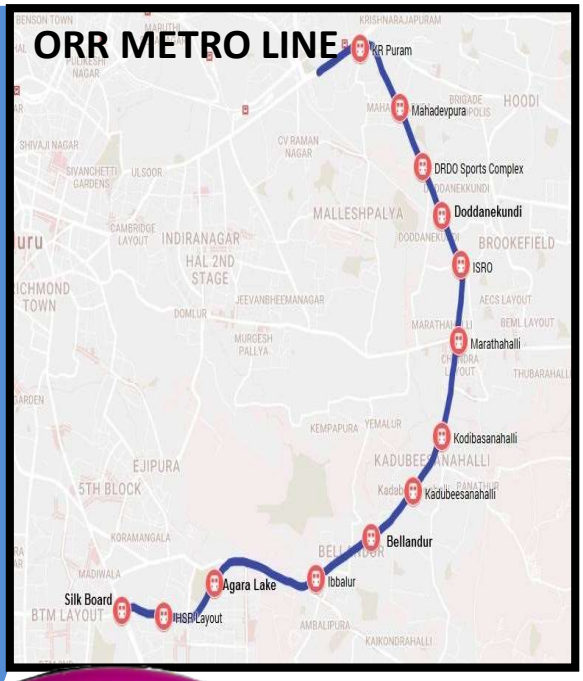
# DETAILED PROJECT REPORT FOR PHASE 2A OF BANGALORE METRO

## "ORR Metro Line" on Outer Ring Road from Central Silk Board (CSB) Junction to KR Puram




**Volume 1**

## Bangalore Metro Rail Corporation Ltd.

**January 2019 (Updated)**

# FOREWORD

This is the updated Detailed Project Report for constructing and commissioning a new Metro line, called ORR Metro line, on the Outer Ring Road between Central Silk Board Junction to K R Puram with operational length of 17.13 Km and line length of 19.45 Km. The DPR for this line was prepared initially by an in-house team of BMRCL in October 2016. This updated DPR has also been prepared by BMRCL team of experts, based on the experience it gained while implementing the Phase-1 of Namma Metro and also while preparing, scrutinising and approving the DPRs of Phase-2 extensions, Reach 5 and Reach 6 of Namma Metro.

The DPR has now been revised incorporating the requirements prescribed in the Metro Rail Policy- 2017 issued by MoHUA, GoI, revising the land cost duly taking into account the increased land requirement, current land rates, design improvements and updating the cost for all items of work including the projected cost increase during the construction period.

During the preparation of updated DPR there was continuous interaction with other agencies tasked with development of Bengaluru city like DULT, BDA, BBMP, BMTC and Transport Department Government of Karnataka who have furnished relevant information needed for preparing this report.

After development of IT Industry in Electronic City and Whitefield of Bengaluru, there has been phenomenal growth of IT Industry on the ORR between Central Silk Board and K.R. Puram. With these, road Traffic on this road has become unmanageable though it consists of 6 Lane Main Carriage way and Service roads. Phase-1 and Phase-2 of BMRCL passes at the extremities of this Corridor and connecting these two important junctions is not only necessary but also inevitable.

This report is a compendium of study results carried out by BMRCL with its unique background, experience and considerable effort. The technical solutions recommended herein are sole property of BMRCL. These cannot be copied or made use of by any other agency or person except for the sole use of Bengaluru city, without the consent of BMRCL.

Bengaluru

January 2019

AJAY SETH
Managing Director
Bangalore Metro Rail Corporation Ltd.

# Executive Summary

# EXECUTIVE SUMMARY

## 0.0 Introduction

Approval of Government of Karnataka (GoK) for implementing the Metro Project between Central Silk Board to K R Puram on Outer Ring Road for a length of 19.45 Km by BMRCL at a cost of Rs. 4202 Cr based on July 2016 prices was communicated vide G.O UDD 78 PRJ 2016 dated 15.03.2017. Following the approval, part funding from Government of India (GoI) was requested. The GoI sought several clarifications in respect of the proposal for meeting the norms and requirements set out on subsequent introduction of Metro Rail Policy in August 2017.

