MYANMA RAILWAYS
MINISTRY OF TRANSPORT AND COMMUNICATIONS
THE REPUBLIC OF THE UNION OF MYANMAR

FEASIBILITY STUDY REPORT ON THE YANGON CIRCULAR RAILWAY LINE UPGRADING PROJECT

FINAL REPORT

SEPTEMBER 2016

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS GLOBAL CO., LTD.
NIPPON KOEI CO., LTD.
ALMEC CORPORATION
JAPAN INTERNATIONAL CONSULTANTS FOR TRANSPORTATION CO., LTD.
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USD	1.00 = JPY	21.81
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MMK	1.00 = JPY	0.097

(as of September, 2015)

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Summary

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List of Abbreviation

No.	Abbreviation	Official Name
1	ADB	Asian Development Bank
2	ASEAN	Association of South-East Asian Nations
3	ATC	Automatic Train Control
4	ATP	Automatic Train Protection
5	B/C	Benefit to Cost Ratio
6	DEL	Diesel Electric Locomotive
7	DHL	Diesel Hydraulic Locomotive
8	DL	Diesel Locomotive
9	DEMU	Diesel-Electric Multiple Unit
10	DMU	Diesel Multiple Unit
11	DRC	Diesel Rail Car
12	EIRR	Economic Internal Rate of Return
13	EMU	Electric Multiple Unit
14	F/S	Feasibility Study
15	FC	Freight Car
16	FIRR	Financial Internal Rate of Return
17	GDP	Gross Domestic Product
18	IMF	International Monetary Fund
19	IRR	Internal Rate of Return
20	JBIC	Japan Bank for International Cooperation
21	JETRO	Japan External Trade Organization
22	JICA	Japan International Cooperation Agency
23	LRBE	Light Rail Bus Engine
24	METI	Ministry of Economy, Trade and Industry
25	MOR	Ministry of Rail Transportation
26	MOT	Ministry of Transport
27	MR	Myanma Railways
28	NEXI	Nippon Export and Investment Insurance
29	OD	Origin Destination
30	ODA	Official Development Assistance
31	OECD	Organisation for Economic Co-operation and Development
32	PC	Passenger Car
33	PC	Prestressed Concrete
34	PC	Precast Concrete
35	PPP	Public-Private Partnership
36	RBE	Rail Bus Engine
37	SDR	Social Discount Rate
38	STEP	Special Terms for Economic Partnership
39	VAT	Value Added Tax
40	USAID	United States Agency for International Development

Summary

Chapter 1 Introduction

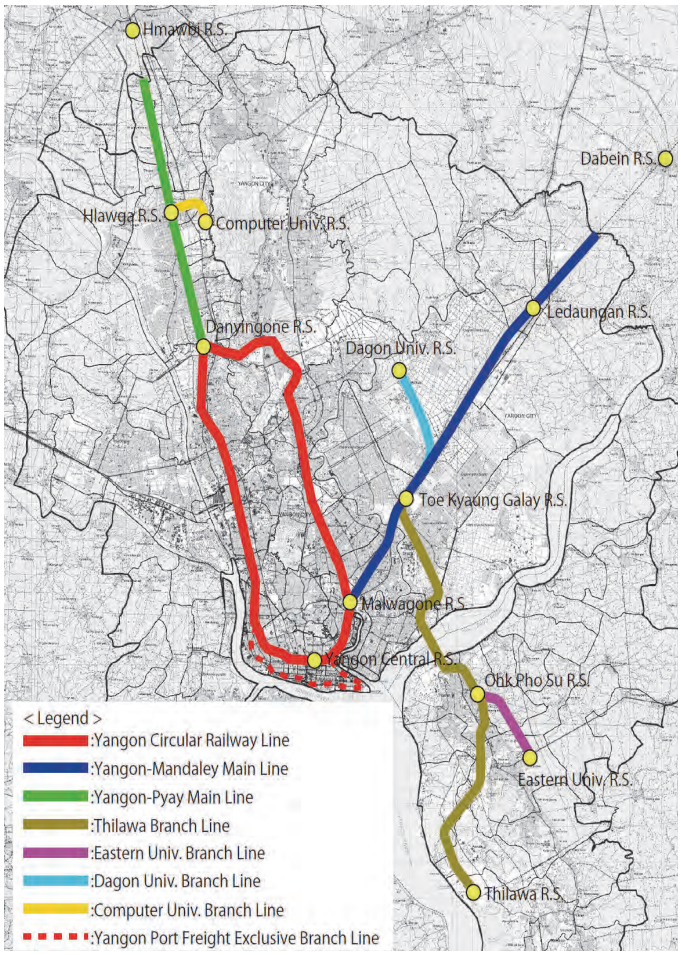
1.1 Existing Rail Lines in the Study Area

The current railway network in the Greater Yangon is composed of eight lines, which include three main lines and five branch lines (including one exclusive freight line), as shown in Figure 1.1.1.

All of the railway systems in the Greater Yangon are managed and operated by Myanma Railways (MR), which is under the umbrella of the Ministry of Transport and Communications (MOTC).

The existing rail lines that are studied in this survey program include (refer to Figure 1.1.1):

- Yangon Circular Railway Line (YCR),
- Yangon Mandalay Line (the section between Yangon Central and Dabein station),
- Pyay Line (the section from Yangon Central to Hmawbi station,
- Thilawa Line (the section between Toe Kyaung Galay and Thilawa), and
- Short spur lines including the Computer University Line, Dagon University Line and Eastern University Line.



Source: JICA Study Team

Figure 1.1.1 Existing MR Rail Network in the Greater Yangon

1.2 Existing problems and issues

With regard to the existing rail services in the Greater Yangon area, the particular issues are summarized as follows:

- Decreasing level of service (speed, punctuality, riding comfort, cleanness, and safety)

Operation of the YCR Line commenced in January 1959. After about half century since the commencement, the existing train operation speed has fallen down to almost half (15km/h) of that of the opening year because of the deteriorated tracks and limited partial rehabilitation of signalling & telecommunication system and other facilities.

- Increasing demand

The population in the city has been growing. The existing rail system in Yangon carries about 75,000 passengers per day, while an improved YCR Line (with EMU) is expected to carry about 700,000 passengers or more per day in 2035 (refer to Chapter 3 Demand Forecast).

Corresponding technical problems with regard to the existing YCR Line are summarized as follows:

- Deterioration of infrastructure, equipment, system and rolling stock

In almost all aspects the existing rail and related facilities need improvement, including roadbed, rail track, signalling and train control system, telecommunication, level crossings and rolling stock.

- Insufficient maintenance work of the track and other facilities

The deformation of the track due to heavy rainfall in the rainy season is one of the main causes of derailment accident. Because of the limited technical capacity in terms of skilled workers and machine, the level of maintenance work has remained at low level. Improvement of track condition together with introduction of mechanical maintenance methods with modern machines is required to achieve a decent maintenance work level.

- Aged rolling stock

The existing MR's rolling stock need to be attractive to the Yangon residents by improving its low performance and comfort level and unfavourable design for vulnerable people. The interior of the rolling stock are not properly designed nor furnished for commuting users, and its ride comfort is far below the desired level as a transit system of the international gateway city of Myanmar.

- Bottleneck section

Priority in the current train operation is given to the long distance train, namely the Yangon – Mandalay Line. The train operation of the YCR Line is sometimes disturbed by this operation because there is a cross-over rail segment between Pa Zun Taung station and Yangon Central station. The YCR trains need to wait until the Yangon-Mandalay Line trains pass this segment. This crossing operation needs to be improved by installing the signal system on the YCR Line.

- Increasing road traffic volume crossing the manually operated level crossings

All of the existing level crossings along the YCR Line (27 in total) are manually operated by MR staff. Closing time of the level crossings tends to be longer because of the manual operation and selfish behaviour of car drivers. Sometimes trains need to stop at a level crossing because of never-ending car passing. Replacement of the existing level crossing system with automated level crossings is needed to improve the level of safety.

- Deteriorated station buildings

Almost all of the existing stations are timeworn and heavily deteriorated so that rehabilitation of station facilities essential. There are no decent facilities such as toilet, ceiling of platform, benches, passenger information board and etc., which resulted in low level of the passenger service.

Other than the technical issues, following issues need consideration.

- Poor accessibility to rail stations

There is no feeder bus services to/from the existing rail stations, in other words, there is no integration between the rail and the bus services in Yangon. In addition to this, roads to/from the rail stations are not well developed nor maintained, accordingly it is quite difficult for vulnerable people to use the existing rail service. An idea of universal design must be incorporated in the modernization process of MR's system.

- Traffic congestion

The paralleling roads along the YCR Line are the major arterial roads in the city, namely Pyay road, Insein road, Baho road, and Waizayandar road. The traffic congestion and traveling time on these roads have been increasing. Improvement of the YCR Line will contribute to the improvement of the traffic environment along the major arterial road.

1.3 MR's Yangon Transit System (MR-YTS) Development Objective

MR is expected to perform as a primary urban transit service provider in the Greater Yangon including adjacent Yangon extended urbanized areas. However, the existing poor level of service (LOS) of the MR's rail lines has resulted in a small share in the transport market today.

The transportation demand in the Greater Yangon area will continue to increase as the economy and the population grow (from 7.4 million in 2014 to over 10 million in the Yangon Region in 2035). The transport model developed by YUTRA forecasts almost doubled mechanized trips, from 4.9 million trips in 2013 to 9.5 million trips by 2035. If the rail services remain unattractive for the residents and the visitors in the future, the city of Yangon will be faced with very serious vehicular traffic congestion, accordingly a large-scale economic and environmental loss is expected.

Considering the existing and the expected travel demand in the future, a decent level of rail transit service should be provided by MR in the Greater Yangon area as soon as possible. In this regard, modernization of the MR's rail services together with effective transit network development in the Greater Yangon is highly desired. On the other hand, considering the limited financial capacity and other constraints, MR's rail service should be modernized in a phased manner. Based on this understanding, a phased rail transit network development plan is shown as a part of the MR's modernization roadmap in this report. And as the first priority project, a feasibility study was carried out on the YCR in this study.

Chapter 2 YTS Development Plan

2.1 Yangon Transit System Network Development

MR's Yangon Transit System (MR-YTS) is faced with many issues to be solved towards development of a decent urban rail transit system as mentioned in the previous sections. These issues can be addressed in a phased manner with consideration on the budget envelope of the Government of Myanmar.

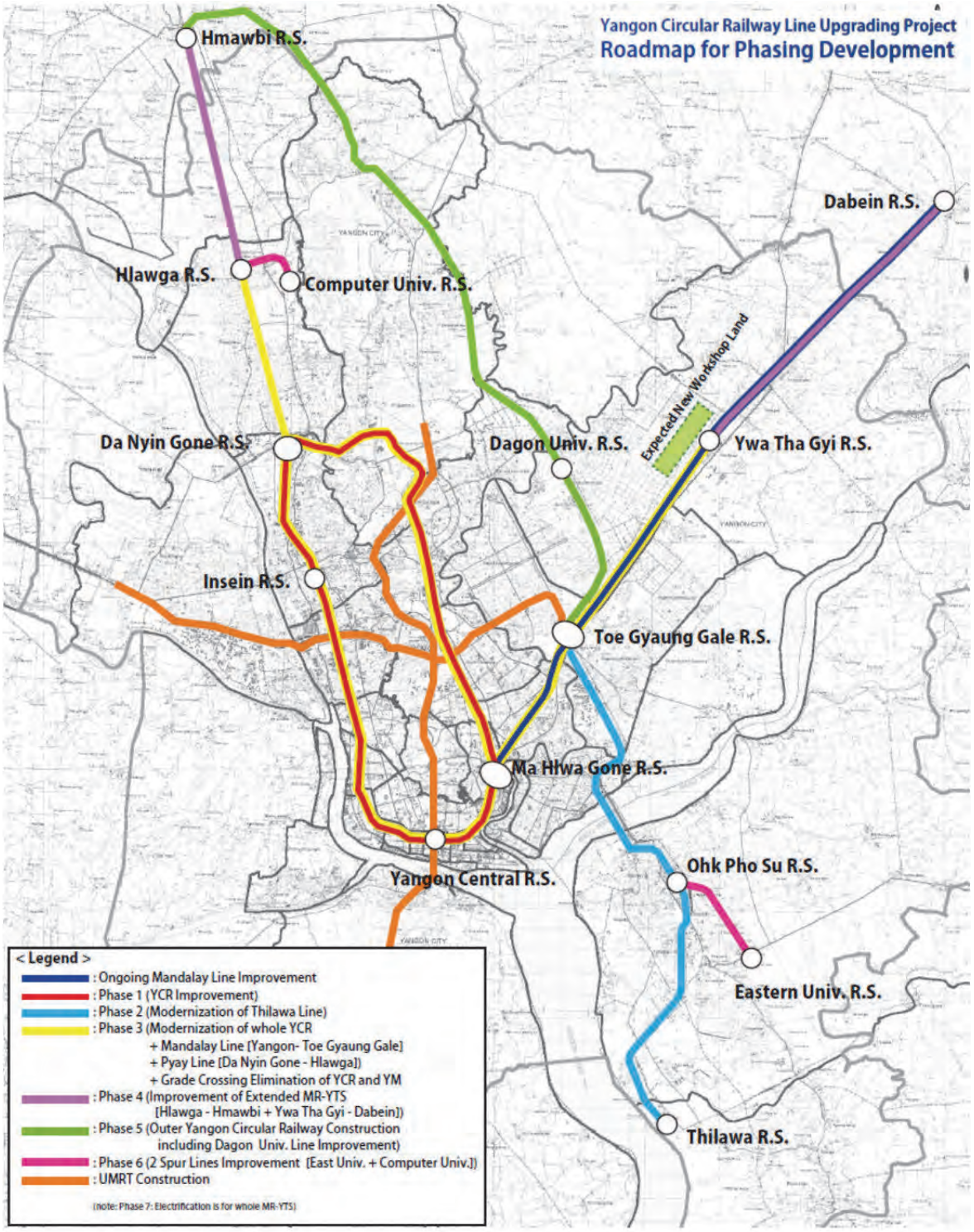
A phased urban rail network development is now prepared as a basis for the roadmap of modernization of MR-YTS based on the principles stated below:

- Full-scale electrification of MR-YTS is planned as a far future project after the year 2035 in consideration of the life time of DEMU purchased by the on-going Japanese ODA loan project. A study on the electrification (and track elevation) can be carried out in parallel.
- SUDP's urban development scenarios and corresponding traffic demand forecasts should be the basis for prioritization of urban rail segments.
- In addition to the urban rail network in the Greater Yangon area, it is assumed that the proposed Outer Yangon Circular Railway is constructed as a detour route for freight trains. By doing so, the capacity of MR-YTS lines can be fully allocated to the MR-YTS commuter trains.
- Projects to increase the level of services of MR-YTS, such as advanced ticketing system introduction (smart card), station plaza development (TOD), etc. should be carefully planned at each phase.

MY-YTS network development is divided into seven (7) phases as shown in Figure 2.1.1.

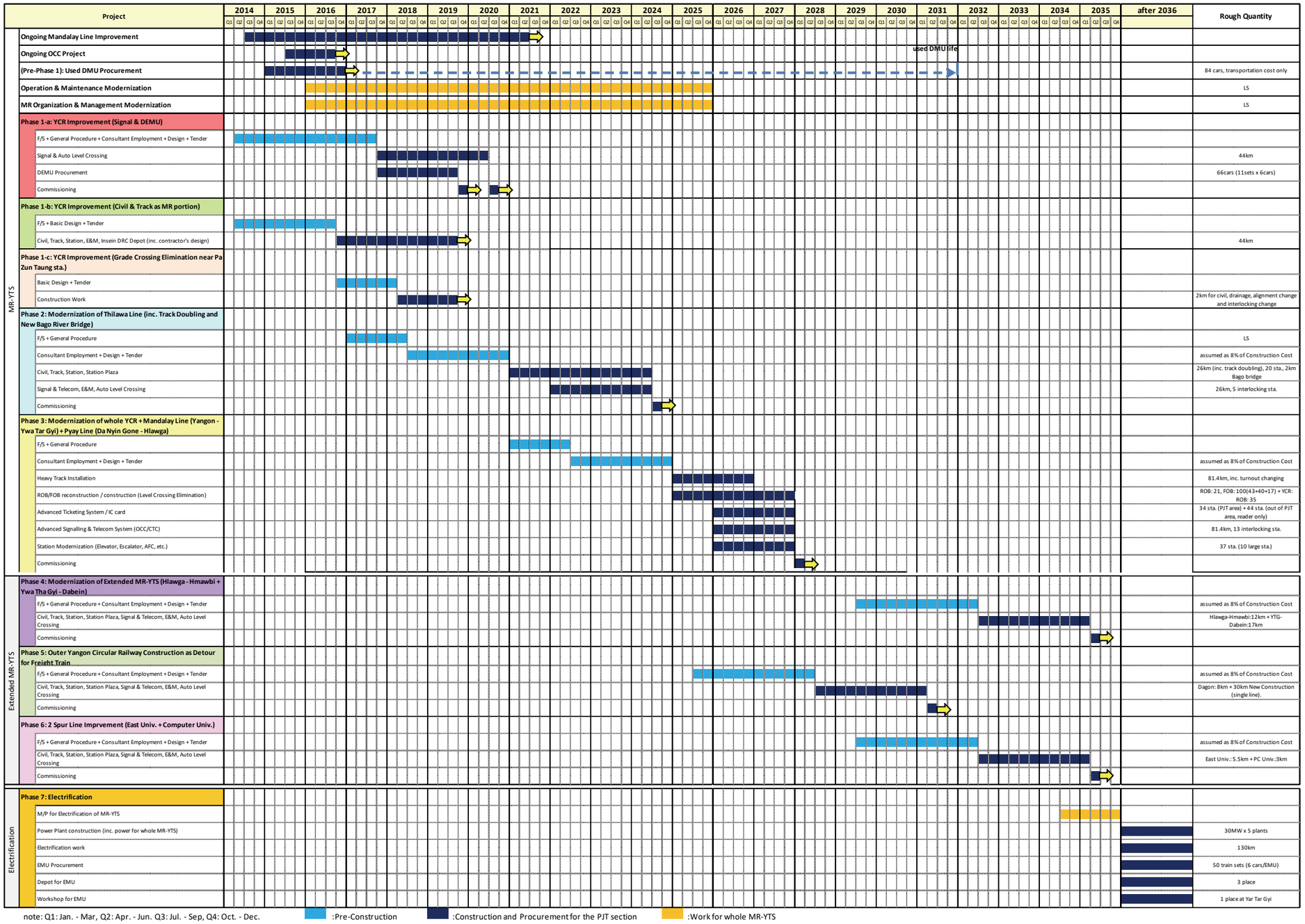
The initial improvement work of the whole YCR (Phase 1), which will be carried out using Japanese ODA loan for rolling stocks and signalling systems and MR's own budget for the civil works, will complete by 2020. In the Phase 2 Thilawa line will be improved in order to support new social and economic activities on the eastern bank of the Bago River, namely Thilawa area. Consequently, radial lines, namely, Pyay line will be improved in Phases 3 and 4. The Outer Ring Rail line will be constructed during the Phase 5. Spur lines of shorter distance will be improved in Phase 6. All projects from Phase1 through Phase 6 shall be carried out by the year 2035.

Immediately after completion of the basic design work for the Phase 1 project, it is expected that MR will carry out a feasibility study on the improvement of Thilawa line and Pyay line (Da Nyin Gone – Hlawga).



Source: JICA Study Team

Figure 2.1.1 Phased Rail Transit Network Development (improvement)



Source: JICA Study Team

Figure 2.1.2 Schedule for Phasing Development Plan

Upgrade Component \ Section		MR-YTS					Extended MR-YTS		Spur Lines			
		YCR West	YCR East	Pyay Line	Mandalay Line	Thilawa Line	Pyay Ext	Mandalay Ext.	East Univ.	PC Univ.	Dagon Univ.	Outer YCR
		Ma Hlwa Gone - Yangon - Da Nyin Gone	Ma Hlwa Gone - Mingalardone - Da Nyin Gone	Da Nyin Gone - Hlawga	Yangon - Ywa Tha Gyi	Toe Gyaung Gale - Thilawa	Hlawga - Hmawbi	Ywa Tha Gyi - Dabein	Okhposu - East Univ.	Hlawga - Computer Univ.	Toe Gyaung Gale - Dagon Univ.	Dagon Univ. - Hmawbi
Existing Line Improvement	Civil / Track work (at-grade)	Phas1-b		Phase 2	by YM	Phase 2	Phase 4	by YM	Phase 6	Phase 6	Phase 5	Phase 5
	Civil / Track work (elevated viaduct)											
	Station / Station Plaza improvement	Phase 3	Phase 3	Phase 3	Phase 3	Phase 2	Phase 4	Phase 4	Phase 6	Phase 6	Phase 5	Phase 5
	Signal improvement (inc. auto level crossing)	Phase 1-a		Phase 3	by YM	Phase 2	Phase 4	by YM	Phase 6	Phase 6	Phase 5	Phase 5
	Telecom. Improvement	Phase 3	Phase 3	Phase 3	by YM	Phase 2	Phase 4	by YM	Phase 6	Phase 6	Phase 5	Phase 5
	E & M improvement	Phase 1-a		Phase 3	by YM	Phase 2	Phase 4	by YM	Phase 6	Phase 6	Phase 5	Phase 5
	(Used DMU procurement)	(Pre-Phase 1)			by YM			by YM	(used YM DEMUand/or used DMU)			
	Depot for DMU	Phase 1-b			by YM			by YM	Phase 6	Phase 6	by YM	
	Workshop for DMU	by YM						Existing and/or by YM				
	Elimination of Grage Crossing of YCR and Mandalay Line	Phase 1-c			Phase 1-c							
Electrification	Electrification Work	Phase 7					Phase 7					
	(Power Plant construction)	Phase 7										
	EMU procurement	Phase 7					Phase 7					
	Depot for EMU	Phase 7										
	Workshop for EMU	Phase 7										
	ROB reconstruction/construction	Phase 3					Phase 4	Phase 4				
	FOB reconstruction/construction	Phase 3					Phase 4	Phase 4				
Other Modernization Items	New Line Consruction											
	OCC/CTC	Phase 3				Phase 2	Phase 4	Phase 4	Phase 6	Phase 6	Phase 5	Phase 5
	Station Modernization (Elevator/Escalator, AFC, Passenger Service Facility Modernization, etc.)	Phase 3				Phase 2	Phase 4	Phase 4	Phase 6	Phase 6	Phase 5	Phase 5
	Advanced Ticketing / IC card	Phase 3					Phase 4	Phase 4	Phase 6	Phase 6	Phase 5	Phase 5
	Operation & Maintenance Modernization	Phase 1 - 3										
	MR Organization & Management Modernization	Phase 1 - 3										

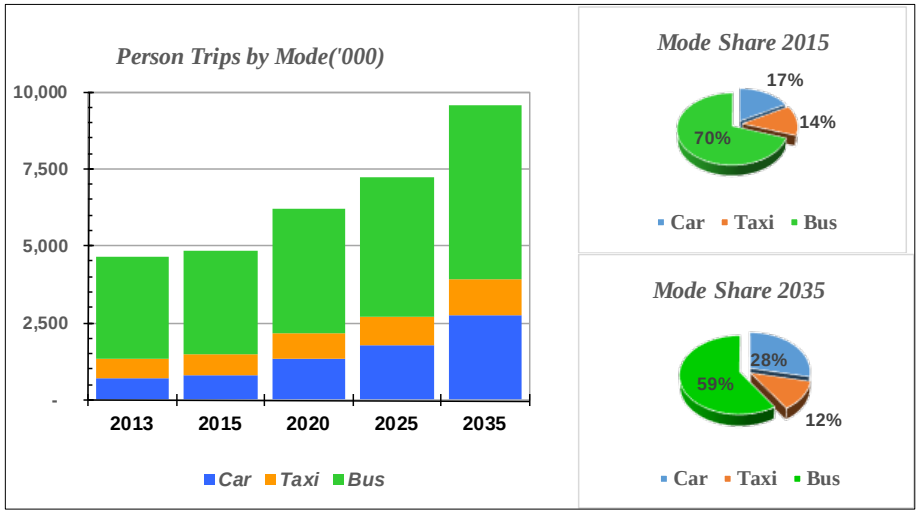
Source: JICA Study Team

Figure 2.1.3 Project Components for Phasing Development Plan

2.2 Demand Forecast

2.2.1 Total Travel Demand Forecasts

The final total travel demand as used in this study is presented below in Figure 2.2.1. It can be seen that the public transport mode share (rail trips are included in the bus trips) is forecast to decline from 70% in 2015 to about 59% by 2035. However, the public transport trips are still estimated to increase from the current (2015) 3.4million trips to about 5.7 million trips by 2035, giving an average annual growth rate of 2.6% per annum, slightly above the population growth rate.



Source: JICA Study Team

Figure 2.2.1 Total Travel Demand by Mode of Travel

2.2.2 Travel Demand Forecast – MR Lines

The travel demand forecast for the MR Lines was estimated in the traffic assignment process. A number of model runs for each forecast year were carried out. The scenarios adopted included:

- Travel demand by year 2015, 2020, 2025 & 2035.
- MR fare level, base case or +20 for the upgraded lines, depending on scenario and year of operation.
- Average rolling stock speed estimated for the 2015, from the travel time surveys with DEL in operation. These are illustrated in Figures 3.6 and 3.7 below.
- Travel time/ speed between each pair of stations for the rolling stock in operation on the upgraded lines as appropriate.
- Highway network as proposed in the YUTRA master plan.

Using the above assumptions, the CUBE model was run for 2015, 2020, 2025 & 2035 for the do-noting situation and with various test scenarios. With the revised forecast for the roadmap study a premium fare of Base+20% was found to be near optimal in the case of YCR upgrading from DEL to DEMU operation. This increase in fare resulted in 15% reduction in demand. Hence, for all subsequent tests MR fare were set to be Base+20%. The upgraded YCR in 2020 with higher (+20%) fares would increase the YCR patronage by three times in comparison with the do-nothing case (2020_DN), and double the overall MR ridership to 416k Pax/ day.

The patronage demand estimate suggests that opening the whole YCR in 2020 would attract patronage of about 416k with fares set at +20% from their current level (2020_+20% case). This would increase by about 20% by the year 2025 (2025_Case_1). However, if by 2025 all MR lines were to operate DEMU at ten-minute intervals the demand on the system would increase

to over 630k per day (2025_Case_2), and further increase in frequency to 12 trains per hour would increase the patronage by almost 48% by 2035 (2035_Case_1).

2025_Case_2 (all DEMU, 10 minutes headway) Line Volume	2035_Case_3 (All EMU, 5 minutes headway) Line Volume
	
Legend: TOT_PAX=12500 TOT_PAX=25000	

Source: JICA Study Team

Figure 2.2.2 Travel Demand Volume on MR Network 2025_Case-2 & 2035 (Case-3)

Chapter 3 YCR Improvement Plan

3.1 YCR Improvement Project - The ODA Loan Project

The Project components, which shall be financed through the Japanese ODA loan, consist of installation of new signalling system and procurement of new DEMUs, while, other works including civil work (drainage system, fence, rail bridge rehabilitation, roadbed, etc.), track work (rail welding, track irregularity improvement, etc.), power supply work, station work (high height platform), depot work, etc. shall be carried out by MR using its own budget, which should be carried out prior to execution of the components covered by the Japanese ODA loan.

The signalling work as a part of the Project starts from the west side of Yangon central station, passing though Da Nyin Gone station, to the west side of Pa Zun Taung station (44.0km in total), which covers most of the Yangon Circular Railway Line (46.0km in total). The section from Yangon Central station to Pa Zun Taung station (2.0km in total) is covered by the Project for Installation of Railway Operation Control Center System and Safety Equipment.

New DEMUs shall be procured in accordance with the Rolling Stock Procurement Works as part of the Project.

Improvement of the at-grade level crossing operation of the two lines, namely the YCR Line and the Yangon – Mandalay (Bago), which is in the rail section between the Yangon Central station and the Pa Zun Taung station, will be considered separately from this Project.

The scope of the project financed by Japanese ODA loan is summarized in Table 3.1.1.

Table 3.1.1 Scope of the Project

Package	Items	Scope
Package 1	Signalling Works (44 km from the west side of Yangon Central Station to the west side of Pa Zun Taung Station	• Interlocking System of major stations • Automatic Block System (ABS) • Automatic Train Stop (ATS-S) • Automatic railway level crossings (27 crossings)
Package 2	Rolling Stock Procurement Works	• Type of Train: DEMU Units: 66 cars (6 cars x 11 train sets)
Consulting Services	Consulting Services	• Tender assistance (TA) • Construction supervision (CS) • Advisory services to MR works, including – Civil work – Hydrology / drainage – Railway bridge – Building – Depot (Insein DRC, Ma Hlwa Gone Depot) – Environmental and social consideration • Disbursement management • Facilitation of implementation of – Environment Management Plan (EMP), – Environmental Monitoring Plan(EMoP), – Abbreviated Resettlement Plan(ARP), and – HIV/AIDS Protection Plan (HAPP) • Technology transfer on: – On the Job Training – Track maintenance capacity improvement – Train operation improvement – Customer service improvement • Passenger service and rail business performance improvement

Source: JICA Study Team (2015)

3.1.1 Project Cost

The cost estimates of the project are summarized in Table 3.1.2.

Table 3.1.2 Project Costs

Unit: (JPY million)

Breakdown of Cost	Foreign Currency Portion			Local Currency Portion			Total		
	Total	Japanese ODA loan Portion	Myanmar Portion	Total	Japanese ODA loan Portion	Myanmar Portion	Total	Japanese ODA loan Portion	Myanmar Portion
Eligible Portion	(JPY)	(JPY)	(JPY)	(JPY)	(JPY)	(JPY)	(JPY)	(JPY)	(JPY)
Signalling Rolling Stock Price Escalation Physical Contingency Consulting Services Administration Cost VAT Import Tax	CONFIDENTIAL								
Sub-Total									
Non-Eligible Portion									
Civil Works Track Works Signal & Telecom Procurement of Rolling Stock Price Escalation Physical Contingency Land Acquisition Administration Cost VAT Import Tax Interest during construction Commitment Charge	CONFIDENTIAL								
Sub-Total									
Grand Total									

Note:

1. Exchange rate: US$ 1= Kyat 1028.8 = ¥118.6（Kyat 1=¥0.115）
2. Price escalation factors: 4.7% per annum (local currency portion), 2.0% per annum (foreign currency portion)
3. Physical contingency: 5.0% (Base Cost + Price Escalation)
4. Base year for cost estimation: February 2015
5. Non eligible portion was calculated as follows:
   - Administration Cost = 5.0%
   - Commercial Tax = 5.0%
   - Import Tax = 7.0%
   - Actual Non Eligible Portion will be adjusted according to the provision by the Government of Myanmar
6. The total amount may not be the same as the sum, due to the round off

3.1.2 Viability of the Project

EIRR of the Project is callculated at 20.7%, and NPV is Ks. 948,461 million (B/C raitio is 4.2). From these figures, it is safe to say that the Project is economically viable. While FIRR is calculated at 5.2%. This figure seems very low, that is, the project seems not so attractive, however, the FIRR is higher than the proposed interest of Japanese ODA loan, which is 0.01%, which means that a sort of leverage effect can be expected by using this preferred loan scheme. A cash flow analysis suggests that MR would be able to eliminate its accumulated deficits by FY 2044. In conclusion, the Project is also acceptable from the aspect of financial viability as well.

3.1.3 Environmental Category

The Project is deemed "category B" in accordance with JICA Guidelines for Environmental and Social Considerations (April 2010). There is no significant negative environmental and social impact caused by the Project during the construction and the operation phases.

3.1.4 Land Acquisition and Involuntary Resettlement

The number of PAPs who might be requested to move to other locations is confirmed as shown in the column "Number of persons to be resettled" in the same table below.

Table 3.1.3 PAUs and PAPs of the Project

Project Component	Type of buildings / business activities	PAUs	PAPs	Number of persons to be physically resettled
Along the Project section (44.0 km)	MR staff house *	5	25	25
	Non-MR staff house	2	9	9
	MR shop	0	0	0
	Non-MR shop	3	14	14
	Public facilities	0	0	0
	Community facilities	0	0	0
	Fence (lettuce plantation)**	1	9	0
	Vegetable plantation for own use (not for sale)**	1	6	0
Total		**12**	**63**	**48**

* Although MR staff houses belong to MR, the project proponent, people living in the houses including MR officers are considered as PAPs with involuntary resettlement according to JICA's Guidelines for Environmental and Social Considerations.

** Agriculture activity will be able to continue with reduced area

In conclusion, the total number of PAPs is 63 persons including 48 persons of involuntary resettlement as of March 21, 2015 based on the Abbreviated Resettlement Plan (ARP).

There observed some agricultural activities along the project section, namely, using liner spaces along the rail line (within MR Right of Way), some people are cultivating vegetables such as lettuce. These spaces are rented from MR to those people for their cultivation purpose. The Project may affect this kind of agricultural activities, namely, newly constructed fence along the project section may make them not to enter into those spaces. In this regard, MR is requested to take a proper action for them.

It should be noted that some trees and electric poles along the project section need to be removed and replaced by the Project. MR, the executing agency, needs to obtain approval from concerned agencies to do such work.

3.1.5 Technology of the Project

(1) Construction gauge and loading gauge

The maximum height of newly procured rolling stock for the YCR Line can be 3,620mm (3,820 – 200mm). The size of the newly procured rolling stock should be large as much as possible within a technically justifiable range in order to provide comfort and effective space for passengers and goods. Based on this consideration, the height of 3,620mm shall be applied as a new loading gauge regulation for the YCR Line.

(2) Safety System Improvement

Significant improvement of the existing system or installation of new system is required to achieve an international standard level of safety. To meet this objective, the technologies used in the Project shall be as follows:

Signalling System

- Automatic Block System (ABS)
- Direct current track circuit system
- Automatic Train Stop System (ATS-S)
- Interlocking system in major stations other than the Yangon Central station
- Automatic barrier level crossings (installation of automated level crossing barriers is required to save train running time and increase the safety for pedestrians.)

(3) New DEMU Procurement

In order to attract more people to the improved YCR in the future, it is recommended to introduce modern rolling stock of higher performance in terms of safety, ride comfort, running speed, travel time, easy maintenance, etc.

Since electrification of the YCR Line is not scheduled in the near future, non-electrified system, namely Diesel Electric Multiple Units (DEMUs) shall be introduced in the initial stage of modernization of the YCR Line.

Use of DEMUs, instead of using a train being composed of a locomotives and passenger coaches, makes MR easier in operating passenger trains on the YCR Line because there is no need to do shunting operation at terminal stations.

(4) Drainage system improvement

The heavy rainfall in a short time period during the rainy season (from June to September) in Yangon frequently causes flooding over the rail facilities and other problems such as malfunction of signalling control system (due to shirt-circuit of track circuit).

Locations and segments of frequent flooding along the Project section are already identified by MR. MR shall construct proper drainage facilities in these locations before installation of new signalling system.

(5) Improvement of rail track irregularity

In order to achieve the target maximum running speed of 60kph of this Project, the existing track should be improved (irregularity should be removed) before introduction of new rolling stock. MR shall employ skilled engineers and workers for this work, some of them shall be who experienced JICA's technical assistance for Railway Safety and Service Improvement (2014/2015).

(6) Station platform improvement

All of the existing rolling stock used for the YCR Line's services shall be replaced with new rolling stock and used DMUs in the Project. Floor height of these new rolling stock is higher than the existing station platform. Accordingly all of the station platforms need to be improved (elevated) in order to provide easy boarding and alighting for rail passengers. This improvement is also necessary to reduce the boarding/alighting time (time duration for stoppage).

(7) Safety Operation

Planned frequent and fast train operation requires appropriate safety facilities such as fences along the railway line to prevent the residents from entering into the railway area.

(8) Construction gauge and loading gauge

The maximum height of newly procured rolling stock for the YCR Line can be 3,620mm (3,820 – 200mm). The size of the newly procured rolling stock should be large as much as possible within a technically justifiable range in order to provide comfort and effective space for passengers and goods. Based on this consideration, the height of 3,620mm shall be applied as a new loading gauge regulation for the YCR Line.

(9) Electrification

MR has a vision of electrification of the urban rail transit system in the Yangon metropolitan area, including the YCR Line and other connecting lines in the future, which is also recommended as part of the long-term urban transit development plan in YUTRA.

MR and JICA understand that preparation of an urban transit electrification master plan, including development of exclusive power supply system for the urban transit system, is necessary, and this planning work shall be carried out after completion of the existing feasibility study on the YCR Line.

3.2 Actions for Smooth Project Implementation

3.2.1 Coordination of the Project

A steering committee shall be established to supervise the implementation of the Project.

In addition, a technical committee shall be formulated under the steering committee as a technical coordination body of projects carried out by PMUs. Those projects include, but not limited to, the Yangon Central Station Redevelopment project, Yangon-Mandalay Railway Improvement Project Phase I and the Project for Installation of Railway Operation Control Center System and Safety Equipment.

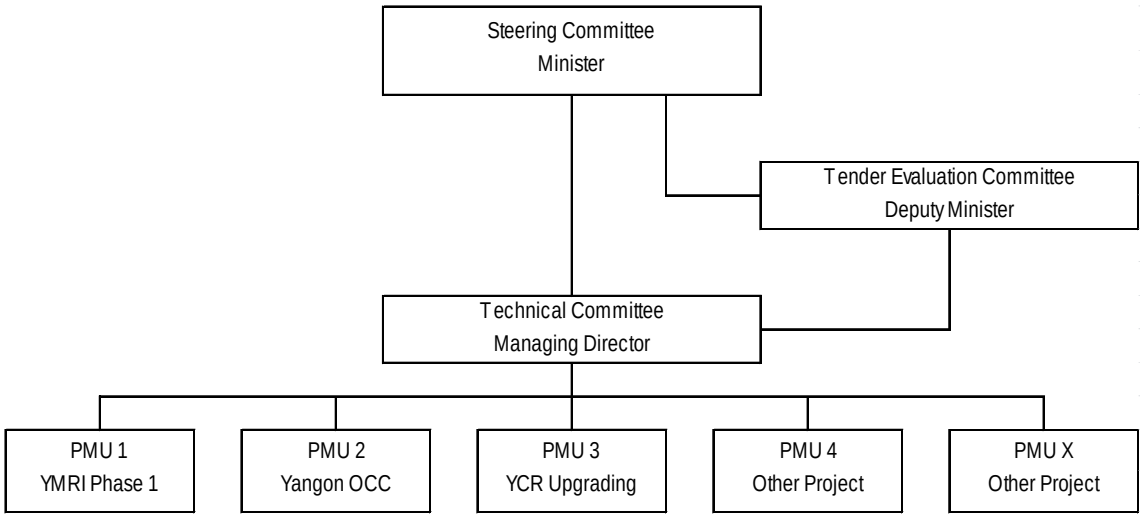
A tender evaluation committee for the Project shall be established separately from the steering committee to supervise a series of tender activities of this Project, including selection of TA and CS consultants and contractors for actual construction / installation works.

3.2.2 Project Management Unit (PMU)

It is highly recommended that MR establishes Project Management Units (PMUs) for each of the projects financed by Japanese ODA loan for their smooth and efficient implementation. An indicative organizational structure for the overall project management is depicted in Figure 3.2.1.

The Project Director shall have the authority to take necessary decisions and actions for the smooth implementation of the Project and make decision on all payment and other matters related to the Project.

The task assigned to the PMU is not limited to supporting the implementation of the Project, but also includes arrangement of training programs for train operation, signalling and telecommunication, etc. and passenger service improvement such as advanced ticketing system. Such additional feature (function) will be placed in the PMU because the Project needs careful management to assure effective operation of renewed urban mass transit services in the Greater Yangon and the surrounding area.



Source: JICA Study Team (2015)

Figure 3.2.1 Indicative organizational structure for overall project management

Members of the steering committee, the evaluation committee and the technical committee can be invited from MOTC and other concerned ministries and external organizations and individuals (third party).

Principles of organization and operation of the PMU shall be as follows, but not limited to:

- The PMU is established to assist the implementation of the Project.
- Task assignment and authorization to the PMU shall be specified in the decision on establishment of such PMU or in specific authorization documents issued by MOTC.
- The PMU shall follow the provisions of Myanmar law and the agreements signed with Japan International Cooperation Agency (herein after referred to JICA).
- The PMU and its head (the Project Director) shall take responsibility for their acts in performing their assigned tasks under the provisions of Myanmar law and agreement with JICA.
- All activities of the PMU shall be monitored and supervised by MOTC through the Steering Committee.
- The PMU is requested to manage the Project efficiently, and avoid loss and waste of resources of the Project.
- The PMU is requested to report the progress of the Project to MOTC periodically.
- Referring the anti-corruption policy instructed by the higher authorities, the PMU is requested to adopt measures to prevent any kinds of corruption.

3.2.3 Institutional Strengthening for Project Implementation

The PMU requires trained personnel for the effective and smooth implementation of the Project. In this regard, it is highly recommended to increase capable human resources to assure the delivery of the Project as scheduled. Staff of the PMU can be recruited from other organizations or individuals to strengthen the capacity in advance.

3.2.4 Counterpart Fund

For smooth implementation of the Project, MR needs to take all the necessary measures to secure the fund for the MR works and non-eligible costs including (i) project components covered by MR (MR works), (ii) the administration and management costs of the PMU, (iii) taxes and duties incurred (e.g. commercial tax and custom duties) as stipulated in E/N, (iv)

purchase of land and other matters related to real estate property, (v) compensation, (vi) wages for casual labourer hired on a daily basis, and (vii) other indirect items, and to secure the sufficient funds for adequate operation and maintenance.

3.2.5 Environmental Monitoring

Management and Monitoring for Environmental and Social considerations for the Project should be conducted by the Government of Myanmar in accordance with the Environmental and Social Monitoring Plan.

3.2.6 Business Improvement

Although, the adequacy ratio (equity-to-asset ratio) of MR is quite high, recording more than 90%, the source of the equity is not the cash surplus from its operating profit but the Government's subsidy entirely. Therefore, the repayment of the loans from foreign donors and the other liabilities is principally covered by this Government's subsidy. In this regard, it can be described that MR is not financially self-sufficient. In 2013, the deficit recorded around 43 billion Kyat, and its operation ratio (operating expenses / revenues) is higher than 150%.

