

Cost Estimation

Costs of the construction work are estimated as table below.

Item	Mn. USD	Mn. LKR
Monorail System	1,288.1	168,046
E&M System, Rolling Stock, Track Switch and Maintenance	507.9	66,255
Civil Works	366.0	47,744
Station Construction	266.2	34,728
Depot Construction	148.1	19,319
MmTH at Fort/Pettah	376.6	49,129
MMC at Malabe	32.6	4,215
P&R (Welikada, Lumbini Temple, and Sethsiripaya)	6.9	904

Note: - Cost are estimated based on May 2014 price
- Exchange Rate (USD 1.00 = SLRs(LKR) 130.4550 = JPY 101.79)

Economic Evaluation

The current travel time from Battaramulla to Fort at peak hour is 50 min, and more time would be taken in the future since heavy traffic congestion is expected. By introducing the monorail, it would be decreased to 24 min. This time reduction is considered as one of the economic benefits. Thus, the economic feasibility of a project is examined through cost-benefit analysis as the difference of scenarios between “With Project” and “Without Project”. The benefits are; **a)** Vehicle operating cost (VOC), **b)** Passenger travel time cost (TTC), **c)** Reduction in traffic accidents, and **d)** Reduction in carbon dioxide (CO₂).

Result of Cost Benefit Analysis

Economic Internal Rate of Return (EIRR)	15.2%
Net Present Value (NPV)	57.6 Bn. LKR
Cost Benefit Ratio	1.39

In addition, there is a variety of benefits such as land value, reduction of air pollutants and greenhouse gases. These benefits also contribute to the SKYTRAIN project.

Financial Evaluation

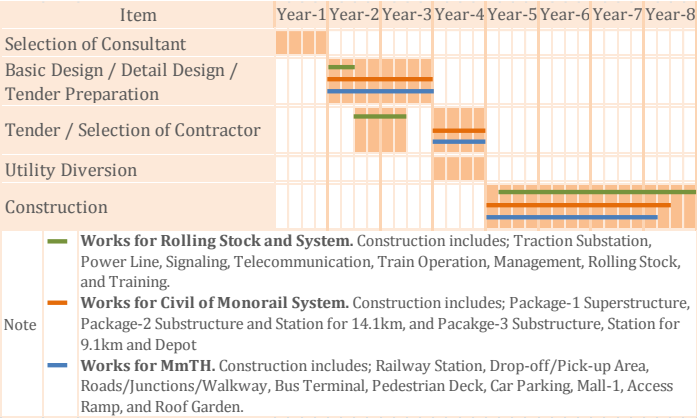
Financial evaluation is implemented based on the estimation in terms of revenues, construction costs, and operation and maintenance costs (O&M). When the government is responsible for the construction of the monorail and rolling stocks, loan repayment and interest, and receives the loan, and a public corporation operates and takes responsible for the O&M cost and receives the revenue, NPV of the public corporation is computed as table below.

Scenarios by different fare level	NPV of the Public Corporation
Normal Bus Level	13.28 Bil. LKR
Semi-luxury bus Level	33.10 Bil. LKR
Luxury bus Level	49.75 Bil. LKR
Increases in steps	41.39 Bil. LKR

Note: When the government takes a STEP loan from JICA to cover the construction cost, and then operates, and receives the revenue from the operation of all components, NPV of the government is-123.76 Bil. LKR.

Implementation Schedule

The project implementation will take 8 years. It is assumed that all land acquisition must be completed before the construction, and relocation of Manning Market must be done before the tender by the Sri Lankan Government.



Findings and Recommendations

Monorail System: It is technically and economically suitable and effective as a new transit system. It captures many passengers and helps to alleviate traffic congestion.

- Project Costs:** It will be economically covered by the large amount of benefits from the monorail system.
- Financial Sustainability:** The public corporation is possible to operate a monorail system when the public corporation receives the additional revenue from the MmTH with Mall-1.
- Environment and Social Aspect:** Environmental impacts are mainly during the construction stage, and it could be minimised with appropriate measures. Socially, impacts on agricultural land is high due to depot, however, impacts of houses and commercial establishments are low, since the monorail route traverses mainly through the existing road.

Recommendations

It is recommended [to establish the Project Management Unit \(PMU\)](#) very early since they shall play an essential role in communicating among stakeholders and to drive the project.

Early establishment of appropriate [institutional framework](#) for monorail operation is essential for effective O&M.

