure is shown in Figure 4.1-2.

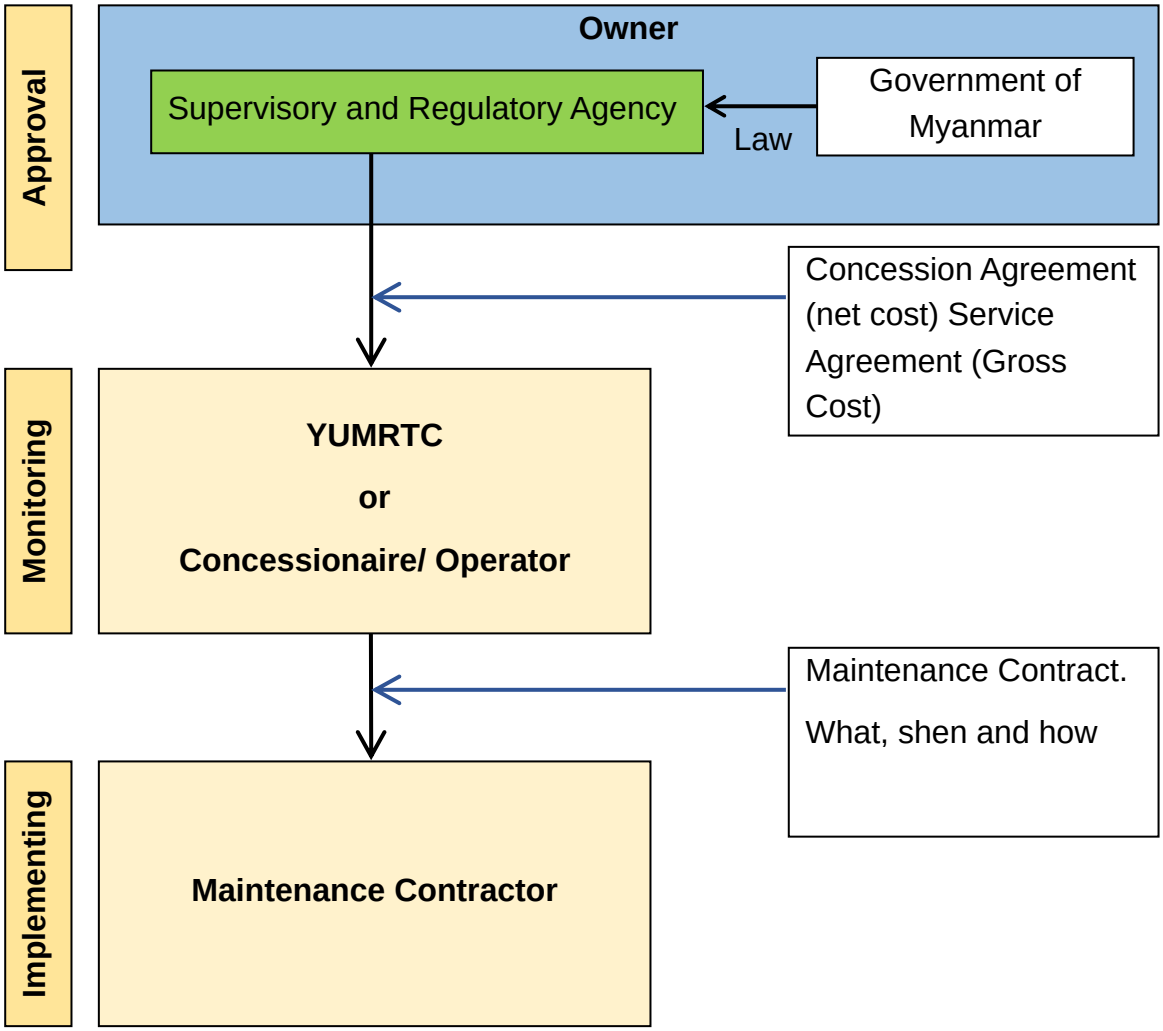
The following measures should be taken in consideration to avoid the issues seen in other railway systems;

- It is important that the Owner/Operator be able to have some hands-on control over the maintenance process in order to maintain the growth of the capacity building of the in-house workforce at all levels, especially the technician level.
- Although in the beginning all works should be assigned to the Maintenance Contractor, eventually, YUMRTC would desire to have more control and expertise throughout Capacity Building programs over the years in order to reach a level where the ***what*** and ***when*** are controlled by the Owner/Operator.
- Approved training programs should be carried out periodically to the benefit of the YUMRTC's in-house technical staff in all related activities of the O&M of the system.

(3) Organization Structure

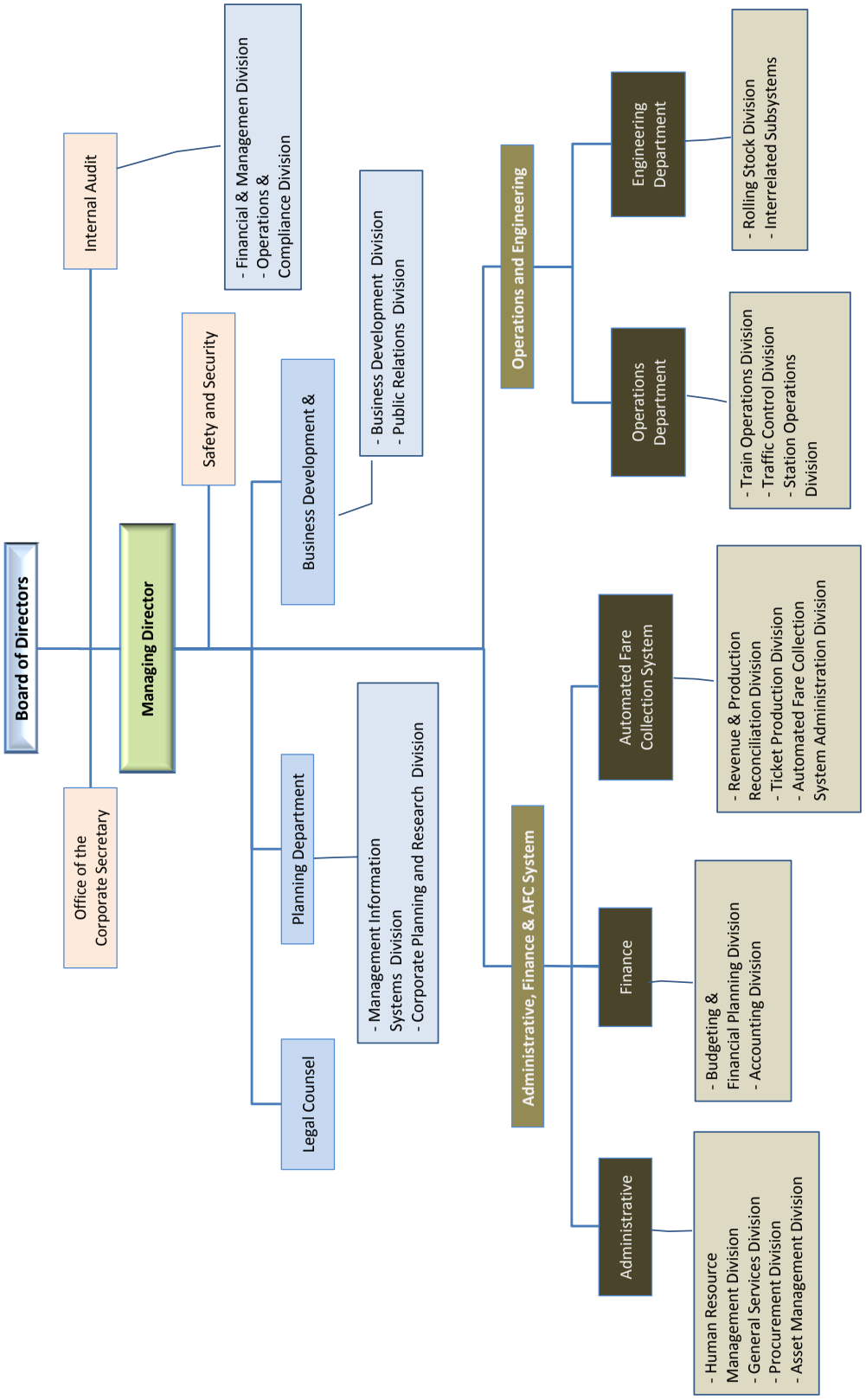
The Operator and the Maintenance Contractor's objective in selecting and developing the organization structure is to ensure that the organization will provide clear lines of formal communication and control, and effective informal communications (networking). The organization must also function smoothly both internally and in its relationship with its counterpart (YUMRTC/Contractor) and the various Agencies that will be involved directly or indirectly with the project. It will clearly identify the functional requirements related to the management of this contract, it will provide the correct balance of management and operational staff, and the optimum numbers, categories and disciplines of staff to ensure the technical and managerial success of the maintenance activities for YUMRT.