To struggle with this problem, it is highly recommended that MR carries out has a series of countermeasures to increase its operating revenue to contribute reducing the government's deficit by improving the non-passenger transport services, which are utilization of land and improvement of freight transportation.

a) Utilization of the idle (un-employed) lands:

MR is currently planning to develop the vicinal land areas of the railway stations; i.e. 16 plots in the Yangon, 2 plots in Mandalay, and 3 plots in Myitkyina, through the BOT basis. As the market value of the own land adjacent to the railway stations is hundred times higher than the book value, the commission fees from the private developers through the BOT contract can contribute to the improvement of its financial status.

b) Modernization of cargo freight services:

To meet the growing demand of door-to-door logistics services, there is a good opportunity for MR to introduce the containerization in association with the private forwarders. In order to settle the problem of "one-way loading" due to the economic disparities between Yangon and regional cities, strengthening of connectivity with the other transportation modes through the development of logistic centres like in-land container terminal, and promotion of the industrialization in each region through the investment promotion and industrial development strategies by the strong initiatives of the Government.

3.3 Operation and Effect Indicators

Operation and Effect Indicators are summarized in Table 3.3.1 and 3.3.2.

Table 3.3.1 Operation Indicators

Operation Indicators	Unit	Present (Year 2015)	Target (Year 2022)
Minimum operation interval during peak hours	minutes	15~45	10~12
YCR Train operation number per day	number per day	122	175
Passenger train-km per day	passenger train-km per day	2,860	4,100
Maximum running speed (on the improved section)	km per hour	48	60

Source: JICA Study Team

Table 3.3.2 Effect Indicators

Effect Indicators	Unit	Present (Year 2015)	Target (Year 2022)
Passenger-km per day	passenger train-km per day	850,200 (on average in January ~ March 2015)	2,140,000
Travel time of passenger train (round trip)	minutes	170	110
Accidents (derailment) in the YCR Line	case(s)	19 cases in 2014 - Gate accident: 4 - Track: 5 - Human (driver) error : 1 - Railcar : 4 - Track + railcar: 5	0 or 1 case only (unpredictable human error)

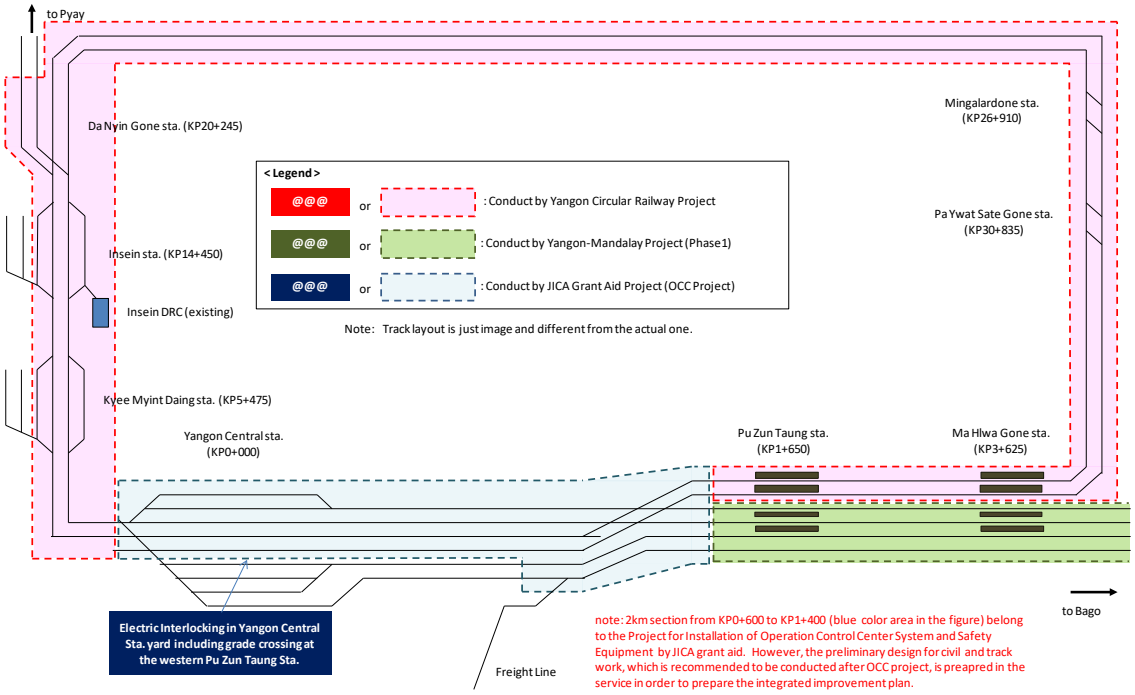
Source: JICA Study Team

3.4 Demarcation of the Project

Several projects which should be considered in improving the YCR are on-going, namely, Yangon-Mandalay Line Improvement Project and OCC Project. A special attention needs to be paid to the section between Yangon Central Station and Ma Hlwa Gone Station.

In order to avoid duplicated works in the future, the project section should be clearly defined. Based on the discussions among the concerned project teams and MR, the section improved by this Project was determined. The Project covers the section coloured red in Figure 3.4.1.

It should be noted that there are some bridges along the parallel section of Yangon-Mandalay line and YCR. It is recommended to improve these bridges as a one project, not separated projects, from the viewpoint of technical easiness and cost saving.



Source: JICA Study Team

Figure 3.4.1 Schematic Figure for Positioning of Project

3.5 Implementation Schedule

The project schedule of each work is summarized in the following Tables.

Table 3.5.1 Schedule of Signalling Works

Items	Schedule
Pledge	CONFIDENTIAL
Project steering committee / PMU / Tender evaluation committee	
Loan Agreement	
Selection of JICA BD Consultant by JICA	
Basic Design & Performance Specification (draft)	
Selection of TA and CS Consultant by MR	
Pre-Qualification of Contractor	
Selection of Contractor	
Signalling Works	
Project Completion Date	
Warranty / Defect Liability Period	

Source: JICA Study Team

Table 3.5.2 Schedule of Rolling Stock Procurement Works

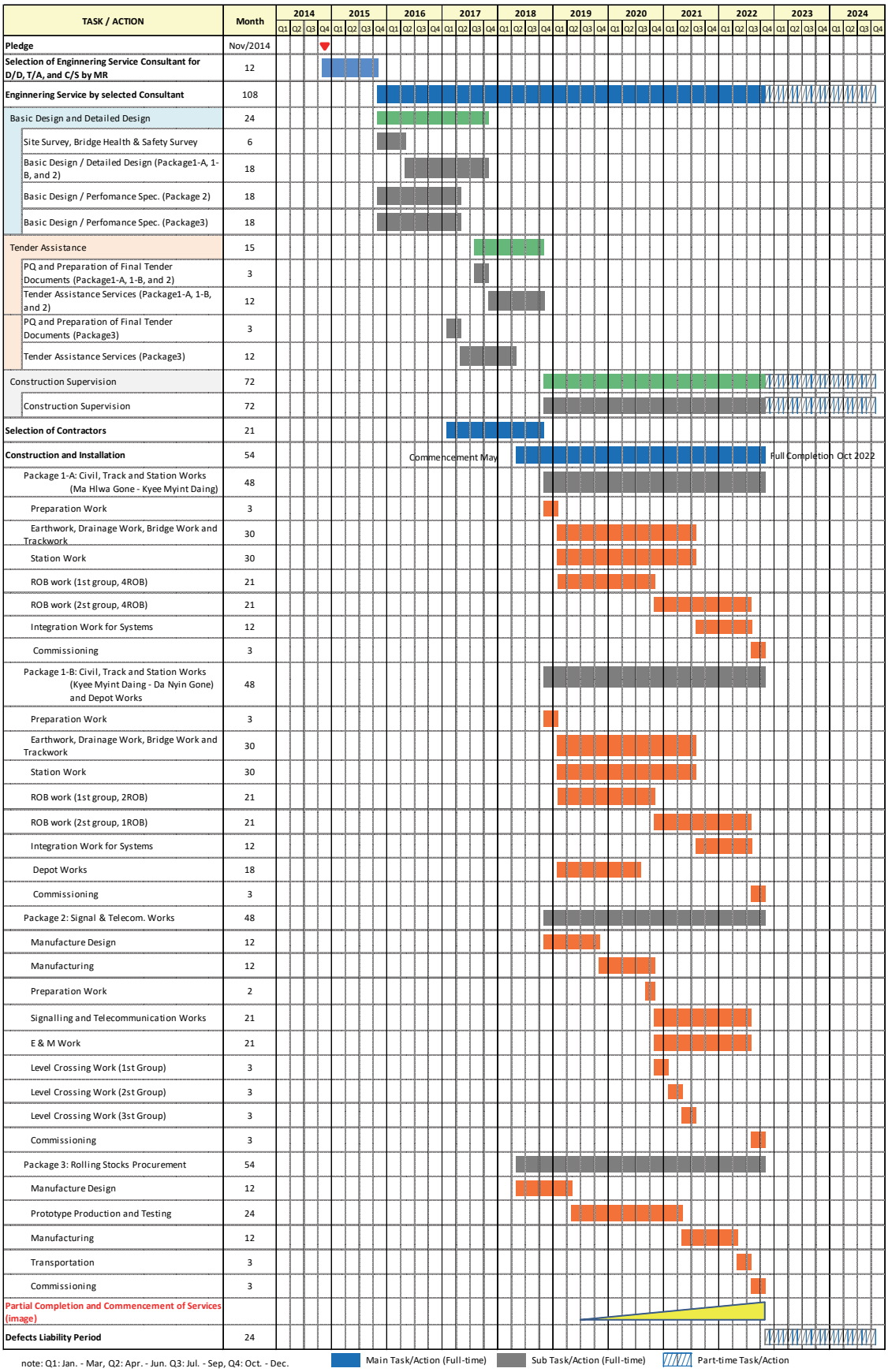
Items	Schedule
Pledge	CONFIDENTIAL
Project Steering Committee / PMU / Tender evaluation committee	
Loan Agreement	
Selection of JICA BD Consultant by JICA	
Basic Design & Performance Specification (draft)	
Selection of TA and CS Consultant by MR	
Pre-Qualification of Contractor	
Selection of Contractor	
Rolling Stock Procurement Works	
Project Completion Date	
Warranty / Defect Liability Period	

Source: JICA Study Team

Table 3.5.3 Schedule of Other Works

Items	Schedule
Rolling stock procurement and modification	CONFIDENTIAL
Rail welding and track irregularity improvement, wooden sleeper replacement at turnouts	
Resettlement (if necessary)	
Basic Design	
Selection of TA and CS Consultant by MR	
Tender for Design-Build Contractor	
MR Work	
Work Completion Date	

Source: JICA Study Team



Source: JICA Study Team

Figure 3.5.1 Overall Project Implementation Schedule Chart

Part 1

Roadmap for
The Greater Yangon Transit System Development

Chapter 1 Introduction

1.1 Existing problems and issues

The current railway network in the Greater Yangon is composed of eight lines, which include three main lines and five branch lines (including one exclusive freight line), as shown in Figure 1.4.1.

All of the railway systems in the Greater Yangon are managed and operated by Myanma Railways (MR), which is under the umbrella of the Ministry of Transport and Communications (MOTC).

With regard to the existing rail services in the Greater Yangon area, the particular issues are summarized as follows:

- Decreasing level of service (speed, punctuality, riding comfort, cleanness, and safety)

Operation of the YCR Line commenced in January 1959. After about half century since the commencement, the existing train operation speed has fallen down to almost half (15km/h) of that of the opening year because of the deteriorated tracks and limited partial rehabilitation of signalling & telecommunication system and other facilities.

- Increasing demand

The population in the city has been growing. The existing rail system in Yangon carries about 75,000 passengers per day, while an improved YCR Line (with EMU) is expected to carry about 700,000 passengers or more per day in 2035 (refer to Chapter 3 Demand Forecast).

Corresponding technical problems with regard to the existing YCR Line are summarized as follows:

- Deterioration of infrastructure, equipment, system and rolling stock

In almost all aspects the existing rail and related facilities need improvement, including roadbed, rail track, signalling and train control system, telecommunication, level crossings and rolling stock.

- Insufficient maintenance work of the track and other facilities

The deformation of the track due to heavy rainfall in the rainy season is one of the main causes of derailment accident. Because of the limited technical capacity in terms of skilled workers and machine, the level of maintenance work has remained at low level. Improvement of track condition together with introduction of mechanical maintenance methods with modern machines is required to achieve a decent maintenance work level.

- Aged rolling stock

The existing MR's rolling stock need to be attractive to the Yangon residents by improving its low performance and comfort level and unfavourable design for vulnerable people. The interior of the rolling stock are not properly designed nor furnished for commuting users, and its ride comfort is far below the desired level as a transit system of the international gateway city of Myanmar.

- Bottleneck section

Priority in the current train operation is given to the long distance train, namely the Yangon – Mandalay Line. The train operation of the YCR Line is sometimes disturbed by this operation because there is a cross-over rail segment between Pa Zun Taung station and Yangon Central station. The YCR trains need to wait until the Yangon-Mandalay Line trains pass this segment. This crossing operation needs to be improved by installing the signal system on the YCR Line.

- Increasing road traffic volume crossing the manually operated level crossings

All of the existing level crossings along the YCR Line (27 in total) are manually operated by MR staff. Closing time of the level crossings tends to be longer because of the manual operation and selfish behaviour of car drivers. Sometimes trains need to stop at a level crossing because of never-ending car passing. Replacement of the existing level crossing system with automated level crossings is needed to improve the level of safety.

- Deteriorated station buildings

Almost all of the existing stations are timeworn and heavily deteriorated so that rehabilitation of station facilities essential. There are no decent facilities such as toilet, ceiling of platform, benches, passenger information board and etc., which resulted in low level of the passenger service.

Other than the technical issues, following issues need consideration.

- Poor accessibility to rail stations

There is no feeder bus services to/from the existing rail stations, in other words, there is no integration between the rail and the bus services in Yangon. In addition to this, roads to/from the rail stations are not well developed nor maintained, accordingly it is quite difficult for vulnerable people to use the existing rail service. An idea of universal design must be incorporated in the modernization process of MR's system.

- Traffic congestion

The paralleling roads along the YCR Line are the major arterial roads in the city, namely Pyay road, Insein road, Baho road, and Waizayandar road. The traffic congestion and traveling time on these roads have been increasing. Improvement of the YCR Line will contribute to the improvement of the traffic environment along the major arterial road.

1.2 MR's Yangon Transit System (MR-YTS) Development Objective

MR is expected to perform as a primary urban transit service provider in the Greater Yangon including adjacent Yangon extended urbanized areas. However, the existing poor level of service (LOS) of the MR's rail lines has resulted in a small share in the transport market today.

Majority of the existing rail service users are i) commuters and ii) peddlers (farmers) of agricultural products (mainly vegetables). Many of the peddlers come from the northern area of Yangon where open-field cultivation areas are extended along the circular rail line. In terms of income level, the existing rail users are mostly categorized into a lower income group.

Many of the rail users come to the rail stations by foot. Actually no feeder bus services are provided to/from the existing rail stations, accordingly the service coverage of the existing rail lines is limited.

The transportation demand in the Greater Yangon area will continue to increase as the economy and the population grow (from 7.4 million in 2014 to over 10 million in the Yangon Region in 2035). The transport model developed by YUTRA forecasts almost doubled mechanized trips, from 4.9 million trips in 2013 to 9.5 million trips by 2035. If the rail services remain unattractive for the residents and the visitors in the future, the city of Yangon will be faced with

very serious vehicular traffic congestion, accordingly a large-scale economic and environmental loss is expected.

Considering the existing and the expected travel demand in the future, a decent level of rail transit service should be provided by MR in the Greater Yangon area as soon as possible. In this regard, modernization of the MR's rail services together with effective transit network development in the Greater Yangon is highly desired. On the other hand, considering the limited financial capacity and other constraints, MR's rail service should be modernized in a phased manner. Based on this understanding, a phased rail transit network development plan is shown as a part of the MR's modernization roadmap in this report.

1.3 MR Management Modernization Study

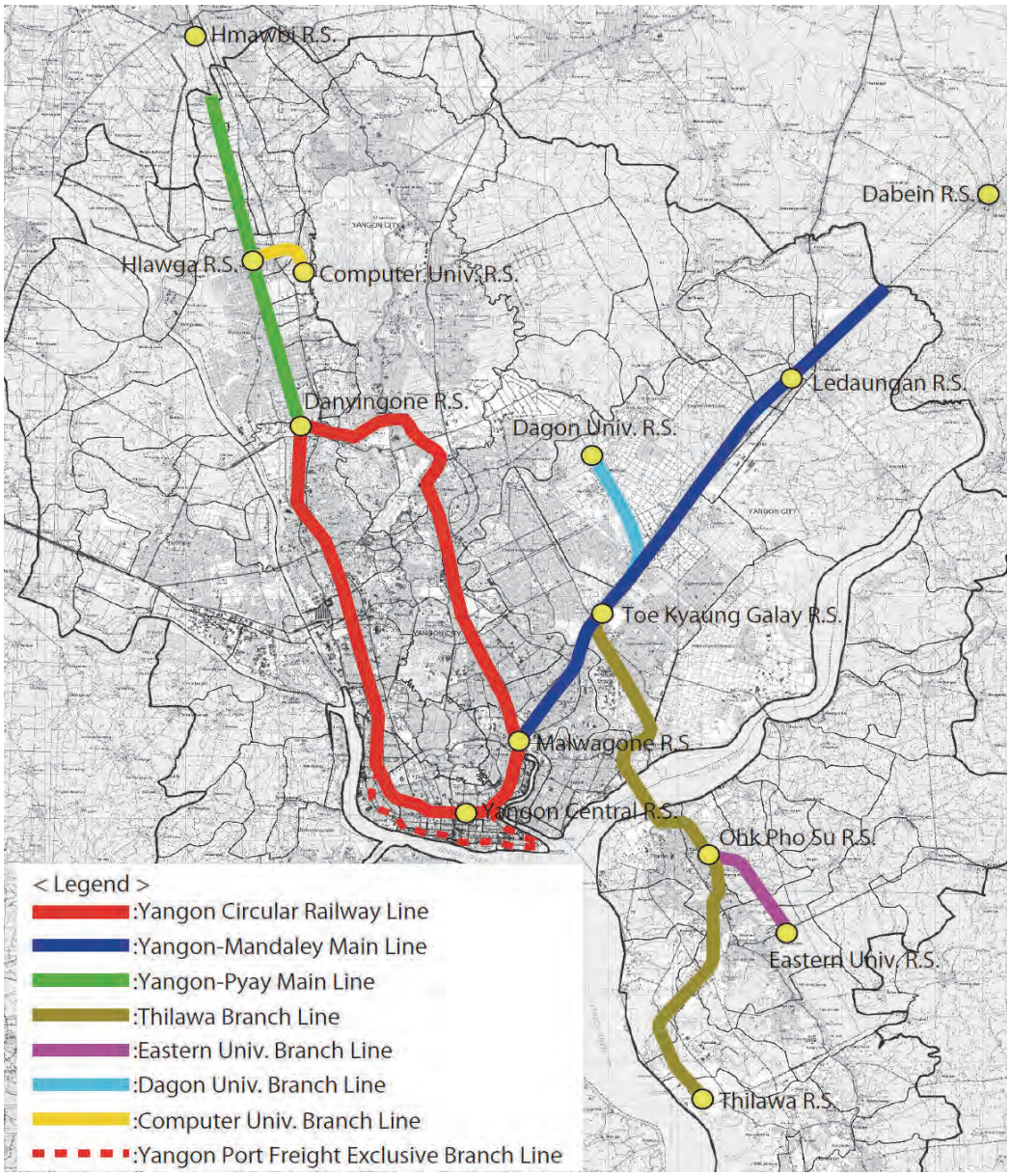
A study on the modernization of MR management was carried out in 2015, which was sponsored by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan. This study discusses modernization of the MR's management in a phased manner, namely Short-term modernization including Phase 1: "Build up the basis of modernization" and Phase 2: "Level up towards modernization" and Medium- and Long-term modernization to achieve full-scale modernization.

This MR-YTS development roadmap is drawn up in line with the MR management modernization study.

1.4 Study Area

The existing rail lines that are studied in this survey program include (refer to Figure 1.4.1 and Table 1.4.1):

- Yangon Circular Railway Line (YCR),
- Yangon Mandalay Line (the section between Yangon Central and Dabein station),
- Pyay Line (the section from Yangon Central to Hmawbi station,
- Thilawa Line (the section between Toe Kyaung Galay and Thilawa), and
- Short spur lines including the Computer University Line, Dagon University Line and Eastern University Line.



Source: JICA Study Team

Figure 1.4.1 Study Area – existing MR Rail Network in the Greater Yangon Area

Table 1.4.1 Summary of the existing MR Rail Network in the Greater Yangon Area

Route Name	Section	Length (km)	No. of Railway Stations	Single track/ Double track	No. of Trains Operated Daily	Remarks
Main Line						
Yangon Circular Railway Line	Whole Yangon Circular Railway	46.12 km	38	Double-double Track: (Yangon–Ma Hlwa Gone:3.6km) Double Track: (Remaining Section)	Yangon – Ma Hlwa Gone: 102 Ma Hlwa Gone – Paywatseikkone: 38 Paywatseikkone – Mingalardon: 34 Mingalardon – Da Nyin Gone:14 Da Nyin Gone – Insein: 54 Insein – Yangon: 79	
Yangon – Mandalay Main Line	Ma Hlwa Gone R.S. – a point between Ledaungan R.S. and Dabein R.S.	28.3 km	6	Double Track	Ma Hlwa Gone – Toe Kyaung Galay: 64 Toe Kyaung Galay – Ywa Tar Gyi: 16	
Yangon – Pyay Main Line	Da Nyin Gone R.S.- Hlawga R.S.- a point between Hlawga R.S. and Hmawbi R.S.	20.1 km (10.5 km +9.6 km)	4	Double Track: (Yangon–Hlawga) Single Track: (Hlawga – Hmawbi)	Da Nyin Gone – Hlawkar: 40	
Branch Line						
Thilawa Branch Line	Toe Kyaung Galay R.S. – Ohk Pho Su R.S. – Thilawa R.S.	26.2 km	5	Single Track	Toe Kyaung Galay – Ohk Pho Su: 18 Ohk Pho Su – Thilawa: 4	
Eastern Univ. Branch Line	Ohk Pho Su R.S. – Eastern Univ. R.S.	5.4 km	1	Single Track	12	
Dagon Univ. Branch Line	Toe Kyaung Galay R.S. – Dagon Univ. R.S.	8.0 km	1	Single Track	18	
Computer Univ. Branch Line	Hlawga R.S. – Computer Univ. R.S.	2.9 km	1	Single Track	4	
Yangon Port Freight Exclusive Branch Line	Pazundaung R.S. – Botahtung Freight R.S. – Wadan Freight R.S. - Kyee Myint Daing R.S	9.9 km	2	Single Track	2 to 3 (irregular trains, Botahtaung Sta. / Dahnitaw Oil Sta. – Ma Hlwa Gone Sta.) 0 (No operation between Kyee Myint Daing Sta. and Botahtaung Sta.)	No Passenger service. Freight train only.
Total		148.3 km (138.4 km for passenger line)	58 (56 passenger stations)		200	No. of R.S. is except Halts. R.S. + Halts =80 (78 for Pax.)

Source: "Traffic Data Yangon Circular Railway 2012 by MR", interview with MR, and Google Earth

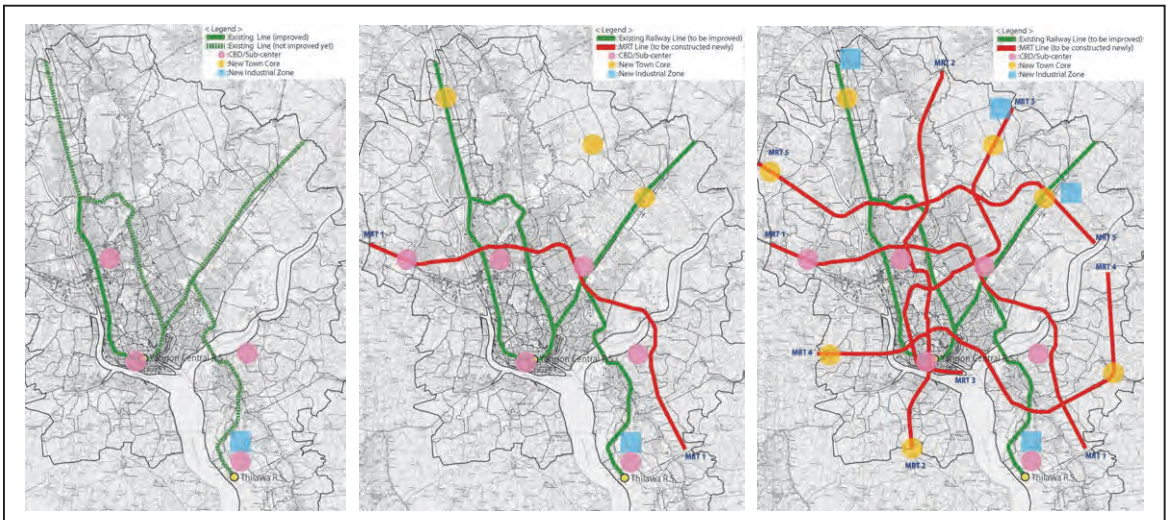
Chapter 2 Upstream plans and other relevant projects

2.1 Strategic Urban Development Plan (SUDP)

The Strategic Urban Development Plan (SUDP) is deemed as a kind of structure plan of the Greater Yangon area which was drafted by YCDC with the technical support from JICA in 2013.

SUDP presents a phased rail transit network development plan as part of SUDP's implementation plan by the target year of 2018, 2025 and 2035. The proposed transit network includes the upgraded MR network and five lines of new urban mass rapid transit (UMRT).

Regarding the Yangon Circular Railway (YCR), the plan suggests earlier improvement of the western half of the YCR line as a short-term project, and followed by improvement of the eastern half of the YCR as a medium-term project. This phased improvement plan is based on the planning principles employed by SUDP, namely "to give priority to the improvement and upgrading of the existing railway line", and "to give priority to high population density areas in case of improvement of the existing railway line". Figure 2.1.1 shows a phased transit network development plan proposed by SUDP.



Source: SUDP, JICA (2013)

Figure 2.1.1 SUDP's Transit Network Development Plan

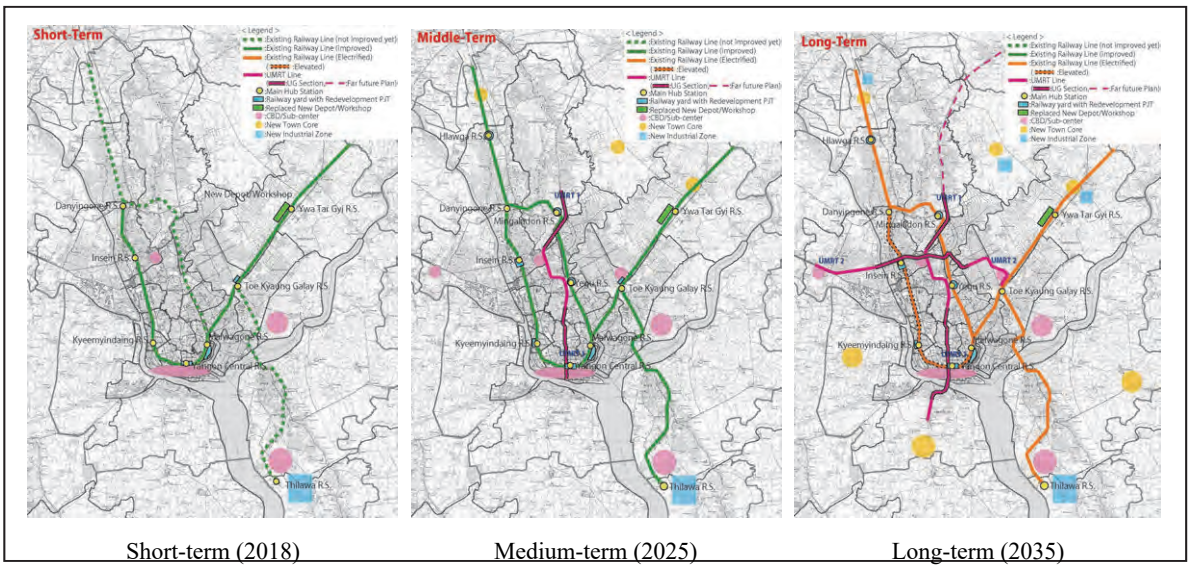
It should be noted that this phased development plan was proposed at a conceptual level of detail, while this MR network development roadmap proposes a phased network development plan based on YUTRA and newly updated demand forecast. Conclusively this roadmap recommends that the whole YCR should be upgraded as one of the short-term projects, which is discussed in the consequent chapters in this report.

2.2 Comprehensive Urban Transport Master Plan of the Greater Yangon (YUTRA)

Following SUDP, an urban transport master plan of the Greater Yangon area was drawn up by the Government of Yangon Region with the technical support from JICA in 2014, which is named YUTRA. Following the SUDP's planning horizon, YUTRA shows a phased transport network plan for each of the target years, namely 2018 as a short-term, 2025 as a middle-term, and 2035 as a long term.

As part of the YUTRA study a strategic transport model was developed based on a comprehensive household interview survey (HIS) and a series of traffic count surveys. The SUDP's transit development concept was tested using this transport model. The model analysis, using the planning parameters based on the SUDP's urban development framework, informs that modernization of all MR lines in the Greater Yangon area and two new urban mass transit lines (UMRT) are necessary as the rail-based public transport systems in 2035.

With regard to the Yangon Circular Railway line, YUTRA has proposed a step-wise development, namely, 1) the YCR shall be developed as an at-grade and non-electrified system in the initial stage of its modernization process, and 2) the YCR shall be developed as an elevated and electrified system in the later phase. Figure 2.2.1 shows the phased modernization plan proposed by YUTRA. A preliminary feasibility study on the YCR was carried out based on this plan in early 2015.



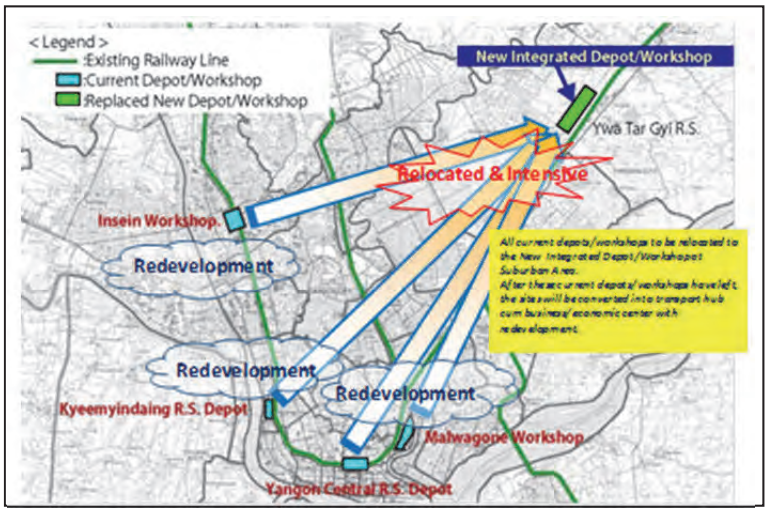
Source: YUTRA Project Team (2013)

Figure 2.2.1 YUTRA's Rail Transit Network Development Plan

The YCR runs through the highly urbanized areas in Yangon. It is recognized that there are great opportunities to increase efficiency of land use and value of land along the YCR by taking opportunity of upgrading of the YCR line, especially peripheral areas of YCR rail stations with development of intermodal facilities such as bus and taxi bays at the stations.

YUTRA proposes an important urban development concept, namely rail-based transit oriented development (TOD). It is an important agenda as of today for MR to improve accessibility to/from rail stations in order to encourage people to use MR systems and to increase attractiveness of the rail use and value of its own asset by adopting TOD. Actually MR has an idea to regenerate potential prime areas of its own lands such as the shed/stabling yard in the Yangon Central station, the Kyee Myint Daing station yard, the Insein workshop/maintenance shed yard, and the Ma Hlwa Gone depot/maintenance shed yard. In order to make these ideas happen, it is necessary to move the existing facilities such as workshop/depot to another convenient place. In this regard, YUTRA proposes relocation of such functions to a large vacant

area located at the northern side of Ywa Tar Gyi station along the Yangon-Mandalay Line as shown in Figure 2.2.2.

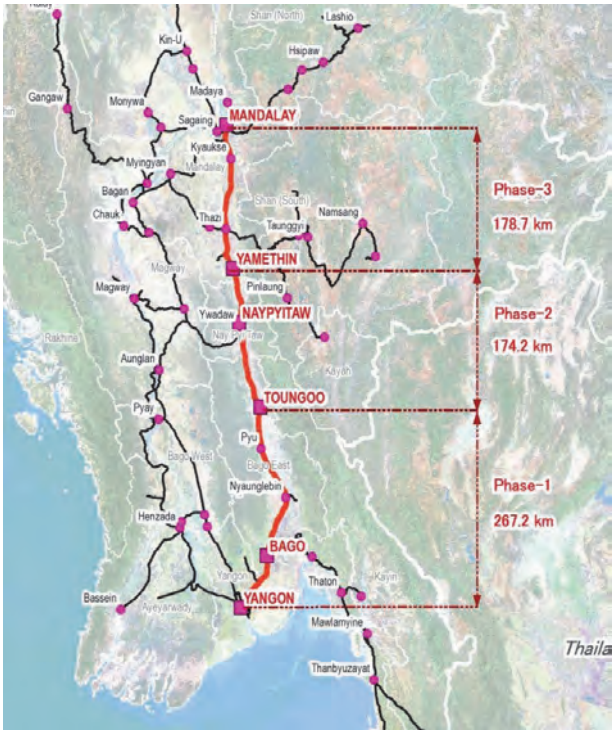


Source: YUTRA Project Team (2013)

Figure 2.2.2 Relocation of Depot and Workshop functions Proposed by YUTRA

2.3 Yangon – Mandalay Railway Improvement Project

The Yangon – Mandalay Railway Line (about 620km in length) was constructed during the period of 1884 ~ 1889 (Yangon – Taung Oo Line completed in 1885 and extension to Mandalay completed in 1889) as a single track, non-electrified rail line. During the period of 1899～1926 double tracking work was carried out, now having 98 stations. Since April 1989 all the railway development, operation and management have been under the responsibility of Myanma Railways (MR). The Government of Myanmar had been making a significant effort in extending the rail lines to rural areas since 1989 until quite recently, while level of ride comfort and carrying capacity of the existing major lines, namely the Yangon - Mandalay line, the Bago – Mottama – Mawlamyine -Yay line and the Yangon-Pyay line, etc., have been deteriorated because of limited budget (shortage of the budget) for their maintenance work.



Source: JICA Study Team

Figure 2.3.1 Yangon – Mandalay Railway Improvement Project

An agreement between the Government of Myanmar and the Government of Japan was made in 2013 with regard to the provision of a Japanese ODA loan to the Yangon-Mandalay Line Improvement Project, which is expected to perform again as one of the transport spines in the Central North – South Corridor designated in the Myanmar National Transport Master Plan 2014 (MYT-Plan). The improvement work will be carried out in a phased manner:

- Phase 1: Yangon – Taung Oo, 267km, 44 stations
- Phase 2: Tanung Oo – Yamethin, 174km, 27 stations
- Phase 3: Yamethin – Mandalay, 179km, 27 stations

The Yangon – Mandalay Line (Phase 1) improves the section from the Yangon Central Station to Taung Oo, of which detailed design work has completed and is now ready for actual implementation.

The section from the Yangon Central station to Toe Kyang Galay station has been used as part of the rail commuter systems in the Greater Yangon area. After completion of the Yangon – Mandalay Railway Improvement (Phase 1) project, the existing commuter service can be extended to Ywa Tar Gyi station or beyond. In addition to the extension of the urban commuter services in the Greater Yangon area, improved inter-city passenger service between Yangon and Bago can also be expected.

Chapter 3 Passenger Demand Forecast

3.1 Travel Demand Forecast – Introduction

This chapter presents the travel demand forecasts prepared for the development/ upgrading program of Myanma Railways (MR) transit network in the Greater Yangon area (MR Yangon Transit System) as main part of this modernization roadmap. It includes the broad travel demand forecast methodology based on the update and use of YUTRA travel demand model, which was developed for the YUTRA study in 2013. This chapter covers the following:

1. Background studies, their outcome and influence on the MR Roadmap Study;
2. Update of YUTRA travel demand forecast model;
3. Current travel demand characteristics on MR network;
4. Travel demand forecast model input assumptions for MR Roadmap;
5. Study area socio-economic framework and total travel demand;
6. Rail patronage forecasts for 2020, 2025 and 2035 for the YCR and three suburban lines with different rolling stock and operating assumptions; and
7. An aggregate assessment of overall network performance.

3.2 Background and Objectives of Travel Demand Forecasts for the Roadmap Study

Travel demand forecasts for the MR Yangon Circular Railway Line (YCR Line) were initially prepared by 'YUTRA' – a master plan study of Yangon area completed in 2013 including its assessment and evaluation of the integrated transport master plan for the Greater Yangon area.

The study showed that the upgrading of the YCR and existing suburban MR network is essential. It emphasised that the upgrading of Yangon MR network should be implemented as an integral part of the transport infrastructure development programme, in a phased manner.

A pre-feasibility and a number of feasibility studies have been conducted to upgrade parts and/or all of the YCR. The development/ upgrading and phasing of the MR suburban services in Yangon, at a broad level to ascertain the effects of upgrading of YCR and subsequently of the timing of upgrading the suburban lines are the key objectives of this study.

3.2.1 YUTRA Travel Demand Forecast Model Update

The YUTRA transport demand model is a conventional 4-stage strategic demand model. The model forecast years were, 2018, 2025 and 2035. For this roadmap study, it was considered necessary to apply a simplified approach, as the objectives were simple enough to be able to forecast patronage on the rail network under different upgrade scenarios. Therefore, it was assumed that the following items could be accomplished at the outset:

- Update the 2013 data regarding the highway network to incorporate recent road upgrades, completion of new bridges and flyovers since the YUTRA traffic surveys. This includes upgrading regarding the road bridge over Hlaing river at Bayint Naung

which was under construction in 2013; five (5) flyovers (completed by 2015) and three (3) flyovers which are soon to be completed.

- Update of highway network data for the base year to reflect that all (25) RoB's are adequately represented in the model to reflect their current road capacity.
- All public vehicular (17 out of a total of 25, where the other 8 are either private or are located on unpaved roads) level crossings on YCR, which was not quite the case, as some minor level crossings were not included in the 2013 YUTRA strategic road network.
- Travel demand matrices were estimated for the current year 2015, to ascertain the current traffic conditions. The 2015 travel demand matrices, by mode, were estimated by interpolating the demand between the year 2013 and 2018 YUTRA trip matrices. This approach was simple and did not require the use of all the input data necessary to run the full 4-stage model.
- Similarly, the 2020 travel demand matrices by mode were estimated by interpolating the YUTRA forecast demand for the years 2018 and 2025. The sections of year 2020 as one of the forecast years were made so as to be able to represent the opening of the upgraded YCR in 2020.
- The other model input economic parameters such as GRDP/capita were also estimated by interpolation between the two relevant years.
- Estimation of MR proposed Diesel-Electric Multiple Unit (DEMU) and likely Electric Multiple Unit (EMU) rolling stock for the YCR and the three suburban lines and spurs.
- Update of the 'full' MR existing Greater Yangon area network characteristics: extending the rail network in the YUTRA model to the boundary of the YUTRA study area to better represent external travel demand. This implied including the Pyay Line up to Hmawbi station in the north, and Mandalay commuter line to Dabein in the east.
- Update the distances between stations incorporating the results of latest general surveys of the complete MR Yangon area network and the latest topographic survey data of the YCR survey studies.
- Update the base year train travel speed/ travel times based on new surveys of the YCR line.
- Further analysis of existing MR available travel demand to better understand the current travel patterns. For this purpose, both the YUTRA railway surveys and latest available MR data was further analysed and the results used to enhance the YUTRA model performance. The analysis results are presented in the next section.

3.2.2 Current MR Travel Demand Characteristics on MR in Yangon Area

The Yangon area MR network is about 143km long with 59 stations and it is summarised line-by-line below and depicted in Figure 3.2.1. The MR system runs three main lines, namely:

1. Yangon Circular Railway (YCR) line – this line is generally divided into two main sections: West section from Yangon Central to Da Nyin Gone via Insein (20.1km & 21 Stations, clockwise) and eastern section from Yangon Central to Da Nyin Gone via the east side (anti-clockwise direction) of the Circle Line 26.0km with 17 Stations; in total 46.6 km and 38 stations.
2. Pyay Line – It stretches north of Da Nyin Gone to Hmawbi a 19.4km section with 6 stations and a 3.0km spur section to serve Yangon Computer University. Total 22.4km with 7 stations.
3. Yangon-Mandalay line section – This is part of the Yangon-Mandalay north-south main line section from Yangon to Mandalay, the section from Yangon Central to Dabein is a 36.0km section with 7 stations and a 6.4km spur to Dagon University

north-east of Yangon. Passengers using the stations of Ma Hlwa Gone and pa Zuntaung are expected to use the YCR.