[The Environmental impact assessment \(EIA\)](#) report shall be submitted to Central Environment Authority (CEA) for their approval. It is also recommended to conduct stakeholder meeting to seek comments from public.

For a smooth land acquisition and resettlement, all the necessary measures should be taken in accordance with the [Resettlement Action Plan \(RAP\)](#) prepared for the Project.



Examples of Monorail in the World

Source: Hitachi, Ltd.

SKYTRAIN

“Integrated Transport System with Monorail”



Introduction

Due to rapid economic growth and motorization, person trips made by private cars would increase from 0.93 million trips in 2013 to 5.55 million trips in 2035. Under such circumstances, the CoMTrans Master Plan (urban transport master plan for Colombo Metropolitan Area), recommended; 1) to promote public transport, 2) to improve transport network and transfer convenience, and 3) to introduce commercial facilities associated with public transport for securing its financial sustainability. Thus, the “Integrated Transport System with Monorail, SKYTRAIN” is recommended as the primary project.

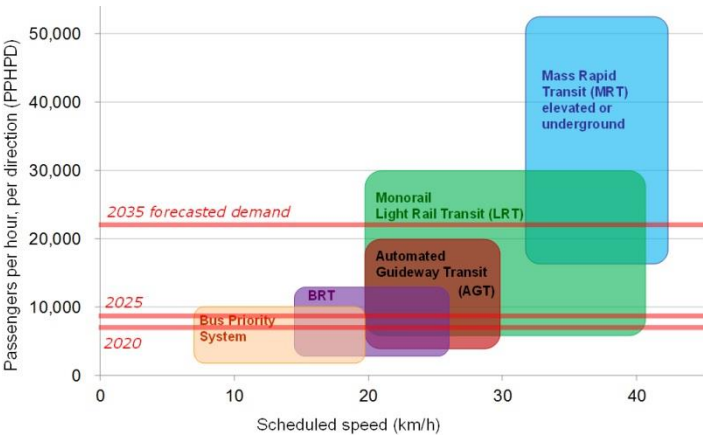
Why Malabe Corridor?

Highest Demand: Due to traffic congestion on the 7 transport corridors, improvements of public transport are required. Especially, Malabe Corridor connecting Colombo Municipal Council (CMC), Battaramulla, Malabe and Kaduwela has the highest vehicle volume among them. Travel speed on Malabe corridor is the lowest of 14km/h during peak hour at the boundary of CMC.

Corridor without Rail-based Public Transit System: It is the corridor without a public transit system, except for bus, and it is unable to handle increasing passenger demand due to planned urban developments. Therefore, the corridor has requires urgent policy intervention to shift private mode users to public transport.

Why Monorail System?

Transport capacity and scheduled speed are key indicators for selecting the mode, and they are shown in figure below. The forecast demand for Malabe corridor is 21,000 passengers per hour, per direction (PPHPD) in 2035 in the high demand scenario.



Scheduled Speed and Passenger Capacity of Public Transport Mode

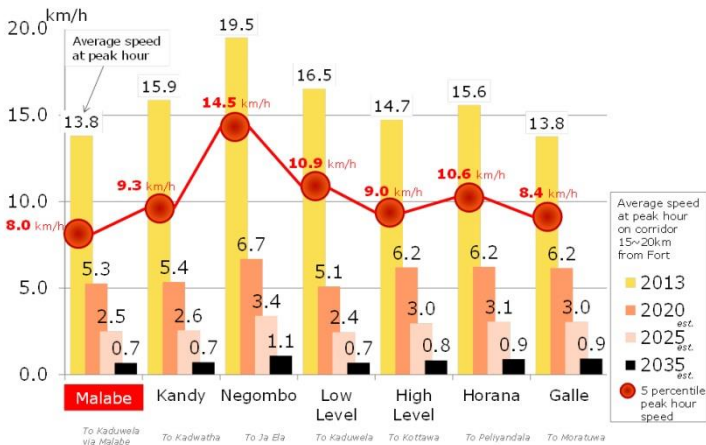
The components of SKYTRAIN are as follows.

1. Monorail System for Malabe Corridor,
2. Multi-modal Transport Facilities (MmTH*1 and MMC*2),
3. Park and Ride Facilities (P&R).

While each single component might not be sufficient, this package mutually benefits each component by improving the convenience of the public transport system as a network.

*1: Multi-modal Transport Hub at Fort/Pettah

*2: Multi Modal Centre



Peak Hour Travel Speed of Major Transport Corridors

The bus priority system, bus rapid transit (BRT) and underground mass rapid transit were screened out due to negative aspects such as capacity, land acquisition and implementation cost. Among the other modes, monorail was selected for various aspects such as less impact on daylight interference and landscape due to simple beam structure, minimum land acquisition, appropriate passenger capacity, and high scheduled speed.