Accordingly, the Operator/Maintenance Contractor should take the guiding principle in its organization structure and adopt the concept of fully integrated teams. The entire organization could be subdivided into a Management/Administration Group and a Site Maintenance Group. The recommended functional structures are shown in the Figure 4.1-3 for Operator/Supervisory Agency and Figure 4.1-4 for Maintenance Contractor.



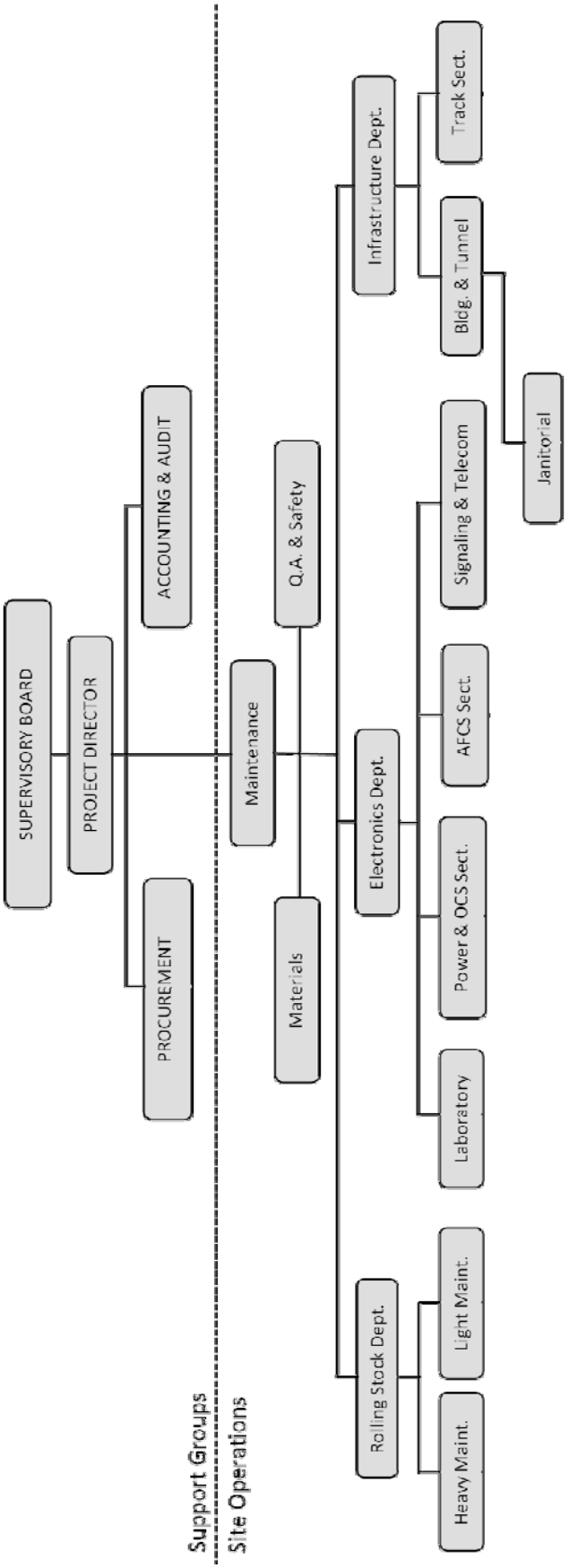
Source: Survey Team

Figure 4.1-2 Proposed Organization Structure of YUMRT



Source: Survey Team

Figure 4.1-3 Proposed Organizational Chart for Operator/ Supervisory Agency



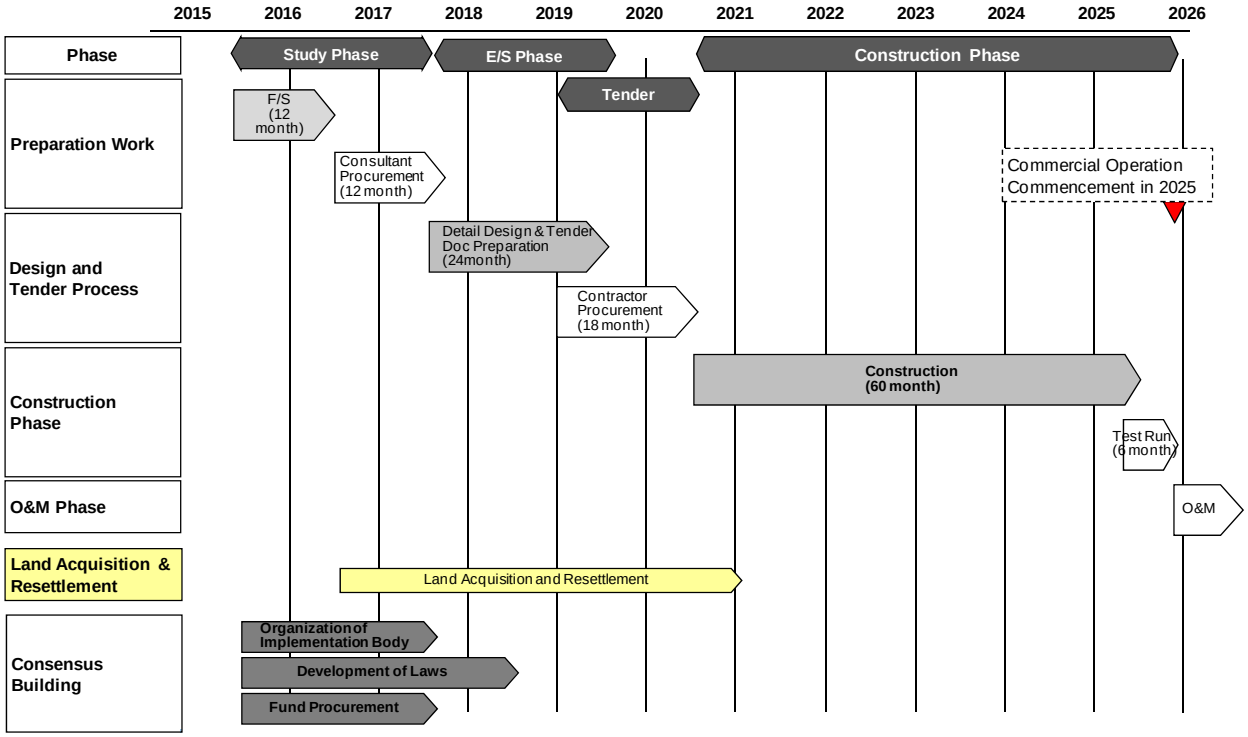
Source: Survey Team

Figure 4.1-4 Proposed Organizational Chart for Maintenance Contractor

4.2 Implementation Schedule

Implementation schedule of YUMR is shown in the figure below. Feasibility Study is supposed to start in the middle of next year (2015) in this schedule. This schedule is based on the traditional “Design-Bid-Build” scheme. There may be other options for the project schedule if other scheme is applied.

Actually, although there are rough standards for schedule of each activity from F/S to operation commencement, consensus building, development of laws and organizing implementation body tend to take much more time than critical schedule of standard activities. It is strongly recommended to start discussions on how to implement YUMRT project as early as possible in order to meet the schedule.



Source: Survey Team

Figure 4.2-1 Implementation Schedule

5 Environmental and Social Consideration

5.1 Outline of the Survey

5.1.1 Aim of the Survey

The main aim of the considerations for Social Environment here is to confirm the approximate scope of replacement of structures exist in the Project affected area along the planned Yangon Urban Mass Rapid Transit Line1, and to estimate scope of resettlement approximately.

Accordingly, area of this survey does not include the underground portion of the YUMRT where resettlement does not occur.

JICA's category of the project can be classified temporarily by the results of this suvey.

One of main condition of classification is number of persons to be resettled.