Accordingly, the DPR has been updated as per Metro Rail Policy-2017 at September 2018 prices. The Updated Detailed Project Report (DPR) of January 2019 has been prepared by in-House team of BMRCL. The team has relied upon Draft Comprehensive Mobility Plan 2019 for Bengaluru City, the Draft Revised Master Plan 2031 for Bengaluru Region and various other studies undertaken for Traffic and Transportation for the city by GoK. This Report has been prepared as per Metro Rail Policy 2017 in 2 Volumes i.e., Volume 1 covering all the aspects given in Appraisal Guidelines for Metro Rail Project proposals issued by Ministry of Housing and Urban Affairs (MoHUA), GoI during September 2017 and also taking into account the latest Standards and Specifications issued by MoHUA for various Systems and Volume 2 consisting of relevant drawings and geo-technical details for the proposed corridor.

Vide G.O UDD 384 PRJ 2018, Bengaluru, dated 24.01.2019, GoK has accorded approval for implementation of the Outer Ring Road Metro line from Central Silk Board to K R Puram as Phase 2A of the Metro project by BMRCL at a revised estimated cost of Rs. 5994.90 Cr.

## 0.1 Background

Bengaluru, with a population of over 12 million is a key engine for driving global growth. The city is one of the fastest growing major metropolis in the country with an economic growth of 10.3 per cent and possesses world class infrastructure in housing, education & research. Bengaluru is the most urbanized district with 90.94 per cent of its population residing in urban areas and contributes 35.90 per cent to GSDP. The district tops in contribution to secondary and tertiary sectors due to high concentration of major industries and infrastructure facilities.

Bengaluru is the heart of modern India and has been driving growth through its state of the art Industrial Hubs. It continues to be a leader in the establishment of knowledge based industries such as Information Technology, Biotechnology and Engineering, and also in the exports of Electronics, Computer Software. Make in India started as a journey for Karnataka way back in 1953, with Bosch's (earlier Mico) manufacturing facility in Bengaluru and since then, Bengaluru, has become the hub of next-gen

technologies which include Nano-tech, robotics, 3D printing, space, drone, rocket, military and aircraft technologies, as well as high-end electronics.

Today, Bengaluru, country's leading IT exporter has the youngest tech workers and most efficient among all global start-up hubs. Bengaluru among the 20 best start up city ecosystems in the world has emerged as the IT Start Up Capital of India with more than 30 per cent of national share. It has also been ranked 2nd in Global start-up ecosystem growth index by "Compass". It has the largest hub of semiconductor design companies, outside the Bay Area in California. Nearly 70 per cent of the country's chip designers work from Bengaluru and around 80 per cent of the sector's revenues in design are from this city alone.

Bengaluru is also known as the Garment Capital of India and has been one of the leading contributors in the growth of textile and apparel market. It houses large manufacturing capacities across the complete manufacturing value chain viz. natural and manmade fiber production, spinning, weaving, knitting, processing, garmenting, made-ups and technical textiles. Bengaluru retains 2nd position after Delhi with most vehicles on roads and has more than 6000 plus electric vehicles.

Home to a large number of education and research institutions have played a major role in supporting and promoting the ecosystem. The vast entrepreneurial and workforce talent available in the city can be attributed to these institutes. The city is also recognized as the fountainhead of global Research and Development – with Multi-National Companies having their global Research and Development Centres here – perhaps the largest concentration of such centres anywhere in the World. United Nations has ranked Bengaluru as the 4th largest technology cluster in the world after Silicon Valley, Boston, and London. Recently, Bengaluru was also ranked as the No.1 Digital City in the World as of November 2017 and was the only city in India to be ranked 19th among world's 25 hi-tech cities ahead of Berlin, Hong Kong and Shenzhen. Bengaluru has been ranked as No.1 – 'Best place to live and work' by the Global HR Consultancy Mercer.