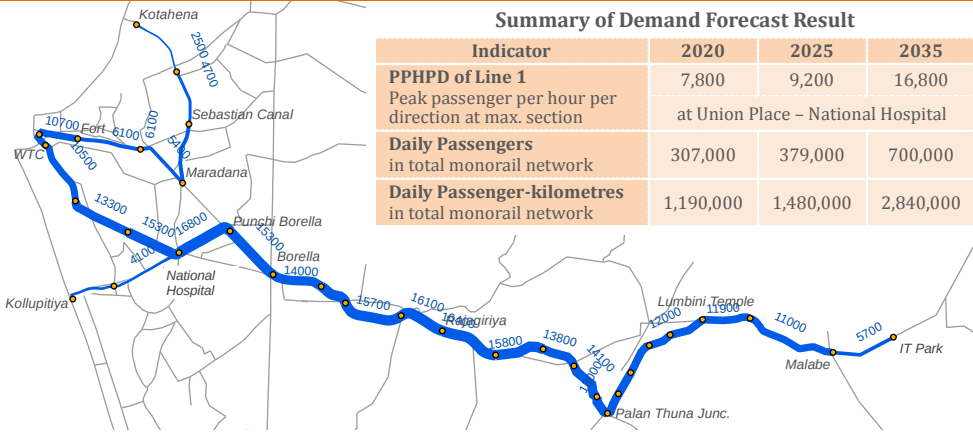
View of Simple Beam Structure



View of the Slab Structure

Passenger Demand (Estimated)

Based on the estimated daily passenger volume, peak hour sectional passenger volume was estimated. Daily passengers and passenger kilometres are expected to increase by 2035 due to urban development projects along the corridor and improvement of public transport network. Peak hour traffic volumes in 2035 are illustrated.



Peak Hour Passenger Volume per Direction in 2035 (Stage 1)

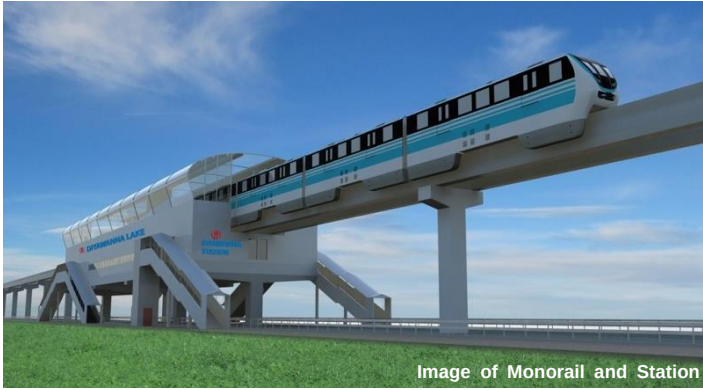


Image of Monorail and Station

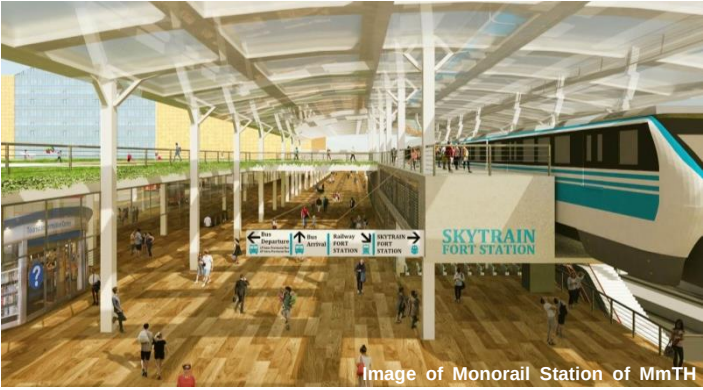


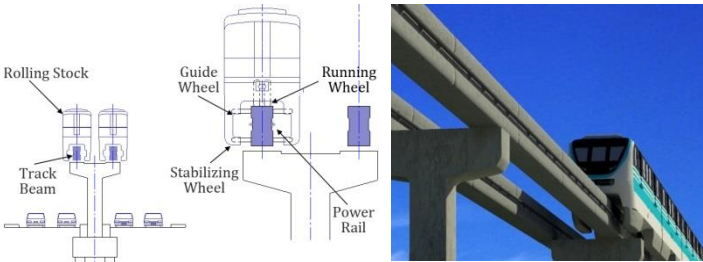
Image of Monorail Station of MmTH

Monorail System and Structure

Proposed system is straddle type monorail system proven in 5 cities in Japan, 2 cities in the USA, China, the UAE and Malaysia. In view of these successes, a number of cities have recently decided to introduce the monorail system.