-More than 200 persons: Category A (likely to have significant adverse impact)

-Less than 200 persons: Category B (some extent impact is expected)

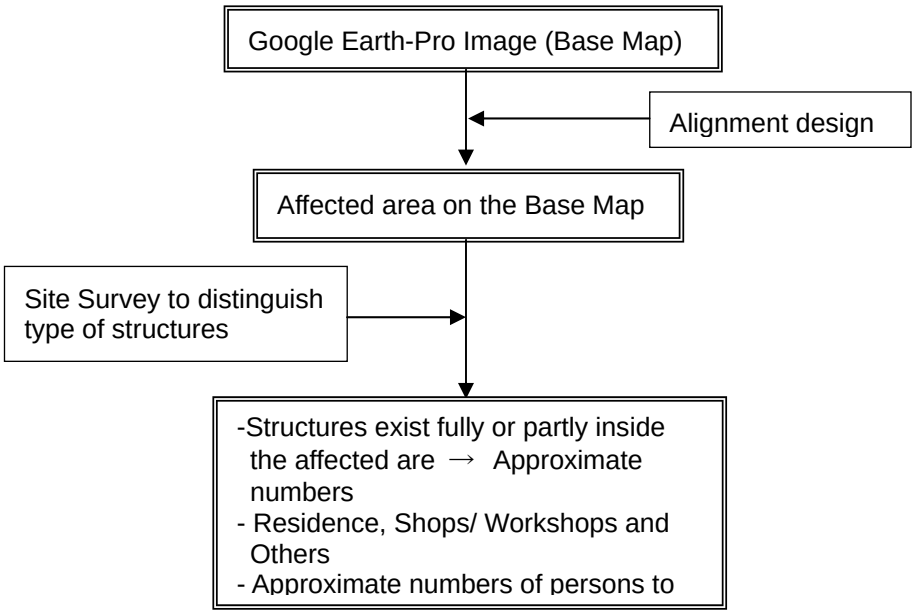
5.1.2 Method of the Survey

(1) Procedure of the survey

Structures exist fully or partly inside the planned ROW are surveyed.

Approximate numbers of structures expected to be affected by the Project and to be replaced are estimated

Structures are sorted into residence, shops/workshops and others, and approximate numbers of resettlement are estimated.



Source: Survey Team

Figure 5.1-1 Flow of the Survey

(2) Procedure of the survey

Setting parameters for estimation of numbers of PAPs are as follows.

- Number of persons per household = 6 (average in Greater Yangon area)
- (For Phase 1 area)

Number of persons living in usual type shops /workshops = 2.33

1/3 of usual building type shops are combined with shop and residence. For 1/3 of usual building type shops only owners live in the shop. 1/3 of usual building type shops are leased shop and no one lives in the shops

- (For Phase 2 area)

Number of persons living in usual type shops /workshops = 6

(3) Other pre-set condition

- Numbers of the Project affected small shops of easy assembly type or mobile type were not estimated.

The reason is that looking at the Google earth image, these small shops are often hided under the trees and are difficult to recognize.

Most of shop owners of these small shops do not live in the shops.

5.2 Results of the Survey

5.2.1 Phase 1 Section

(1) From Sedona Sta. to Kaba Aye Pagoda Sta.

Table 5.2-1 Project Affected Structures (1)

	Structures to be replaced	Type	Number of structures to be replaced	Number of persons to be resettled	Remarks
1	Residence	One-two storey stand-alone house	0		
2	Shop/ Restaurant/ Office/ Workshop	Usual building type	0		
3	Small-middle size office	Usual building type	0		
4	Large Facilities/ Factories	Large building (private /public organization)	0		
5	Community or Cultural facilities	Religious facilities	0		
Total				0	

Source: Survey Team

Kaba Aye Pagoda Rd
There is no affected structure


Source: Survey Team

Photo 5.2-1 Kabar Aye Pagoda Rd.