The IT industry in the past was concentrated in the Electronic City area in the South and the Whitefield area in the East. With these 2 areas getting saturated, the IT industry moved along the Outer Ring Road (ORR) between Central Silk Board and K R Puram. This new stretch of ORR which was constructed in early 2000 acted as a major attraction for these IT industries to set up their facilities alongside. However, the rapid growth of IT sector along this corridor has placed a huge burden on the transport infrastructure. As a result, this growth corridor has become a transportation bottleneck. Hence, the route from Central Silk Board (CSB) to K.R. Puram along the ORR is planned to be connected by Metro as an extension of the already sanctioned Phase 2 of BMRCL and is named as ORR (Phase 2A) Metro line.

BMRCL, the agency responsible for implementing and operating Metro in Bengaluru, has fully commissioned the Phase-1 Metro consisting of 42.3 km, which includes 8.8 km of Underground line and 40 Stations in stages from October 2011 to June 2017.

The Phase-2 of Metro for a length of 72.1 km is under implementation, which includes extension of Phase-1 lines on all four directions and two new lines. Phase 2A is also planned to be implemented by BMRCL (an SPV incorporated for implementing the Metro projects in Bengaluru).

### 0.1.1 Population and Population Density

Bangalore, officially Bengaluru, is the Capital of the Karnataka State. Bengaluru is located in the South Eastern region of the State on the Deccan Plateau and it is the third most populous city and the 5th most populous urban area in India. Bengaluru has an estimated population of 12.34 million in its urban area as off 2017, up from 8.5 million in 2011. It is now the 24th most populous city in the world and the fastest-growing Indian Metropolis behind New Delhi, growing at a whopping 47.18% from 2001 to 2011. As per the census records of 2001 and 2011, the population density values for the BMA and the BBMP have gone up from 47 to 70 and 82 to 119 PPH, respectively, whereas the population density in villages has doubled from 5 to 10 PPH.

### 0.1.2 Transportation System in the City

- The public transport in Bengaluru is operated by Bengaluru Metropolitan Transport Corporation (BMTC). At present BMTC is operating 6,143 schedules on 2,253 routes with a fleet size of 6,677 buses and the buses cover 54,187 daily trips at an average trip length of 24.60 Km. The Bengaluru Metropolitan Transport Corporation (BMTC) buses traverse a whopping 13.33 lakh Km across the city every day.
- Apart from the bus transport system, two corridors of Metro rail are fully operational since June 2017. The North-South corridor starts at Nagasandra and ends at Yelchanahalli covering a route length of 24.2Kms. The East-West corridor starts at Baiyappanahalli and ends at Mysore Road over a route length of 18.1 Kms. Metro currently carries 3.75 lakh commuters every day with maximum single day ridership being 4.5 lakh. The East-West line (Purple line) carries about 56% and the North-South line (Green line) carries 44% of the commuters.
- Auto rickshaws and taxis are the IPT facility available in Bengaluru. Autos are the popular form of transport and can be called common man’s taxi in Bengaluru. In addition, car Aggregators Ola and Uber have their extensive services in Bengaluru and are well patronised.

### 0.1.3 Economy

Karnataka is home to over 3,500 IT companies, contributing to over 51.6 billion USD (Rs. 3.67 lakh Crores) of exports, giving direct employment to over 12 lakh professionals and creating over 31 lakhs indirect jobs. The industry contributes to over 21% of the State’s GDP. The share of Karnataka Information Technology exports is nearly 38% of the country’s export of 155 billion USD.

The establishment and success of high technology firms in Bengaluru has led to the growth of Information Technology (IT) in India. IT firms in Bengaluru employ about 1.5 Million which is 37.5% of India's pool of 4 million IT professionals and account for the highest IT-related exports in the country. Many biggest IT-firms are located in Bengaluru which earned this southern city the name 'Silicon Valley of India'. The city also houses some major manufacturing industries like Bharat Heavy Electricals Limited, Bharat Electronics Limited and Bharat Earth Movers Limited among others. The IT majors Infosys and Wipro have their headquarters in Bengaluru.