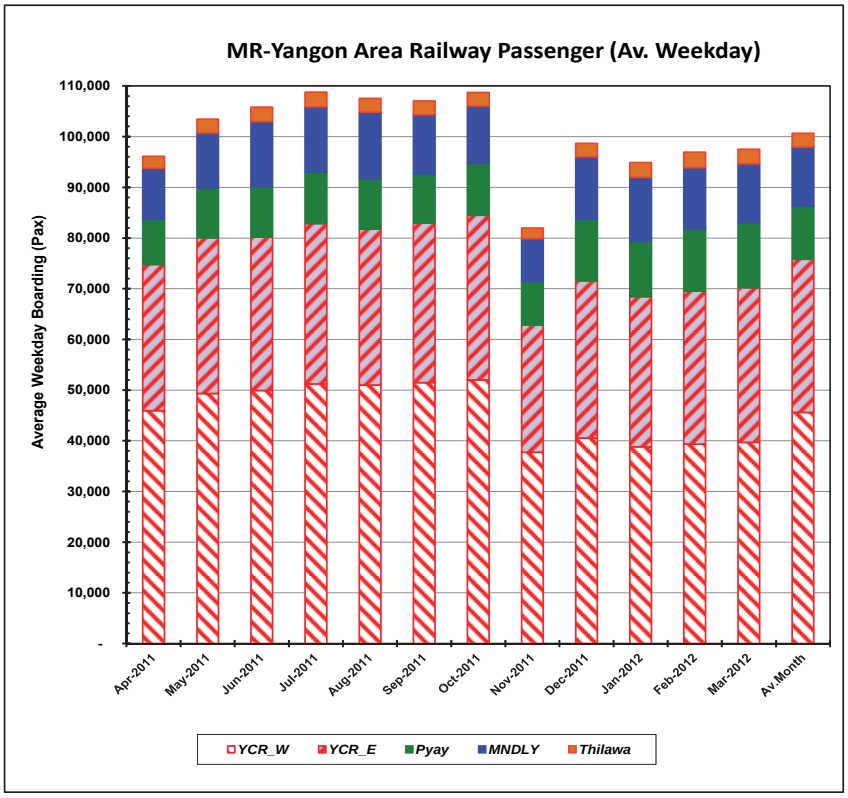
4. Thilawa Line – This is a branch line of 26.7km long to the south east industrial area of Yangon with 5 stations and a 5.0km spur which serves the East University of Yangon.

Source: JICA Study Team

Figure 3.2.1 MR Rail Line Network in the Greater Yangon Area

The YUTRA survey was analysed to build a station to station travel matrix. The matrix was then expanded to include all the stations in the MR network. The travel sample data collected by YUTRA surveys was expanded to cover the un-surveyed stations with the data from the MR

annual demand[1] data and later updated to the 2014 demand level. The latest data available from MR sources was for 2011-12, and average weekday demand by line is illustrated in Figure 3.2.2. The fall in demand in November 2011 is due to doubling of the fare from 100 to 200 MKY. However, the demand picked up soon after that and by mid-2012 was back at the almost the same level as it was early 2011.



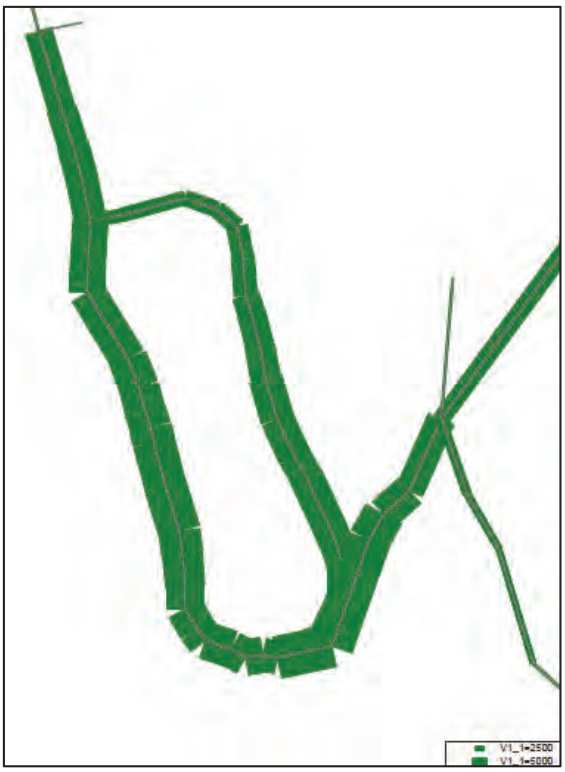
Source: YUTRA Study Team

Figure 3.2.2 Average Weekday Passenger Demand on the Four MR Lines in 2011-12

The figure illustrates that highest demand is on the circle line followed by patronage on the Mandalay line. Figure 3.2.3 depicts the passenger travel pattern along the four lines. It can be seen that the demand is highest on the YCR and Mandalay Line. The demand on both Pyay and Thilawa Lines is concentrated in the YCDC area. It is our considered view that demand as illustrated is reflective of the level of service on those lines. It is evident that because there are only two trains per day to Thilawa the demand is also limited. The Mandalay line demand appears to be high, that is due to the inclusion of intercity passengers in the demand, as the MR data is based on the ticket sales and not on the passenger origin and destination.

The overall demand and MR line characteristics are summarised in Table 3.2.1 below. The table demonstrates the currently low passenger volumes on the network. The average trip length is presented in the table and shows that on the YCR and the two suburban lines average trip length is low (under 10 km) with the exception of Mandalay line, which includes intercity travellers.

[1] MR Annual passenger data for 2011-12.



Source: JICA Study Team

Figure 3.2.3 Average Weekday Passenger Demand on the Four MR Lines in 2014

Table 3.2.1 Characteristics of MR Network and Current (2015) Travel Demand

Line	Stations	Line Description	Line Length (km)	Pax Boarding	Pax*km	Pax*Hrs	Pax*km /km
YCR-West	21	YCR West - YNG-DNG	20.1	43,000	417,400	32,500	20,800
YCR-East	17	YCR East DNG-YNG	26.0	43,400	87,000	15,400	3,300
YCR	**38**	**Full Circle Line**	**46.1**	**86,400**	**504,400**	**47,900**	**10,900**
Pyay	7	Pyay Line	22.4	29,800	95,300	30,000	4,200
Mandalay	8	Mandalay Line	42.4	13,800	110,700	7,600	2,600
Thilawa	6	Thilawa Line	31.7	3,500	21,400	2,900	700
Totals	**59**	**All Rail Lines**	**142.6**	**133,500**	**731,800**	**88,400**	**5,100**

Source: MR & YUTRA Survey Data and FS Study Team Analysis

3.2.3 Travel Demand Forecast – Demand Model Parameters

The YUTRA strategic travel demand forecast model was updated as described above in Section 3.2.1 to forecast the travel demand on the YCR west section. The following figure provides an outline of the overall model structure of the YUTRA demand model, and also illustrates the sub-models for YCR west section patronage forecast. The over model structure remained the same except the update and expansion of the railway network. As the changes made to the model network did not warrant model recalibration or new validation, the initial three stages of the YUTRA 4-stage model were retained.

The assignment sub-model with enhanced public and highway networks and future year public transport demand matrices was run to estimate the future year YCR patronage. The assignment process is based on minimum generalised cost of travel between each origin and destination pair, and it includes: fare, access/ egress time, walk time, wait time (based on route headway), in vehicle time and transfer time (where applicable). The output from the assignment model is the boarding and alighting passengers at bus stops, rail stations, and line volumes. The model input parameters used for the transit assignment are summarised in Table 3.2.2.

Table 3.2.2 YCR Feasibility Study Assignment Model Parameters

Description	Parameter Value
Bus & Other Para-transit Road Modes	
Bus, minibus, truck-bus and other para-transits	On all roads – no specific route
Fare (Kyat)	35.5kyt/km (2025) 71.8kyt/km (2035)
Bus Average Operating Speed (kph)	80% of mix traffic speed (km/h) to account for stopping time at bus stops
Railway Network (YCR, other MR Lines in Yangon Area)	
Fare - Distance Based (Kyat/km) (+20% premium fare on upgraded lines and current fares on remaining lines according to model test run)	Upgraded Lines: 35Kyt/km (2020) and 86Kyt/km (2035)
	Other Lines 29/km (2020) and 72/km (2035)
Average Daily Headway (minutes) & Rolling Stock, Depending on the model test run, as specified.	YCR 2020 & 2025 – 10 minutes (DEMU) YCR 2035 – 5 minutes(DEMU/EMU) Other Lines: 2025 & 2035 10 or 5 minutes, on DEMU and 10 or 5 minutes on EMU *No UMRT or BRT in 2020, 2025 & 2035*
Average Railway Operating Speed (km/h) using different rolling stock	See Figures 3.4.1 & 3.4.2 below
Ferry Services	
Fare (Kyat)	106+21.3/km (2025) 194+38.8/km (2035)
Headway (min)	15
Ave. Operating Speed (km/h)	20
Other Data Input for Transit Assignment	
Total Daily Public Transport Person Trips Overall mode share is reported below	4.09million (2020) 4.56million (2025) 5.67million (2035)
Other Forecast Year Network	YUTRA Master Plan (Do Maximum Scenario)
Value of Time of Public Transport users (excluding Taxi) Users	17.4 (2020) 23.4 (2025) 42.7 (2035)
• Average walking speed to access or egress the station 4kph • Average distance to walk to the station from nearest road - 100m • Average walking distance to transfer between lines - 100m • No additional fare paid to transfer between lines • Wait time is set at ½ the train headway, however for trains with longer headway a maximum value of 10 minutes is assumed as passenger will arrive according to the timetable, and not more than 10 minutes before the train arrives. • Wait time inconvenience factor, as passengers do not like to wait is set to be +50% of the wait time. • Walking and access/ egress or transfer inconvenience is set to be the same as the walking speed of 4kph. • In vehicle time factor, i.e. time spent in the train is calibrated to be 0.75 times the train travel time – as passengers would feel that they are travelling faster than the other mode, which they will be when compared to the average bus speed of under 15kph in 2035.	

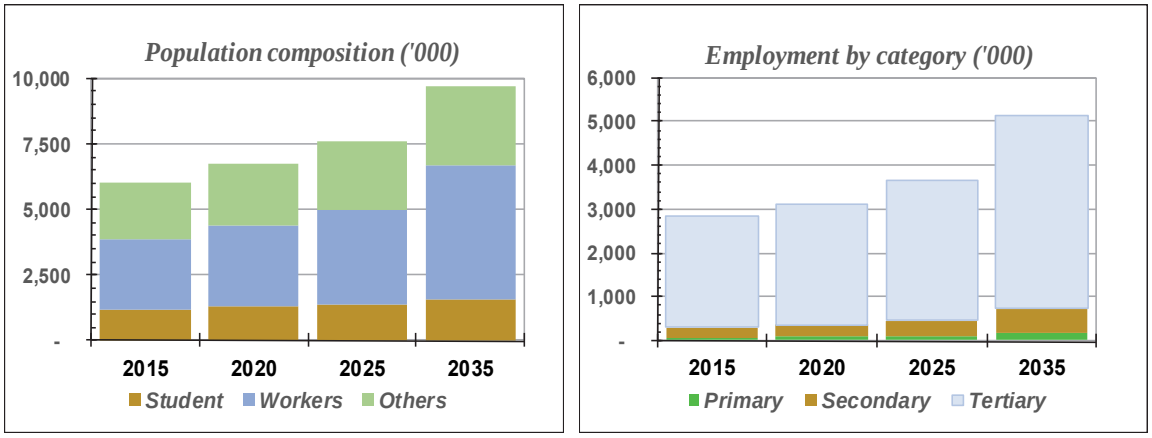
Source: JICA Study Team (2015)

3.3 Travel Demand Forecast

3.3.1 Socio-economic Framework

The travel demand forecast used for this roadmap development is based on the socio-economic framework prepared for the YUTRA study. The YUTRA socio-economic framework estimated the Yangon study area population, jobs, the number of students and the remainder population for the years 2013 to 2035.

The population is expected to grow at about 2.4% per annum, whereas the jobs/ working population growth rate would be around 3.3% p.a. indicating that the population will grow older and combined with economic growth by 2035 the workforce will represent about 53% of the population compared with nearly 45% in 2015. Figure 3.3.1 illustrates the population growth from 2015 to 2035, and also depicts the changes in jobs by each sector.



Source: JICA Study Team

Figure 3.3.1 Population and Jobs in Yangon Area

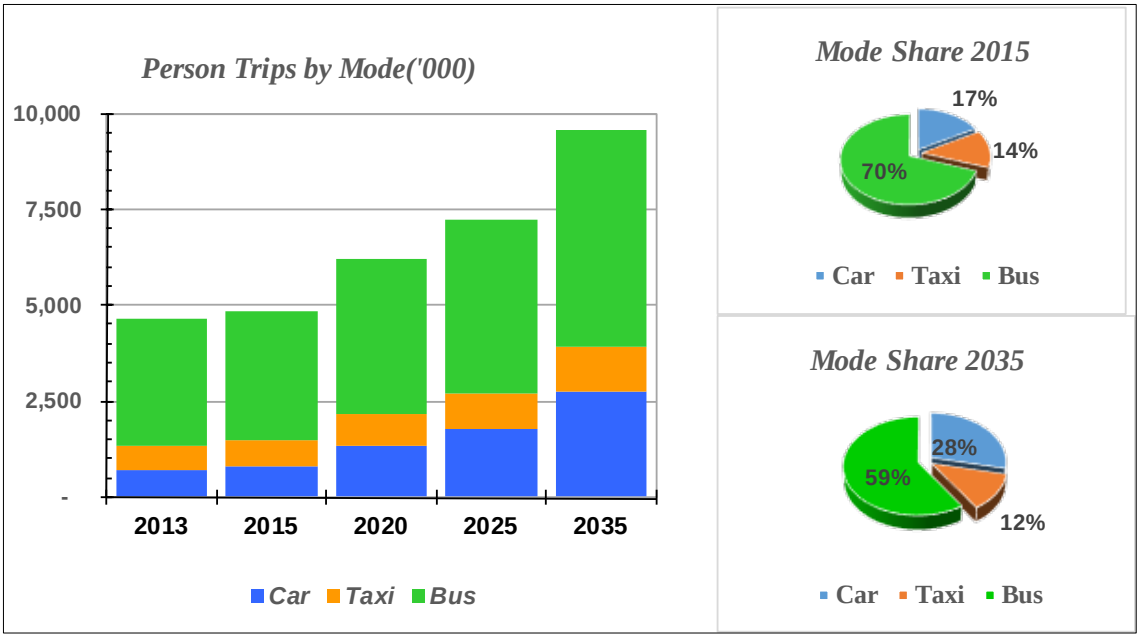
The growth in travel demand also relates directly to growth in the GRDP of the area, which in turn affects the vehicle ownership and the level of travel. These aspects are detailed in the YUTRA reports, and adopted here as estimated.

3.3.2 Total Travel Demand Forecasts

The YUTRA study estimated forecast travel demand in terms of total trips by mode of travel for the years 2013, 2018, 2025 and 2035. The 2015 and 2020 trip matrices were estimated by interpolation as outlined above in Section 3.2.1. The final total travel demand as used in this study is presented below in Figure 3.3.2. It can be seen that the public transport mode share (rail trips are included in the bus trips) is forecast to decline from 70% in 2015 to about 59% by 2035. However, the public transport trips are still estimated to increase from the current (2015) 3.4million trips to about 5.7 million trips by 2035, giving an average annual growth rate of 2.6% per annum, slightly above the population growth rate.

This would have direct impact on the demand for rail travel. However, if the rail mode to have sizeable share of the transport demand, which is currently only about 130,000 trips per day out of a total of over 4.8million trips per day is negligible.

The bicycle, motorcycle and goods vehicle trips were also modelled by the YUTRA study and used in this Roadmap study, as appropriate, but these trips are of little significance here. Hence are not detailed.



Source: JICA Study Team

Figure 3.3.2 Total Travel Demand by Mode of Travel

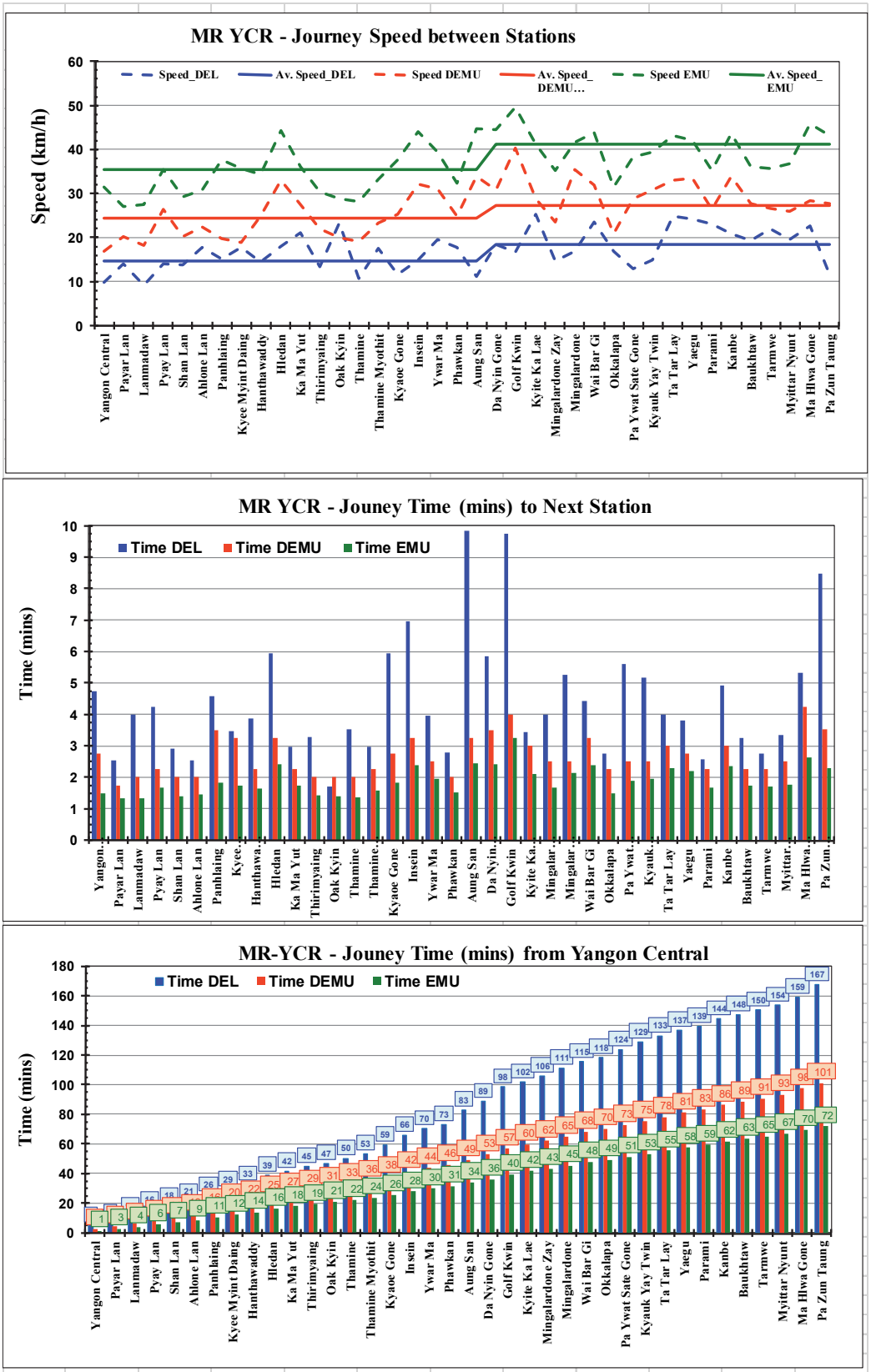
3.4 Travel Demand Forecast – MR Lines

The travel demand forecast for the MR Lines was estimated in the traffic assignment process. A number of model runs for each forecast year were carried out. The scenarios adopted included:

- Travel demand by year 2015, 2020, 2025 & 2035.
- MR fare level, base case or +20 for the upgraded lines, depending on scenario and year of operation.
- Average rolling stock speed estimated for the 2015, from the travel time surveys with DEL in operation. These are illustrated in Figures 3.4.1 and 3.4.2 below.
- Travel time/ speed between each pair of stations for the rolling stock in operation on the upgraded lines as appropriate.
- Highway network as proposed in the YUTRA master plan.

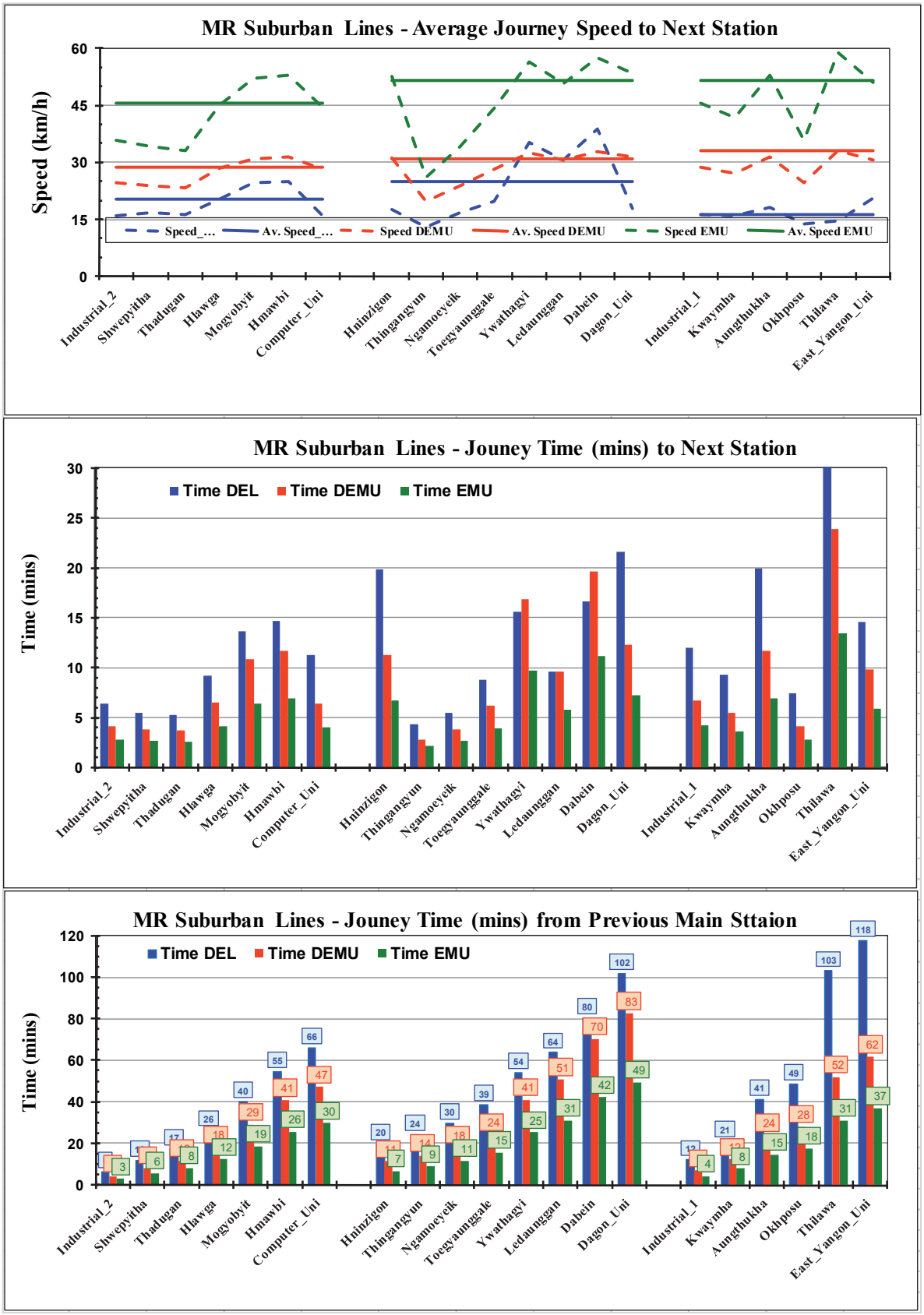
The travel demand assignment model, used a multi-user-class equilibrium assignment technique to assign trips to the road and rail network. All passenger trips had the choice to use road or rail mode according to total generalised cost of travel between each pair of traffic zones. Road traffic speeds are adjusted after each iteration of the assignment process depending upon the road capacity, free flow speed and traffic volume. In the case of the rail network, no capacity restraint was applied, and the rail speeds as input remain constant during the assignment model iteration process.

The MR rail speeds used were calculated using train, acceleration, deceleration, and 30 second dwell time for passenger to alight and board the train at each station. It is realised that the dwell time could be lower for stations with lower, demand, however in order to keep the variables to a minimum the same dwell time was used for all stations, except terminal or interchange stations.



Source: JICA Study Team

Figure 3.4.1 YCR Travel Speed and Times for DEL, DEMU & EMU

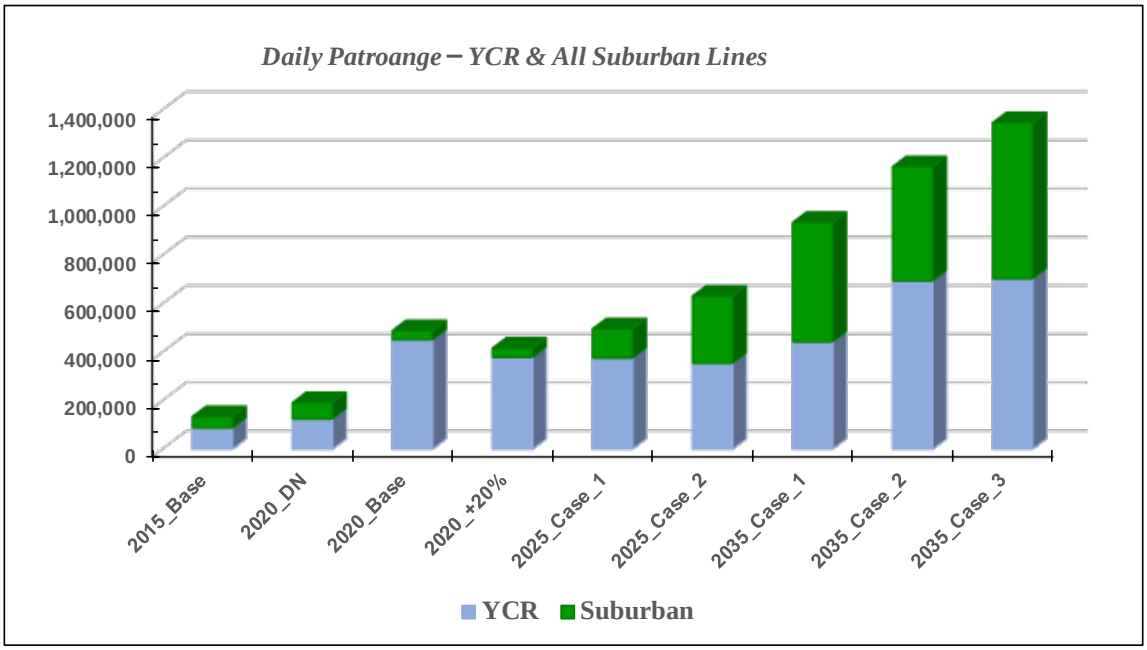


Source: JICA Study Team

Figure 3.4.2 MR Yangon Suburban Travel Speed and Times for DEL, DEMU & EMU

Using the above assumptions, the CUBE model was run for 2015, 2020, 2025 & 2035 for the do-noting situation and with various test scenarios. Initial results revealed that using the current fare would not be financially viable. It is true that lower fares attract much patronage, but this does not mean optimal accrual of revenue. Therefore, in previous studies a fare of current-fare +25% fare was used. But with the revised forecast for the roadmap study a premium fare of Base+20% was found to be near optimal in the case of YCR upgrading from DEL to DEMU operation. This increase in fare resulted in 15% reduction in demand. Hence, for all subsequent tests MR fare were set to be Base+20%.

The MR patronage forecast is illustrated in Figure 3.4.3 below and detailed by line in Table 3.4.1. The upgraded YCR in 2020 with higher (+20%) fares would increase the YCR patronage by three times in comparison with the do-nothing case (2020_DN), and double the overall MR ridership to 416k Pax/ day.



Source: JICA Study Team

Figure 3.4.3 MR Patronage Forecast Demand 2015 to 2035

The patronage demand estimate suggests that opening the whole YCR in 2020 would attract patronage of about 416k with fares set at +20% from their current level (2020_+20% case). This would increase by about 20% by the year 2025 (2025_Case_1). However, if by 2025 all MR lines were to operate DEMU at ten-minute intervals the demand on the system would increase to over 630k per day (2025_Case_2), and further increase in frequency to 12 trains per hour would increase the patronage by almost 48% by 2035 (2035_Case_1).

In the past, during various studies it had been discussed to upgrade the MR and electrify the system so that it could operate modern state-of-the art EMU. The higher speed of EMU would yield substantial time savings for the MR users, leading to much higher patronage. Under such scenario, ten minute headway would not be able to accommodate the demand, and would need to operate at 5 minute intervals.

The electrification of YCR, and the remainder of MR operating DEMU at the same headway would give 1,2 million pax per day (2035_Case_2), and the whole MR System using EMU at 5miute headway could attract as much as 1.3million pax per day (2035_Case_3). More than 50% of this demand would be on YCR, followed by Mandalay suburban line and Thilawa line. Pyay Line, which attracts relatively higher demand in earlier years, would not be as attractive as the other two suburban lines, as the long term future population and employment growth are likely to be in the north-east and south-east regions of greater Yangon.

Table 3.4.1 Number of Boarding Passengers and MR Lines – *All Test*

Roadmap CUBE Model Test Options	Fare Level	Demand Level	Network (Highway, Railways and NO UMRT & NO BRT)										
			MR Line Rolling Stock/ Headway				Road Net	Patronage (Pax/day)					
			YCR	Pyay	Man-dalay	Thilawa		YCR	Pyay	Man-dalay	Thilawa	Sub-Total Suburban	Total
Base year	Current	2015	*DEL/20*	DEL/30	DEL/30	DEL/30	Base	87,200	29,100	13,800	3,600	46,500	**133,700**
YCR - NO Upgrade	Current	2020	*DEL/20*	DEL/30	DEL/30	DEL/30	MP	124,400	40,100	5,300	21,400	66,800	**191,200**
YCR Upgrade			DEMU/10	DEL/30	DEL/30	DEL/30	MP	451,300	34,300	1,300	1,500	37,100	**488,400**
	Current +20% Only on Upgraded Sections		DEMU/10	DEL/30	DEL/30	DEL/30	MP	378,500	34,300	1,500	1,600	37,400	**415,900**
YCR Upgrade		2025	DEMU/10	*DEL/20*	*DEL/20*	*DEL/20*	MP	375,300	55,500	41,400	23,300	120,200	**495,500**
ALL MR Operating DEMU			DEMU/10	DEMU/10	DEMU/10	DEMU/10	MP	353,800	73,500	109,600	94,100	277,200	**631,000**
		2035	DEMU/ 5	DEMU/ 5	DEMU/ 5	DEMU/ 5	MP	442,200	142,200	175,400	175,100	492,700	**934,900**
YCR EMU			EMU/ 5	DEMU/ 5	DEMU/ 5	DEMU/ 5	MP	693,600	144,000	154,700	172,800	471,500	**1,165,100**
ALL MR - EMU			EMU/ 5	EMU/ 5	EMU/ 5	EMU/ 5	MP	702,600	181,800	255,100	207,100	644,000	**1,346,600**

NB: DEL= Diesel Electrical Locomotive, as Used Currently; DEMU=Diesel Electrical Multiple Units; & EMU=Electrical Multiple Units / = Headways in Minutes.

NB: Fare Increase Only Applies to Upgraded Lines Operating DEMU or EMU [With Higher Frequency]

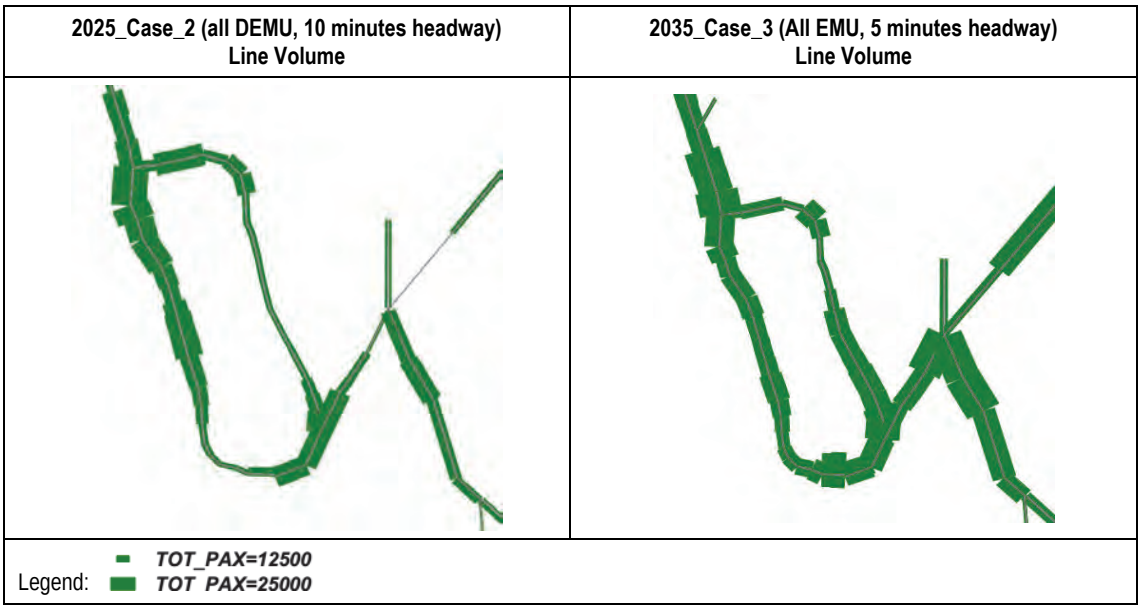
YCR - Complete Circle Line, After proposed upgrade, with simple circular operation at stated headway

Pyay Line: - Line modelled up to Hmawbi - just outside Greater Yangon, with Spur to Computer Uni.

Yngn-Mndly - to Dabein just outside Greater Yangon, with Spur to Dagon Uni [Not serving Ma Hlwa Gone & Pa Zun Taung stations, served by YCR]

Thilawa line + spur line to Eastern Univ assuming current stations only

Source: JICA Study Team



Source: JICA Study Team

Figure 3.4.4 Travel Demand Volume on MR Network 2025_Case-2 & 2035 (Case-3)

3.5 Assessment of MR Rail Network Performance

The realisation of the benefits of introduction of an upgraded rail network may be expressed in terms of network-wide total travel in units of passenger-km travelled on the road and similarly the amount of time spent by passengers. The following Table 3.5.1 gives the changes to travel distance and times for each of the patronage scenarios discussed above, these changes are further illustrated in Figure 3.5.1. It should be noted that the comparison should be only in relative terms within each year of scenario test, and not in absolute numbers, as the changes in travel times and distance also reflect the changes to the highway network (to reflect the Master Plan – MP) with that test year.

Table 3.5.1 Network Assessment, MR Lines – *All Tests*

Roadmap CUBE Model Test Options	Fare Level	Demand Level	Network (Highway, Railways and NO UMRT & NO BRT)						Network Evaluation			
			Rolling Stock/ Headway		Road Net	Patronage (Pax/day)			Bus Only		All Modes	
			YCR	ALL Suburban		YCR	Sub-Total Suburban	Total	Pax*km ('000)	Pax*Hr ('000)	TTC MKY(m)	VOC MKY(m)
Base year	Current	2015	*DEL/20*	DEL/30	Base	87,200	46,500	**133,700**	37,324	1,304	1,980	6,695
YCR - NO Upgrade	Corrent	2020	*DEL/20*	DEL/30	MP	124,400	66,800	**191,200**	48,118	2,375	5,714	12,305
YCR Upgrade	Current		DEMU/10	DEL/30	MP	451,300	37,100	**488,400**	45,092	2,282	5,602	12,198
	Current +20% Only on Upgraded Sections		DEMU/10	DEL/30	MP	378,500	37,400	**415,900**	45,949	2,306	5,627	12,206
YCR Upgrade		2025	DEMU/10	*DEL/20*	MP	375,300	120,200	**495,500**	43,049	1,316	4,860	10,684
ALL MR Operating DEMU			DEMU/10	DEMU/10	MP	353,800	277,200	**631,000**	42,082	1,283	4,804	10,643
YCR EMU		2035	DEMU/ 5	DEMU/ 5	MP	442,200	492,700	**934,900**	57,442	1,563	12,160	15,803
ALL MR - EMU			EMU/ 5	DEMU/ 5	MP	693,600	471,500	**1,165,100**	55,268	1,535	12,077	15,755
			EMU/ 5	EMU/ 5	MP	702,600	644,000	**1,346,600**	52,992	1,473	11,894	15,676

NB: DEL= Diesel Electrical Locomotive, as Used Currently; DEMU=Diesel Electrical Multiple Units; & EMU=Electrical Multiple Units

NB: Fare Increase Only Applies to Upgraded Lines Operating DEMU or EMU [With Higher Frequency]

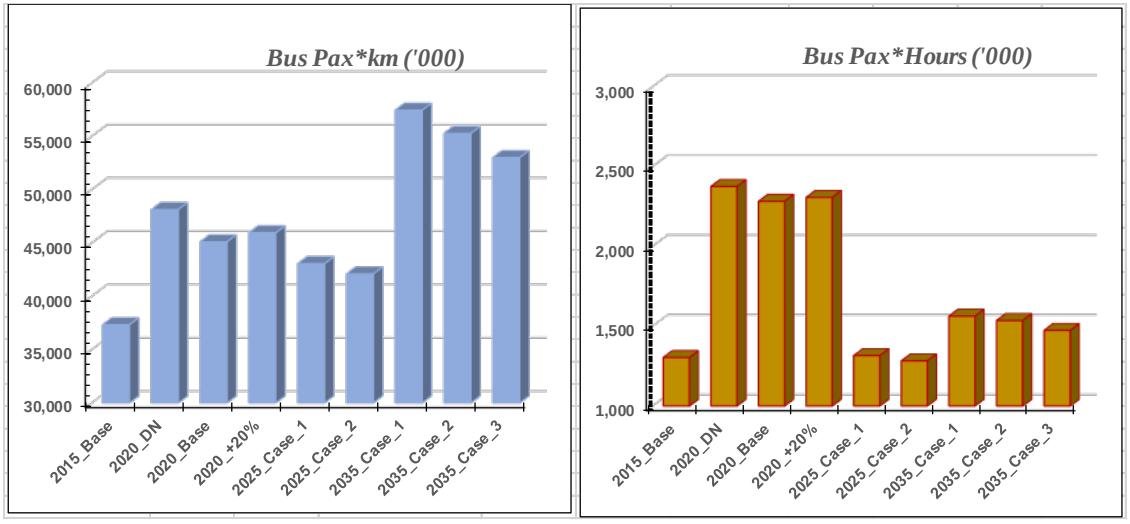
YCR - Complete Circle Line, After proposed upgrade, with simple circular operation at stated headway

Pyay Line: - Line modelled up to Hmawbi - just outside Greater Yangon, with Spur to Computer Uni.

Yngn-Mndly - to Dabein just outside Greater Yangon, with Spur to Dagon Uni [Not serving Ma Hlwa Gone & Pa Zun Taung stations, served by YCR]

Thilawa line + spur line to Eastern Univ assuming current stations only

Source: JICA Study Team



Source: JICA Study Team

Figure 3.5.1 Network Assessment passenger-km and Passenger-hours – All Scenarios

It can be seen that in 2020 the introduction of an upgraded YCR would reduce the Pax-km and Pax-hours substantially from the do-nothing scenarios, and the increase in fares has limited impact on these indicators. In 2025, when part of the inner urban ring road (IRR) and other arterial roads are constructed the overall Pax-km and Pax-hrs are substantially lower. However, the impact of introduction of DEMU on YCR and suburban lines is noticeable, and this reduces both the Pax-km by 967,000 Pax-km and over 33,000 Pax-hours per day.

In 2035, Case-1 represents all lines are served by DEMU operating at a 5-minute headway. The Introduction of EMU on YCR at the same headway would reduce the travel by 2.1m Pax-km and 28k Pax hours. The further introduction of EMU on the suburban lines (2035_Case_3) would further reduce the Pax-km by over 2,2m Pax-km and 22k Pax hours in 2035. Therefore, a case could be made for an early introduction of EMU on the entire MR Yangon area network.

MR has a vision of electrification of the urban rail transit system in the Yangon metropolitan area, including the YCR Line and other connecting lines in the future, which is recommended as part of the long-term urban transit development plan in YUTRA.

Necessary power supply for electrification of the YCR Line is estimated more than 100MW in the YUTRA study, and which must be stable to run the trains. While, there is a continued power supply shortage problem in the Yangon metropolitan area. Actually it is difficult to fully accommodate neither the daily activities of the residents nor industrial activities in the metropolitan area as of today. Continued effort to improve the power supply condition has been made by the Myanmar Government, while the demand for power is also growing sharply.

Considering this situation, it is recommended that preparation of urban transit electrification master plan, including development of exclusive power supply system for the urban transit system, is carried out after completion of the improvement of the existing facilities of the YCR Line.

Chapter 4 MR's Yangon Transit System Development Roadmap

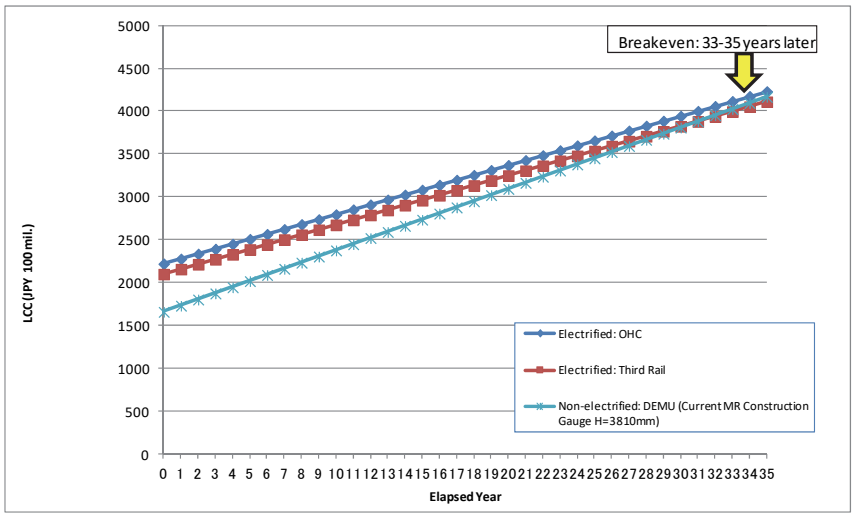
4.1 Electrification of YCR

4.1.1 Timing of Electrification

The demand forecast suggests that the Yangon Circular Railway needs to be electrified in the future in order to achieve higher performance of train operation and accordingly quality level of service as one of the main rail transit systems in the mega city of Yangon.