<Matters to be considered for Social Environment>

- There is no particular matter

(2) From Kaba Aye Pagoda Sta. to 9th Mile Sta.

Table 5.2-2 Project Affected Structures (2)

	Structures to be replaced	Type	Number of structures to be replaced	Number of persons to be resettled	Remarks
1	Residence	One-two storey stand-alone house	1	106	18 household/floor 1-2 floors are for business use
2	Shop/ Restaurant/ Office/ Workshop	Usual building type	3	0	-Buddhism shop -Office furniture shop (on 2nd floor of the above building) -Security equipment shop
3	Small-middle size office	Usual building type	0	0	
4	Large Facilities/ Factories	Large building (private /public organization)	1	0	Office of a company office (2,5 storey)
5	Community or Cultural facilities	Religious facilities	1	10	Old Monastery
Total				116	

Source: Survey Team

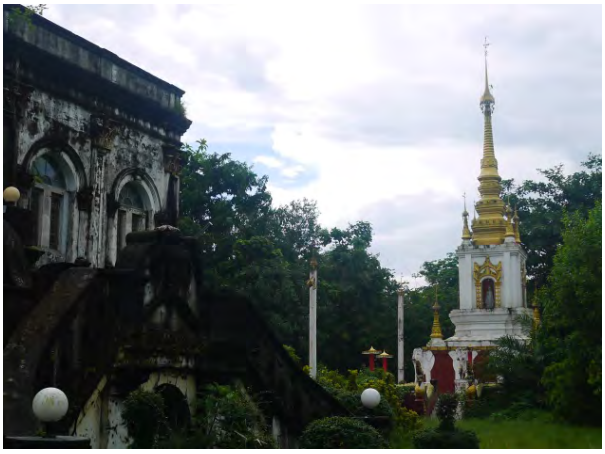
- Building (8 storey) for residence and business shop office (backward)
- Building for office of a company (front side)
- Building for the security equipment (left side)
- Building for office of a company (right side)

Source: Survey Team

Photo 5.2-2 A building to be affected

Buddhism shop

Old Monastery



Source: Survey Team

Photo 5.2-3 Religious Structures along the route

<Matters to be considered for Social Environment>

- Important structures that are affected in this sub-section are the Monastery and the multi-storey building mainly used for residence.
- The Monastery should not be replaced. It is recommended that the alignment shall be changed in order to avoid replacement of the Monastery in FS phase.
- It's better to avoid replacement and resettlement of the multi-storey residence, because various problems easily occur in the process of the replacement and resettlement. It is recommended that alternative alignment shall be considered in FS.

(3) From 9th Mile Sta. to YNG Airport Sta.

Table 5.2-3 Project Affected Structures (3)

	Structures to be replaced	Type	Number of structures to be replaced	Number of persons to be resettled	Remarks
1	Residence	One-two storey stand-alone house	0		
2	Shop/ Restaurant/ Office/ Workshop	Usual building type	0		
3	Small-middle size office	Usual building type	0		
4	Large Facilities/ Factories	Large building (private /public organization)	0		
5	Community or Cultural facilities	Religious facilities	0		
Total				0	

Source: Survey Team

<Mattes to be considered for Social Environment>

-There is no particular matter

(4) From YNG Airport to Okkalapa Sta

Table 5.2-4 Project Affected Structures (4)

	Structures to be replaced	Type	Number of structures to be replaced	Number of persons to be resettled	Remarks
1	Residence	One-two storey stand-alone house	18	108	
2	Shop/ Restaurant/ Office/ Workshop	Usual building type	2	5	
3	Small-middle size office	Usual building type	0	0	
4	Large Facilities/ Factories	Large building (private /public organization)	2	0	
5	Community or Cultural facilities	Religious facilities	0	0	
Total				113	

Source: Survey Team

Office (affected)

Factory (affected)

Source: Survey Team

Photo 5.2-4 Structures to be Affected Along the Route (1)

Stand-alone two-storey house

Source: Survey Team

Photo 5.2-5 Structures to be Affected Along the Route (2)

<Mattes to be considered for Social Environment>

-One of the features of this sub-section is that a lot of stand-alone houses are affected.

(5) From Okkalapa Sta. to Mingaladon Sta. (North end point)

Table 5.2-5 Project Affected Structures (5)

	Structures to be replaced	Type	Number of structures to be replaced	Number of persons to be resettled	Remarks
1	Residence	One-two storey stand-alone house	1	6	Simple structure
2	Shop/ Restaurant/ Office/ Workshop	Usual building type	1	2	Simple structure
3	Small-middle size office	Usual building type	0	0	

4	Large Facilities/ Factories	Large building (private /public organization)	0	0	
5	Community or Cultural facilities	Religious facilities	0	0	
Total				8	

Source: Survey Team

Near North Okkalapa Railway Sta.

House (affected)

Shop(affected)

House near Mingaladon Sta.(not affected)

Source: Survey Team

Photo 5.2-6 Structures to be Affected Along the Route (3)

<Matters to be considered for Social Environment>

- There is no particular matter

5.2.2 Phase 2 Section

(1) From Dala Central Sta. to Dala Sta.

Table 5.2-6 Project Affected Structures (6)

	Structures to be replaced	Type	Number of structures to be replaced	Number of persons to be resettled	Remarks
1	Residence	One-two storey stand-alone house	28	168	
2	Shop/ Restaurant/ Office/ Workshop	Usual building type	6	36	
3	Small-middle size office	Usual building type	2	0	
4	Large Facilities/ Factories	Large building (private /public organization)	0	0	
5	Community or Cultural facilities	Religious facilities	0	0	
Total				204	

Source: Survey Team

Dala Ferry Terminal

Oak Hlange St. a house (affected)

Kanaung Rd. a office (affected)

Source: Survey Team

Photo 5.2-7 Existing Conditions along the Route (1)

Affected a structure of shop combined with residence

Bon Min Yaung St (affected road)

Affected houses near wet land

Looking at the site of Dala Central Sta. in the south direction

Source: Survey Team

Photo 5.2-8 Existing Conditions along the Route (2)

<Matters to be considered for Social Environment>

- Feature of this area is that the proportion of wetlands is large. It is necessary to consider preventing negative impacts so as not to increase water damage.
- Most of affected residences are old stand-alone houses with simple structure using materials such as bamboo.