Rolling stock straddle on reinforced concrete beam and rubber tire is used for running gear and stabilizing wheel. Therefore higher ride quality and steeper gradient is expected than steel rail and steel wheel system.

Figure below indicates the outline of the monorail system and the image of the monorail.



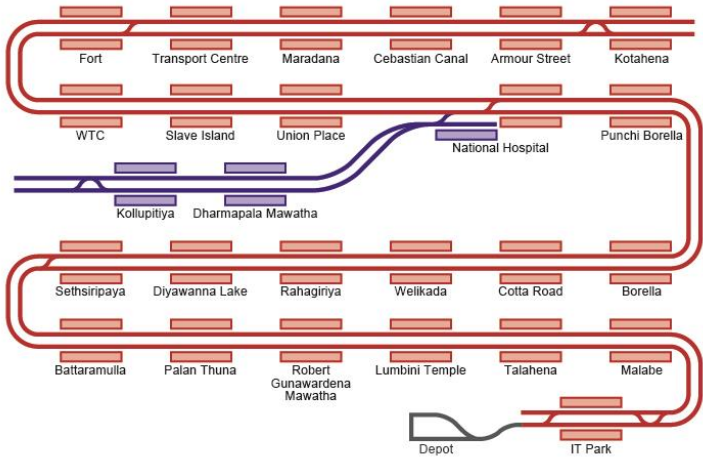
Outline and Image of Monorail System

Specifications of Monorail System			
Item	Specification	Item	Specification
Type	Straddle type monorail	Power supply	DC 1500V, Third Rail
Width of track	850mm	Maximum axle load	11t
Minimum curve radius	60m (50m at depot)	Train consist	4 cars
Maximum gradient	6%	Length of train	Approx. 60m
Distance between track centre	3.7m	Signalling system	ATP, ATO, OCC
Platform length	65m	Telecomm unication system	Telephone system, Passenger Information System, Public address system, Radio system, CCTV,

Train Operation Plan

The monorail system consists of two lines (Line 1: Kotahena to IT Park / Line 2: National Hospital to Kollupitiya). The figure below shows the track layout of the monorail operation.

Based on demand forecast and transportation capacity, required headway of peak hour at each milestone year was estimated and required number of rolling stock based on train diagram is calculated as table below.



Track Layout of the Monorail

Number of Rolling Stocks						
Year	2020~2024		2025~2029		2030~	
Line	Line 1	Line 2	Line 1	Line 2	Line 1	Line 2
Headway (min)	6	8	4	8	3	8
Train / hour	10	7.5	15	7.5	20	7.5
Number of Trains in Operation	19	2	29	2	38	2
Reserved Trains	3		4		4	
Total Number of Trains	24		35		44	
	Rolling Stocks: 96		Rolling Stocks: 140		Rolling Stocks: 176	

Multi-modal Transport Facilities and P&R Facilities

In order to ensure smoothness and safety of transfer among transport modes, the CoMTrans Urban Transport Master Plan recommended development of the multi-modal transport facilities. In particular;

a) Transport facilities developed around the existing Fort Railway Station to improve smooth transfer between the monorail stations, integrated bus terminals, and the railway station, namely **Multi-modal Transport Hub at Fort/Pettah (MmTH)**, with possibility of commercial facilities aimed to have additional revenue for operation and management of the new transit system, and

b) **Multi Modal Centres (MMC)** and **Park and Ride Facilities (P&R)** developed in the suburban areas, which aim to reduce vehicle traffic towards the centre of Colombo.

Concept of MmTH at Fort/Pettah

The land for the MmTH (approx. 12ha) is located around the existing Fort Railway station. There are Manning Market and many shops on the site; however, they are to be relocated by the Sri Lankan Government.