The figure below shows the comparison between electrified and non-electrified rail transit systems on YCR in terms of life cycle cost (LCC). In general, operation and maintenance (OM) cost of an electrified railway (assuming overhead catenary system) is lower than that of a non-electrified system (assuming DEMU), while the initial investment cost of an electrified railway is much higher than that of a non-electrified system where train operation of high frequency is needed.

This indicates that there is a breakeven point between the two options, namely electrified and non-electrified options, in terms of accumulated capital cost and OM costs. Figure 4.1.1 shows a breakeven point could be found at around 35 years after the commencement of operation. If no significant additional investment is made to upgrade the YCR within 35 years after the opening year, a non-electrified option is still preferred in terms of accumulated capital and OM costs, but at the same time it can be said that an electrified option has an advantage in the long run in terms of OM costs and expected higher fare box revenue (higher patronage in comparison with a non-electrified system). In addition, it should be noted that this discussion is limited to the railway sector's aspect only but not includes other benefits of electrification such as increased opportunity of TOD brought from higher patronage.



note) Common O&M cost for both electrified and non electrified is not included in LCC. Therefore , actual LCC and O&M cost will be increased from above number.

Source: JICA Study Team

Figure 4.1.1 Comparison of Life Cycle Cost of Electrified and Non-Electrified Urban Railways

4.1.2 Electrification Technology

The YCR will be upgraded using Japanese ODA loan for rolling stocks and signalling systems and MR's own budget for the corresponding civil works, as an at-grade non-electrified system in its initial stage of modernization. The opening of the improved YCR transit service is scheduled in 2022, and MR continues to provide the service using the upgraded non-electrified system. While electrification (and track elevation with TOD) can be from now by MR.

As part of such advanced modernization study, a study on technical options of electrification shall be included. In general, there are three options as follows:

- Over Head Catenary (OHC) type [proven technology as of today]
- 3rd rail type [proven technology as of today]
- Catenary-less power type [under development]

Characteristics of each electrification option type are summarized in Table 4.1.1.

In the future an option of catenary-less power can be considered as one of the suitable systems if the technology is recognized as a proven technology.

Table 4.1.1 Advantages and Disadvantages of Electrification Options

	OHC Type	3rd Rail Type	Non-Catenary type
Figure			
Advantages	• Proven technology • Widely used technology across the world • Level crossing can be installed freely.	• Proven technology • Low construction gauge / car gauge height required.	• Low construction gauge / car gauge height required. • Level crossing can be installed freely. • Both disadvantages of OHC type and 3rd rail type can be solved.
Disadvantages	• High construction gauge / car gauge height required. • Many existing ROB must be reconstructed (elevated higher).	• Low railway line expandability due to 3rd rail, which is installed beside track, is not suitable for long distance train and complicated track layout • Level crossing installation to be avoided due to danger of electric shock.	• Under development stage, but the availability is unknown • The height of ROBs can remain as they are.
Evaluation	Possible as of today	Not recommended for YCR due to low expandability	Desirable But subject to timing of availability of the technology

Source: JICA Study Team

4.2 Phased Yangon Transit System Development

4.2.1 Rail Transit Network Development

MR's Yangon Transit System (MR-YTS) is faced with many issues to be solved towards development of a decent urban rail transit system as mentioned in the previous sections. These issues can be addressed in a phased manner with consideration on the budget envelope of the Government of Myanmar.

A phased urban rail network development is now prepared as a basis for the roadmap of modernization of MR-YTS based on the principles stated below:

- Full-scale electrification of MR-YTS is planned as a far future project after the year 2035 in consideration of the life time of DEMU purchased by the on-going Japanese ODA loan project. A study on the electrification (and track elevation) can be carried out in parallel.
- SUDP's urban development scenarios and corresponding traffic demand forecasts should be the basis for prioritization of urban rail segments.
- In addition to the urban rail network in the Greater Yangon area, it is assumed that the proposed Outer Yangon Circular Railway is constructed as a detour route for freight trains. By doing so, the capacity of MR-YTS lines can be fully allocated to the MR-YTS commuter trains.
- Projects to increase the level of services of MR-YTS, such as advanced ticketing system introduction (smart card), station plaza development (TOD), etc. should be carefully planned at each phase.

MY-YTS network development is divided into seven (7) phases as shown in Figure 4.2.1.

The initial improvement work of the whole YCR (Phase 1), which will be carried out using Japanese ODA loan for rolling stocks and signalling systems and MR's own budget for the civil works, will complete by 2020. In the Phase 2 Thilawa line will be improved in order to support new social and economic activities on the eastern bank of the Bago River, namely Thilawa area. Consequently, radial lines, namely, Pyay line will be improved in Phases 3 and 4. The Outer Ring Rail line will be constructed during the Phase 5. Spur lines of shorter distance will be improved in Phase 6. All projects from Phase1 through Phase 6 shall be carried out by the year 2035.

Immediately after completion of the basic design work for the Phase 1 project, it is expected that MR will carry out a feasibility study on the improvement of Thilawa line and Pyay line (Da Nyin Gone – Hlawga).

4.2.2 Operation Control Centre (OCC)

In addition to the on-going OCC project for the Yangon – Mandalay Railway, a compatible OCC shall be installed to monitor the Yangon Transit System including YCR and other extended transit lines. OCC is expected to be installed in Phase 2 and 3. To achieve this target a detailed study on the OCC shall be carried out in parallel with the Phase 1 improvement work.

4.2.3 Station modernization and transit oriented development (TOD)

Improvement of the existing station by MR, including renovation (or reconstruction) of existing station buildings and installation of associated facilities such as escalator/elevator and automated fare collection system, will be carried out from Phase 2, immediately after

completion of Phase 1 (Phase 1 improvement does not include installation of such facilities because of budget constraint), through Phase 6.

In addition to this, there is a critical issue which should be addressed in MR's modernization process, namely land value capture issue. The existing urbanized areas in Yangon, especially those of low density, will be regenerated as the urban economy grows and the population increases. Ideally it is expected that such urban regeneration happens in a form of transit oriented development (TOD), especially in peripheral areas of the YCR stations. In addition to the regeneration of the existing railway station areas, introduction of new stations provides great opportunity in increasing efficiency of land use having potential of high value along the YCR. As part of MR's roadmap of transit system development, such land value capture (LVC) opportunity must be seriously considered. In this regard it is highly recommended to carry out another study on the land value capture of MR's land in the Greater Yangon Area. Potential stations that require TOD study include, but not limited to:

- Yangon Central Station
- Kyee Myint Daing
- Thamine
- Insein
- Da Nyin Gone
- Mingalardon
- Pa Ywat Sate Gone
- Yaegu (Okkala TOD Center in the future)
- Ma Hlwa Gone

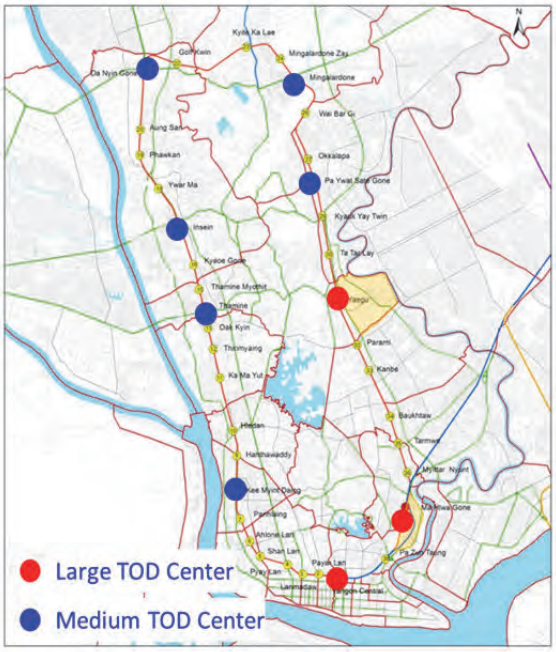


Figure 4.2.1 Candidate TOD Centres

4.2.4 Advanced Ticketing System

In parallel with the modernization of rail based Yangon Transit System, other public transport systems including buses and taxis, and pedestrian environment should be improved to improve the level of service of public transport systems in the Greater Yangon area as a whole. One of the key strategies is to develop a common ticketing system (smart card) which can be used for all public transport systems in the area. Such advanced ticketing system is expected to be fully available in Phase 3. A detailed study on the common ticketing system shall be carried out during Phase 1 and 2.

4.2.5 Modernization of O&M

The existing operation and maintenance (O&M) of the YCR and other lines in the Greater Yangon area is carried out by Division 7, MR. The role of Division 7 will remain the same to operate the Yangon Transit System after series of upgrading works. Modernization of O&M for the Yangon Transit System shall be carried out from Phase 1 through Phase 2 as shown in Figure 4.2.3.

Daily maintenance work for the rolling stock will be carried out in the Insein depot (ex-Insein DRC) by the staff of mechanical and electric department of Division 7 using newly purchased maintenance equipment for DEMU. Periodic heavy maintenance work will be carried out in the Ywa Thar Gyi workshop where maintenance work of all rolling stock in Myanmar will be carried out under the direct control of MR HQ's mechanical and electric department.

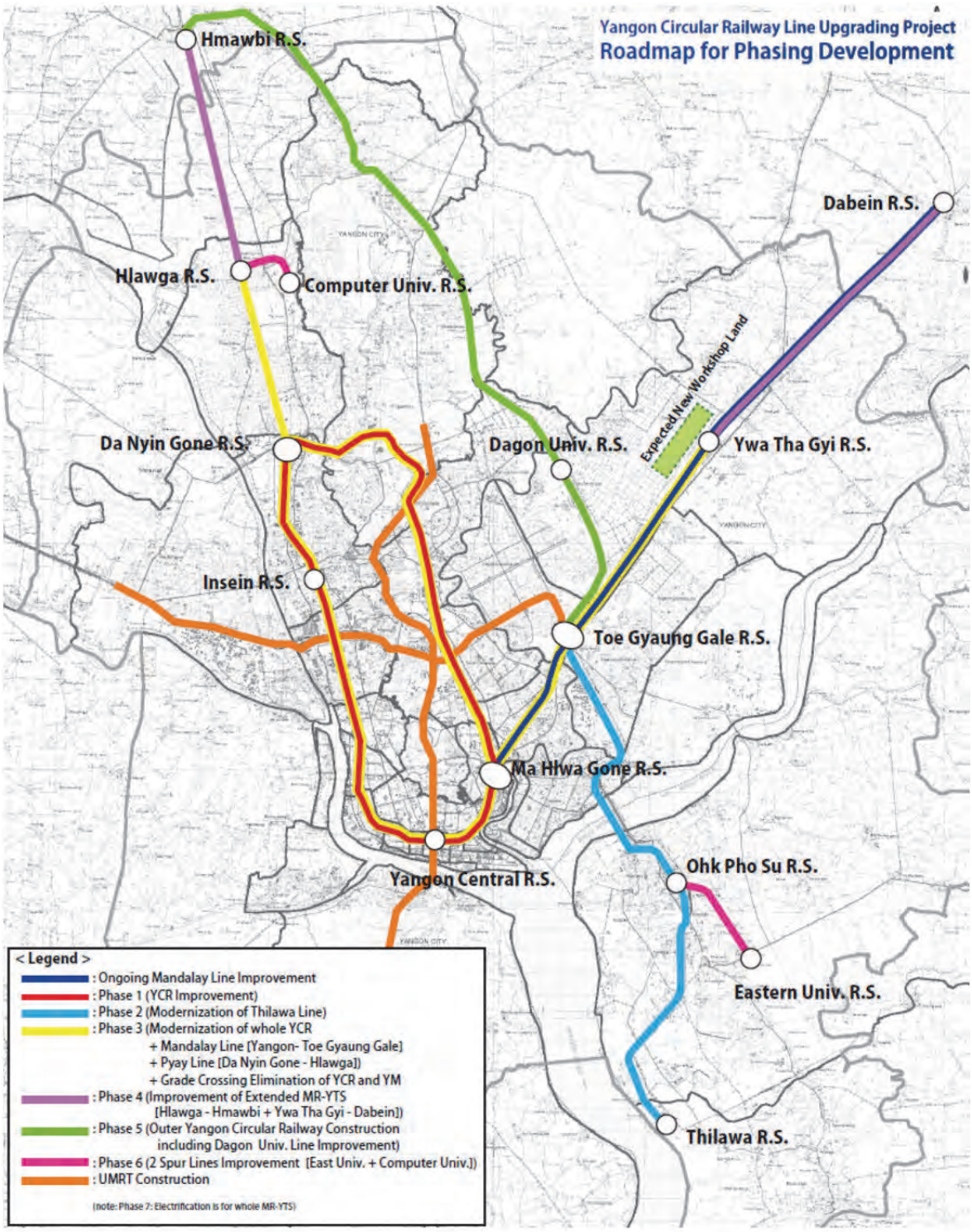
Division 7 is also responsible for the maintenance of track, signalling, and telecommunication by corresponding department namely civil department and signal & telecom department of Division 7.

4.2.6 Modernization of MR management

Division 7 requires further improvement and capacity increase in terms of advanced O&M and customer service development during the course of the modernization of MR.

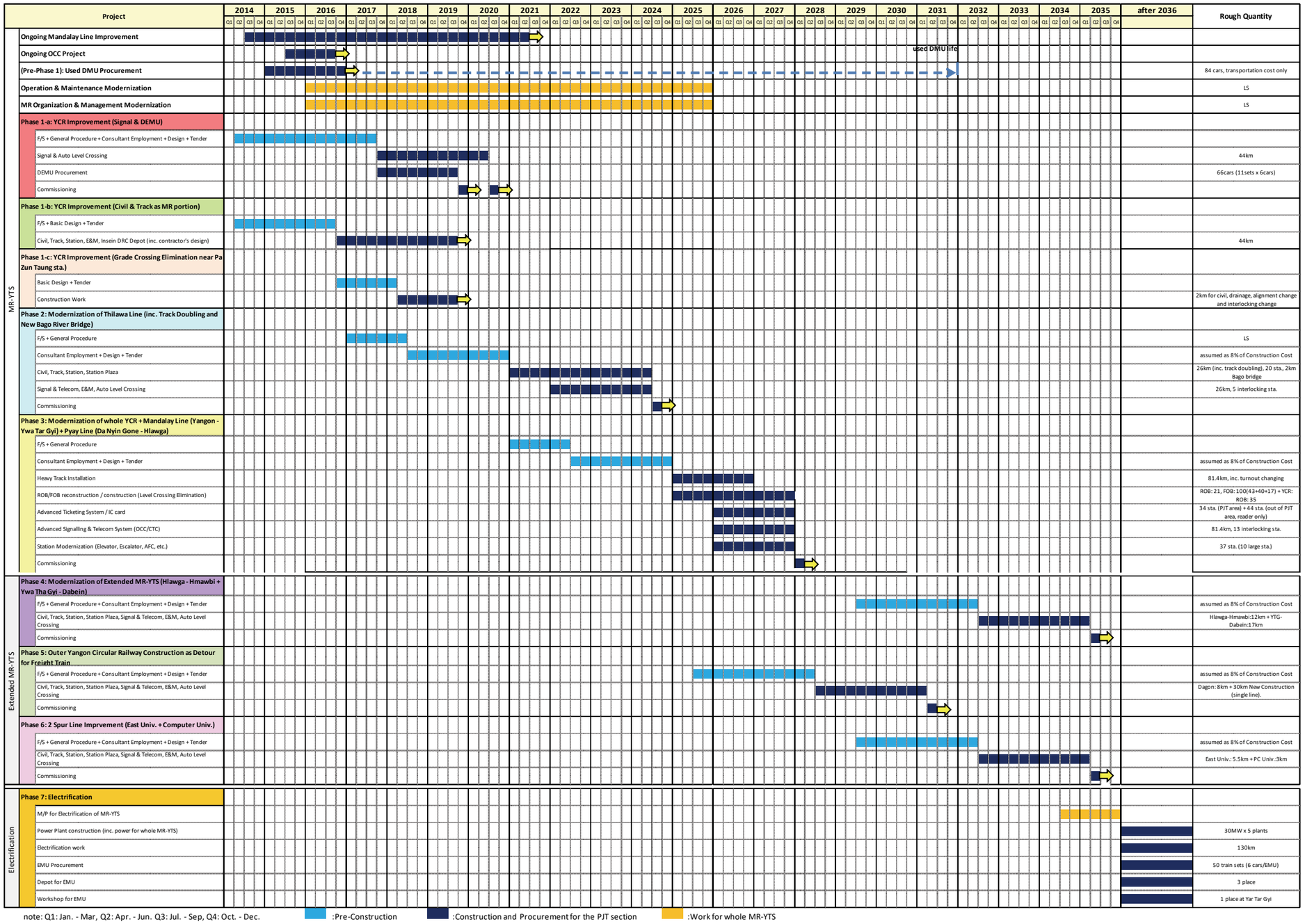
Japan International Cooperation Agency (JICA), Ministry of Land, Transport and Tourism (MLIT) and Japan Railway (JR) have been providing technical assistance in improving the capacity of MR staffs in various fields to date. Such technical transfer is recommended to be continued and further strengthened to improve the MR staff capacity as part of the modernization roadmap.

With regard to the service level the Yangon Transit System (firstly the YCR Line), it is recommended that Division 7 establishes a special department, namely, "Customer Service Department". Since the existing MR is not well accustomed to customer service development, in this regard introduction of skills and knowledge from private railway companies such as Japan Railway (JR) is highly recommended.



Source: JICA Study Team

Figure 4.2.2 Phased Rail Transit Network Development (improvement)



Source: JICA Study Team

Figure 4.2.3 Schedule for Phasing Development Plan

Upgrade Component \ Section		MR-YTS					Extended MR-YTS		Spur Lines			
		YCR West	YCR East	Pyay Line	Mandalay Line	Thilawa Line	Pyay Ext	Mandalay Ext.	East Univ.	PC Univ.	Dagon Univ.	Outer YCR
		Ma Hlwa Gone - Yangon - Da Nyin Gone	Ma Hlwa Gone - Mingalardone - Da Nyin Gone	Da Nyin Gone - Hlawga	Yangon - Ywa Tha Gyi	Toe Gyaung Gale - Thilawa	Hlawga - Hmawbi	Ywa Tha Gyi - Dabein	Okhposu - East Univ.	Hlawga - Computer Univ.	Toe Gyaung Gale - Dagon Univ.	Dagon Univ. - Hmawbi
Existing Line Improvement	Civil / Track work (at-grade)	Phas1-b		Phase 2	by YM	Phase 2	Phase 4	by YM	Phase 6	Phase 6	Phase 5	Phase 5
	Civil / Track work (elevated viaduct)											
	Station / Station Plaza improvement	Phase 3	Phase 3	Phase 3	Phase 3	Phase 2	Phase 4	Phase 4	Phase 6	Phase 6	Phase 5	Phase 5
	Signal improvement (inc. auto level crossing)	Phase 1-a		Phase 3	by YM	Phase 2	Phase 4	by YM	Phase 6	Phase 6	Phase 5	Phase 5
	Telecom. Improvement	Phase 3	Phase 3	Phase 3	by YM	Phase 2	Phase 4	by YM	Phase 6	Phase 6	Phase 5	Phase 5
	E & M improvement	Phase 1-a		Phase 3	by YM	Phase 2	Phase 4	by YM	Phase 6	Phase 6	Phase 5	Phase 5
	(Used DMU procurement)	(Pre-Phase 1)			by YM			by YM	(used YM DEMUand/or used DMU)			
	Depot for DMU	Phase 1-b			by YM			by YM	Phase 6	Phase 6	by YM	
	Workshop for DMU	by YM						Existing and/or by YM				
	Elimination of Grage Crossing of YCR and Mandalay Line	Phase 1-c			Phase 1-c							
Electrification	Electrification Work	Phase 7					Phase 7					
	(Power Plant construction)	Phase 7										
	EMU procurement	Phase 7					Phase 7					
	Depot for EMU	Phase 7										
	Workshop for EMU	Phase 7										
	ROB reconstruction/construction	Phase 3					Phase 4	Phase 4				
	FOB reconstruction/construction	Phase 3					Phase 4	Phase 4				
Other Modernization Items	New Line Consruction											
	OCC/CTC	Phase 3				Phase 2	Phase 4	Phase 4	Phase 6	Phase 6	Phase 5	Phase 5
	Station Modernization (Elevator/Escalator, AFC, Passenger Service Facility Modernization, etc.)	Phase 3				Phase 2	Phase 4	Phase 4	Phase 6	Phase 6	Phase 5	Phase 5
	Advanced Ticketing / IC card	Phase 3					Phase 4	Phase 4	Phase 6	Phase 6	Phase 5	Phase 5
	Operation & Maintenance Modernization	Phase 1 - 3										
	MR Organization & Management Modernization	Phase 1 - 3										

Source: JICA Study Team

Figure 4.2.4 Project Components for Phasing Development Plan

4.3 Recommended improvements in earlier Phases

4.3.1 Heavy Rail Track

MR uses 37kg/m rail for all of the railway lines including trunk lines such as the Yangon Circular Railway and the Yangon-Mandalay Line to date. 37kg/m rail, however, which is categorized as light track, is recognized as not suitable for urban railways because frequent maintenance and corresponding higher maintenance costs are expected due to frequent train operation in urban areas. For example, in Japan, many rail companies use 50kg/m or 60kg/m rail (heavy rail) in urban areas.

The initial installation cost of light rail track such as 37kg/m rail is lower than that of heavy rail, but the life cycle cost of installing heavy rail is normally lower.

A simple comparative analysis was made to understand the pros and cons in using rails of different weight.

Three track component alternatives are prepared for this analysis:

- Alternative A: New 50N (long rail) + New PC + New Ballast (250mm)
- Alternative B: New 37kg/m (24m rail) + Old PC + New Ballast (250mm)
- Alternative C: New 37kg/m (12m rail) + Old PC + New Ballast (250mm)

  Note: The above Alternatives do not include turnouts and yards.

Detail track components of the alternatives are shown in the table below.

Table 4.3.1 Detail Track Components of the Alternatives

Item \ Alternatives	A	B	C
New 50^{N} (Long rail)	✔		
New 37 (24^{m} rail)		✔	
New 37 (12^{m} rail)			✔
New PC	✔		
Old PC		✔	✔
New Ballast ($250^{m/m}$)	✔	✔	✔
Tamping	✔	✔	✔
Machine & Instrument	✔	✔	✔

Source: JICA Study Team

The initial installation cost of each alternative is estimated based on the current material prices, construction cost of similar projects, etc. as shown in Table 4.3.2.

Table 4.3.2 Initial Investment Cost for the Alternatives (per 1track-km)

(Unit: mil. JPY)

Item \ Alternatives	A	B	C
New 50^{N} (Long rail)	25.3	–	–
New 37 (24^{m} rail)	–	20.2	–
New 37 (12^{m} rail)	–	–	18.2
New PC	9.4	–	–
Old PC	–	0.6	0.6
New Ballast (250$^{m/m}$)	6.0	6.0	6.0
Tamping	10.0	10.0	10.0
Machine & Instrument	20.0	10.0	5.0
Total	**70.7**	**46.8**	**39.8**

Source: JICA Study Team

Operation and maintenance (O&M) cost of each alternatives is also estimated based on the current labour and material prices and required quantities of similar works, etc. Table 4.3.3 shows O&M cost of each alternative.

Table 4.3.3 O&M Cost for the Alternatives (per 1track-km)

(Unit: mil. JPY)

Item \ Alternatives	A	B	C
Tamping	0.63	0.84	1.05
Material	0.35	1.05	1.05
Inspection & Management	0.60	0.75	0.75
Total	**1.58**	**2.64**	**2.85**

Note: The price escalations for tamping, material and inspection & management are to be adopted for the comparison of Life Cycle Cost (LCC) among the Alternatives as follows:

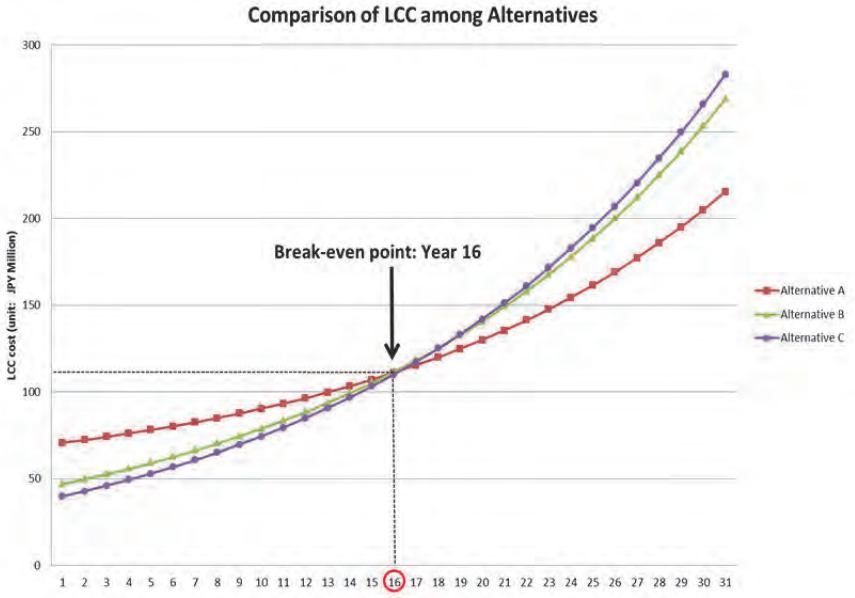
Tamping: 7% per annum

Material: 4% per annum

Inspection & Management: 7% per annum

Source: JICA Study Team

Figure 4.3.1 shows accumulated cost of each alternative. From this figure, it is observed that the breakeven point between light track (37kg/m) and heavy track (50N) is expected at approximately 16 years after installation.



Source: JICA Study Team

Figure 4.3.1 Comparison of Accumulated total cost

A generic idea about the life cycle cost of rail track installation is summarized as shown in Table 4.3.4.

Table 4.3.4 Comparison of alternatives

Alternatives / Cost	Initial	O&M	LCC
Alternative A	Middle	Low	**Low**
Alternative B	Low	High	**High**
Alternative C	Low	High	**High**

Source: JICA Study Team

It can be concluded that from a long term perspective, total cost of Alternative A (heavy rail track) is preferred. It is highly recommended that MR uses heavy rail track as soon as possible (ideally from Phase 1) in its modernization process.

4.3.2 Level crossings

There are 25 level crossings on the YCR. Their locations and key characteristics are summarised in the following Table 4.3.5. In fact, public traffic uses 17 of these, whereas the remaining are either built to provide direct access to private factories/ properties or these are just left over from old rural un-paved streets. These level crossings provide accessibility across the YCR rail track, reducing severance. However, there are also 25 road bridges over the YCR and an underpass making it in total 51 facilities to cross the YCR.

The level crossings draw more attention as these cause delays to traffic and often end up being a nuisance due to excessive delays to traffic, particularly when the train is late. Also on occasions delays are also caused to the trains when the barriers are not closed. Another major concern is public safety.

The major issues concerning YCR level crossings are summarized as follows:

- At some locations, their close proximity to RoB;
- Close proximity to each other, without any rationale;

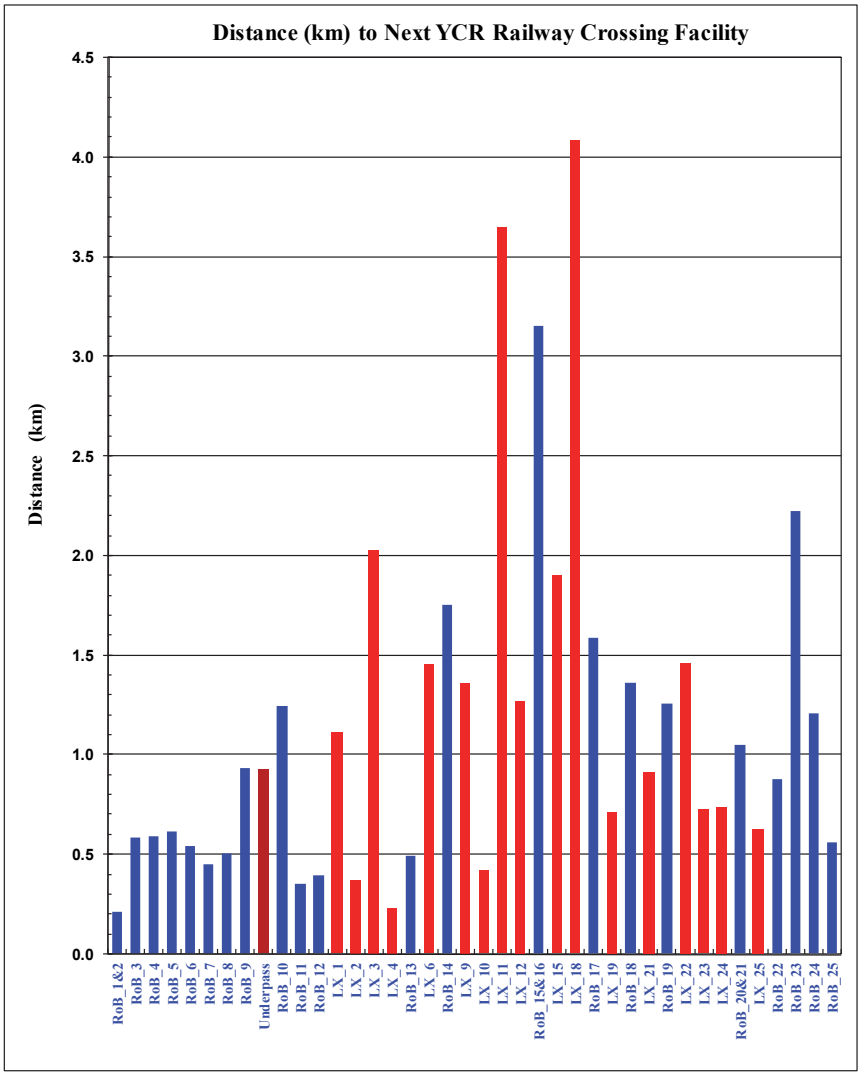
- Why keep private unpaved level crossings?;
- Delays to trains; particularly when trains are to operate at high frequency;
- Excessive delays to traffic, when trains are late and specifically when there is a road junction adjacent to the level crossings; and
- Excessive delays to traffic when the level crossings are at the end of platforms, e.g. Da Nyin Gone Station.

Table 4.3.5 General Characteristics and Location of Level Crossings on YCR

Level Crossing	Street Name	Between Stations				2-way No of Lanes
LX_01	Ywar Ma Kyaung Rd.	10	Hledan	11	Ka Ma Yut	4
LX_02	Hlaing Buter Yone Rd.	10	Hledan	11	Ka Ma Yut	4
LX_03	Oak Kyin Buter Yone St.	12	Thirimyaing	13	Oak Kyin	**2**
LX_04	Parami Rd.	13	Oak Kyin	14	Thamine	4
LX_05	***Unpaved***	14	Thamine	15	Thamine Myothit	
LX_06	Say War Set Yone Rd.	15	Thamine Myothit	16	Kyaoe Gone	4
LX_07	***Private***	*17*	Insein	18	Ywar Ma	
LX_08	***Private***	*17*	Insein	18	Ywar Ma	
LX_09	Buter Yone St.	18	Ywar Ma	19	Phawkan	**2**
LX_10	Bayint Naung Rd.	18	Ywar Ma	19	Phawkan	4
LX_11	Da Nyin Gone Station Rd.	21	Da Nyin Gone	22	Golf Kwin	4
LX_12	No.4 Main Rd.	21	Da Nyin Gone	22	Golf Kwin	4
LX_13	***Private & Unpaved***	*22*	Golf Kwin	23	Kyite Ka Lae	
LX_14	***Private & Unpaved***	*22*	Golf Kwin	23	Kyite Ka Lae	
LX_15	Kha Yay Pin Rd.	24	Mingalardone Zay	25	Mingalardone	6
LX_16	***Unpaved***	*26*	Wai Bar Gi	27	Okkalapa	
LX_17	***Private***	*26*	Wai Bar Gi	27	Okkalapa	
LX_18	Nilar Rd.	27	Okkalapa	28	Pa Ywat Sate Gone	**2**
LX_19	Bone Gyi Rd.	29	Kyauk Yay Twin	30	Ta Tar Lay	**2**
LX_20	***Private & Unpaved***	*30*	Ta Tar Lay	31	Yaegu	
LX_21	Gandmar Rd.	31	Yaegu	32	Parami	4
LX_22	Thitsar Rd.	33	Kanbe	34	Baukhtaw	4
LX_23	Aung Zay Ya	33	Kanbe	34	Baukhtaw	4
LX_24	Pyi Thar Yar St.	34	Baukhtaw	35	Tarmwe	**2**
LX_25	Mar Lar New St	35	Tarmwe	36	Myittar Nyunt	**2**

Source: JICA Study Team

The following figure shows the distance between YCR traffic crossing facilities. The distances of less than 1.0km do not really warrant traffic crossing facilities. There are numerous level crossings and RoB's which are less than one km apart. Hence, the need to rationalise the level crossing facilities, not just the level crossings in isolation but also in conjunction with RoB's and pedestrian foot bridges.

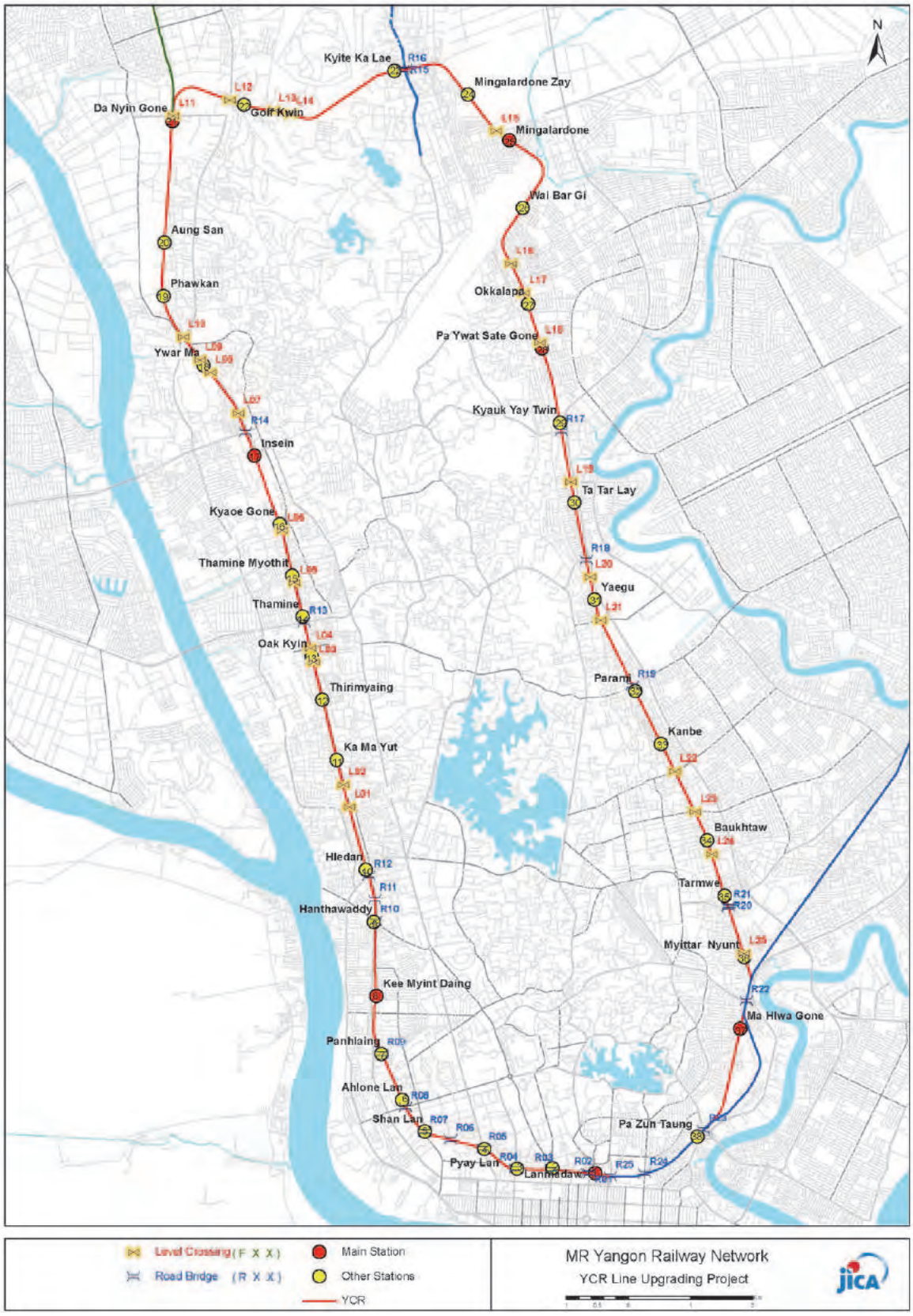


RoB/ Level Crossing	Dist.(km) to Next Crossing
RoB_1&2	0.213
RoB_3	0.581
RoB_4	0.587
RoB_5	0.614
RoB_6	0.543
RoB_7	0.447
RoB_8	0.503
RoB_9	0.934
Underpass	0.928
RoB_10	1.246
RoB_11	0.349
RoB_12	0.395
LX_1	1.110
LX_2	0.368
LX_3	2.029
LX_4	0.231
RoB_13	0.491
LX_6	1.452
RoB_14	1.753
LX_9	1.361
LX_10	0.421
LX_11	3.646
LX_12	1.267
RoB_15&16	3.152
LX_15	1.900
LX_18	4.080
RoB_17	1.588
LX_19	0.711
RoB_18	1.363
LX_21	0.913
RoB_19	1.256
LX_22	1.457
LX_23	0.723
LX_24	0.738
RoB_20&21	1.050
LX_25	0.629
RoB_22	0.877
RoB_23	2.225
RoB_24	1.206
RoB_25	0.562

Private and unpaved road Level Crossings are omitted

Source: JICA Study Team

Figure 4.3.2 Distance to Next RoB or Level Crossing on YCR



Source: JICA Study Team

Figure 4.3.3 Location of RoB and Level Crossings on YCR

4.3.3 Safety Improvement

(1) Signalling System

Significant improvement of the existing system or installation of new system is required to achieve an international standard level of safety as soon as possible. To meet this objective, the technologies used in the modernization process shall be as follows:

- Automatic Block System (ABS)
- Direct current track circuit system
- Automatic Train Stop System (ATS-S)
- Interlocking system in major stations other than the Yangon Central station
- Automatic barrier level crossings (installation of automated level crossing barriers is required to save train running time and increase the safety for pedestrians.)
- Fencing along the rail line

Automated Block System

Many of the residents along the YCR and other lines do not pay attention to safety issues, often cross the rail lines or even walk along the rail line and sitting on the rail track. Fencing facility to prevent the people from entering into the rail track as well as enlightenment of the people is highly needed.

4.4 Inter-modality improvement – station square

Three stations of the YCR, namely Da Nyin Gone station, Ma Hlwa Gone station and Kyee Myint Daing station, were selected as the case study stations for their improvement of inter-modality. Connectivity with other modes of transport at the rail stations and accessibility to the stations in the Greater Yangon are generally poor, accordingly the service coverage (sphere of influence) of these stations are very limited. Taking this opportunity of the YCR upgrading project, it is highly desired to improve inter-modality at the YCR rail stations. This idea can be extended to a transit oriented development (TOD) concept, which is one of the key considerations that lead to the success of the YCR upgrading project.

4.4.1 Characteristics of the three stations

(1) Da Nyin Gone Station

- Various agricultural products including vegetables, fruits and processed foods are brought by farmers and peddlers to the Da Nyin Gone Market by YCR trains and trucks from suburbs of Yangon. This market is next to the Da Nyin Gone station, and accordingly it has a great potential to become a TOD centre in the area.
- YCDC owns several land pieces near the Da Nyin Gone station. Using these lands, YCDC has a plan to develop a new wholesale market which can be used by the existing peddlers and farmers selling their products in the Danynegone station area as well as the merchants in the existing market.
- This YCDC's development plan needs to be taken into consideration in improving the Da Nyin Gone station.

- Some available (vacant) spaces (land pieces) are identified near the Da Nyin Gone station, which can be used in improving the station square to accommodate the increasing demand in the future.

(2) Ma Hlwa Gone Station

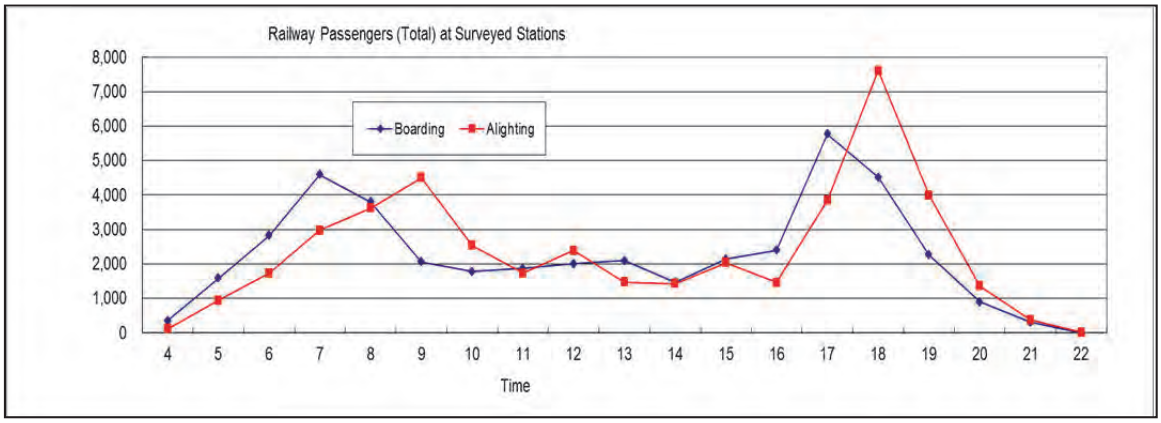
- Myanma Railways (MR) has a large rail stabling yard (50ha) adjacent to the Ma Hlwa Gone station.
- The function of this stabling yard will be transferred to Ywa Tar Gyi after completion of the Yangon – Mandalay Rail Improvement Project.
- SUDP suggests that the existing rail stabling yard can be used as a new transport (intermodal) terminal (hub) with mixed development such as commercial and residential development.
- It is expected that re-generation of the Ma Hlwa Gone station area including the existing stabling yard can generate money for further improvement of YCR.