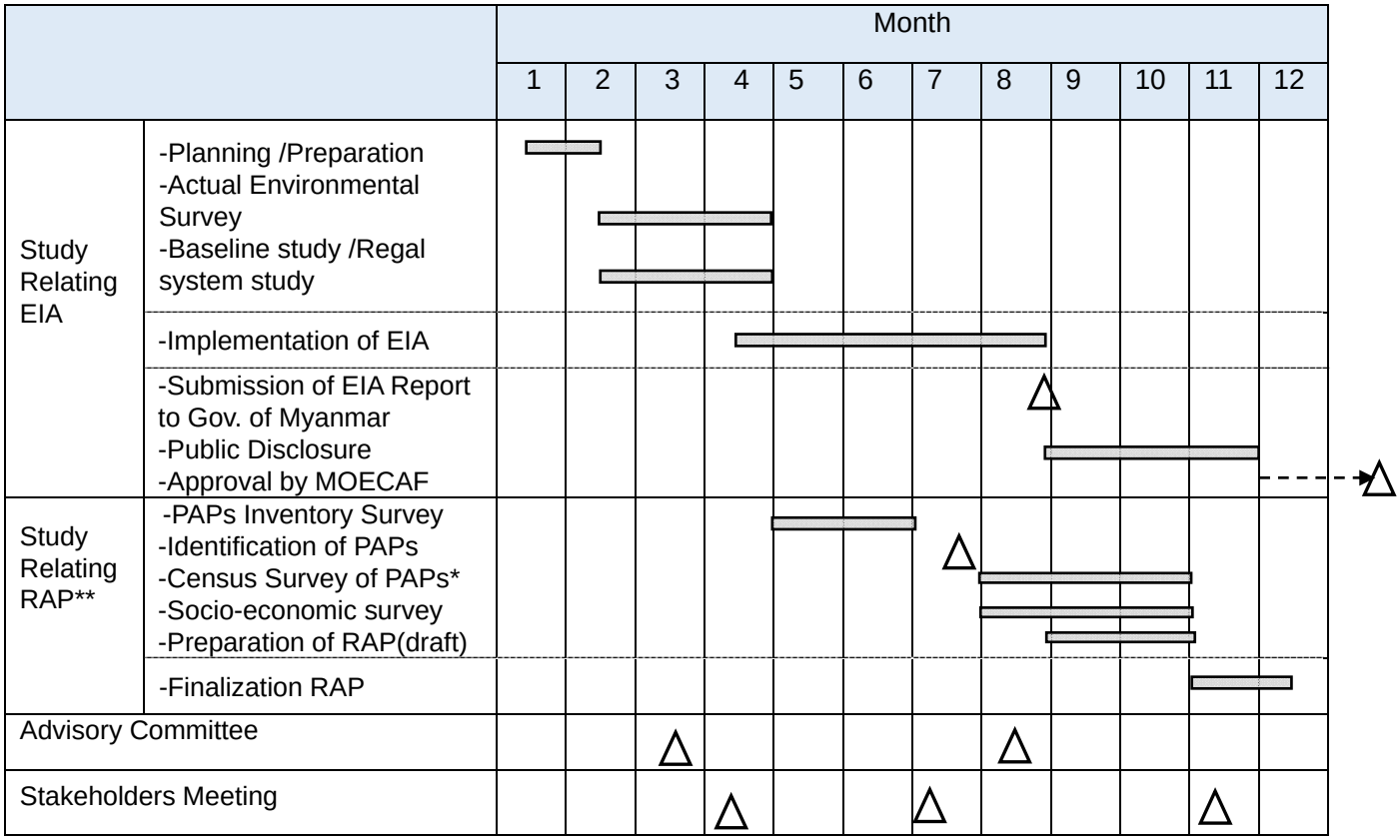
5.2.3 Summary of estimated numbers of Persons to be resettled

Table 5.2-7 Summary of Project Affected Structures

Project Section	Sub-Section	Number of persons to be resettled	
Phase 1	(1) From Sedona Sta. to Kaba Aye Pagoda Sta.	0	237
	(2) From Kaba Aye Pagoda Sta. to 9th Mile Sta.	116	
	(3) From 9th Mile Sta. to YNG Airport Sta.	0	
	(4) From YNG Airport to Okkalapa Sta.	113	
	(5) From Okkalapa Sta.to Mingaladon Sta.	8	
Phase 2	(6) From Dala Central Sta. to Dala Sta.	204	204
Phase 1+ 2 Total			441

Source: JICA Survey Team

5.3 FS Study Schedule for Environmental and Social Considerations



PAPs *: Project Affected Persons
RAP** :Resettlement Action Plan

Source: JICA Survey Team

Figure 5.3-1 FS Study schedule for Environmental and Social Considerations

6 Project Evaluation

6.1 Project Cost Estimation

6.1.1 General Conditions

The construction cost of civil works is estimated by build-up style calculation method. Although productivities of each works are based on the cost estimation of similar UMRT project in other country, unit price of labour and materials in Myanmar have been studied and updated. Unit price for machinery in Myanmar are not updated since the reliable information source could not be acquired. Cost of station architecture works and E&M works, railway system works and rolling stock are referred to the similar project.

The cost estimate has been carried out for each of the following work item;

Table 6.1-1 Work Items for Cost Estimation

Civil Works	- At-grade Station - At-grade Track way - Underground Station - Cut and Cover Tunnel for Scissor Crossing - Shield Tunnel - Elevated Station - Elevated Guide way -Transition (Cut & Cover)
Depot	- Depot construction including Buildings - Workshop Equipment
Railway System	- Substation (RSS) - Substation (TSS) - Power SCADA - Overhead Contact System - Power Distribution System - Signaling System - Telecommunication System - Facility SCADA System - AFC System - Platform Screen Door - Elevator - Escalator - Track Works
Rolling Stock	- Rolling Stock

Source: Survey Team

Other conditions applied to the cost estimate are described hereunder;

(1) Exchange rate

JICA's official exchange rate in September, 2014 has been applied.

US$1.0 = JPY103.7

MMK1.0 = JPY 0.108

US$1.0 = MMK 960.8*
(*this figure is not from JICA's official figure and is obtained by the two rates shown earlier.)

(2) General Item

General items such as surveys, additional soil investigation and various monitoring works etc are calculated by applying the following ratio to the cost of work items listed in Table 6.1-1;

- Underground works : 20%
- Elevated works :10%
- Depot works :5%
- System and RS :2%

(3) Engineering Service Cost

Design	2% of construction cost
Construction Supervision	5% of construction cost

(4) Physical contingency

Construction	10%
Engineering Service	5%

(5) Indirect Cost

Temporary works	4%
Site Management cost	25%
Administration cost	7%

(6) Tax

Commercial Tax	5%
Import Tax	7%

(7) Others

Administration cost	5%
Interest during the construction period	0.01%

6.1.2 Estimated Cost

Estimated costs have some ranges since it is considered to fluctuate with various factors in the future. Estimation results are shown in the following tables by phases;