The Economy of Bengaluru is an important part of the economy of India as a whole.With a national growth rate of more than 7 percent, the State of Karnataka has an estimated GSDP of $196.88 billion and Bengaluru the capital of Karnataka has an estimated GDP of $110 billion. The value of Software exports of Bengaluru alone is $ 45 billion of the total State's Software export of $ 58.9 billion which is 76.4% of State's Software exports.

## 0.2 Alignment of the Corridor

It is estimated that about half a million IT professionals are employed on this corridor of Outer Ring Road between Central Silk Board and K R Puram and with various support services and indirect employment, this corridor which measures about 17.13 Kms and provides employment to one million people.

The biggest challenge these people are facing is the long time spent during transportation thereby bringing down their efficiency and also affecting the overall economic efficiency in this corridor. Though the Phase-1 and Phase-2 of the Metro network has been planned and Phase-1 is completed, this corridor has been left untouched by both Phase-1 and Phase-2. However, the Metro line in Phase-2 passes through the two extremities of this corridor. Thus, connecting these two extremities one at Central Silk Board and other at K R Puram is not only necessary but at the same time will also add to effectiveness of the Metro network. The present proposal is for implementation of Metro line on the Outer Ring Road from Central Silk Board to KR Puram for operational length of 17.13 km and line length of 19.45 Km upto the Depot.

The surveys including reconnaissance/topographical survey, traffic and transportation studies, geo-tech investigations etc., were carried out along the above proposed route. The corridor proposed is from terminal station at Central Silk Board junction to terminal station at K R Puram and further up to Baiyappanahalli Depot, the other stations being HSR Layout, Agara Lake, Ibbalur, Bellandur, Kadubeesanahalli, Kodibeesanahalli, Marathahalli, ISRO, Doddenakundi, DRDO Sports Complex & Mahadevapura.

## 0.3 Traffic Demand Forecast

Traffic and Transportation Study has been carried out to analyse the traffic volume and assesses the variation of traffic level, composition, growth rate and forecasts the future traffic for the selected corridor.

### 0.3.1 Study Area

The study area includes the Bengaluru Metropolitan Area (BMA) area comprising of major part of the BBMP (excluding area under BMICAPA) and 251 villages around the BBMP. The area of BMA comprising of Local Planning Area (LPA) of BDA and LPA of BMICAPA as per the amended boundaries admeasures 1306 Sqkm including 65.31 SqKm BMICAPA. The urban development in several villages and BBMP are governed by two authorities, viz., BDA and BMICAPA. For this reason, the Master Plan has considered the entire BMA, BBMP and Villages for extraction and analysis of population within BMA.

### 0.3.2 Zoning System

The traffic study model has 534 zones, out of which, 519 zones are in the study area (including BMR). The zones within BMR include 202 Traffic zones (based on ward boundaries) within BBMP, 251 zones (based on village boundaries) covering rest of the area under and balanced BMR area has been divided into 66 outer zones based on the urban conurbation of the Local Planning areas (LPAs).

### 0.3.3 Travel Demand Forecast

An urban transport model to replicate the Bengaluru Metropolitan Area transportation system (roads, congestion delays, transit system, etc.) has been developed with a state-of-the-art software and modelling technology. This model has been used for forecasting, using altered model inputs to reflect future year scenario. By simulating roadway conditions and travel demand on those roadways, deficiencies in the system have been assessed. Potential major future network enhancements such as introduction of an MRTS or land use modifications are analysed using this tool.

The model is based on a conventional 4-stage transport model approach, which includes:

- Trip Generation - calculating the number of origins and destinations for each zone.
- Trip Distribution - attaching the origins and destinations for complete trips
- Mode Choice - determining the mode for each trip, car, Intermediate Public Transport (IPT), Public transport.
- Assignment - assigning passengers to their respective highway and transit networks.