(3) Kyee Myint Daing Station

- Myanma Railways (MR) also has a large rail stabling yard adjacent to the Kyee Myint Daing Station.
- MR has a plan to regenerate the Kyee Myint Daing station area to increase profit from the asset for further development of YCR.
- The Kyee Myint Daing Station is designated as one of the heritage buildings in Yangon by the Yangon Heritage Trust. Accordingly it is necessary to maintain the existing features, but at the same time it is necessary to improve attractiveness for visitors and tourists.
- It is highly desired to improve connectivity between the station and the bus stop on the Upper Kyee Myint Daing road.

4.4.2 Passenger (pedestrian) movement plan

A traffic volume data of the peak-hour rail passenger is a basis for planning an effective passenger movement. Figure 4.4.1 shows the hourly rail passenger volume (boarding and alighting) of YCR from YUTRA study. From this information, it is understood that the morning peak-hour is the time between 7:00 and 9:00, while the evening peak-hour is between 17:00 and 19:00. The peak-hour ratio (traffic volume of the peak hours / total traffic volume) is calculated at 13%.



Source: Survey Report, Comprehensive Urban Transport Plan of the Greater Yangon (YUTRA)

Figure 4.4.1 YCR hourly passenger volume

Table 4.4.1 shows passenger demand forecast of YCR by station. The demand forecast of the year 2035 is used for this pedestrian movement planning. A total of 3,100 rail passengers (boarding and alighting) using Kyee Myint Daing station in 2014 (base year) is estimated to increase to 7,500 passengers in 2035. The rail passenger using Da Nyin Gone station increases sharply from 5,500 in 2014 to 33,400 in 2035. The rail passenger using Ma Hlwa Gone station increases from 3,300 in 2014 to 9,800 in 2035, but it should be noted that this estimation does not assume any significant urban re-generation in the surrounding area of Ma Hlwa Gone station.

Table 4.4.1 YCR Passenger Demand Forecast

	Station	2014	2025	2035	2025/14	2035/25
1	**Yangon Central**	**10,200**	**49,600**	**86,200**	**4.9**	**1.7**
2	Payar Lan	**3,500**	**8,400**	**34,300**	**2.4**	**4.1**
3	Lanmadaw	1,000	20,700	17,400	20.7	0.8
4	Pyay Lan	800	5,700	12,200	7.1	2.1
5	Shan lan	1,100	9,200	7,600	8.4	0.8
6	Ahlone lan	800	12,200	10,500	15.3	0.9
7	Panhlaing	1,100	12,700	10,300	11.5	0.8
8	**Kyee Myint Daing**	**3,100**	**5,200**	**7,500**	**1.7**	**1.4**
9	Hanthawaddy	1,500	5,100	10,500	3.4	2.1
10	Hledan	2,000	5,000	7,500	2.5	1.5
11	Ka Ma Yut	2,500	3,400	4,400	1.4	1.3
12	Thirimyaing	2,100	2,400	3,400	1.1	1.4
13	Oak Kyin	2,000	3,100	3,100	1.6	1.0
14	Thamaine	3,200	3,500	8,900	1.1	2.5
15	Thamine Myothit	2,100	7,800	8,800	3.7	1.1
16	Kyaoe Gone	1,000	7,600	1,300	7.6	0.2
17	**Insein**	**3,000**	**13,200**	**31,600**	**4.4**	**2.4**
18	Ywar Ma	1,100	2,900	3,600	2.6	1.2
19	Phawkan	800	2,200	20,700	2.8	9.4
20	Aung San	1,300	9,200	12,000	7.1	1.3
21	**Da Nyin Gone**	**5,500**	**14,900**	**33,400**	**2.7**	**2.2**
37	**Ma Hlwa Gone**	**3,300**	**5,300**	**9,800**	**1.6**	**1.8**
38	Pa Zun Taung	4,900	40,100	38,500	8.2	1.0
Total YCR West Section		**57,900**	**249,400**	**383,500**	**4.3**	**1.5**

Source: JICA Study Team

(1) Da Nyin Gone Station

Table 4.4.2 shows the forecasted rail passenger using Da Nyin Gone station in 2035. A total of 33,400 rail passengers use this station in 2035. The peak-hour rail passenger volume is estimated at about 2,200 for each of boarding and alighting.

Table 4.4.2 Rail passenger using Da Nyin Gone station in 2035

Da Nyin Gone	Total passsenger per day in 2035	33,400
	Boarding	Alighting
Total railway passenger	16,700	16,700
Per peak hour (13%)	2,171	2,171

Source: JICA Study Team

Table 4.4.3 shows access modes for boarding passengers and egress modes for alighting passengers in 2035.

Table 4.4.3 Access and egress modes of transport at Da Nyin Gone station in 2035

Proposed % by Mode of Access/ Egress					Number of vehicle		Processing capacty	Plan (Number of parking lot)		Number of lots (parking)
Walk	75	1,628	1,628		1,503					
Bicycle	3	65	65		60					
Car	4	87	87	Number of passengers of one car (2.0)	43	Three minutes for getting on and off	20	2		2
Taxi	6	130	130	Number of passengers of one car (2.0)	65	Three minutes for getting on and off	20	3		3
Bus	10	217	217	of one car (25.0) (source:Insein Station	9	Five minutes for getting on and off	12	1	lots for getting on and off	2
Others	2	43	43	Three wheels	40	Three minutes for getting on and off	20	2		2

Source: JICA Study Team

Based on the forecasted figures, key considerations in planning the passenger movement at the Da Nyin Gone station are made as follows:

- Since the station is close to the Da Nyin Gone market which is operated by YCDC, space for commodity loading and unloading facilities is provided in the station square.
- Spaces for taxis and buses are provided close to the station for convenience of the rail users.
- Since the level crossing is close to the gate of the station square, the bus stop (pool) in the station square should have enough distance from the gate.
- Space for cars for picking-up and dropping-off rail passengers is provided in the station square.

From an aspect of universal design, following considerations are made in designing the station square:

- The ground height of pedestrian walk way is 30 cm above the carriage way, which makes easier for bus passengers in getting on and off the bus.
- Warning tile blocks are provided for visually impaired person.
- Surface of the pedestrian walkway and other spaces should have no gap for smooth use of wheelchairs.
- Shading facilities (roof) along the movement (traffic) lines and ticketing booth are provided.
- Benches and other facilities are provided for comfort of the users.

Based on the above considerations, a station square layout plan is designed as shown in Figure 4.4.2.

Source: JICA Study Team

Figure 4.4.2 Layout Plan of the Station Square, Da Nyin Gone Station

Source: JICA Study Team

Figure 4.4.3 Perspective of the Station Square, Da Nyin Gone Station

(2) Ma Hlwa Gone Station

Table 4.4.4 shows the forecasted rail passenger using Ma Hlwa Gone station in 2035. A total of 9,800 rail passengers use this station in 2035. The peak-hour rail passenger volume is estimated at about 640 for each of boarding and alighting.

Table 4.4.4 Rail passenger using Ma Hlwa Gone station in 2035

Ma Hlwa Gone	Total passsenger per day in 2035	9,800
	Boarding	Alighting
Total railway passenger	4,900	4,900
Per peak hour (13%)	637	637

Source: JICA Study Team

Table 4.4.5 shows access modes for boarding passengers and egress modes for alighting passengers in 2035.

Table 4.4.5 Access and egress modes of transport at Ma Hlwa Gone station in 2035

Proposed % by Mode of Access/ Egress					Number of vehicle		Processing capacty	Plan (Number of parking lot)		Number of lots (parking)
Walk	75	478	478		1,503					
Bicycle	3	19	19		60					
Car	4	25	25	Number of passengers of one car (2.0)	13	Three minutes for getting on and off	20	1		2
Taxi	6	38	38	Number of passengers of one car (2.0)	19	Three minutes for getting on and off	20	1		3
Bus	10	64	64	of one car (25.0) (source:Insein Station	3	Five minutes for getting on and off	12	0.2	lots for getting on and off	2
Others	2	13	13	Three wheels	12.74	Three minutes for getting on and off	20	1		1

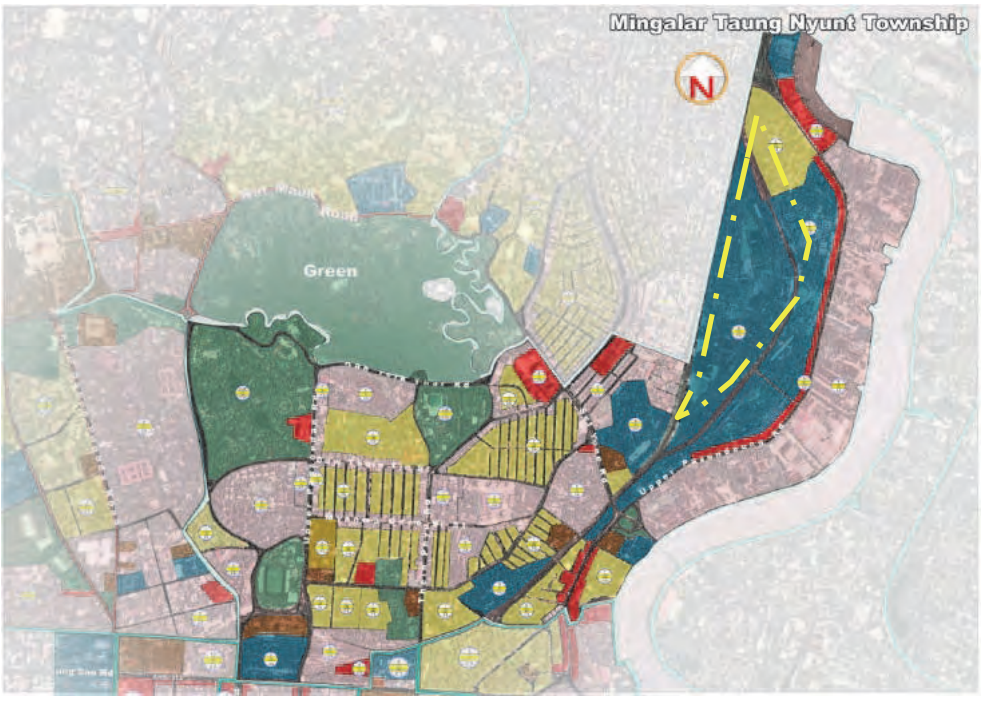
Source: JICA Study Team

Key considerations in planning the passenger movement at the Ma Hlwa Gone station are made as follows:

- As stated before, the 2035 demand forecast presented in Table 4.4.1 does not assume the proposed urban re-generation of the Ma Hlwa Gone station area. Actually it is not so useful to design the station square of Ma Hlawa Gone based on this assumption. Therefore the currently proposed urban re-generation of the Ma Hlwa Gone station area is considered in planning the station square.
- The new station square is planned in the east of the Ma Hlwa Gone station because the land in the west of the station is fully occupied by housing and others, and it is difficult to build roads to access to the station.

Zoning Plan

Zoning regulations of the Ma Hlwa Gone station area, which is under consideration of YCDC and MOC, is presented below (Figure 4.4.4).



Source :YCDC and MOC (Draft)

Figure 4.4.4 Zoning regulation, Mingalar Taung Nyunt Township

This zoning regulation has not been enacted yet, but YCDC development permission section refers this regulation for their judgment. Following this on-going exercise, land coverage ratio of 50% and floor area ratio of 800% are applied in the land use planning of Ma Hlwa Gone station area. In the zoning regulation, the type of land use is changed to industrial and logistics use. However, assuming that use of the existing station area is changed to mixed use, namely, housing, commercial and office use, this station square plan is made.

Conceptual Land Use Plan of the Ma Hlwa Gone station area

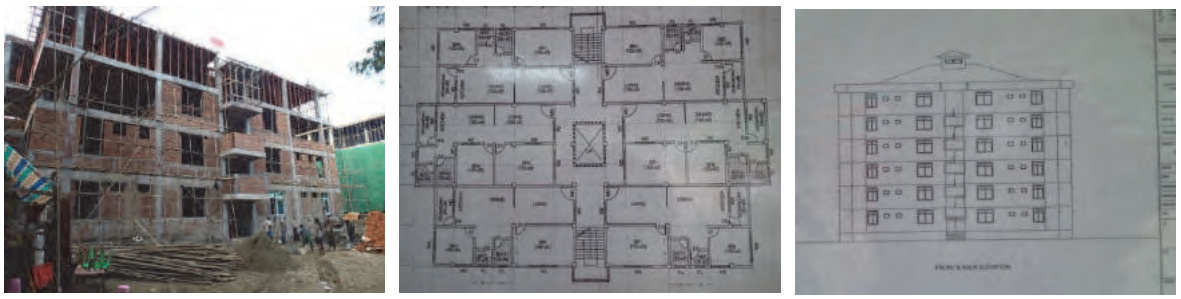
Following planning concepts are incorporated into development of the Ma Hlwa Gone station area.

Access Roads: The primary arterial road in the target area is Pazun Daung road. Secondary arterial roads are provided in the development area to reach the Pazun Daung road.

Land Use: Future land use around the Ma Hlwa Gone Station includes residence area (the west and fringe areas), commercial and office area (the central area).

Population: Based on the model apartment plan, which is developed close to the Ma Hlwa Gone development area, future population of the residential area is estimated (refer to Figure 4.4.5)

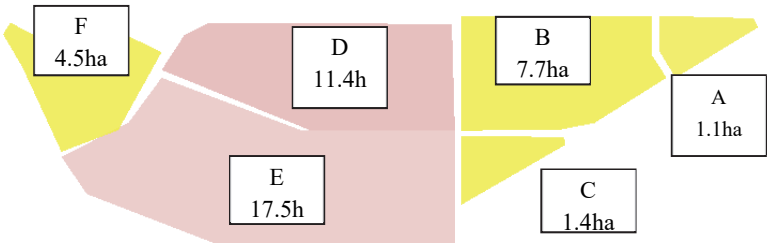
- Capacity of one residential building is 180 persons assuming 6 households (five persons per one household in average) for one floor x 6-stories
- Building area is 490m^2 and land coverage is 60% (by actual measurement)



Source: JICA Study Team

Figure 4.4.5 YCDC Staff Housing (Cleaning Section)

- 13 residential buildings (the same design) can be constructed, and accordingly net population density is estimated at 2,340 person/ha (Note: this is the same density as that of Kyauktada Township)
- Total area of Block A-C is 10.2 ha (area for housing), and accordingly planned population is calculated at 24,000 persons.
- Area of Block F is 4.5 ha (housing), and planned population is calculated at 10,000 persons.
- Block D and E are for office and commercial use. Total floor area for the office and commercial use is 2,312,000 m^2 (114,000＋175,000m2).
- Assuming that rentable (effective) floor area ratio is 80% of the total space of the office and commercial use and an average unit space for a worker is 10 m^2, the number of total workers is calculated at 231,200 persons. However, a large park development is planned in the office and commercial zones, an effective floor area can be reduced to 50% of the above calculation, namely 115,600 persons.



Source: JICA Study Team

Figure 4.4.6 Conceptual Development Plan of the Ma Hlawa Gone area (Draft)

Trip rate and modal split

To estimate the trip generation and the modal split of the Ma Hlwa Gone station area, the information from YUTRA survey is referred. Table 4.4.6 shows trip generation rate of the Yangon residents (actually the residents in the YUTRA project area), while Figure 4.4.7 shows the existing modal split of them.

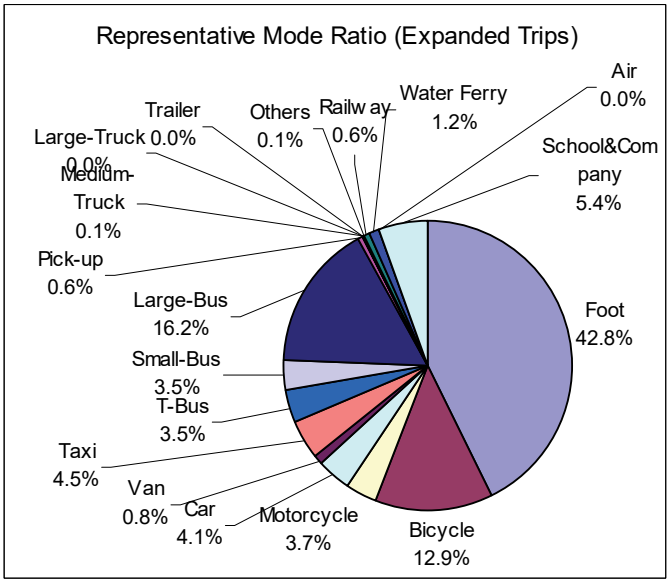
An average net trip rate is estimated at 2.481 trips per person, which is used to estimate the total trip generation of the project area.

The existing share of rail users is very small, namely 0.6% of the total net trips. Assuming that modal shift from the bus users at 5% in the project area will happen, a share of future rail trips is set at 5.6% for this study purpose.

Table 4.4.6 Trip Generation Rates in the YUTRA study area

	Non Motorized Trip	Motorized Trips	Trip Rate
Gross Trip Rates	1.136	0.903	2.039
Net Trip Rates (age above 6 years old)	1.382	1.099	2.481

Source: Survey Report, Comprehensive Urban Transport Plan of the Greater Yangon (YUTRA)



Source: Survey Report, Comprehensive Urban Transport Plan of the Greater Yangon (YUTRA)

Figure 4.4.7 Modal Split in the YUTRA Study area

An estimated total trip generation from the urban re-generation project in the Ma Hlawa Gone station area is estimated at 315,554, and 5.6% of them, namely 17,670 trips could be made by the rail (YCR). By combining this figure (17,670 trips per day) and the forecasted rail trips of 9,800 (shown in Table 4.4.4), a total of 27,470 rail based trips is expected in 2035 in the project area. Accordingly, the peak-hour rail passenger volume is estimated at about 1,800 for each of boarding and alighting as shown in Table 4.4.8.

Table 4.4.7 Estimated Trip Generation of the Project Area

	Population	Trips	Railway trips
	(person)	(trip rate = 2.481)	5.60%
Block A-C	24,000	59,544	3,334
Block F	10,000	24,810	1,389
Subtotal	34,000	84,354	4,723
Block D and E	115,600	231,200	12,947
	(all workers from outside of development area)	(workers x 2.00)	
Total	149,600	315,554	17,670

Source: JICA Study Team

Table 4.4.8 Rail passenger using Ma Hlwa Gone station (with urban regeneration project) in 2035

Ma Hlwa Gone	Total passsenger per day in 2035	27,470
	Boarding	Alighting
Total railway passenger	13,735	13,735
Per peak hour (13%)	1,786	1,786

Source: JICA Study Team

Table 4.4.9 Access and egress modes of transport at Ma Hlwa Gone station (with urban regeneration project) in 2035

Proposed % by Mode of Access/ Egress					Number of vehicle		Processing capacty	Plan (Number of parking lot)		Number of lots (parking)
Walk	75	1,339	1,339		1,339					
Bicycle	3	54	54		54					
Car	4	71	71	Number of passengers of one car (2.0)	36	Three minutes for getting on and off	20	2		4
Taxi	6	107	107	Number of passengers of one car (2.0)	54	Three minutes for getting on and off	20	3		6
Bus	10	179	179	of one car (25.0) (source:Insein Station	7	Five minutes for getting on and off	12	0.6	lots for getting on and off	2
Others	2	36	36	Three wheels	35.71	Three minutes for getting on and off	20	2		4

Source: JICA Study Team

Proposed Layout Plan of the Station Square

The Ma Hlwa Gone station is designated as a strategic intermodal point including park & ride facilities by YCDC. In line with transport strategy of YCDC, 2 bus berths, a bus terminal building and park & ride facilities are proposed in the project area.

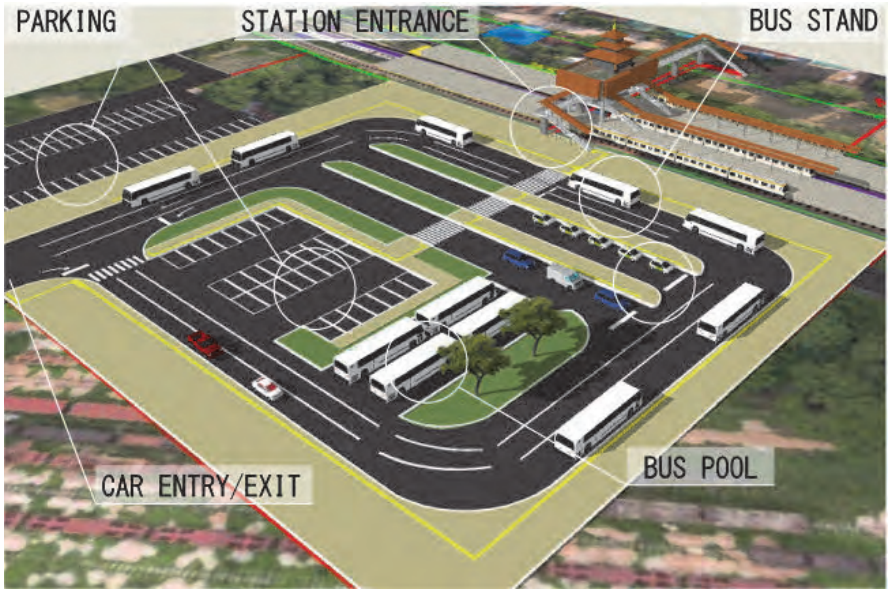
From an aspect of universal design, following considerations are made in designing the station square:

- The ground height of pedestrian walk way is 30 cm above the carriage way, which makes easier for bus passengers in getting on and off a bus.
- Warning tile blocks are provided for visually impaired person.
- Surface of the pedestrian walkway and other spaces should have no gap for smooth use of wheelchairs.
- Shading facilities (roof) along the movement (traffic) lines and ticketing booth are provided.
- Benches and other facilities are provided for comfort of the users.

Based on the above considerations, a station square layout plan is designed as shown in Figure 4.4.8.

Source: JICA Study Team

Figure 4.4.8 Layout Plan of the Station Square, Ma Hlwa Gone Station



Source: JICA Study Team

Figure 4.4.9 Perspective of the Station Square, Ma Hlwa Gone Station

(3) Kyee Myint Daing Station

Table 4.4.10 shows the forecasted rail passenger using Kyee Myint Daing station in 2035. A total of 7,500 rail passengers use this station in 2035. The peak-hour rail passenger volume is estimated at about 500 for each of boarding and alighting.

Table 4.4.10 Rail passenger using Kyee Myint Daing station in 2035

Kyee Myint Daing	Total passsenger per day in 2035	7,500
	Boarding	Alighting
Total railway passenger	3,750	3,750
Per peak hour (13%)	488	488

Source: JICA Study Team

Table 4.4.11 Access and egress modes of transport at Kyee Myint Daing station

by Mode of Access/					Number of vehicle		Processing capacty	Plan (Number of parking lot)		Number of lots (parking)
Walk	75	366	366		1,503					
Bicycle	3	15	15		60					
Car	4	20	20	passengers of one car (2.0)	10	Three minutes for getting on and off	20	0		2
Taxi	6	29	29	passengers of one car (2.0)	15	Three minutes for getting on and off	20	1		3
Bus	10	49	49	passengers of one car (25.0)	2	Five minutes for getting on and off	12	0.2	lots for getting on and off	2
Others	2	10	10	Three wheels	40	Three minutes for getting on and off	20	2		2

Source: JICA Study Team

Proposed Layout Plan of the Station Square

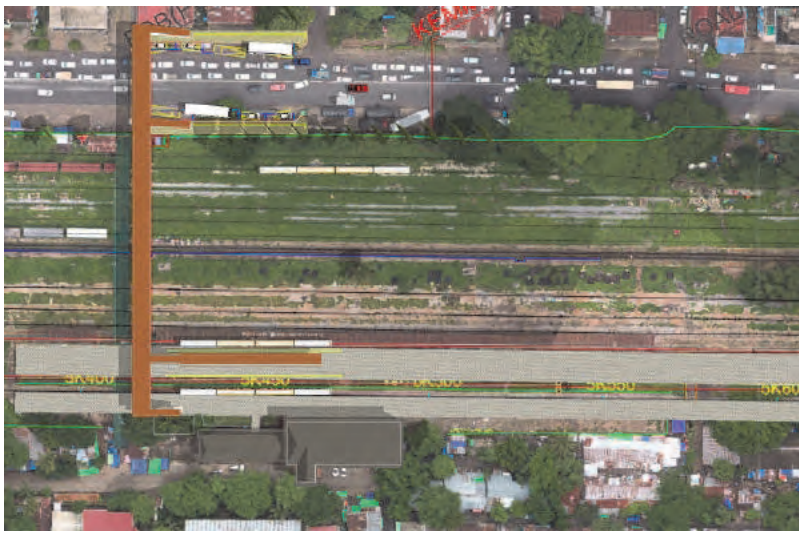
The existing passengers using the Kyee Myint Daing station has a good potential to attract tourists because it has been designated as one of the heritage buildings in Yangon. In this regard some special consideration shall be required.

- An average of 7,500 passengers per day will use the Kyee Myint Daing station in 2035 (in case of without significant regeneration of the station area). The existing rail passengers should access to the rail platform by an old foot over bridge, but the capacity of this foot over bridge is limited. Accordingly renewal of the pedestrian bridge over the rail track is proposed (refer to Figure 4.4.11)
- The Kyee Myint Daing Station building is listed as one of the heritage buildings by the Yangon Heritage Trust. Therefore it is necessary to maintain the existing station building, while the railway yard in the Kyee Myint Daing station can be regenerated.

From an aspect of universal design, following considerations are made in designing the station square:

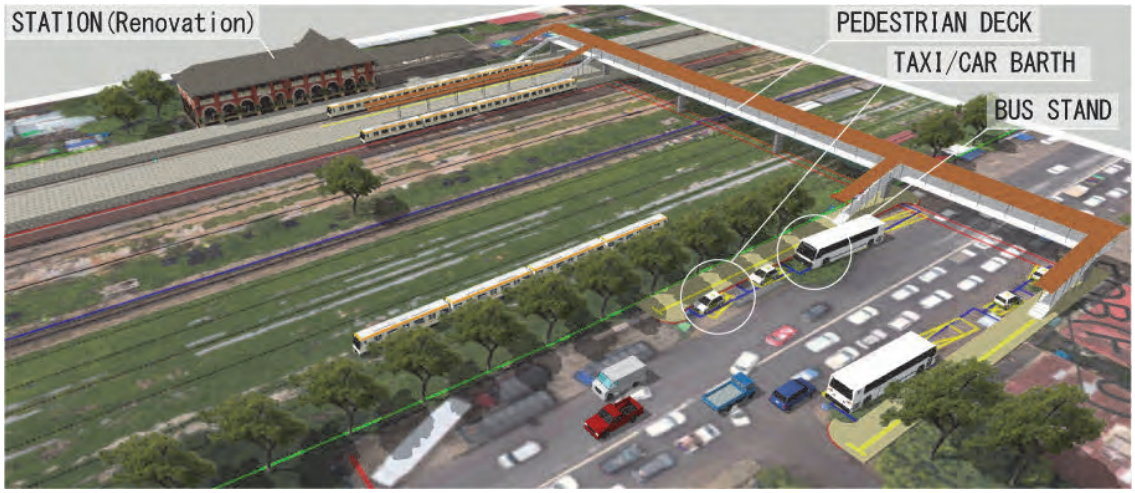
- The ground height of pedestrian walk way is 30 cm above the carriage way, which makes easier for bus passengers in getting on and off a bus.
- Warning tile blocks are provided for visually impaired person.
- Surface of the pedestrian walkway and other spaces should have no gap for smooth use of wheelchairs.
- Shading facilities (roof) along the movement (traffic) lines and ticketing booth are provided.
- Benches and other facilities are provided for comfort of the users.

Based on the above considerations, a station square layout plan is designed as shown in Figure 4.4.10.



Source: JICA Study Team

Figure 4.4.10 Layout Plan of the Station Square, Kyee Myint Daing Station



Source: JICA Study Team

Figure 4.4.11 Perspective of the Station Square, Kyee Myint Daing

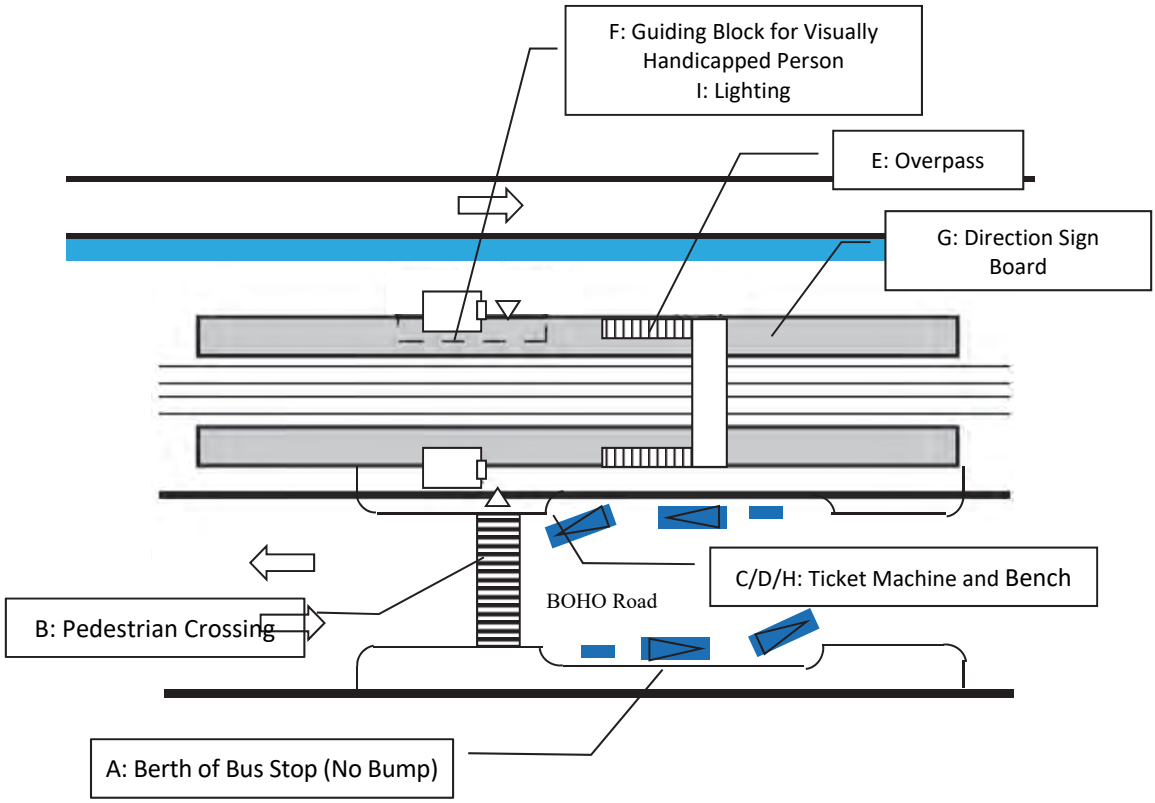
4.5 Universal Design Concept

Every type of rail users, children, elderly people, handicapped people, etc., are the centre of the YCR upgrading project. In this regard, universal design approach should be taken into consideration, which can be adopted with small or even almost no additional costs to cater for specific users' needs in the context of Yangon.

In this study, a preliminary consideration with regard to the application of the universal design concept to the YCR station improvement was made. For this purpose, a total of 23 YCR stations on the YCR western section are selected as case study stations.

4.5.1 General concept of the universal design

Nine elements (facilities) are studied from an aspect of the universal design (refer to Figure 4.5.1: Case of Kmayut station)



Source: JICA Study Team

Figure 4.5.1 Nine elements addressed in considering universal design

A. <u>Bus berth with no bump</u>

- For convenience of the rail users to access to a station, bus stops shall be placed close to the station. Smooth boarding and alighting on/from a bus shall be designed by providing the pedestrian walkway of which height is same as the floor of buses.
- Similarly, park & ride space, exclusive parking space for handicapped people shall be placed near the station.
- Continued smooth surface of the pedestrian walkway from the parking space and bus stops to the station shall be made with no bump (refer Photo A)

B. <u>Pedestrian Crossing or Bridge</u>

- Pedestrian bridge (over the road) shall be provided where the width of road in front of the station is wide (4-lane or more) (refer to Photo B)
- If the access road to the station is narrow (2-lane or less) and the traffic volume is rather small, at-grade pedestrian crossing shall be provided with signal control.

C. Ticket Machine

- A ticket vending machine should be easily used (accessible) by handicapped people by lowering the height (refer to Photo C)

D. Automatic Ticket Gate

- Width of an automatic ticket gate should accommodate three wheels chair (refer to Photo C)

E. Bridge over Railway

- Existing pedestrian bridges over the rail tracks in the stations should be relocated to more convenient locations.
- Specifications of stairs shall be changed: tread width = 30 cm, riser = 15 cm.
- A special slope (8%) shall be provided at the end of platform in case it is necessary for three wheels chair needs to move to the next plat form (emergency case). The gate to this slope should be closed when it is not needed (Photo E).

F. Guiding Block for Visually Handicapped Person

- Guiding blocks for visually handicapped person is shall be installed for their convenience and safety. (Photo D, E, and F)

G. Electric bulletin board and voice guidance

- Electric bulletin boards showing the information of train operation shall be installed.
- At the same time the same information should be provided via announcing and the internet (free WIFI service inside the station) for visually handicapped persons.

H. Rest Facilities (Bench)

- Bench for waiting passengers shall be prepared for their comfort.

I. Lighting Facilities

- Lighting facilities shall be installed in order to increase visibility during the night time.

4.5.2 Categorization of the stations

Passenger volume

Based on the forecasted rail passenger volume, the stations are categorized into five groups, namely, Special, A, B, C, and D, for each of them unique design approach is developed. Table 4.5.1. shows the method of categorization and corresponding approach in applying universal design.

Table 4.5.1 Function of station square by category

Station Category	Definition	2035 Average Daily Pax Boarding	Proposed % by Mode of Access/ Egress {1}					
			Walk {2}	Bicycle {3}	Car {4}	Taxi {5}	Bus {6}	Other {7}
			75%	3%	4%	6%	10%	2%
Special	Central Station for Interchange & Access to CBD, Interchange with Inter-city Lines	86,000	Need major grade-separated covered walkways to CBD	No need for 2-wheel Parking	Will be designed by Developer - needs a major study	Fairly large taxi stand and separate drop-off and pick-up points	Bus Drop-off & Pickup areas	Need Good Transfer between YCR & Regional Line
A	2035 Daily Boarding Pax >> 20,000. or Major Station with TOD Potential	Over 25,000	Would need local at-grade pedestrian signals at most stations	Would need Limited Spaces	Case by case analysis	Limited places taxi stand and drop-off/ pick-up lane	See Note {6} Below	n/a
B	2035 Daily Boarding Pax 10,000 ~ 20,000 - Main Stations	~12,000	Would need local pedestrian crossings at most stations	Would need Limited Spaces	Case by case analysis	Drop-off/ pick-up lane	See Note {6} Below	n/a
C	2035 Daily Boarding Pax 5,000 ~ 10,000 - Medium Size Stations	~8,000	Would need local pedestrian crossings at most stations	Would need Limited Spaces	Case by case analysis	Drop-off/ pick-up lane	See Note {6} Below	n/a
D	2035 Daily Boarding Pax Under 5,000 - Minor Stations or Those proposed to be eliminated - demand will shift to adjacent stations	~3,000	Would need local pedestrian crossings at most stations	Would need Limited Spaces	Case by case analysis	Drop-off/ pick-up lane	See Note {6} Below	n/a
Notes								
Demand forecast model does not explicitly provides mode of access as Modal split between private & public mode is not estimated by station location.								
{1} - Existing Mode of Access is not likely to prevail in the Future. Judgement, land availability and station catchment area and adjacent land use are the key factors which needs to be considered in determining the facilities to be provided at each station. Hence the above % mode share is only given as a guide lines. YUTRA 2014 Mode share is given elsewhere in this file.								
{2} - Walk would be the predominant mode of access in the future as line passes through existing dense urban areas								
{3} - Bicycle and Motorcycle as mode of access would diminish in the future with increase in income levels.								
{4} - Provision should be made on case-by-case basis average requirement are indicative, based on main mode-share.								
{5} - Currently Taxi is a common mode - as many taxis operate as shared between Pax to a common destination. In future Taxi would provide a confortable mode to stations form small street areas where buses cannot operate.								
{6} - Bus transfer areas needs to be near the stations for Pax to have short transfer walk. Stations with high demand in outer areas and those link to west Yangon need to have major bus transfer facilities e.eg Danyingon/ Insein/ Thamaing Stations								
{7} - Provision should be made on case-by-case basis for some Para transit or from other rail lines.								

Source: JICA Study Team

Table 4.5.2 Categorization of the YCR stations (west section)

	Station	Category	2014	2025	2035	2025/14	2035/25
1	**Yangon Central**	**Special**	**10,200**	**49,600**	**86,200**	**4.9**	**1.7**
2	Pha Yar Road	**A**	**3,500**	**8,400**	**34,300**	**2.4**	**4.1**
3	*Lan Ma Daw*	D	1,000	20,700	17,400	20.7	0.8
4	Pyay Road	B	800	5,700	12,200	7.1	2.1
5	Shan Road	C	1,100	9,200	7,600	8.4	0.8
6	Ahlone Road	B	800	12,200	10,500	15.3	0.9
7	Panhlaing Road	B	1,100	12,700	10,300	11.5	0.8
8	**Kemmendine**	**A**	**3,100**	**5,200**	**7,500**	**1.7**	**1.4**
9	Hanthawaddy	B	1,500	5,100	10,500	3.4	2.1
10	Hledan	C	2,000	5,000	7,500	2.5	1.5
11	Kamayut	D	2,500	3,400	4,400	1.4	1.3
12	Thirimyaing	D	2,100	2,400	3,400	1.1	1.4
13	*Okkyin*	D	2,000	3,100	3,100	1.6	1.0
14	Thamaing	C	3,200	3,500	8,900	1.1	2.5
15	*Thamaing Myothit*	D	2,100	7,800	8,800	3.7	1.1
16	Gyogon	D	1,000	7,600	1,300	7.6	0.2
17	**Insein**	**A**	**3,000**	**13,200**	**31,600**	**4.4**	**2.4**
18	Ywama	D	1,100	2,900	3,600	2.6	1.2
19	Phawkan	A	800	2,200	20,700	2.8	9.4
20	Aungsanmyo	B	1,300	9,200	12,000	7.1	1.3
21	**Dan Yin Gon**	**A**	**5,500**	**14,900**	**33,400**	**2.7**	**2.2**
37	**Ma Hlwa Gon**	**A**	**3,300**	**5,300**	**9,800**	**1.6**	**1.8**
38	Pa Zun Daung	A	4,900	40,100	38,500	8.2	1.0
Total YCR West Section			**57,900**	**249,400**	**383,500**	**4.3**	**1.5**

Source: JICA Study Team

Accessibility by roads and land use of the sphere of the stations

In addition to the passenger volume, the stations are categorized by accessibility to the station, namely by the number of lanes of access roads and land use of the surrounding area of the stations. Table 4.5.3 shows the existing situation of access roads to the stations and the land use of the surrounding areas pf the stations.

Based on this method, the stations are categorized into three groups, namely, stations being served by four-lane roads, two-lane roads, and minor roads (6 – 8 meter width).

With regard to the stations being served by minor roads, such stations are further categorized into two sub-groups, namely, the stations having large potential land owned by MR and that of having no land (or limited land).