Table 6.1-2 Construction and Procurement Cost for Phase-1

	Unit	Quatities	Eqivalent Amount FC (Yen/1000)		LC (Khat/1000)	
0 At-grade						
11 Station	nos	2	1,066,000 ~	1,303,000	9,868,000 ~	12,061,000
12 Trackway	km	2.7	1,464,000 ~	1,789,000	13,556,000 ~	16,568,000
10 Under Ground						
11 Station (L-200)	nos	7	38,365,000 ~	46,890,000	355,227,000 ~	434,167,000
12 C&C for Cissor Crossing	nos	1	1,479,000 ~	1,807,000	13,690,000 ~	16,732,000
13 Shield Tunnel	km	4.3	29,046,000 ~	35,501,000	268,948,000 ~	328,714,000
20 Elevated						
21 Station	nos	11	17,438,000 ~	21,313,000	161,462,000 ~	197,343,000
22 Elevated Guideway	km	5.46	8,877,000 ~	10,849,000	82,191,000 ~	100,456,000
30 Transition (Cut & Cover)	nos	1	1,433,000 ~	1,751,000	13,268,000 ~	16,217,000
40 Depot						
41 with Workshop	nos	1	4,403,000 ~	5,381,000	40,765,000 ~	49,823,000
42 Workshop Equipment	LS	1	5,592,000 ~	6,834,000	51,775,000 ~	63,281,000
50 System						
5-1 Substation (RSS)	nos	1	2,112,000 ~	2,582,000	19,560,000 ~	23,907,000
5-2 Substation (TSS)	nos	7	5,912,000 ~	7,225,000	54,737,000 ~	66,901,000
5-3 Power SCADA	LS	1	1,278,000 ~	1,562,000	11,836,000 ~	14,467,000
5-4 Overhead Contact System	km	27.92	3,803,000 ~	4,648,000	35,215,000 ~	43,040,000
5-5 Power Distribution System	km	27.92	3,983,000 ~	4,868,000	36,879,000 ~	45,074,000
5-6 Signaling System	LS	1	1,139,000 ~	1,393,000	10,550,000 ~	12,894,000
Signalling for Depot	LS	1	1,749,000 ~	2,137,000	16,192,000 ~	19,790,000
Signaling for OCC	LS	1	1,409,000 ~	1,723,000	13,050,000 ~	15,950,000
5-7 Telecommunication System	km	27.92	7,621,000 ~	9,315,000	70,567,000 ~	86,248,000
5-8 Facility SCADA System	km	27.92	653,000 ~	799,000	6,049,000 ~	7,394,000
5-9 AFC System	*nos*	20	2,327,000 ~	2,844,000	21,543,000 ~	26,331,000
5-10 Platform Screen Door						
Half PSD for Elv	*nos*	12	2,520,000 ~	3,080,000	23,332,000 ~	28,517,000
Half PSD for Elv	*nos*	1	408,000 ~	499,000	3,778,000 ~	4,617,000
Full PSD for UG (2line)	*nos*	7	2,538,000 ~	3,102,000	23,499,000 ~	28,721,000
5-11 Elevator & Escalator						
Elevator (elv)	*nos*	39	791,000 ~	967,000	7,326,000 ~	8,953,000
Elevator (udg)	*nos*	21	483,000 ~	590,000	4,470,000 ~	5,463,000
Escalator	*nos*	60	2,561,000 ~	3,131,000	23,716,000 ~	28,986,000
5-12 Track Works	km	27.92	5,562,000 ~	6,798,000	51,500,000 ~	62,945,000
5-13 On-board System	nos	132	238,000 ~	290,000	2,200,000 ~	2,689,000
60 Rolling Stock	Car	132	25,184,000 ~	30,780,000	233,182,000 ~	285,001,000
Total			**181,433,000 ~**	**221,751,000**	**1,679,932,000 ~**	**2,053,250,000**

Source: Survey Team

Table 6.1-3 Construction and Procurement Cost for Phase-2

	Unit	Quantities	Eqivalent Amount FC (Yen/1000)		LC (Khat/1000)	
0 At-grade						
11 Station	nos	2	1,066,000 ~	1,303,000	9,868,000 ~	12,061,000
12 Trackway	km	2.67	1,448,000 ~	1,769,000	13,405,000 ~	16,384,000
10 Under Ground						
11 Station (L-200)	nos	1	5,481,000 ~	6,699,000	50,747,000 ~	62,024,000
12 C&C for Cissor Crossing	nos	0	0 ~	0	0 ~	0
13 Shield Tunnel	km	1.5	10,132,000 ~	12,384,000	93,819,000 ~	114,668,000
20 Elevated						
21 Station	nos	0	0 ~	0	0 ~	0
22 Elevated Guideway	km	0	0 ~	0	0 ~	0
30 Transition (Cut & Cover)	nos	1	1,433,000 ~	1,751,000	13,268,000 ~	16,217,000
40 Depot with Workshop	nos	0	0 ~	0	0 ~	0
Workshop Equipment	LS	0	0 ~	0	0 ~	0
50 System						
5-1 Substation (RSS)	nos	0	0 ~	0	0 ~	0
5-2 Substation (TSS)	nos	2	1,689,000 ~	2,064,000	15,639,000 ~	19,115,000
5-3 Power SCADA for Phase-1	LS	0.23358	299,000 ~	365,000	2,765,000 ~	3,379,000
5-4 Overhead Contact System	km	5.12	697,000 ~	852,000	6,458,000 ~	7,893,000
5-5 Power Distribution System	km	5.12	730,000 ~	893,000	6,763,000 ~	8,266,000
5-6 Signaling System	LS	0.23358	266,000 ~	325,000	2,464,000 ~	3,012,000
Signalling for Depot	LS	0	0 ~	0	0 ~	0
Signaling for OCC	LS	0	0 ~	0	0 ~	0
5-7 Telecommunication System	km	5.12	1,398,000 ~	1,708,000	12,941,000 ~	15,816,000
5-8 Facility SCADA System	km	5.12	120,000 ~	146,000	1,109,000 ~	1,356,000
5-9 AFC System	nos	3	349,000 ~	427,000	3,232,000 ~	3,950,000
5-10 Platform Screen Door						
Half PSD for Elv	nos	1	210,000 ~	257,000	1,944,000 ~	2,376,000
Half PSD for Elv	*nos*	1	408,000 ~	499,000	3,778,000 ~	4,617,000
Full PSD for UG	*nos*	1	363,000 ~	443,000	3,357,000 ~	4,103,000
5-11 Elevator & Escalator						
Elevator (elv)	nos	6	122,000 ~	149,000	1,127,000 ~	1,377,000
Elevator (udg)	*nos*	3	69,000 ~	84,000	639,000 ~	780,000
Escalator	*nos*	9	384,000 ~	470,000	3,557,000 ~	4,348,000
5-12 Track Works	*km*	5.12	1,020,000 ~	1,247,000	9,444,000 ~	11,543,000
5-13 On-board System	nos	30	54,000 ~	66,000	500,000 ~	611,000
60 Rolling Stock	Car	30	5,724,000 ~	6,995,000	52,996,000 ~	64,773,000
Total			**33,461,000 ~**	**40,896,000**	**309,820,000 ~**	**378,668,000**

Source: Survey Team

The project cost is estimated by considering price escalation, contingency and taxes etc.

Project cost estimate is summarized in the following table for Phase-1 and Phase-2 respectively.