### 0.3.4 Ridership Assessment for Horizon Years

The travel model generated for RMP 2031 has been used for the estimation of ridership for the proposed Metro corridor from Central Silk Board junction to KR Puram. This Metro line has been incorporated in the model. That assessment has been completed by a subsequent study done by RITES in year 2016 for demand assessment of Metro lines upto year 2041.

0.3.4.1 Boarding and Alighting

The boarding alighting estimates for peak hour for horizon years at the Stations in the corridor is given in the table below.

**Table 0.1 Daily and Peak Hour Station Boardingfor Phase 2A**

| | Daily 2024 | | Peak 2024 | | Daily 2031 | | Peak 2031 | | Daily 2041 | | Peak 2041 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stations** | **Board** | **Alight** | **Board** | **Alight** | **Board** | **Alight** | **Board** | **Alight** | **Board** | **Alight** | **Board** | **Alight** |
| Slik Board | 38,644 | 38,258 | 10,220 | 10,118 | 51,828 | 51,310 | 13,707 | 13,570 | 77,509 | 76,733 | 20,499 | 20,294 |
| HRS Layout | 7,776 | 7,781 | 2,056 | 2,058 | 10,428 | 10,436 | 2,758 | 2,760 | 15,596 | 15,607 | 4,125 | 4,128 |
| Agara Lake | 4,787 | 4,739 | 1,266 | 1,253 | 6,420 | 6,356 | 1,698 | 1,681 | 9,602 | 9,506 | 2,539 | 2,514 |
| Ibbalur | 21,100 | 20,889 | 5,580 | 5,524 | 28,298 | 28,015 | 7,484 | 7,409 | 42,320 | 41,896 | 11,192 | 11,080 |
| Bellandur | 6,510 | 6,445 | 1,722 | 1,704 | 8,731 | 8,643 | 2,309 | 2,286 | 13,057 | 12,926 | 3,453 | 3,419 |
| Kadubeesanahalli | 10,877 | 10,711 | 2,877 | 2,833 | 14,588 | 14,365 | 3,858 | 3,799 | 21,816 | 21,482 | 5,770 | 5,681 |
| Kodibisanahalli | 14,511 | 14,615 | 3,838 | 3,865 | 19,461 | 19,601 | 5,147 | 5,184 | 29,105 | 29,314 | 7,697 | 7,753 |
| Marathahalli | 26,265 | 26,172 | 6,946 | 6,922 | 35,225 | 35,100 | 9,316 | 9,283 | 52,679 | 52,492 | 13,932 | 13,883 |
| ISRO | 10,629 | 10,522 | 2,811 | 2,783 | 14,255 | 14,112 | 3,770 | 3,732 | 21,318 | 21,105 | 5,638 | 5,582 |
| Doddanekundi | 15,745 | 15,904 | 4,164 | 4,206 | 21,116 | 21,329 | 5,585 | 5,641 | 31,579 | 31,898 | 8,352 | 8,436 |
| DRDO Sports Complex | 9,287 | 9,194 | 2,456 | 2,432 | 12,455 | 12,331 | 3,294 | 3,261 | 18,626 | 18,440 | 4,926 | 4,877 |
| Mahadevapura | 8,413 | 8,492 | 2,225 | 2,246 | 11,284 | 11,389 | 2,984 | 3,012 | 16,875 | 17,032 | 4,463 | 4,504 |
| KR Puram | 43,746 | 44,568 | 11,570 | 11,787 | 58,671 | 59,773 | 15,517 | 15,808 | 87,742 | 89,390 | 23,205 | 23,641 |
| **Total** | **2,18,289** | **2,18,289** | | | **2,92,760** | **2,92,760** | | | **4,37,822** | **4,37,822** | | |

0.3.4.2 Peak Hour Peak Direction Traffic (PHPDT)

The below table shows the PHPDT between the stations for the proposed corridor.