Table 4.5.3 Existing condition of the stations (road access and land use)

No.	Station Name	Population		Land use (Radius 500m)							
		Population (Radius of 5km)	Population Density(per./km2)	Commercial &Business	Industries	Residential	RailStation Area	MRown Land	Vegeationt	Access Road (numbers of lane)	Note
1	Yangon Central	23,654	301.0	30.2	0	21.7	19.5	0	0	Kun Chan Street(2) Pansodan Street(4) Bogyoke Aung San Road(4)	Yangon Central Station South Area Development Plan
2	Phaya Road	16,575	211.0	19.2	0	23.8	0	0	0	Shwe Dagon Pagoda Road(4)	New Bogyoke Market development Project
3	Lanmataw	7,104	90.5	4.6	0	22.1	0	0	3.3	Lanmataw Road(2)	non
4	Pyay Road	5,056	64.4	5.5	0	40.1	0	0	7.7	Pyay Road(4)	non
5	Shan Road	10,198	129.8	2.6	0	56.4	0	1.1	1.2	Boho Road(2)	non
6	Ahlone Road	14,636	186.4	0.5	0	53	0	3.9	0.9	Ahone Road(2)	non
7	Panhlaing Road	23,384	297.7	3.4	0	65.7	1.6	0.4	1.2	Hone Lane Road(2)	non
8	Kyeemyindaing	33,959	432.4	2.2	0	47.1	6.5	0.4	1.5	Upper Kyeemyindaing Road(4)	MR own over 5ha land
9	Hanthawaddy	23,097	294.1	8.9	0	45.4	3.6	0	8.3	Upper Kyeemyindaing Road(4) Hanthawaddy Road(4)	Hanthawaddy Junction Bus Stop is next to the station
10	Hletan	21,948	279.4	2.4	13.9	47.4	2.5	0	5.5	Boho Road(2) Hle Dan Road(2)	non
11	Kamayut	17,282	220.0	1.9	0.1	60.8	3.8	0	1	Boho Road(2)	non
12	Thiri Myine	15,052	191.6	1.8	0.2	59.5	2.3	0	7.4	Boho Road(2)	non
13	Okakin	15,951	203.1	3.5	1.6	46.7	1.6	0	5.9	Boho Road(2)	non
14	Thamine	20,058	255.4	1.6	0	57.9	0.7	0	5.7	Boho Road(2) Thamine Buteryon Road(4)	Mya Yadana Market(YCDC)
15	Thamine Myothit	20,075	255.6	1.5	2.7	58.7	1	0	3.2	Boho Road(2)	non
16	Kyuntkon	6,038	76.9	0.9	0	10.7	2.2	0	0.1	Boho Road(2)	non
17	Insein	9,573	121.9	0	1.5	25.7	5.8	4.5	0.2	Yangon Insein Road(2)	MR own over 5ha land
18	Ywama	11,449	145.8	1.1	0.5	21	0.5	0	2.9	Rural Road(2)	non
19	Phwakan	11,589	147.6	7.4	30.8	22.4	0.3	0	7.1	War Oo Street(8.1m)	non
20	Aungsanmyo	4,735	60.3	2.4	12.3	35.3	0.3	0	23.7	Aunghsan Street(6m)	non
21	Danyingone	2,332	29.7	2.9	11	5.1	0.3	5.3	26.3	Danyin Gone Station Road(2)	Danyin Gone Market Redevelopment Plan
37	Malwagone	44,643	568.4	2.1	0	55.9	8.2	0	0	Myo Pat Street(6m)	MR own over 5ha land
38	Pazundaung	35,777	501.8	5.4	0	35.5	2.6	0	0	Upper Pazundaung Road(4)	

Table 4.5.4 Stations served by four lane roads

No.	Station Name	Population			
		Population (Radius of 5km)	Population Density(per./km2)	Access Road (numbers of lane)	Note
1	Yangon Central	23,654	301.0	Kun Chan Street(2) Pansodan Street(4) Bogyoke Aung San Road(4)	Yangon Central Station South Area Development Plan
2	Phaya Road	16,575	211.0	Shwe Dagon Pagoda Road(4)	New Bogyoke Market development Project
4	Pyay Road	5,056	64.4	Pyay Road(4)	non
8	Kyeemyindaing	33,959	432.4	Upper Kyeemyindaing Road(4)	MR own over 5ha land
9	Hanthawaddy	23,097	294.1	Upper Kyeemyindaing Road(4) Hanthawaddy Road(4)	Hanthawaddy Junction Bus Stop is next to the station
14	Thamine	20,058	255.4	Boho Road(2) Thamine Buteryon Road(4)	Mya Yadana Market(YCDC)
38	Pazundaung	35,777	501.8	Upper Pazundaung Road(4)	

Source: JICA Study Team

Table 4.5.5 Stations served by two lane roads

No.	Station Name	Population				
		Population (Radius of 5km)	Population Density(per./km2)	RailStation Area	Access Road (numbers of lane)	Note
3	Lanmataw	7,104	90.5	0	Lanmataw Road(2)	non
5	Shan Road	10,198	129.8	0	Boho Road(2)	non
6	Ahlone Road	14,636	186.4	0	Ahone Road(2)	non
7	Panhlaing Road	23,384	297.7	1.6	Hone Lane Road(2)	non
10	Hletan	21,948	279.4	2.5	Boho Road(2) Hle Dan Road(2)	non
11	Kamayut	17,282	220.0	3.8	Boho Road(2)	non
12	Thiri Myine	15,052	191.6	2.3	Boho Road(2)	non
13	Okakin	15,951	203.1	1.6	Boho Road(2)	non
15	Thamine Myothit	20,075	255.6	1	Boho Road(2)	non
16	Kyuntkon	6,038	76.9	2.2	Boho Road(2)	non
18	Ywama	11,449	145.8	0.5	Rural Road(2)	non
21	Danyingone	2,332	29.7	0.3	Danyin Gone Station Road(2)	Danyin Gone Market Redevelopment Plan

Source: JICA Study Team

Table 4.5.6 Stations served by minor roads

No.	Station Name	Population				
		Population (Radius of 5km)	Population Density(per./km2)	RailStation Area	Access Road (numbers of lane)	Note
17	Insein	9,573	121.9	5.8	Yangon Insein Road(2)	MR own over 5ha land
37	Malwagone	44,643	568.4	8.2	Myo Pat Street(6m)	MR own over 5ha land

Source: JICA Study Team

Table 4.5.7 Stations having large land owned by MR

No.	Station Name	Population				
		Population (Radius of 5km)	Population Density(per./km2)	RailStation Area	Access Road (numbers of lane)	Note
19	Phwakan	11,589	147.6	0.3	War Oo Street(8.1m)	non
20	Aungsanmyo	4,735	60.3	0.3	Aunghsan Street(6m)	non

Source: JICA Study Team

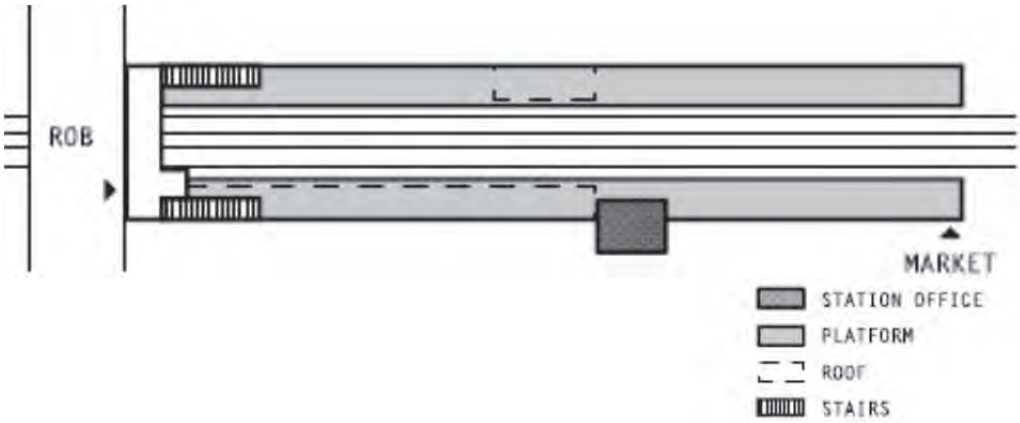
4.5.3 Proposed design concept by station group

Following figures show general design concept of each station based on the universal design approach by type (group) of station.

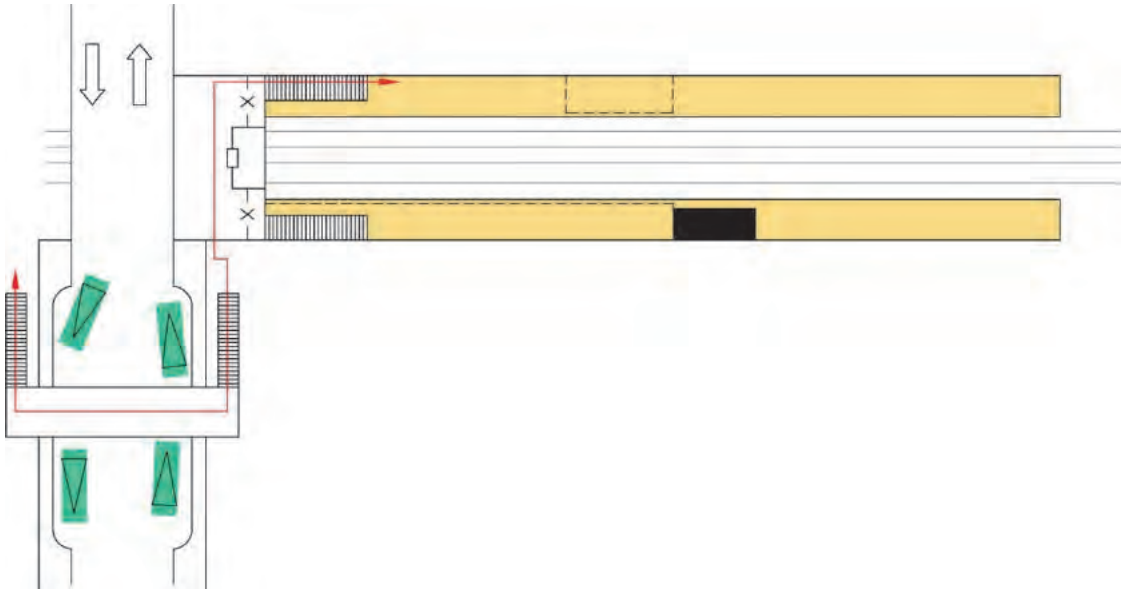
Group-A

1) Phaya Road Station

Existing layout



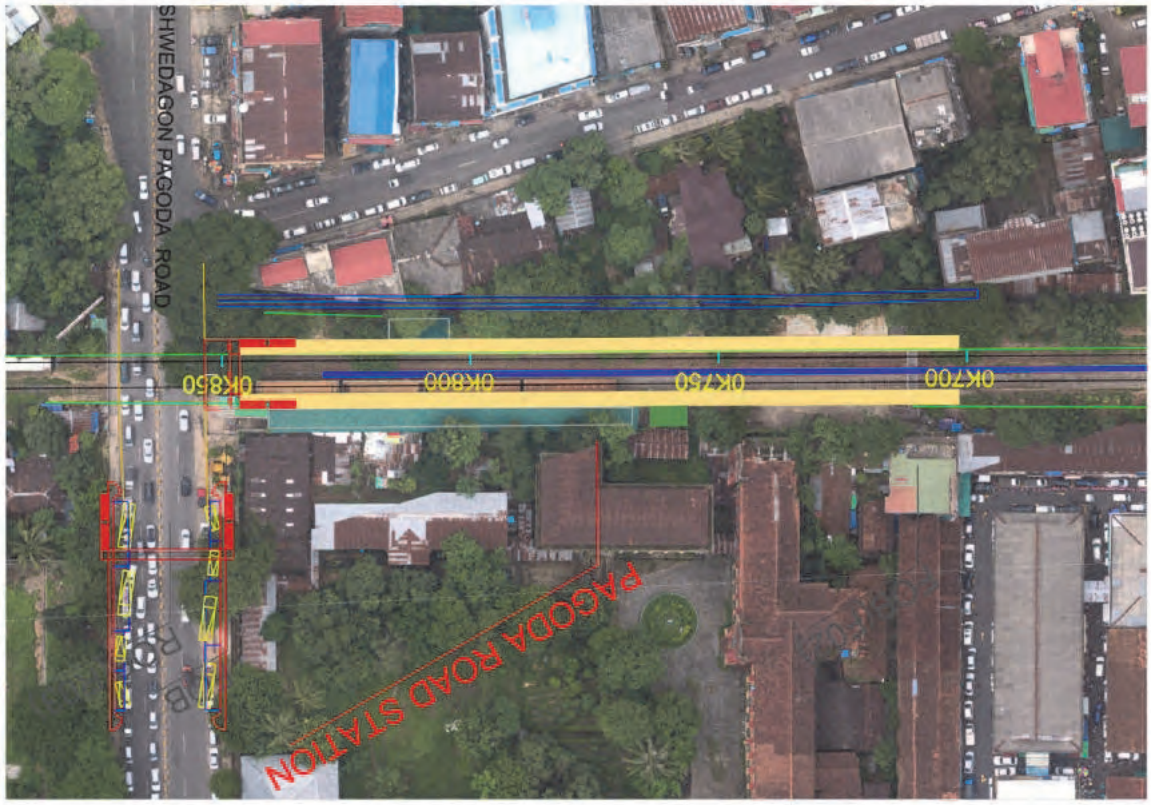
Proposed layout plan



Source: JICA Study Team

Figure 4.5.2 Existing and Proposed Layout Plan (Phaya Road Station)

Proposed layout plan and accessibility

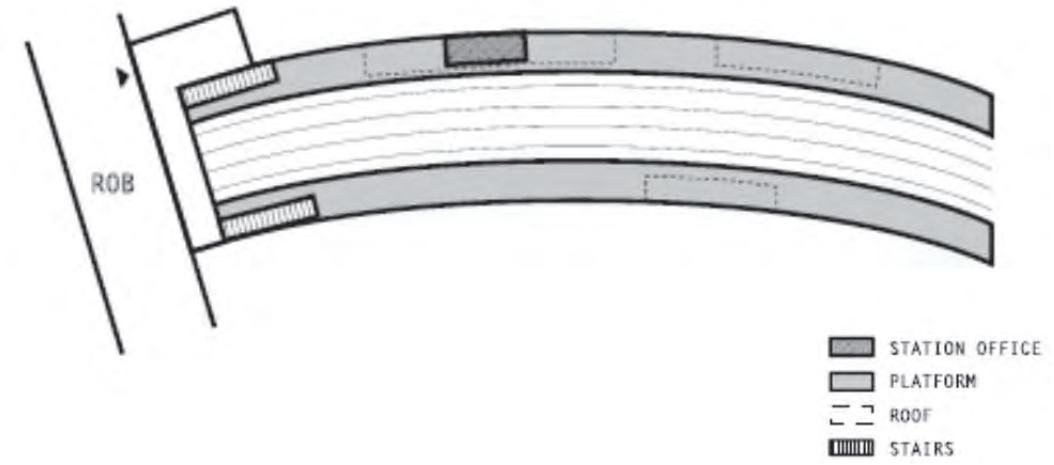


Source: JICA Study Team

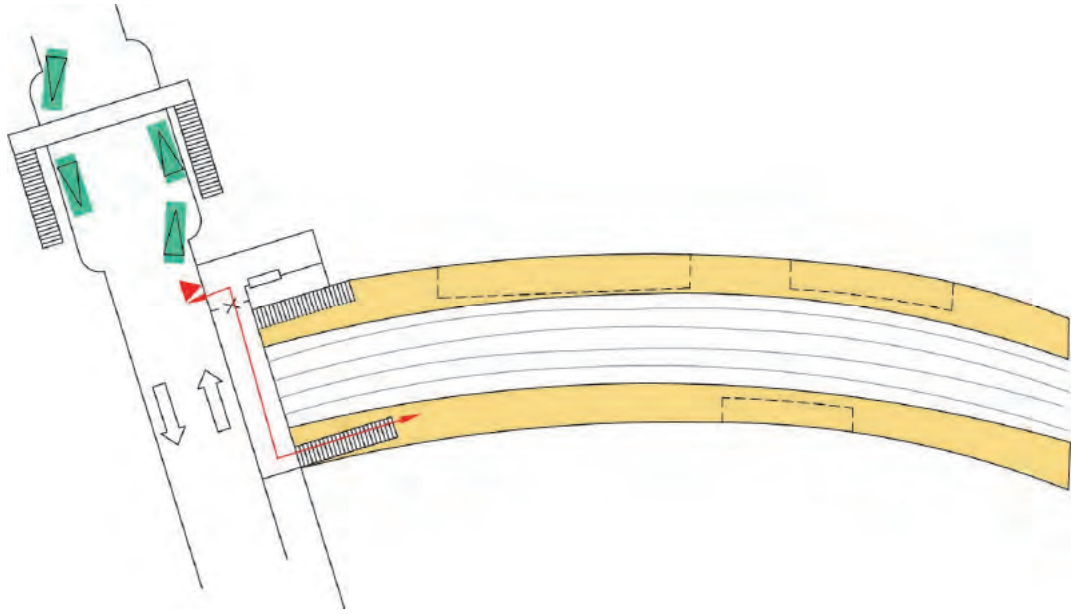
Figure 4.5.3 Proposed Layout Plan and Accessibility (Phaya Road Station)

2) Phaya Road Station

Existing layout



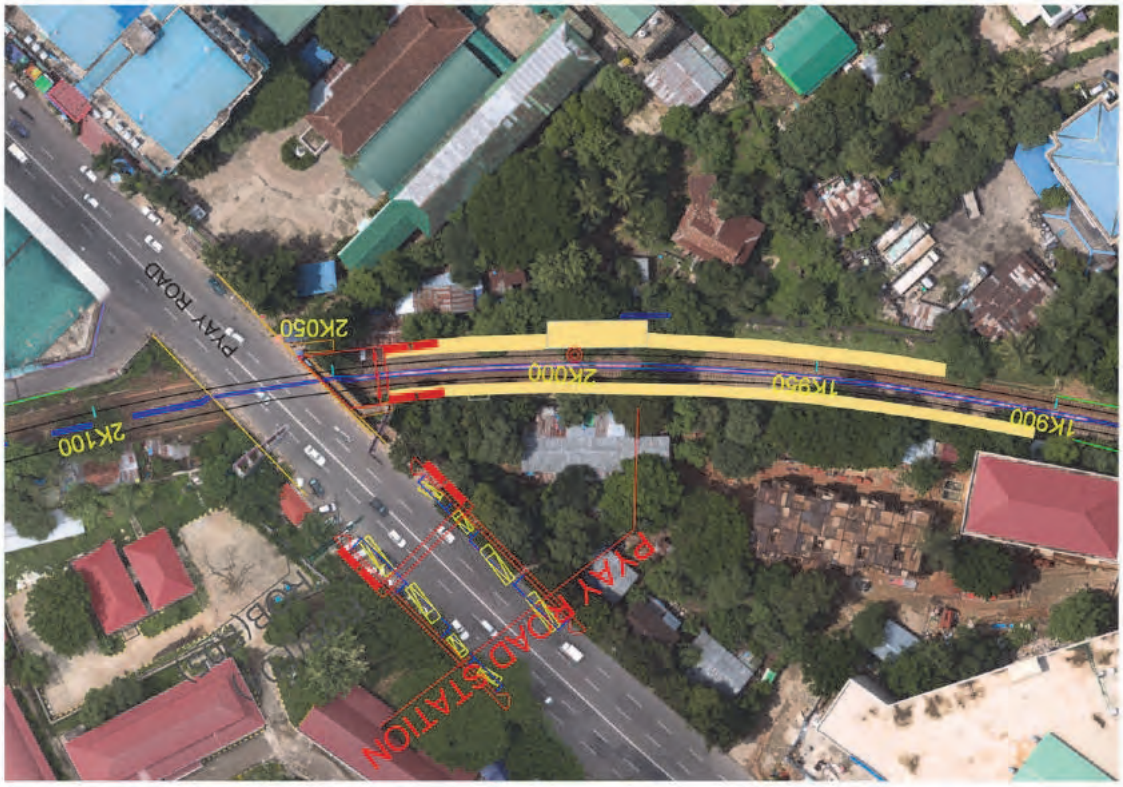
Proposed layout plan



Source: JICA Study Team

Figure 4.5.4 Existing and Proposed Layout Plan (Phaya Road Station)

Proposed layout plan and accessibility

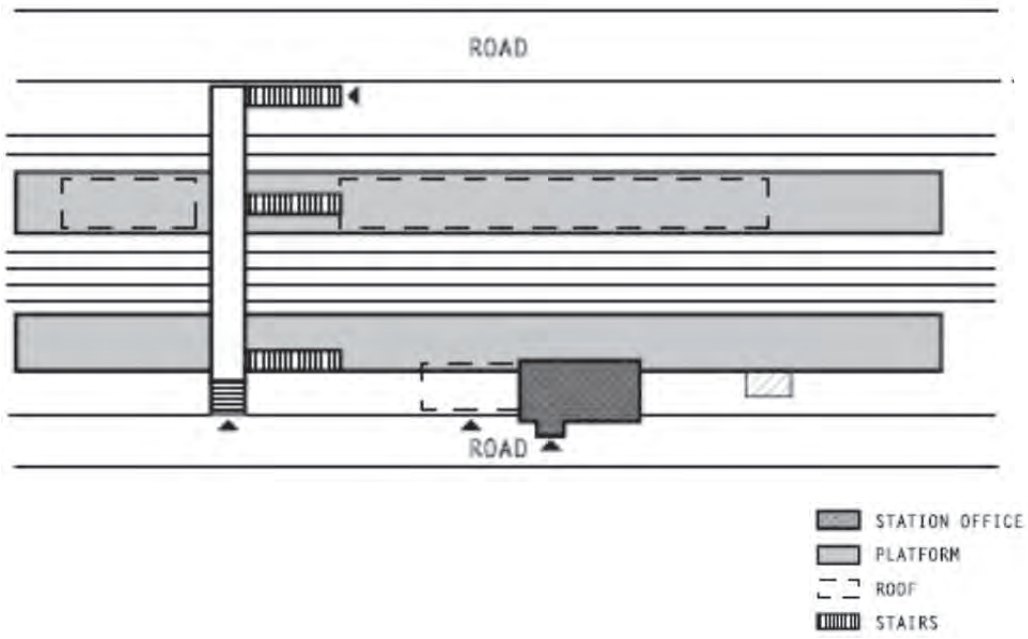


Source: JICA Study Team

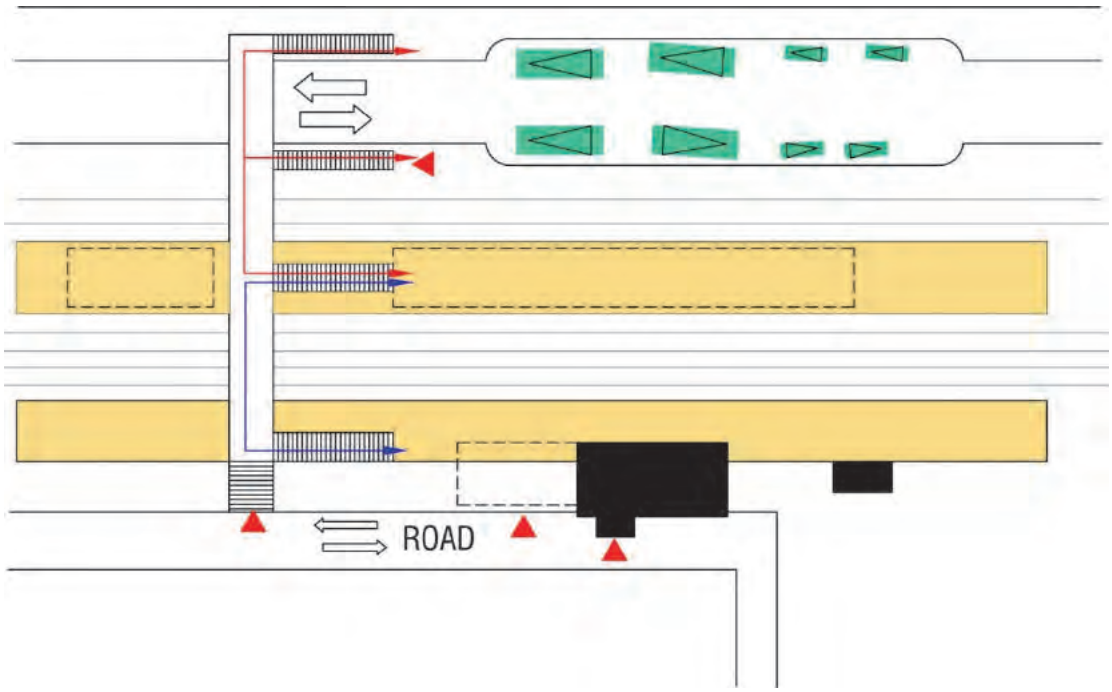
Figure 4.5.5 Proposed Layout Plan and Accessibility (Phaya Road Station)

3) KyeeMyinDaing Station

Existing layout plan



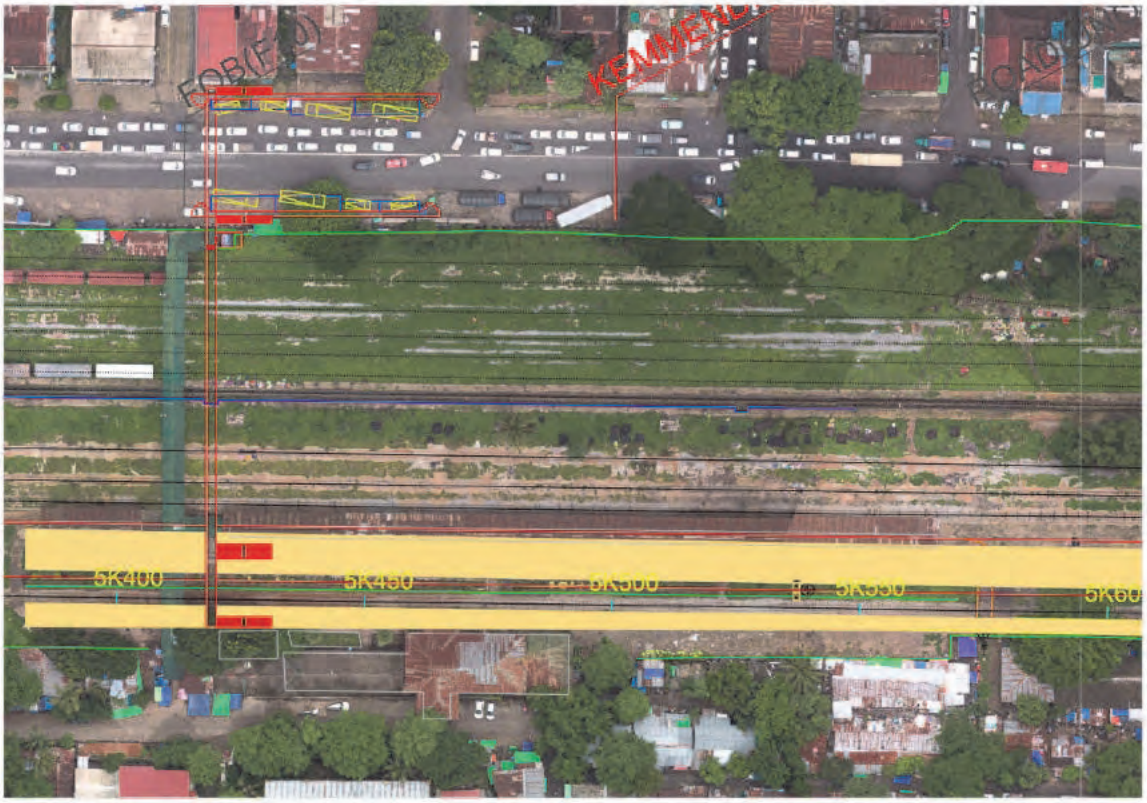
Proposed layout plan



Source: JICA Study Team

Figure 4.5.6 Existing and Proposed Layout Plan (KyeeMyinDaing Station)

Proposed layout plan and accessibility

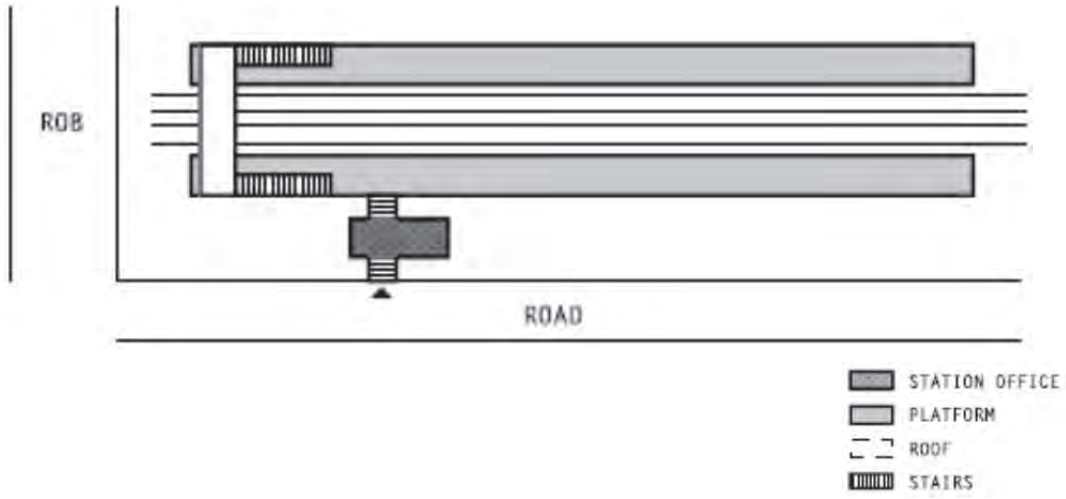


Source: JICA Study Team

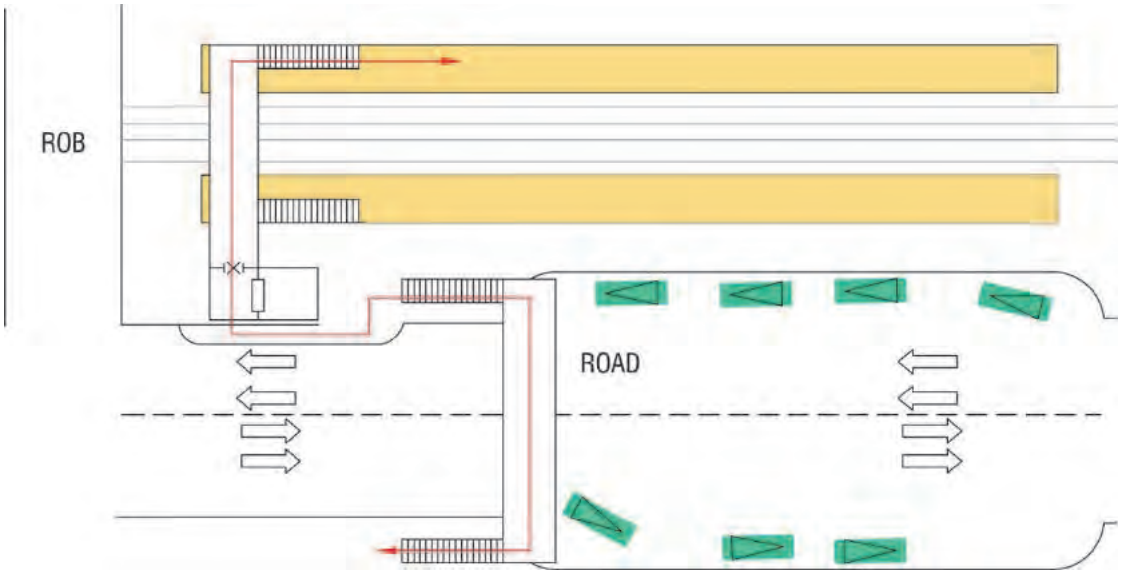
Figure 4.5.7 Proposed Layout Plan and Accessibility (KyeeMyinDaing Station)

4) Hanthawaddy Station

Existing layout plan



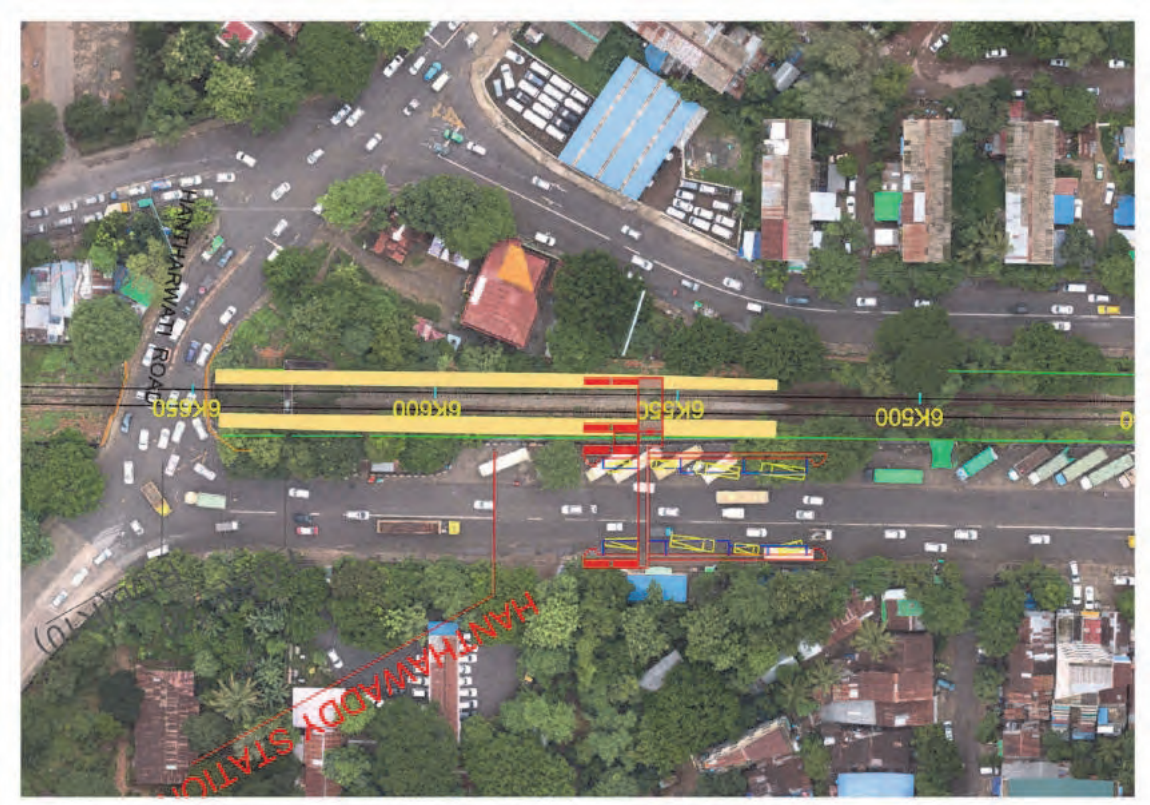
Proposed layout plan



Source: JICA Study Team

Figure 4.5.8 Existing and Proposed Layout Plan (Hanthawaddy Station)

Proposed layout plan and accessibility

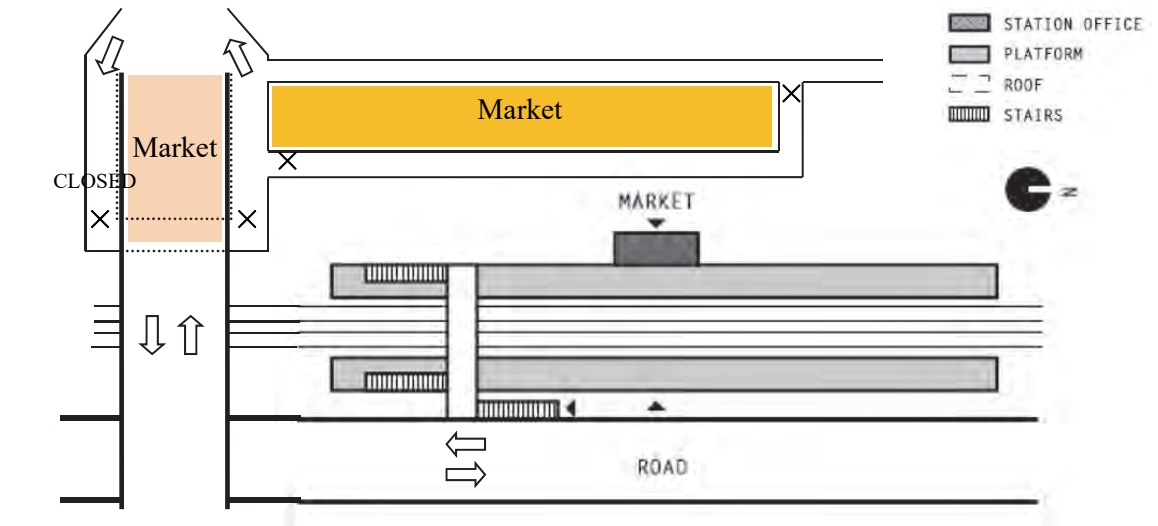


Source: JICA Study Team

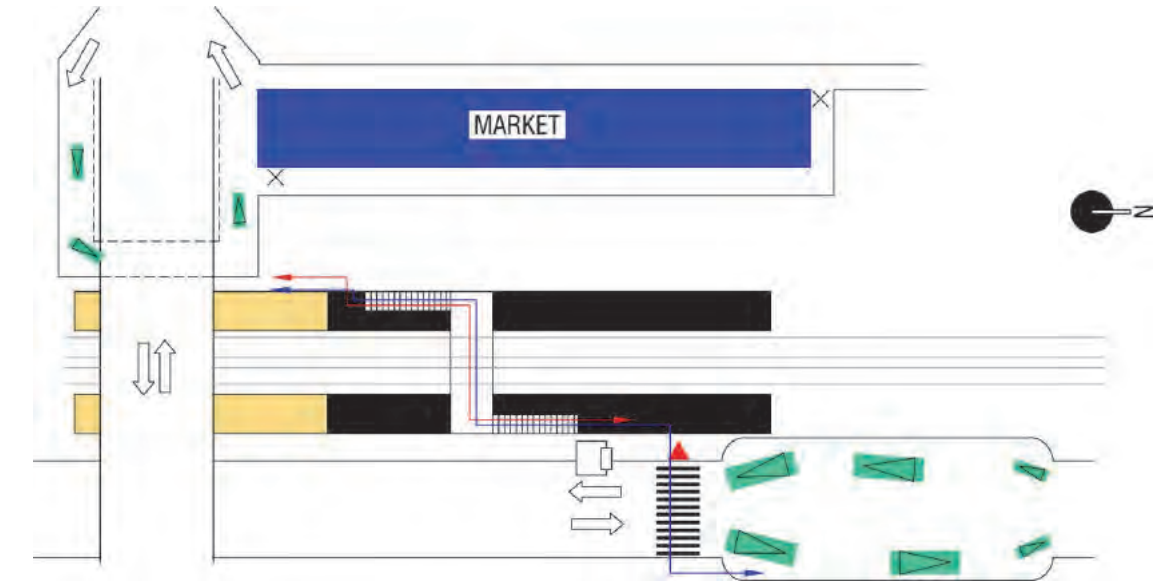
Figure 4.5.9 Proposed Layout Plan and Accessibility (Hanthawaddy Station)

5) hamine Station

Existing



Proposed layout plan



Source: JICA Study Team

Figure 4.5.10 Existing and Proposed Layout Plan (Thamine Station)

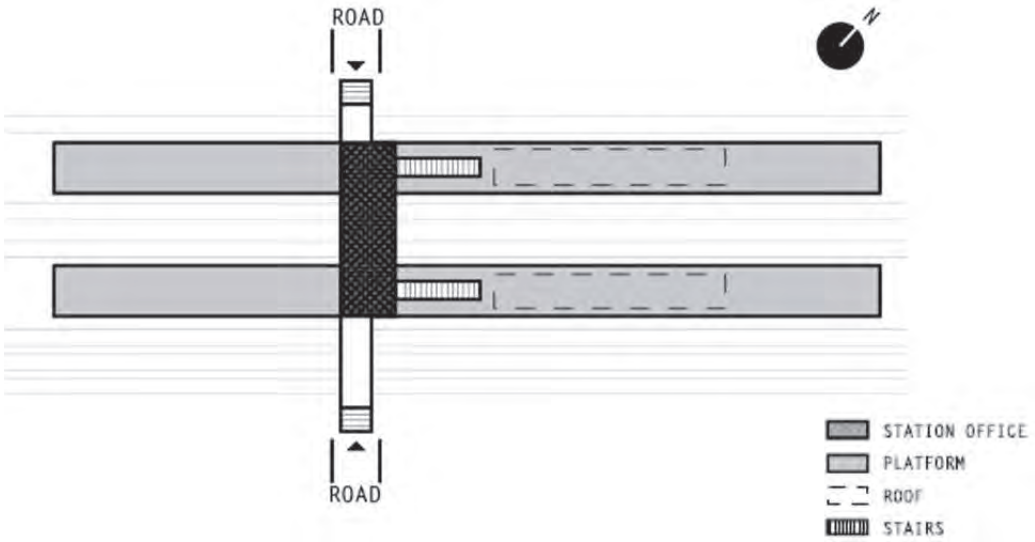
Proposed layout plan and accessibility

Source: JICA Study Team

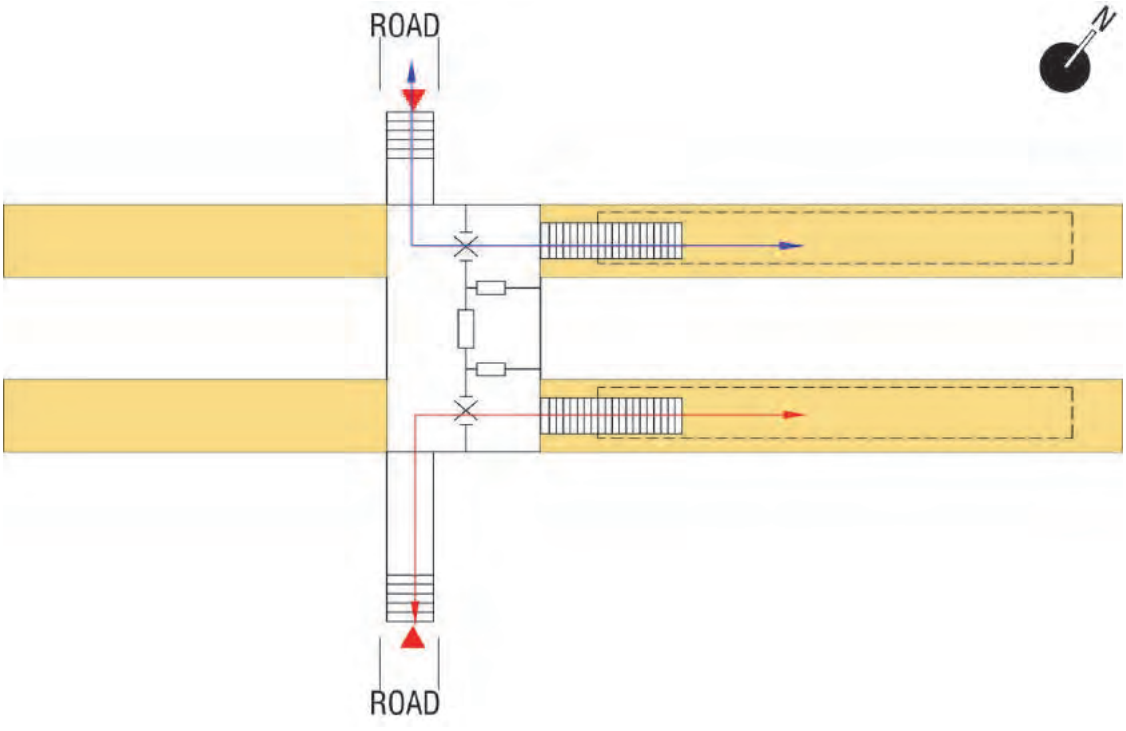
Figure 4.5.11 Proposed Layout Plan and Accessibility (Thamine Station)