Major commercial, business, and transport functions are concentrated around the area, and many passengers arrive every day and at all times of the day. However, the area is



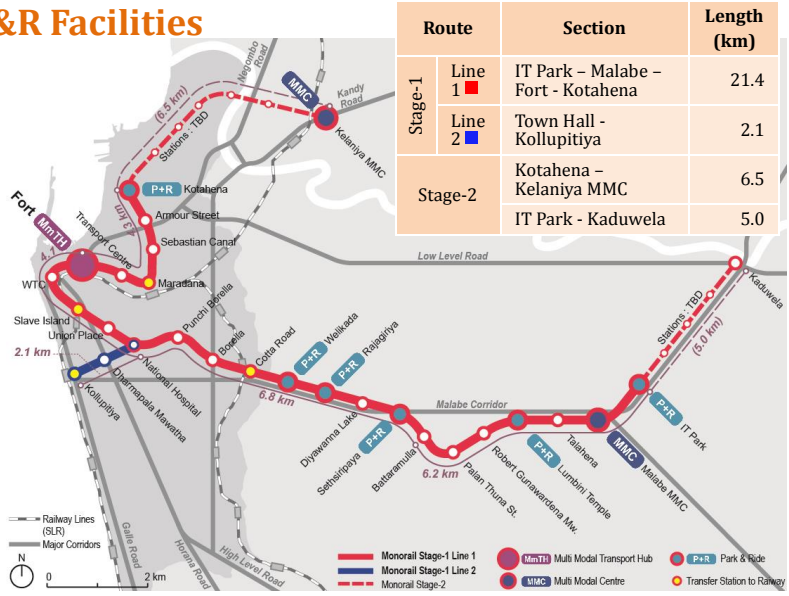
Image of MmTH



Design Concept of MmTH

Concept of MMC

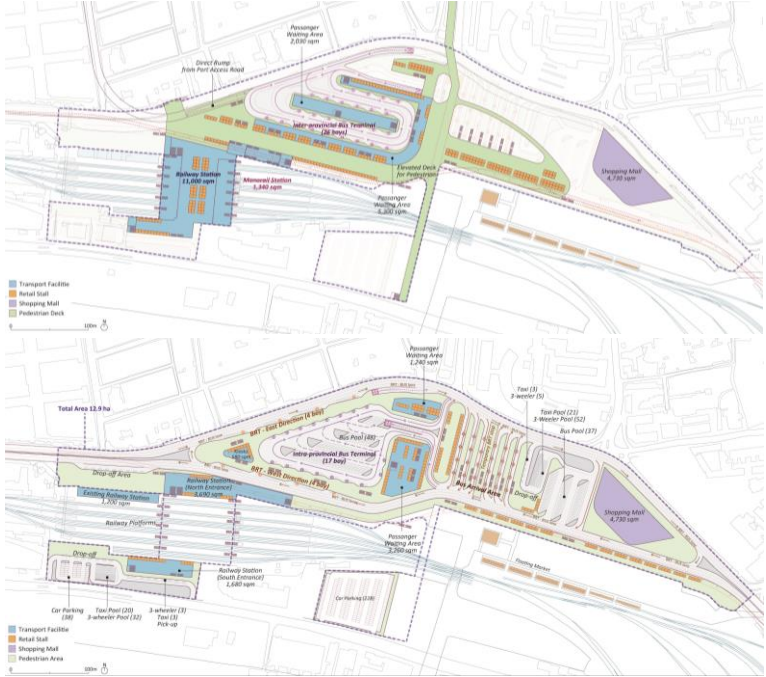
MMCs are proposed in suburban areas and they are the transferring stations for feeder buses and railway passengers, and passenger cars traveling to the monorail. This contributes to ease the traffic congestion from the existing roads and to develop the area as Transit Oriented Development (TOD). Malabe Station is selected as a MMC of the proposed monorail route. A pedestrian deck connects from the monorail station to the upper level of the bus terminal. In addition, a station plaza and taxi and 3-wheeler bays are also set in the MMC.



Monorail Route and Location of MmTH, MMC, and P&R

neither safe nor comfortable for pedestrians.

The MmTH is the main node of all the transport modes, and integrates many functions. A pedestrian deck is proposed for separation of pedestrian areas from the vehicles, and provides safe and smooth access to all facilities, namely, railway station, bus terminals, monorail station, public plaza, and shopping mall.



Concept Layout Plan of MmTH (above; 1st Floor / below; Ground Floor)

Concept of P&R

P&R facilities are car parks with connections to public transport that allow passengers to leave their vehicles and transfer to public transport. This encourages using the Monorail and reducing the number of vehicles on the roads. 6 stations are selected due to land availability and necessity. The concept of the all P&R stations share the same concepts; providing smooth transfer by pedestrian access from the monorail stations to the station plaza, car parking, and facilities located the surrounding area, such as government offices, public areas, commercial facilities, etc.