Table 6.1-4 Project Cost for Phase-1

	Item	Equivalent Total (Million JPY)		Equivalent Total (Million MMK)	
1	At-Grade	2,530 ~	3,092	23,424 ~	28,629
2	Underground	68,889 ~	84,198	637,865 ~	779,613
3	Elevated	26,315 ~	32,162	243,654 ~	297,799
4	Transition (Cut & Cover)	1,433 ~	1,751	13,268 ~	16,217
5	Depot	9,994 ~	12,215	92,540 ~	113,104
6	System	47,088 ~	57,552	435,999 ~	532,888
7	Rolling Stock	25,184 ~	30,780	233,182 ~	285,001
	Sub Total of Construction/ Procurement Cost	181,433 ~	221,751	1,679,932 ~	2,053,250
	Price escalation	50,059 ~	61,183	463,510 ~	566,513
	Physical contingency	23,149 ~	28,293	214,344 ~	261,976
	Total of Construction/ Procurement Cost	254,641	311,228	2,357,786	2,881,739
8	Consulting Service	14,515 ~	17,740	134,395 ~	164,260
	Price escalation	3,294 ~	4,025	30,496 ~	37,273
	Physical contingency	890 ~	1,088	8,245 ~	10,077
	Sub Total of Consulting Service Cost	18,699 ~	22,854	173,135 ~	211,610
	Sub Total of Eligible Cost	273,340 ~	334,082	2,530,922 ~	3,093,349
9	Administration cost	13,667 ~	16,704	126,546 ~	154,667
10	VAT	13,667 ~	16,704	126,546 ~	154,667
11	Import Tax	12,507 ~	15,286	115,806 ~	141,541
12	Interest during Construction	31 ~	38	291 ~	356
GRAND TOTAL		**313,212 ~**	**382,815**	**2,900,111 ~**	**3,544,580**

Source: Survey Team

Table 6.1-5 Project Cost for Phase-2

	Item	Equivalent Total (Million JPY)		Equivalent Total (Million MMK)	
1	At grade	2,514 ~	3,072	23,273 ~	28,445
2	Underground	15,613 ~	19,083	144,566 ~	176,691
3	Elevated	0 ~	0	0 ~	0
4	Transit Section	1,433 ~	1,751	13,268 ~	16,217
5	Depot	0 ~	0	0 ~	0
6	System	8,177 ~	9,995	75,717 ~	92,542
7	Rolling Stock	572 ~	700	5,300 ~	6,477
	Sub Total of Construction/ Procurement Cost	28,309 ~	34,600	262,123 ~	320,373
	Price escalation	19,919 ~	24,345	184,431 ~	225,416
	Physical contingency	4,823 ~	5,895	44,655 ~	54,579
	Total of Construction/ Procurement Cost	53,051	64,840	491,210	600,368
8	Consulting services	4,141 ~	5,061	38,338 ~	46,858
	Base cost	2,265 ~	2,768	20,970 ~	25,630
	Price escalation	1,499 ~	1,833	13,883 ~	16,968
	Physical contingency	376 ~	460	3,485 ~	4,260
	Sub Total of Consulting Service Cost	4,141 ~	5,061	38,338 ~	46,858
	Sub Total of Eligible Cost	57,191 ~	69,900	529,548 ~	647,225
9	Administration cost	2,860 ~	3,495	26,477 ~	32,361
10	VAT	2,860 ~	3,495	26,477 ~	32,361
11	Import Tax	2,521 ~	3,082	23,345 ~	28,533
12	Interest during Construction	19 ~	23	177 ~	217
GRAND TOTAL		**65,451 ~**	**79,995**	**606,026 ~**	**740,698**

Source: Survey Team

6.2 Financial and Economic Evaluation

Preliminary project evaluation on UMRT Line-1 Project was conducted. Due to the limitation of time and budget, only the cost component was amended in this survey, and thereby, the same benefit stream calculated in YUTRA was applied for the evaluation.

6.2.1 Economic Analysis

1) Methodology and Assumption

The basic conditions set for the calculation of economic analysis of UMRT Line-1 remain same as those of YUTRA. The indicators of Economic Internal Rate of Return (EIRR), Net Present Value (NPV), and Cost Benefit Ratio (B/C) were calculated to assess the economic viability of each Sub-project.

The following table is the summary of basic conditions.

Table 6.2-1 Basic Conditions for Calculation

No.	Item	Content
01	Project Evaluation Period	2015 – 2044 (30yrs: 1year delayed from YUTRA)
02	Project Life Period	30years (same as YUTRA)
03	Traffic Assignment	2018, 2025, and 2035 (same as YUTRA)
04	Social Discount Rate	10% (same as YUTRA)
05	Economic Cost	Standard Conversion Factor was set at 0.85 (same as YUTRA)
06	F/S and Design Cost	7% of Construction Cost (same as YUTRA)
07	Maintenance Cost	3% of Construction Cost per annum (same as YUTRA)
08	Exchange Rate	1USD is equivalent to Ks.960.83 (JICA's official exchange rate as of September 2014 was applied.)
09	Tariff	Ks.18.5/ km as of 2013 (same as YUTRA)
10	Land Acquisition Cost	2% of Construction Cost (newly added)

Source: Survey Team based on YUTRA Report

The project costs shown in the foregoing section were firstly converted into the economic value by simply multiplying the same standard conversion factor (SCF) applied to the evaluation in YUTRA. Then, the economic costs of the YUMRT Line-1 project's investment costs were calculated as USD1,516 million for Low Cost Scenario and USD1,853 million for High Cost Scenario for the Phase-1, and USD280 million for Low Cost Scenario and USD342 million for High Cost Scenario for the Phase-2, respectively. The construction period including feasibility study (F/S) and design works of each phase were expected from FY2015 until FY2024 for the Phase-1 and from FY2026 until FY2034 for the Phase-2. As the project life is assumed 30years, the residual value was considered in the final year of evaluation period for each Phase.

Beginning of the operation is expected in FY2024, and therefore, the benefit stream is counted from this year for the cash flow analysis.

All of the assumptions mentioned above were same as the ones applied for the evaluation in YUTRA.

2) Evaluation Results for Economic Analysis

The evaluation results for the economic analysis of the Project were summarized as following Table 6.2-2. The range of EIRRs between the Low Cost Scenario and the High Cost Scenario were from 16.3% to 13.8%.

Table 6.2-2 Economic Evaluation Results

Project Title	EIRR (%)	NPV (USD Mil.)	B/C
Low Cost Scenario	**16.3%**	**710**	**1.7**
High Cost Scenario	**13.8%**	**486**	**1.4**

Source: Survey Team based on YUTRA Report

The calculated major economic indicators for the both cost scenario shown above indicated that the implementation of the YUMRT Line-1 project would generate a certain economic effects. Thereby, the Project can be assessed economically feasible.