6) Pa Zun Daung Road Station

Existing



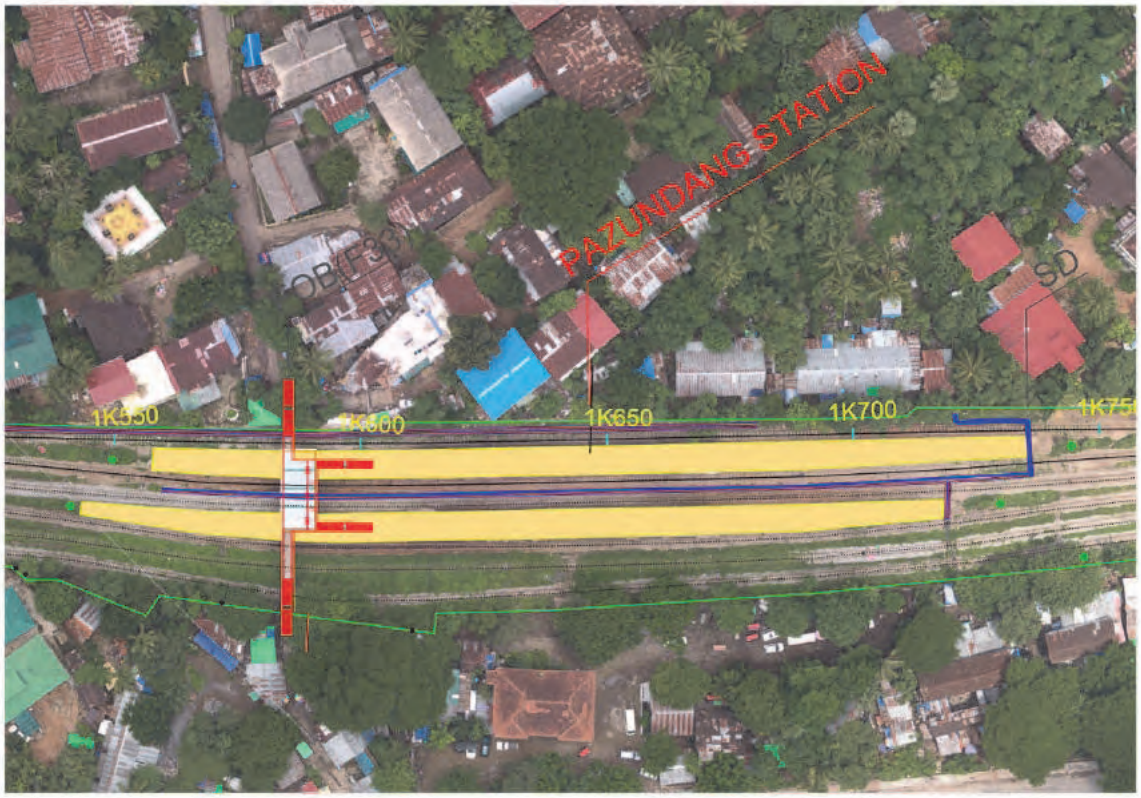
Proposed layout plan



Source: JICA Study Team

Figure 4.5.12 Existing and Proposed Layout Plan (Pa Zun Daung Road Station)

Proposed layout plan and accessibility



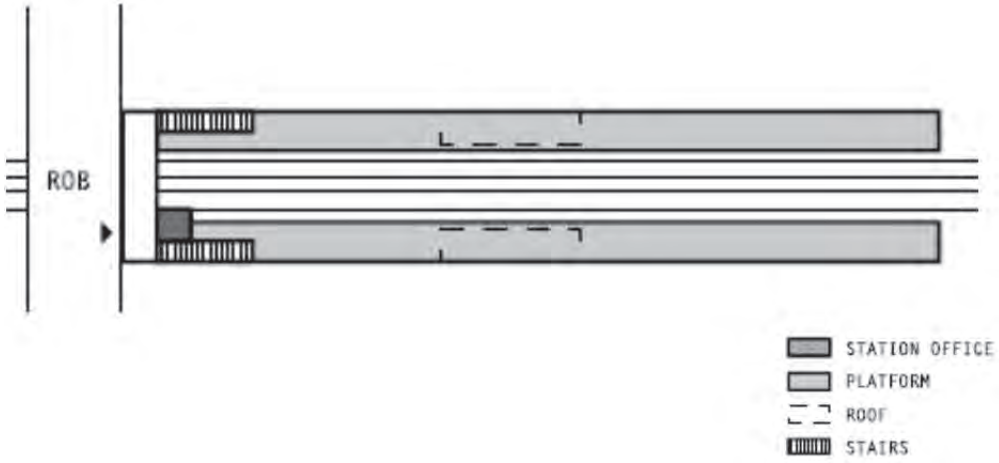
Source: JICA Study Team

Figure 4.5.13 Proposed Layout Plan and Accessibility (Pa Zun Daung Road Station)

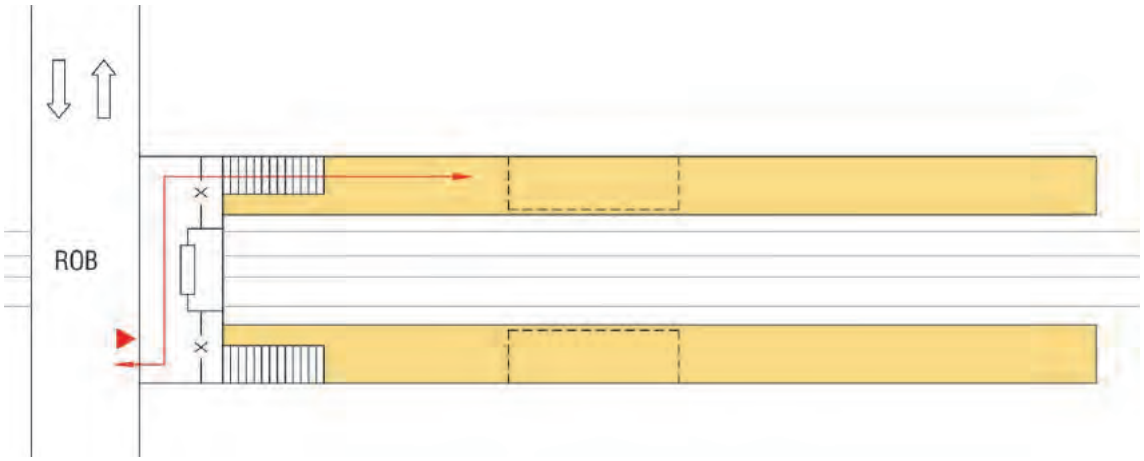
Group-B

1) Lan Ma Daw Station

Existing



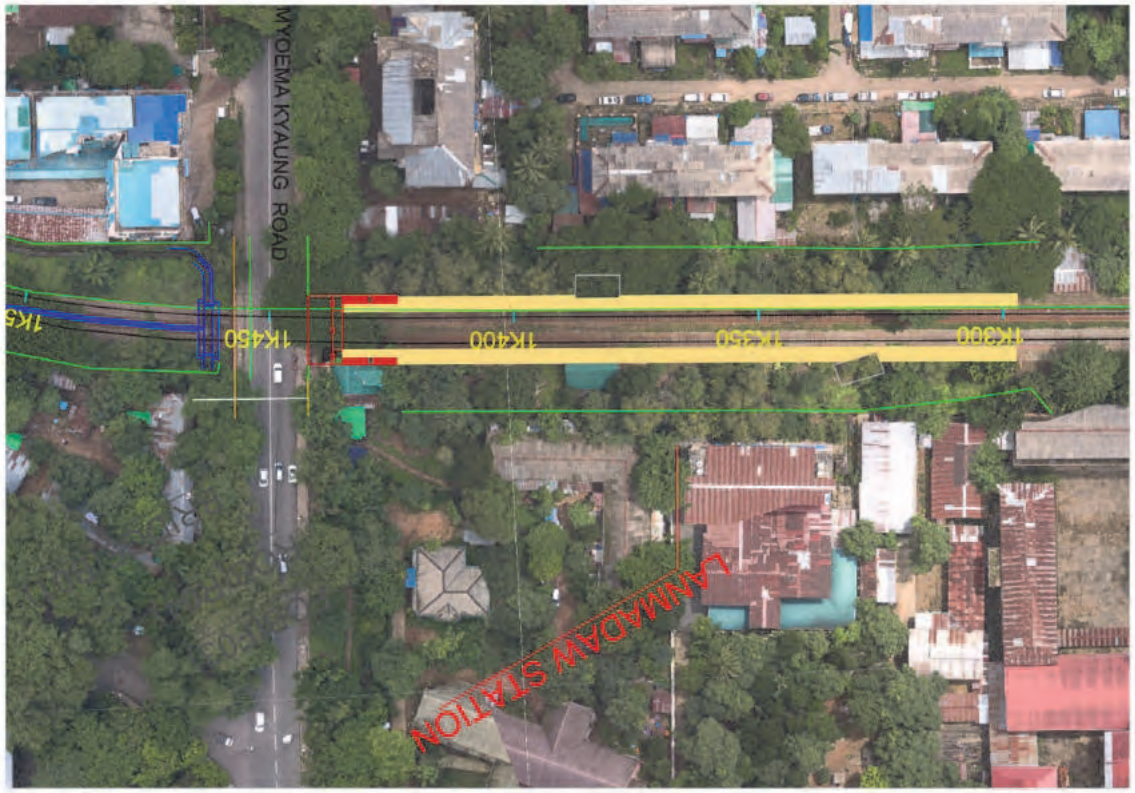
Proposed layout plan



Source: JICA Study Team

Figure 4.5.14 Existing and Proposed Layout Plan (Lan Ma Daw Station)

Proposed layout plan and accessibility

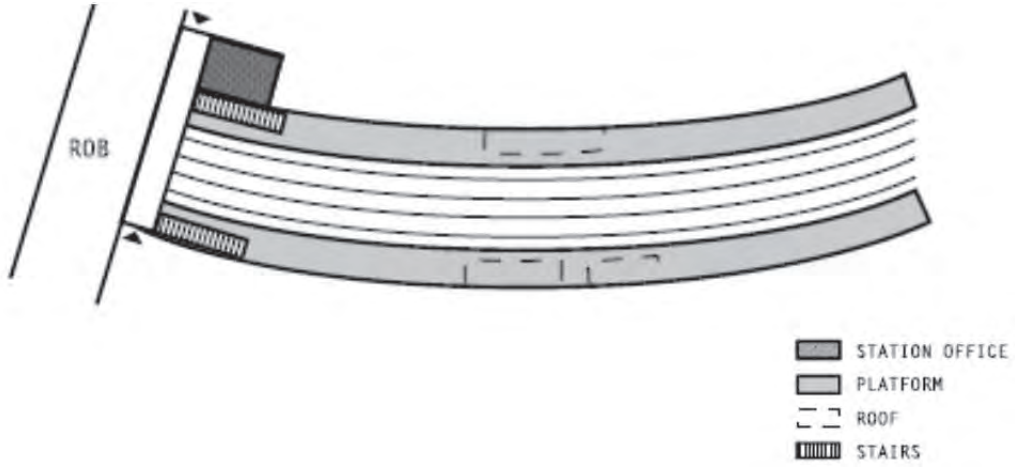


Source: JICA Study Team

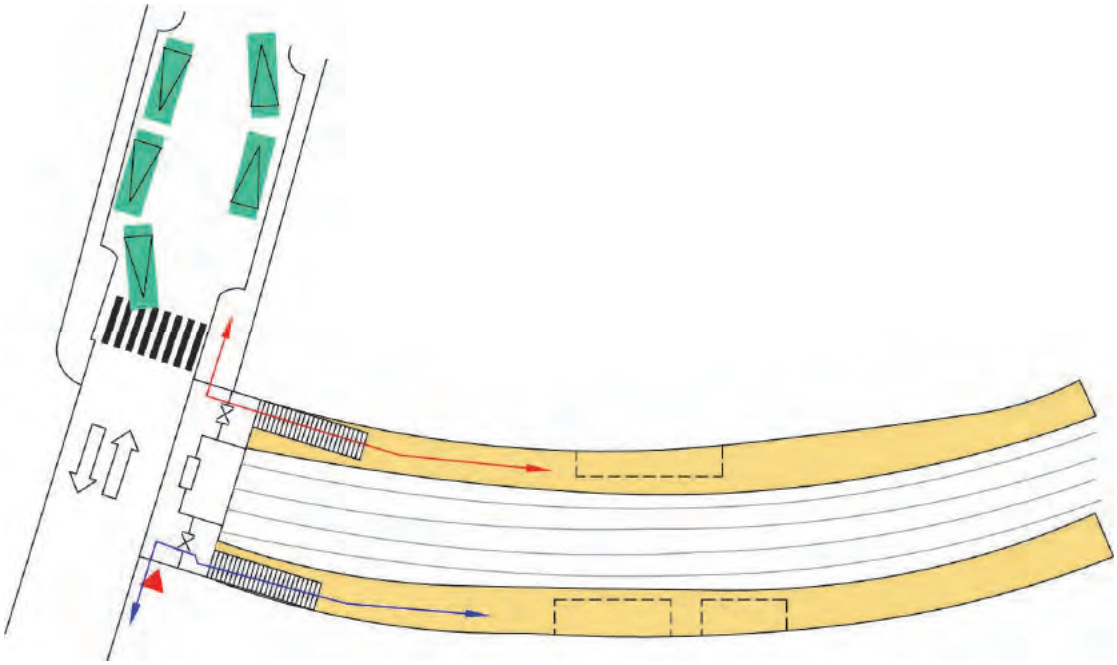
Figure 4.5.15 Proposed Layout Plan and Accessibility (Lan Ma Daw Station)

2) Shan Road Station

Existing layout plan



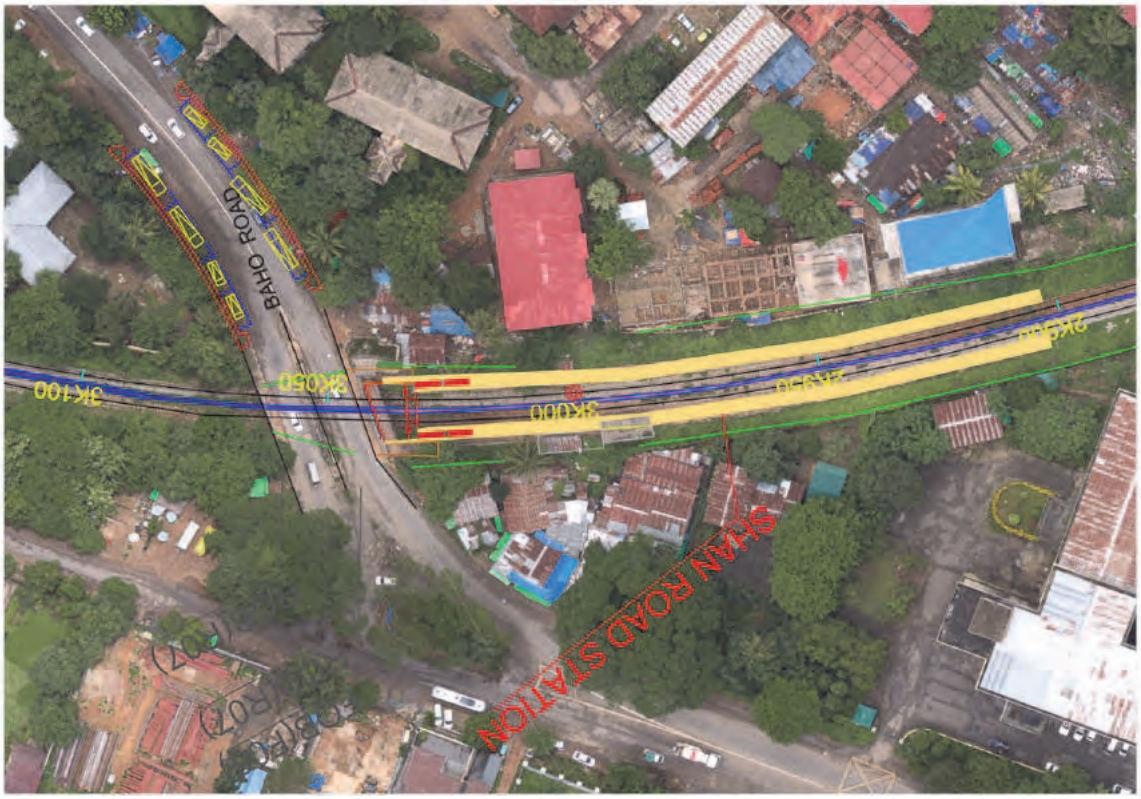
Proposed layout plan



Source: JICA Study Team

Figure 4.5.16 Existing and Proposed Layout Plan (Shan Road Station)

Proposed layout plan and accessibility

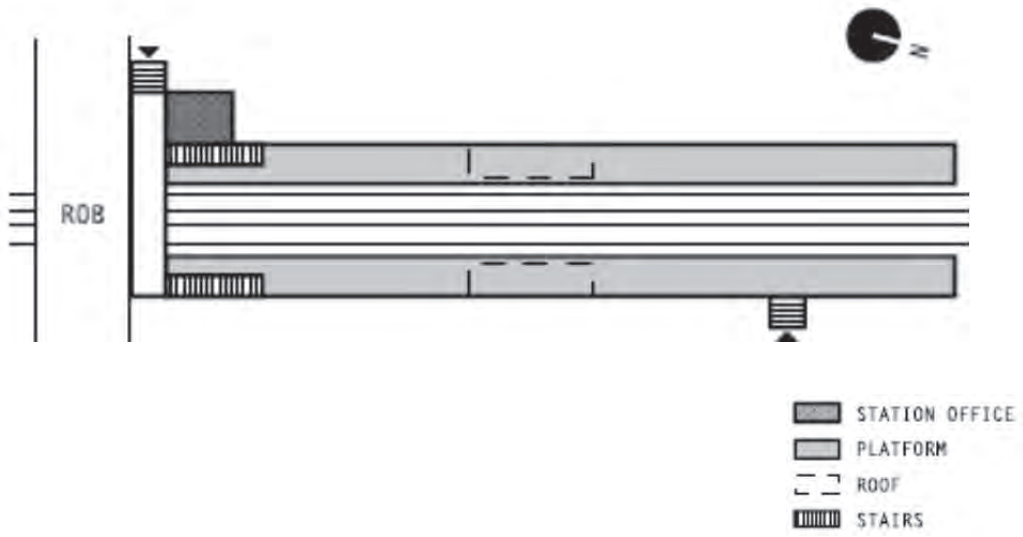


Source: JICA Study Team

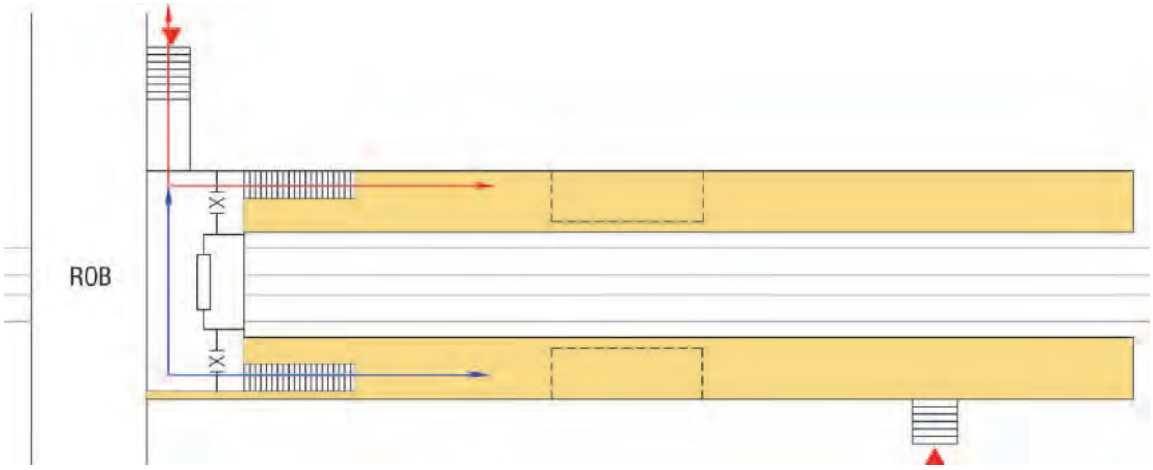
Figure 4.5.17 Proposed Layout Plan and Accessibility (Shan Road Station)

3) Ahlone Road Station

Existing layout plan



Proposed layout plan



Source: JICA Study Team

Figure 4.5.18 Existing and Proposed Layout Plan (Ahlone Road Station)

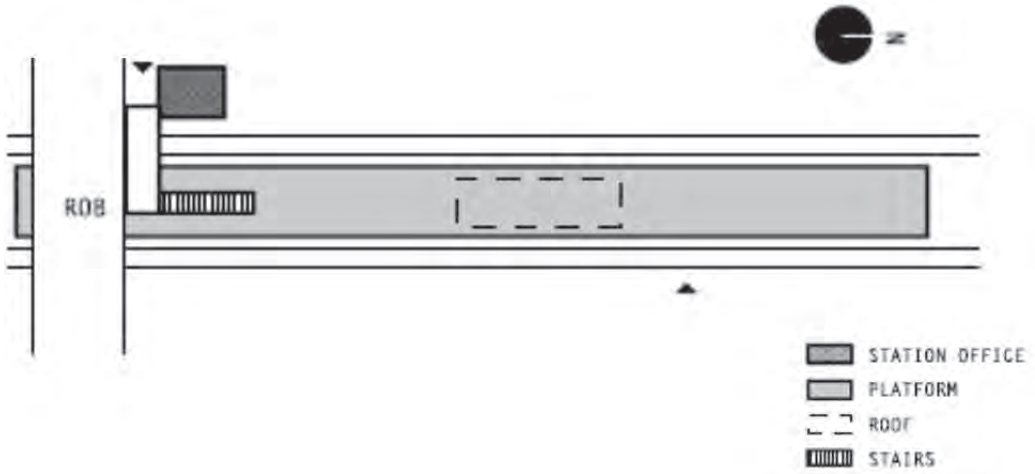
Layout plan and accessibility

Source: JICA Study Team

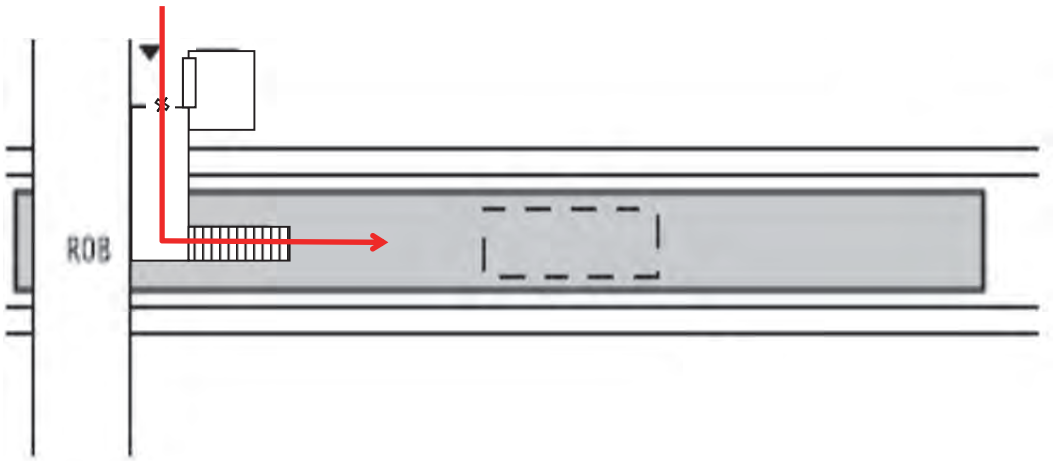
Figure 4.5.19 Proposed Layout Plan and Accessibility (Ahlone Road Station)

4) Panhlaing Road Station

Existing layout plan



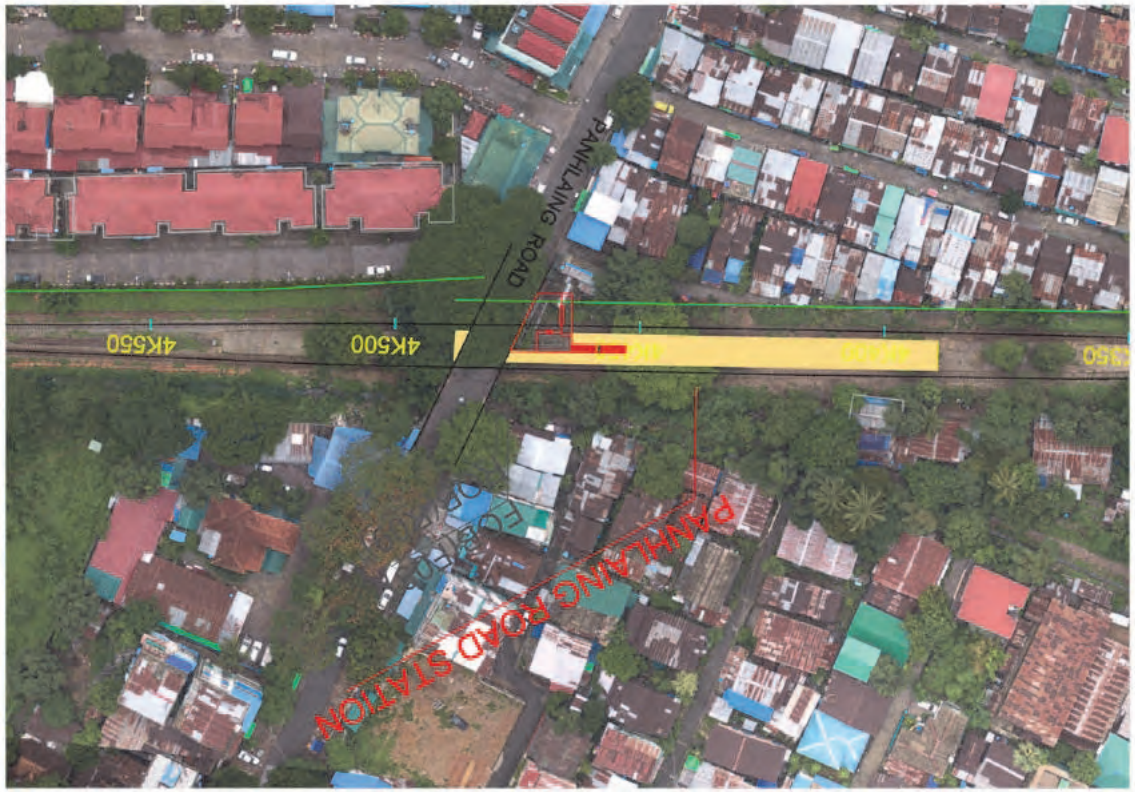
Proposed layout plan



Source: JICA Study Team

Figure 4.5.20 Existing and Proposed Layout Plan (Panhlaing Road Station)

Proposed layout plan and accessibility

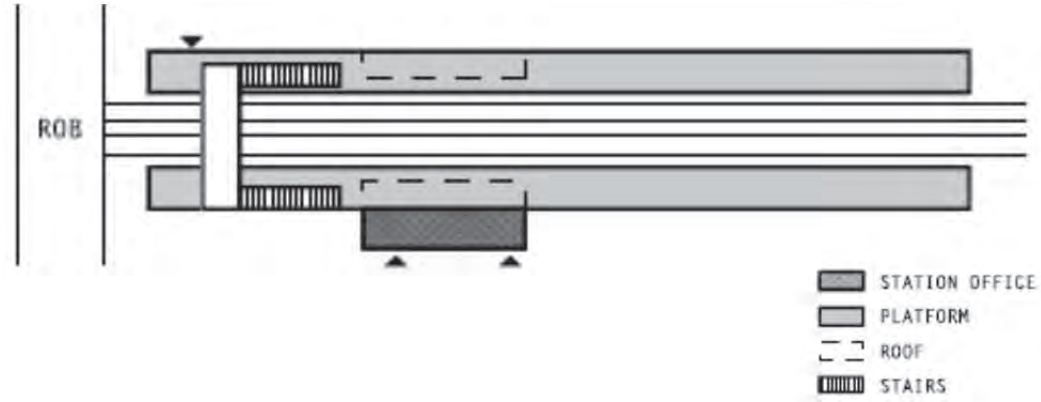


Source: JICA Study Team

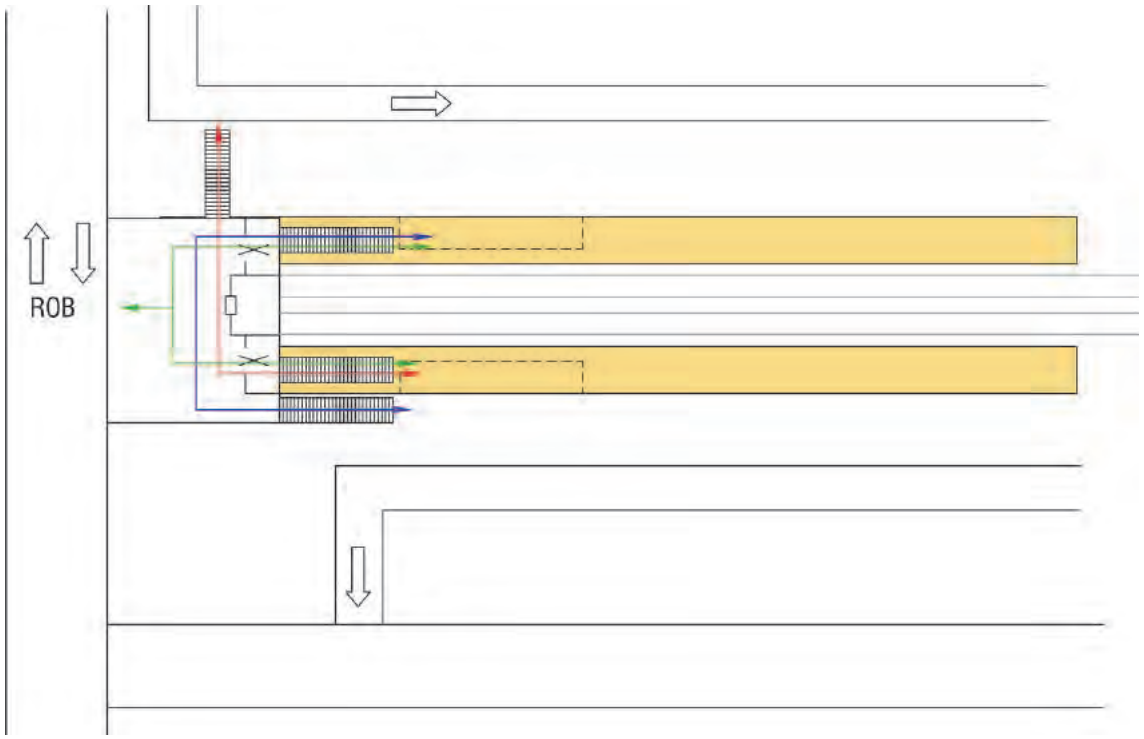
Figure 4.5.21 Proposed Layout Plan and Accessibility (Panhlaing Road Station)

5) Hledan Station

Existing layout



Proposed layout plan



Source: JICA Study Team

Figure 4.5.22 Existing and Proposed Layout Plan (Hledan Station)

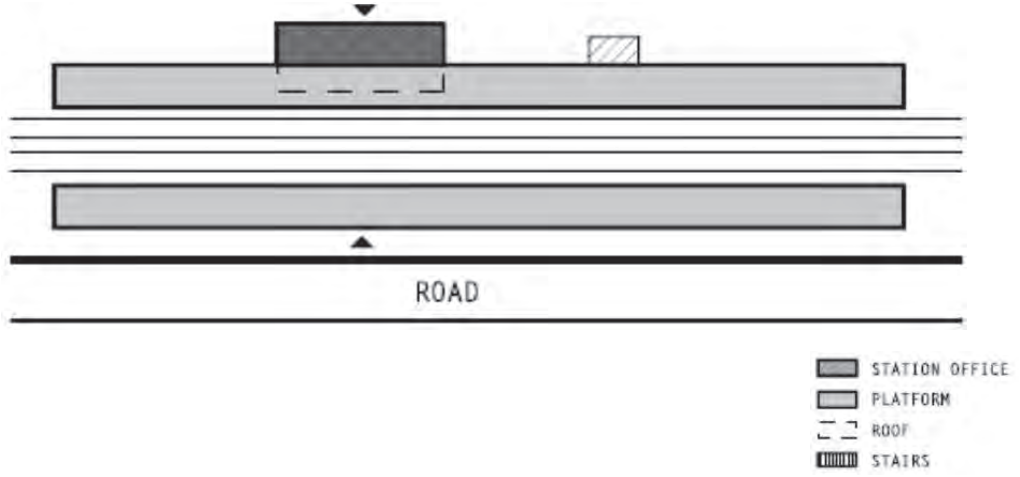
Proposed layout plan and accessibility

Source: JICA Study Team

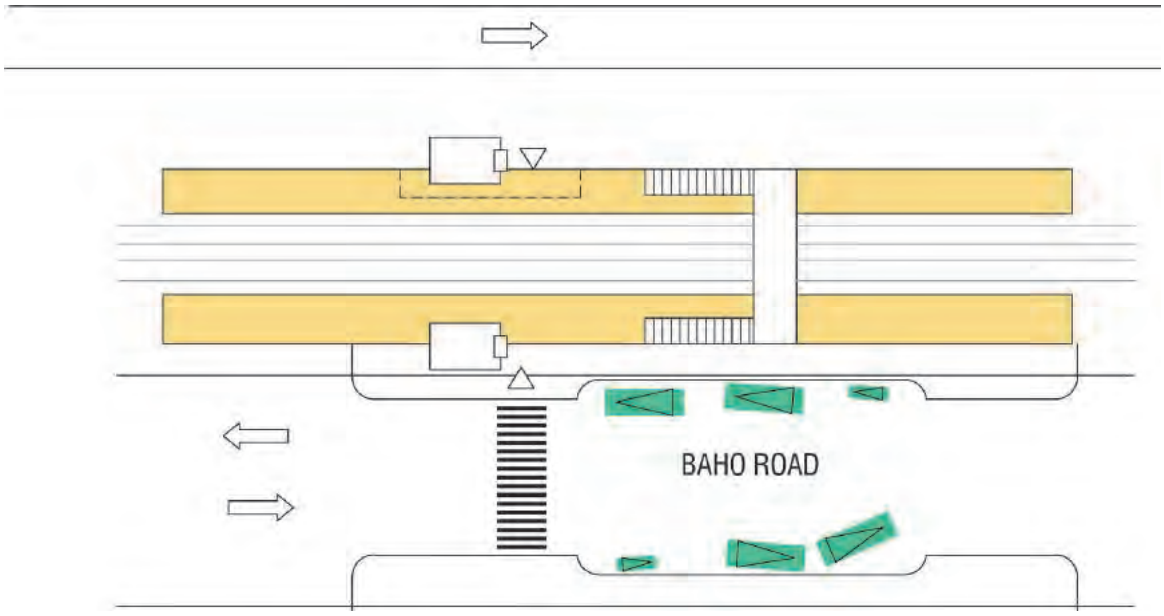
Figure 4.5.23 Proposed Layout Plan and Accessibility (Hledan Station)

6) Kamayut Station

Existing layout



Proposed layout plan



Source: JICA Study Team

Figure 4.5.24 Existing and Proposed Layout Plan (Kamayut Station)

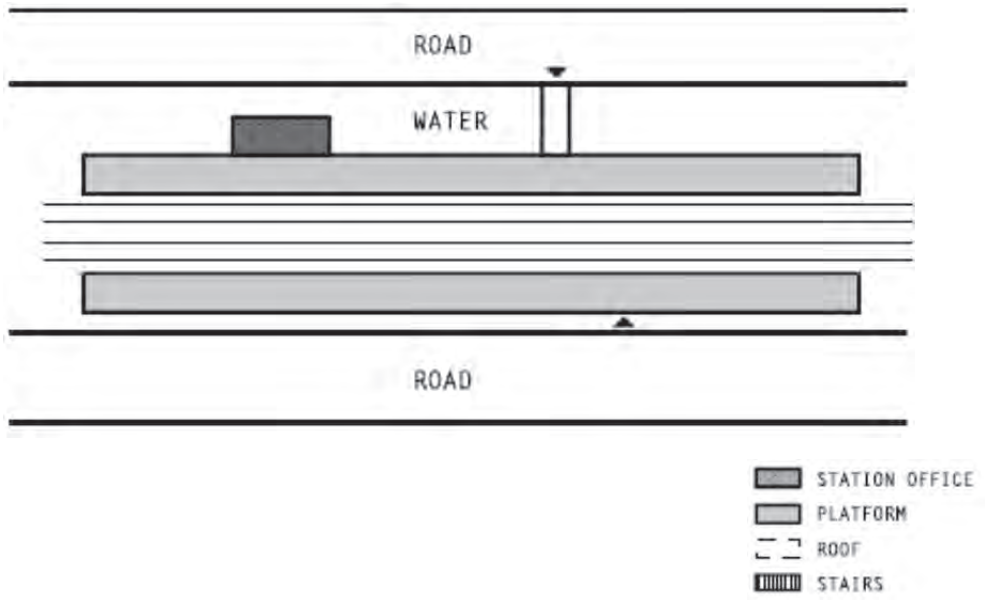
Proposed layout plan and accessibility

Source: JICA Study Team

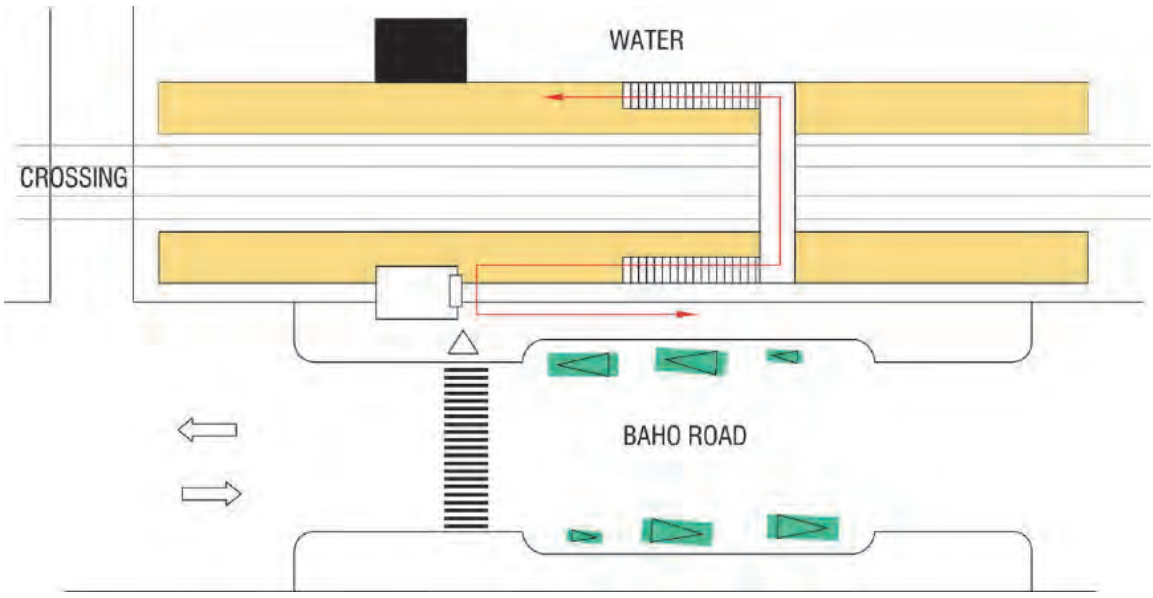
Figure 4.5.25 Proposed Layout Plan and Accessibility (Kamayut Station)

7) Thrimyaing Station

Existing



Proposed layout plan



Source: JICA Study Team

Figure 4.5.26 Existing and Proposed Layout Plan (Thrimyaing Station)

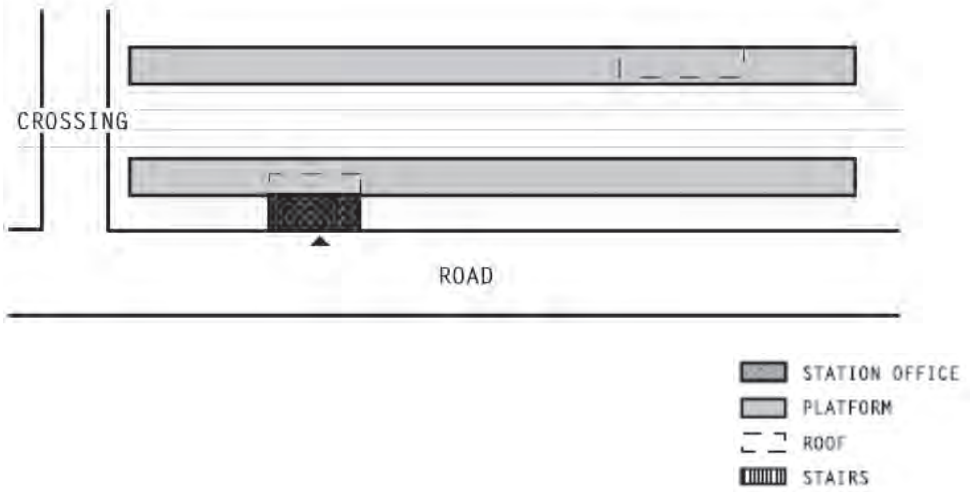
Proposed layout plan and accessibility

Source: JICA Study Team

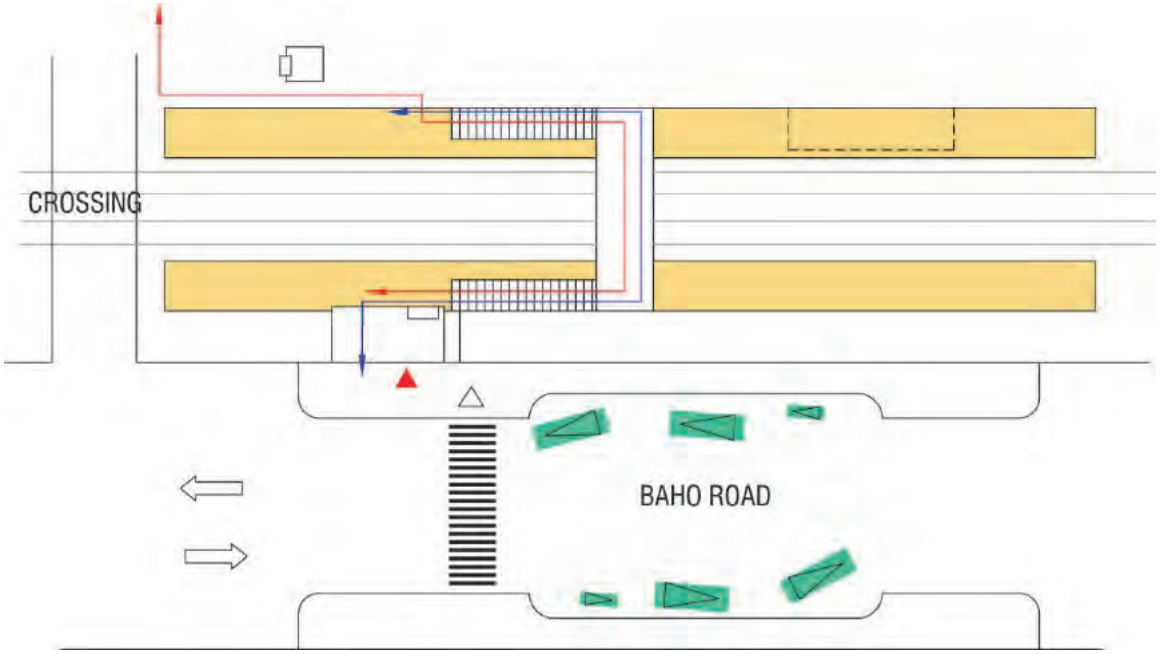
Figure 4.5.27 Proposed Layout Plan and Accessibility (Thrimyaing Station)

8) Okkyin Station

Existing layout



Proposed layout plan



Source: JICA Study Team

Figure 4.5.28 Existing and Proposed Layout Plan (Okkyin Station)

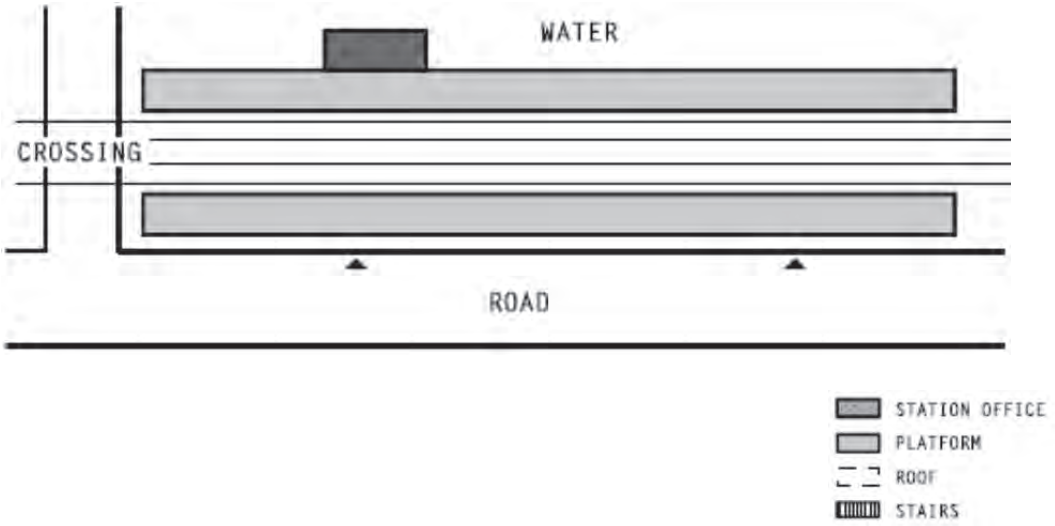
Proposed layout plan and accessibility

Source: JICA Study Team

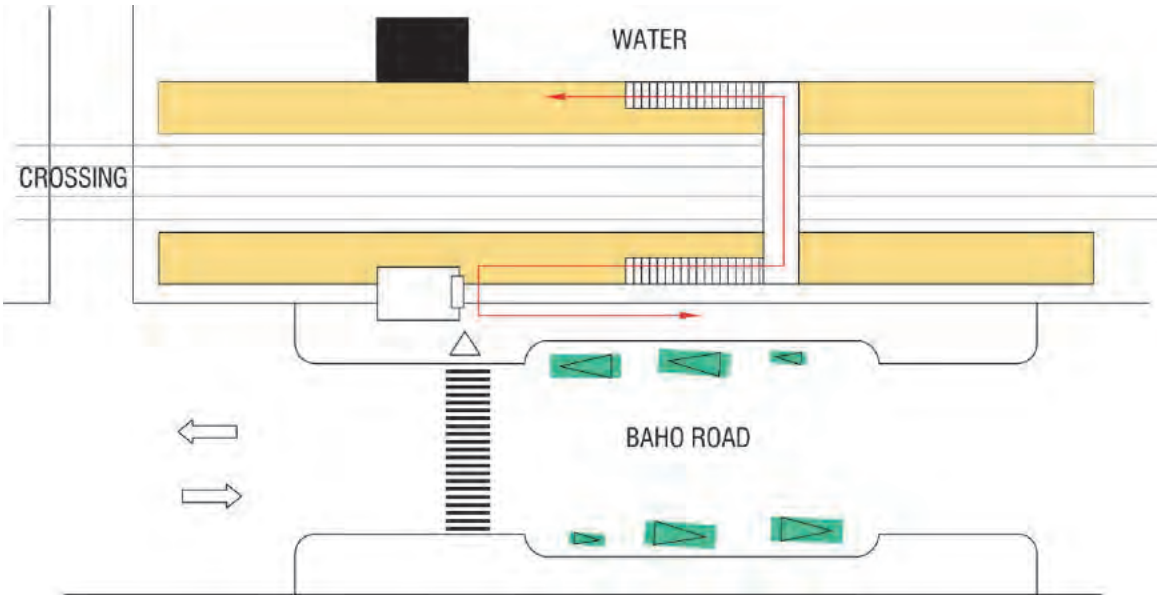
Figure 4.5.29 Proposed Layout Plan and Accessibility (Okkyin Station)

9) Thamaing Myothit Station

Existing layout



Proposed layout plan



Source: JICA Study Team

Figure 4.5.30 Existing and Proposed Layout Plan (Thamaing Myothit Station)

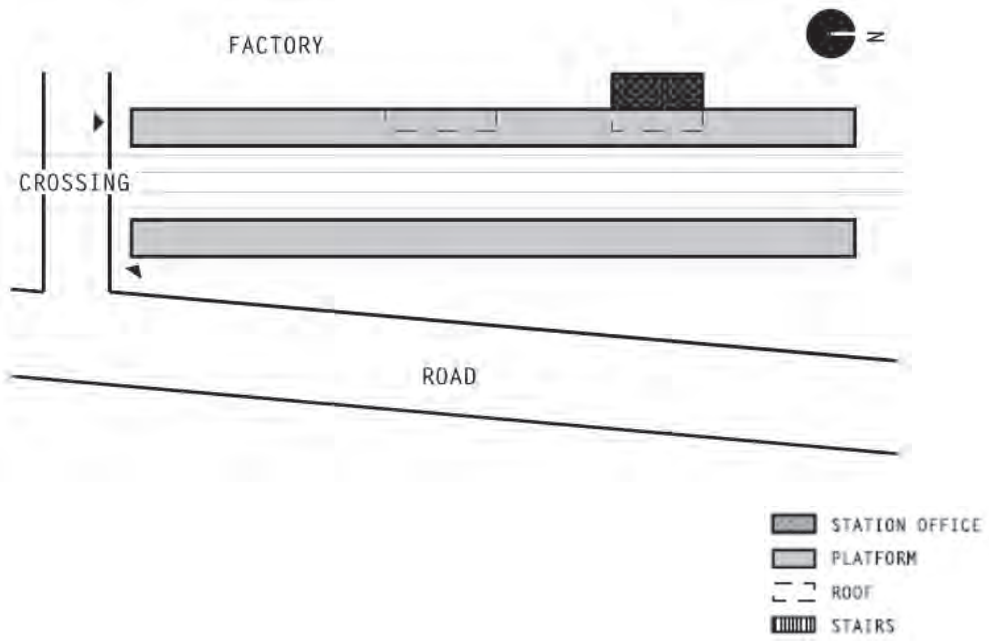
Proposed layout plan and accessibility

Source: JICA Study Team

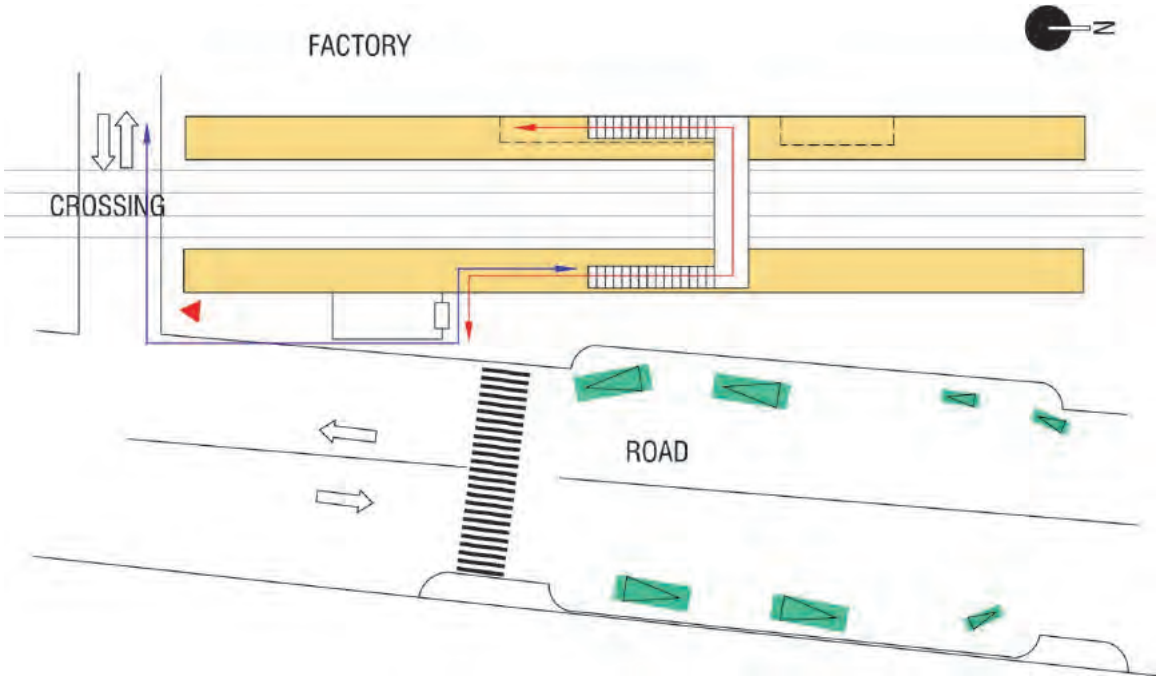
Figure 4.5.31 Proposed Layout Plan and Accessibility (Thamaing Myothit Station)

10) Gyogon Station

Existing



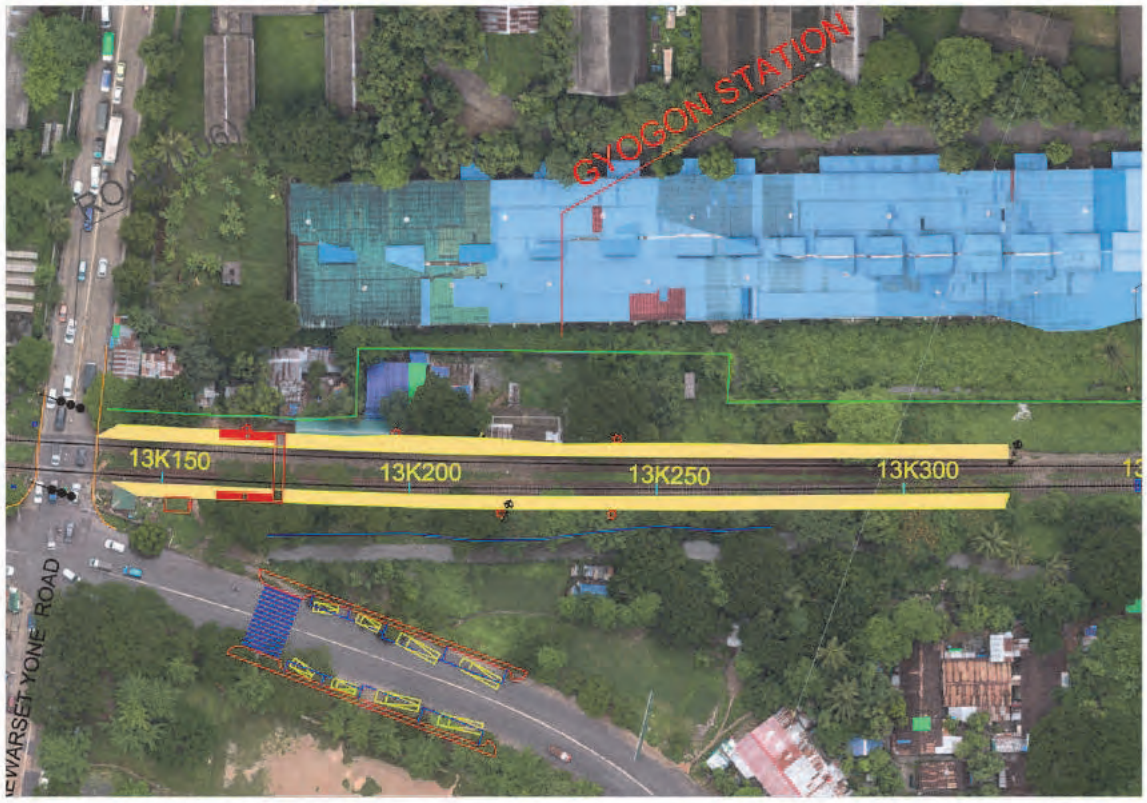
Proposed layout plan



Source: JICA Study Team

Figure 4.5.32 Existing and Proposed Layout Plan (Gyogon Station)

Proposed layout plan and accessibility

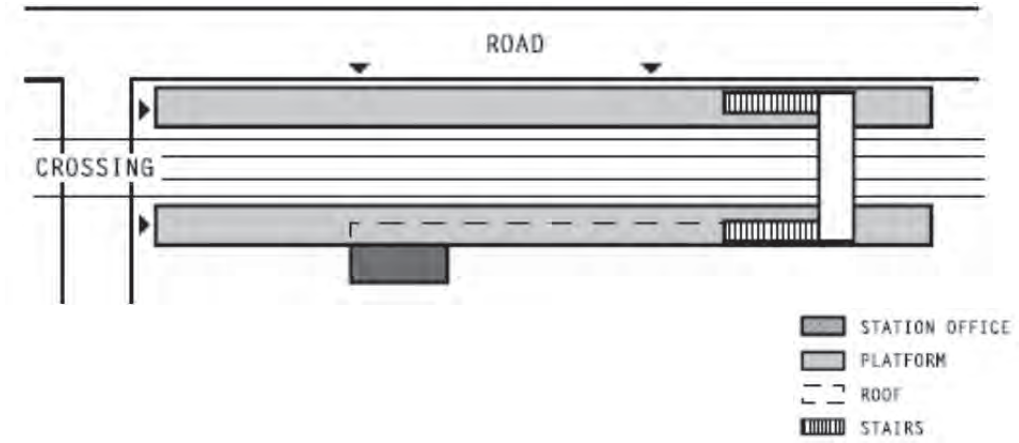


Source: JICA Study Team

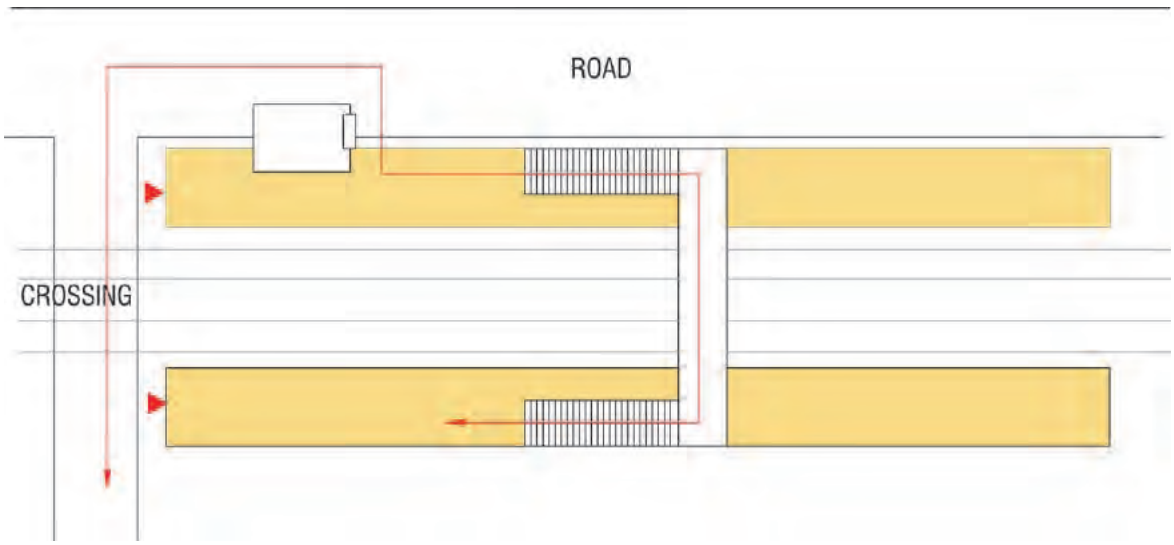
Figure 4.5.33 Proposed Layout Plan and Accessibility (Gyogon Station)

11) Ywama Station

Existing



Proposed layout plan



Source: JICA Study Team

Figure 4.5.34 Existing and Proposed Layout Plan (Ywama Station)

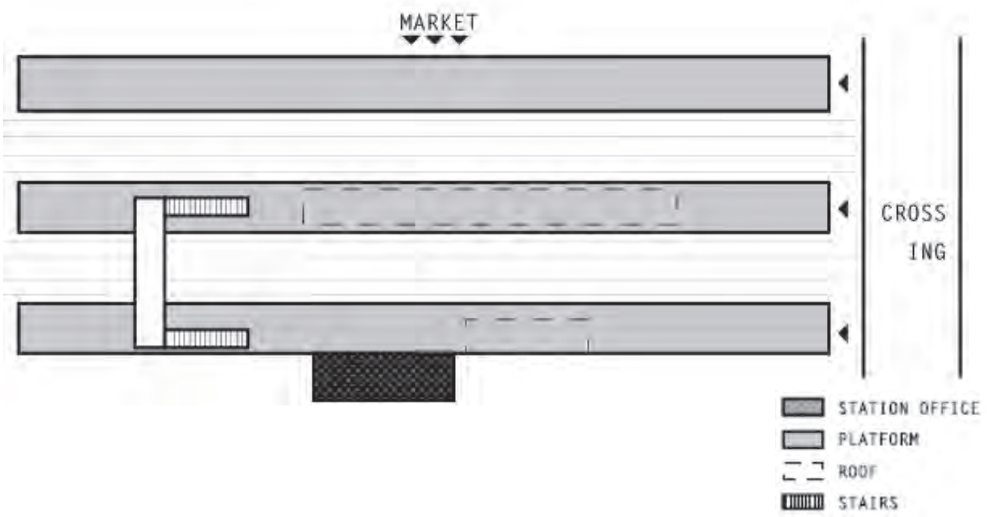
Proposed layout plan and accessibility

Source: JICA Study Team

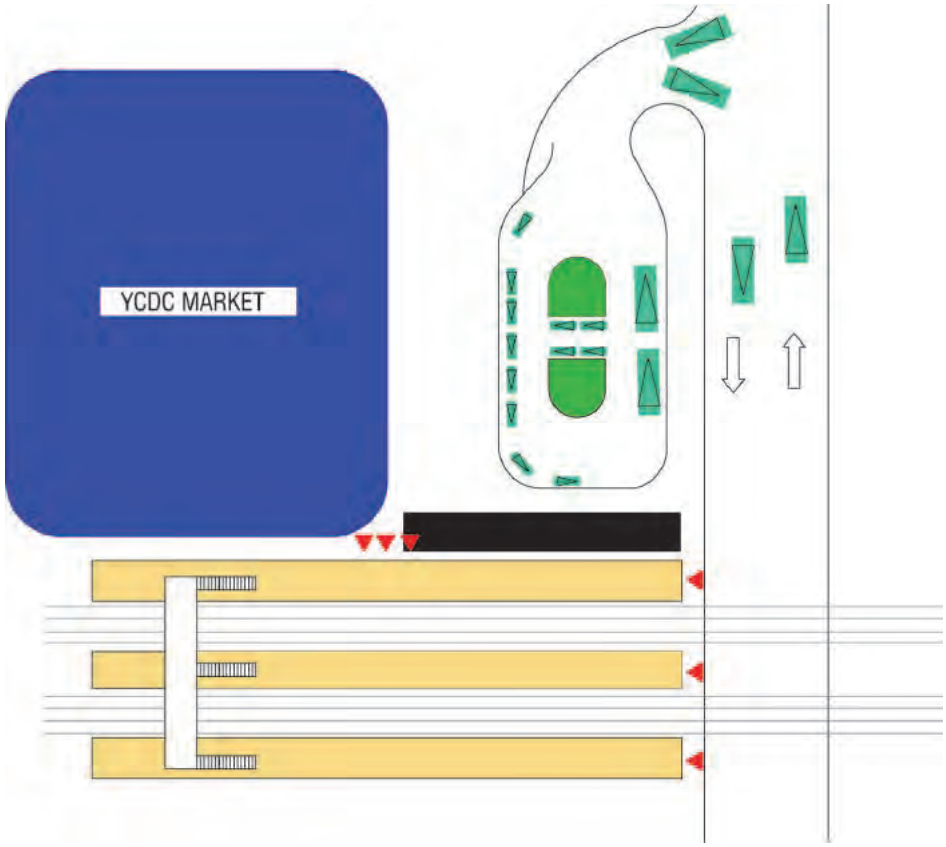
Figure 4.5.35 Proposed Layout Plan and Accessibility (Ywama Station)

12) Dan Yin Gon Station

Existing



Proposed layout plan



Source: JICA Study Team

Figure 4.5.36 Existing and Proposed Layout Plan (Dan Yin Gon Station)

Proposed layout plan and accessibility

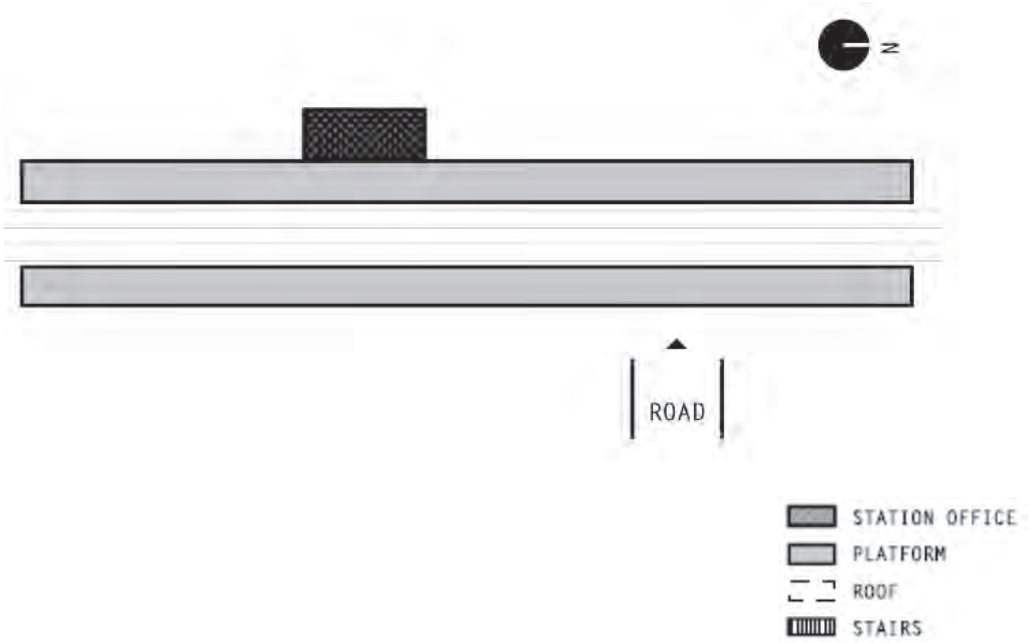
Source: JICA Study Team

Figure 4.5.37 Proposed Layout Plan and Accessibility (Dan Yin Gon Station)

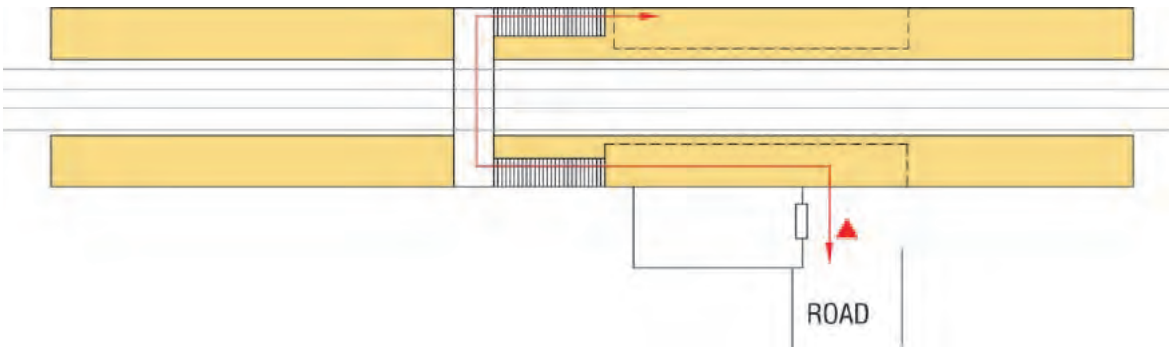
Group C

1) Phawkan Station

Existing



Proposed layout plan



Source: JICA Study Team

Figure 4.5.38 Existing and Proposed Layout Plan (Phawkan Station)

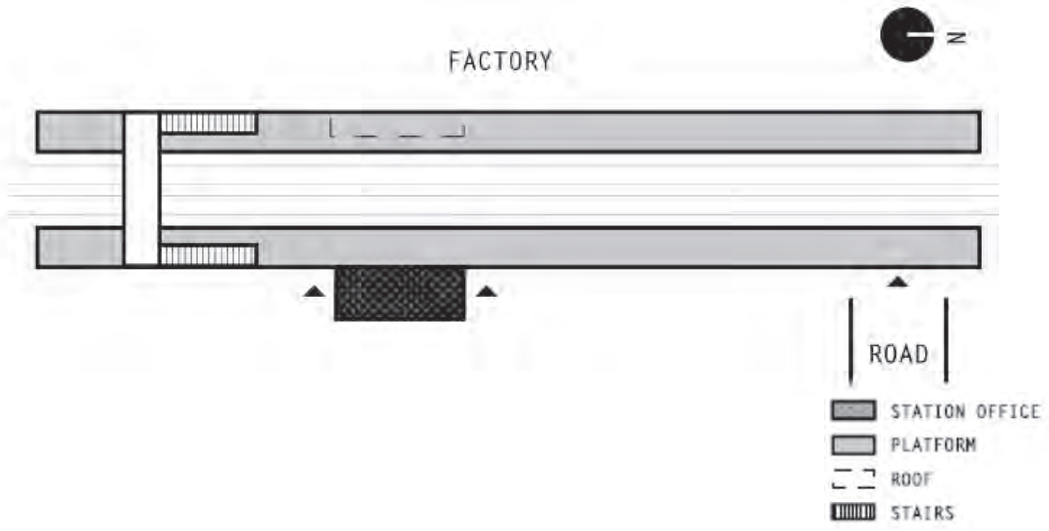
Proposed layout plan and accessibility

Source: JICA Study Team

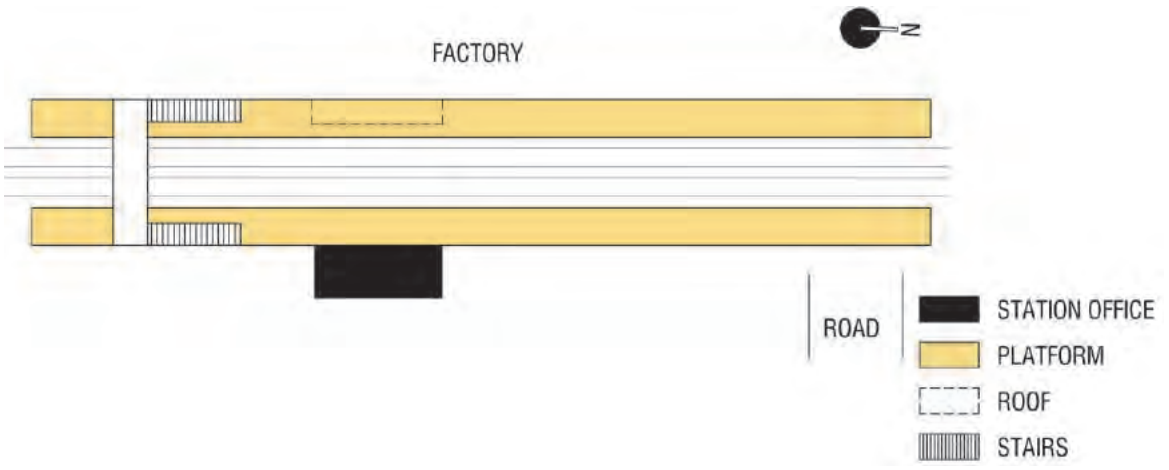
Figure 4.5.39 Proposed Layout Plan and Accessibility (Phawkan Station)

2) AungSunMyo Station

Existing layout



Proposed layout plan



Source: JICA Study Team

Figure 4.5.40 Existing and Proposed Layout Plan (AungSunMyo Station)

Proposed layout plan and accessibility

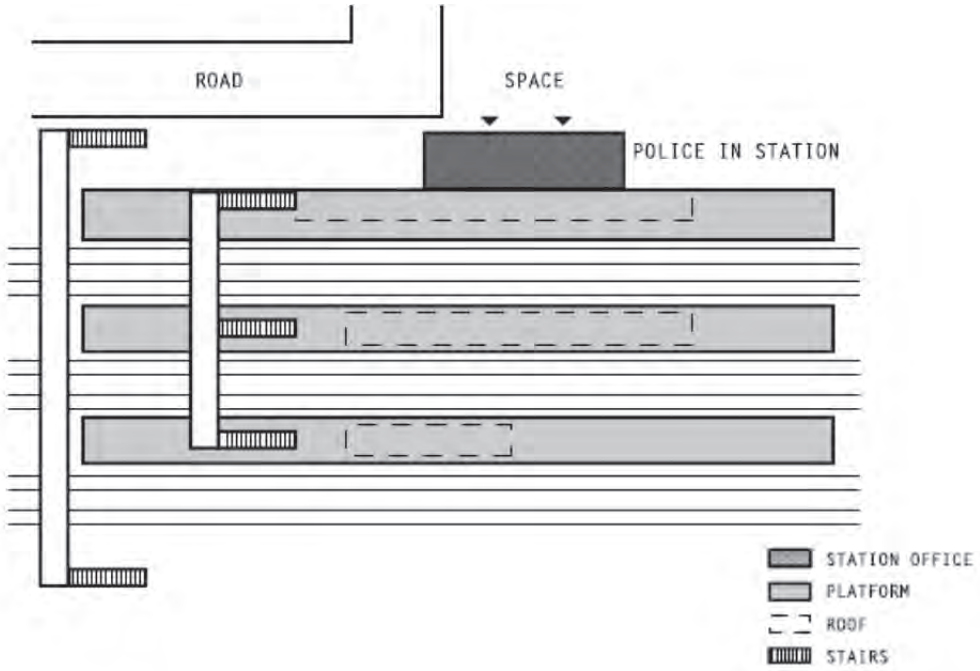
Source: JICA Study Team

Figure 4.5.41 Proposed Layout Plan and Accessibility (AungSunMyo Station)

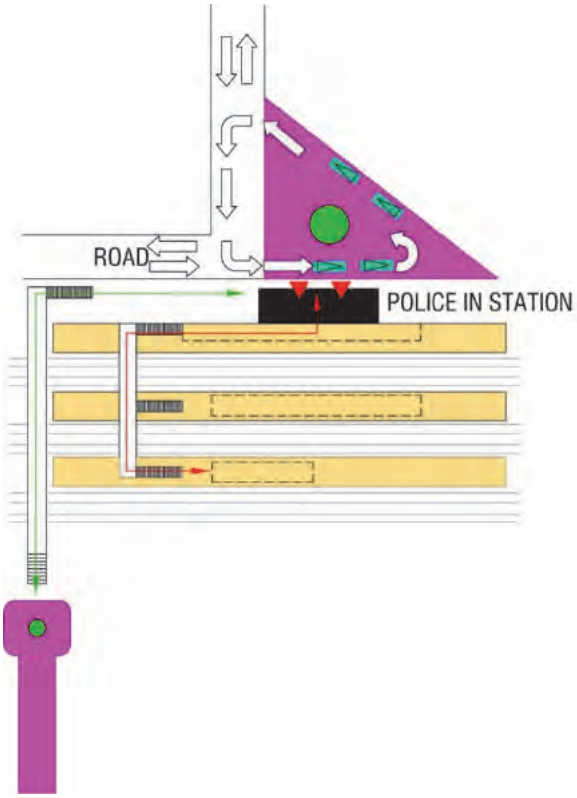
Group D

1) Insein Station

Existing



Proposed layout plan



Source: JICA Study Team

Figure 4.5.42 Existing and Proposed Layout Plan (Insein Station)

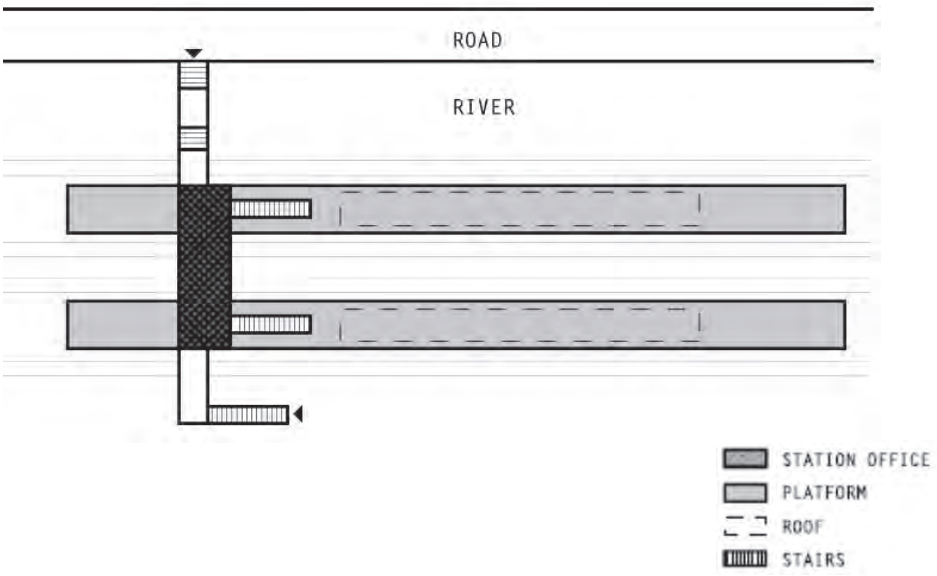
Proposed layout plan and accessibility

Source: JICA Study Team

Figure 4.5.43 Proposed Layout Plan and Accessibility (Insein Station)

2) Ma Hlwa Gon Station

Existing layout



Proposed layout plan

Source: JICA Study Team

Figure 4.5.44 Existing and Proposed Layout Plan (Ma Hlwa Gon Station)

Proposed layout plan and accessibility

Source: JICA Study Team

Figure 4.5.45 Proposed Layout Plan and Accessibility (Ma Hlwa Gon Station)

4.6 Further issues towards modern transit system development

Under the long term urban rail transit development scenario, if the entire MR rail network in the Yangon area is upgraded and electrified to operate EMU with higher acceleration and deceleration, which would facilitate lower headways, the demand on the entire network by 2035 could exceed 1,500,000 daily passengers. In order to realise the full potential of this 143km network a series of further upgrades would be needed, some of these are:

- YCR-West, some of the stations are less than one km apart. Not an ideal distance for a high speed commuter rail system. This limits the maximum speed that otherwise could be achieved between stations, which would have reduced the journey times to make the rail more competitive and attractive to other mode users.
- YCR-East, on the other hand there are a number of stations which are more than 1.5km apart. This limits the catchment area of the station and makes it less attractive to walk-in and walk-out passengers; this requires the passengers to use another mode from station to/ from final destination.
- Pyay, Mandalay and Thilawa Lines – the station density is too low even for a suburban rail system. Ideally the suburban rail stations should be 2.0 to 2.5 km apart. On all these three lines, a number of new stations could be introduced either close to existing developments, or certainly through TOD to enhance the patronage and the make the lines more viable.
- Removal of All level crossings, again at-grade level crossings require trains to obey yet another unnecessary signal along the way. This could limit the number of trains that could be operated with a high number of level crossings next to each other, like on YCR East sections.

The above points outline the key concerns which could limit the rail line potentials in terms of patronage. In this regard rationalization (spacing) of YTS stations should be addressed in particular. However, it should be noted that there are a number of other engineering issues, which could impact the current or future viability of a line.

4.6.1 Rationalisation of station locations

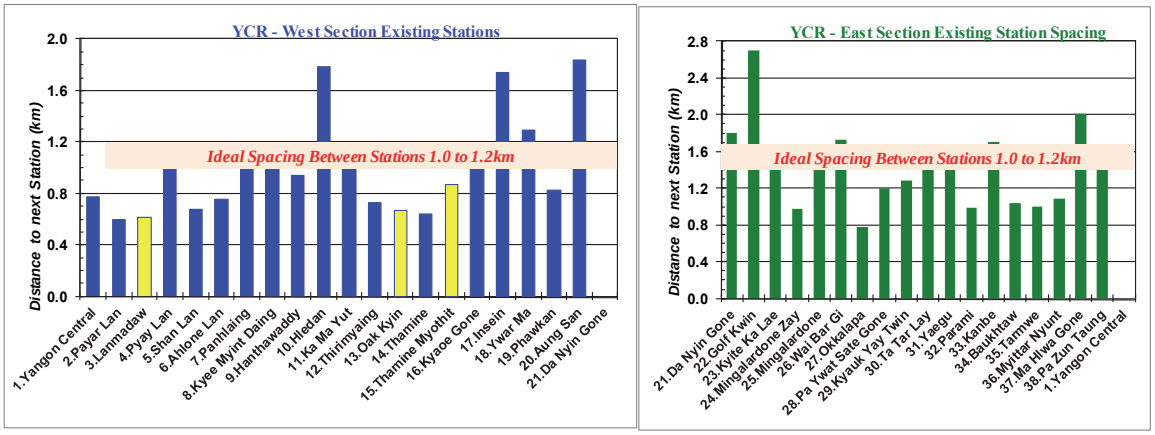
(1) YCR station locations

The YCR line is 46.6 km long. Ideally if such a mass transit line this length is to be built today in Yangon it would have 39~42 stations. This is because, as is a widely accepted and well researched fact, in urban areas passengers are prepared to walk to gain access to a mass transit system for anything up to 400 to 600m.

There are 38 stations on YCR at present, including the Yangon Central railway station. Currently the patronage on these stations varies considerably, which is mainly due to poor train services and to a lesser extent due to poor station accessibility.

There are other reasons too, namely historical and other factors. For example, historically, Yangon city development has also been lop-sided, i.e. more development happened along the western half of YCR (Central to Da Nyin Gone) than along the eastern half, as the area was mostly rural and less densely populated. As result the eastern half had stations more widely spaced than on the western section of the YCR.

Figure 4.6.1 below illustrates the distances between stations for the western and eastern sections of YCR. The western section, which is 20.1km long, has 21 stations, whereas the 26km long eastern section supports 17 stations.



Source: JICA Study Team

Figure 4.6.1 YCR Station Existing Spacing

Initial investigation suggests that stations would have to be rationalised in order to make the YCR a 'viable' modern transit system line. This implies that some of the stations which are too close to the next station would need to be removed, whereas additional stations may be added. The candidate stations to be removed are:

1. ***Lanmadaw station*** – the two adjacent stations on either side are about 0.6km. This implies that the station catchment area severely overlaps with the two adjacent stations. Hence removing this station would not result in much decline in patronage as most passengers would be able to walk to the two adjacent stations.
2. ***Oak Kyin station*** – the two adjacent stations are also less than 0.75km away, hence the above argument applies to remove the station in the future, and same is the case of;
3. ***Thamine Myothit station*** – again the same reasons apply to close the station in any future rationalisation of the line alignment or major redevelopment.

The above figure also shows that there are a number of stations which are more than 1.8 km to 2.7 km apart. This certainly warrants addition of new stations in between these stations. These are:

1. Between Hledan and Ka Ma Yut stations a distance of 1.8km;
2. South of Da Nyin Gone – a gap of 1.84km;
3. East of Golf Kwin a distance of 2.7km (could even be 2 additional stations); and
4. Between Ma Hlwa Gone and Pa Zun Taung ~ 2.0km apart.

However, it must be realised that introduction of every new station would require a serious study, and numerous engineering analyses, before inclusion of a new station could be justified.

(2) Station Locations of Other Lines

The station density on the three suburban lines is also quite low as can be seen from the following Table 4.6.1. In all cases there are historic and other reasons for such low station density on each line. The main reason is that these lines were developed over a century ago, maybe for purposes other than commuting. In order for these lines to act as suburban/ urban mass transit stations the distances between stations would have to be less than 3km. That would most likely require major re-arrangement of existing line operation, station rationalisation, and new station development possibly with TOD. To bring these lines to serve as a mass transit system, a series of serious studies are required for actual implementation based on the preliminary idea of the Roadmap discussed in this report.

Table 4.6.1 Station density on Yangon Suburban Lines, including Spurs

Line	Stations	Line Length (km)	Av. Distance km/ (stations-1)[1]
Pyay Line	7	22.4	3.7
Mandalay[2]	10	42.4	4.7
Thilawa Line	6	31.7	6.3
Note: 1. Line length/ (Total stations -1) to reflect two terminal stations			
Note: 2..Inlcuding Ma Hlwa Gone & Pa Zun Taung Stations			

Source: JICA Study Team

4.6.2 Capacity increase of MR Planning Department

The existing MR Planning Department will be responsible for monitoring and updating of the MR modernization roadmap. This report drafts an outline of the MR modernization roadmap focusing on the transit network development (phasing plan) and some technical issues. Further detailed planning work will be necessary to draw up a practical modernization plan and corresponding action plan and program with corresponding budgetary arrangement by MR. In this regard capacity improvement of the MR Planning Department will be necessary focusing on the following elements:

- Regular inspection and reporting of the modernization projects and programs;
- Periodic statistical data collection and analysis;
- Collection and analysis of customers' opinion;
- Study on international best practices of modern rail facilities, equipment, TOD, etc.; and
- Planning technique and knowledge.