3) Impact on Delay of Commencement of Operation

Finally, as an indicative analysis, the expected economic impact to the Yangon's regional economy by the delay of commencement of the YUMRT operation has been roughly estimated as shown in Figure 6.2-3.

Table 6.2-3 Impact on Delay of Commencement of Operation

	Cost Low Scenario		Cost High Scenario	
	loss on IRR	loss on Benefit	loss on IRR	loss on Benefit
	point	USD million	point	USD million
1year delay	-0.145	-770.0	-0.171	-740.0
2years delay	-0.310	-1,500.0	-0.364	-1,450.0
3years delay	-0.495	-2,200.0	-0.580	-2,140.0
4years delay	-0.718	-2,900.0	-0.821	-2,790.0
5years delay	-0.958	-3,530.0	-1.091	-3,410.0

Source: Survey Team

The analysis results indicated that just one (1) year delay of operation would cause the loss of economic benefits from USD740 million to USD770 million during the evaluation period of 30 years. Furthermore, for the case of five (5) year delay of operation, the regional economy may lose between USD3,410 million and USD3,530 million during the 30 years. So, the delay of the commencement of operation of YUMRT may cause the large economic loss for the future economy of Yangon region.

6.2.2 Financial Analysis

1) Methodology and Assumption

The financial investment costs were calculated as USD1,783 million for Low Cost Scenario and USD2,180 million for High Cost Scenario for the Phase-1, and USD329 million for Low Cost Scenario and USD402 million for High Cost Scenario for the Phase-2, respectively. Based upon the principle of cash flow analysis, the price escalation was excluded from the calculation. In addition, the non-eligible costs, such as tax, administration costs and so on are also not considered in this preliminary evaluation due to adjusting into the same basic conditions applied in YUTRA. Therefore, at the F/S stage, the more detailed and practical conditions are expected to be applied.

For the base passenger fare, just same as what YUTRA suggested, Ks. 18.5/km as of FY2013 was applied. This fare was increased by the same ratio of GRDP growth ratio by 2035, as regarding the growth of value of the services.

2) Evaluation Results for Financial Analysis

By applying same financial revenue stream calculated in YUTRA, the financial internal rate of return (FIRR) of the Project was computed. The calculation result was negative even for the Low Cost Scenario. It is found that in order to make the FIRR positive, at least either the revenue shall be increased by 60% or the cost shall be decreased by 30% for the Low Cost Scenario and 90% and 40% respectively for the High Cost Scenario.

Therefore, in the F/S stage, in addition to the further examination of cost component, it is recommended to consider how to maximize the non-rail business revenues which is not counted for this evaluation. Also, it is expected to study the various passenger fare settings in parallel with considering the impact on the ridership.

7 Conclusion and Recommendation

7.1 Conclusion

(1) Necessity of the project

Traffic congestions are becoming worse every year; part of this is thanks to the recent economic growth of the region. In order not to decelerate current momentum of the economic growth, it is necessary for Yangon City to have a comprehensive transport network. For this purpose, YUTRA was commenced and it confirmed and indicates that UMRT is essential to develop the city. YUTRA indicates that Myanmar's economic status has reached to the level where sustainable operation and maintenance of UMRT project is possible. Yangon City's traffic congestion has been for sure worsened but not worsened to the level of the other south eastern Asian mega cities, such as Bangkok or Jakarta. Once the congestion became worse to the certain level, it may become almost impossible even to start construction works of UMRT since the works interrupt traffic. It's now when actions against realization of YUMRT have to be taken. YUMRT will serve as a first Urban Mass Rapid Transit to support people to move smoothly and punctually and keep other public transport on the surface running, subsequently help its economic growth keep developing. As discussed above, UMRT line 1 project can be justified from various points of view.

(2) Route Selection

A proposed route is selected based on the route shown in YUTRA. Preliminary alignment study has been made along the route and it found that underground section has to be introduced in the south-half of the project area in order to avoid generating a large number of resettlement and land acquisition.

(3) Environmental and Social Considerations

Since some section of the existing roads where YUMRT route has been set are so devious that alignment cannot be fall within the ROW of the existing road, land acquisition and resettlement is inevitable to some extent.

7.2 Recommendation

(1) Earlier Commencement of Feasibility Study

In theory, to commence operation in 2025 as shown in YUTRA, it is necessary to commence a feasibility study as soon as possible since it takes more than 10 years to complete the UMRT project from planning to commencement of the system. Judging from the scale of the project, it is sure that it will take long time to make a consensus among the authorities to give a green light to realize YUMRT project. It is always the case with the first UMRT to fall behind the original schedule because it usually takes time to determine who to take the various risks caused by its huge financial burden. Furthermore, consensus building among authorities and other stake holders have to take long as well. Considering these situation, actions to start UMRT project have to be taken as soon as possible.

In addition to the above, as mentioned in the foregoing section of economic evaluation, a delay of the commencement of operation of YUMRT may cause the large economic loss

for the future economy of Yangon region. Therefore, the necessary administrative coordination system among the concerned authorities is required for achieving the proposed time frame and its smooth implementation.

(2) Necessity of Development of Laws and Regulations

Since there are some 9km-long underground section and part of underground section runs through residential area, laws or regulations which allow public structure to be constructed underground of private property have to be developed. In Japan, “Sectional Surface Rights” has been introduced. It is usual even in Japan that underground tunnel of UMRT goes under private property since it is not possible to avoid all the private property to set UMRT alignment. It is strongly recommended to start developing laws and regulations for underground public structure under private property. As development laws and regulations generally take long time, it is desirable to start some actions as soon as possible. At the same time, existing laws and regulations on land rights have to be studied and reviewed from the view point of YUMRT construction.

(3) Gauge Unification

As indicated in this report, it is recommended that considering possible mutual operation with other MR lines meter gauge which is the same gauge as existing railways should be introduced. For short-tem, one could probably conclude that standard gauge would be better for UMRT, but there are few advantages to apply standard gauge to UMRT since existing railway applies a meter gauge. It is important to know that people will be aware of necessity of gauge unification decades later when railway network has been developed widely. Except for High Speed Railway (HSR), gauge should be unified.

(4) Coordination with other Project

There is an on-going station development project in Yangon Central Station and the proposed Yangon Central Station of UMRT is involved in the station development project area. Although station location is proposed in this study, the final location has to be determined through the discussions with other authorities, the contractor of development project and other stake holders. There should be some other projects in the project area that requires the similar coordination accordingly.

(5) Consensus Building among related Authorities

UMRT Project involves highly-diversified authorities because it requires many issues and matters to be settled in terms of technical, institutional, and zonal aspect. Therefore, it is quite important to establish good coordination among the related authorities and to built consensus among those authorities. At present, it is assumed that Ministry of Rail Transport (MORT), Myanmar Railways (MR), Ministry of Electric Power (MOEP), Yangon Regional Government, YCDC, etc. will be the authorities related to the project.