**Table 0.2 PHPDT between Stations of Phase 2A**

| Station | | PHPDT - 2024 | | | PHPDT - 2031 | | | PHPDT - 2041 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| From | To | Forward | Reverse | Maximum | Forward | Reverse | Maximum | Forward | Reverse | Maximum |
| Silk Board | HRS Layout | 10,220 | 4,156 | **15,411** | 13,707 | 5,574 | **20,668** | 20,499 | 8,336 | **30,909** |
| HRS Layout | Agara Lake | 10,381 | 4,261 | | 13,923 | 5,715 | | 20,822 | 8,547 | |
| Agara Lake | Iblur | 10,731 | 4,348 | | 14,392 | 5,831 | | 21,523 | 8,720 | |
| Iblur | Bellandur | 11,019 | 3,771 | | 14,778 | 5,057 | | 22,100 | 7,563 | |
| Bellandur | Kadubeesanahalli | 11,019 | 3,771 | | 14,778 | 5,057 | | 22,100 | 7,563 | |
| Kadubeesanahalli | Kodibisanahalli | 10,699 | 4,136 | | 14,349 | 5,547 | | 21,459 | 8,296 | |
| Kodibisanahalli | Marathahalli | 10,699 | 4,136 | | 14,349 | 5,547 | | 21,459 | 8,296 | |
| Marathahalli | ISRO | 6,987 | 9,932 | | 9,371 | 13,320 | | 14,014 | 19,920 | |
| ISRO | Doddanekundi | 6,716 | 9,360 | | 9,007 | 12,553 | | 13,470 | 18,773 | |
| Doddanekundi | DRDO Sports Complex | 6,556 | 15,411 | | 8,792 | 20,668 | | 13,148 | 30,909 | |
| DRDO Sports Complex | Mahadevapura | 7,072 | 13,795 | | 9,485 | 18,501 | | 14,185 | 27,668 | |
| Mahadevapura | K R Puram | 7,072 | 11,570 | | 9,485 | 15,517 | | 14,185 | 23,206 | |

0.3.4.3 From the traffic study it is estimated that the daily ridership of this Metro corridor will be 2,18,289 in 2024, when the project is planned to be completed and it will rise to

2,92,760 by 2031 and to 4,37,822 by 2041. Similarly, the PHPDT will be 15,411 by 2024 which will increase to 20,668 by 2031 and to 30,909 by 2041.

## 0.4 Civil Engineering

The entire alignment of this line is planned to be elevated. As the work on the elevated stretches of Phase-1 of the project have already been completed and Phase 2 works are in progress, the planning norms & design parameters viz., horizontal curves, vertical alignment, design speed, track centres etc., as finalized for Phase-1 and Phase-2, shall be used for Central Silk Board to KR Puram Metro line also. 13 stations are planned in this corridor including the two terminal Stations.

### 0.4.1 Geometric Design

BMRCL has already implemented Phase-1 of Bengaluru Metro project & now executing Phase 2. Various design norms and parameters have been firmed up by BMRCL after detailed studies and norms followed by Metro systems in various cities. Certain modifications to the design norms have been recommended keeping in view of the technological advancements and specific needs of Bengaluru city.

In all, 43 horizontal curves are proposed on this stretch. The radii of the curves vary from 193m to 8000m.
Details of Horizontal Curves:

| | |
|---|---|
| Total length of the stretch | : 18.475 Km (Central Silk Board Side dead end to K R Puram side dead end) |
| Number of Horizontal Curves | :43 nos. |
| Total length of the curves | : 5.78Km |
| % length of Curves | : 31.28% |
| Minimum Radius of horizontal curve | : 193m |

In this corridor, all Stations are located on straight alignment and on level gradient.

Vertical curves are to be provided when the change in gradient exceeds 0.4%. However, it is proposed to provide vertical curves at every change of gradient, for enhancing the comfort of the commuters.

Details of Vertical Curves are as below:

| | | |
|---|---|---|
| Minimum Radius | : | 1500 m |
| Maximum Gradient | : | 3.5% |

### 0.4.2 Track Structure

Track on Metro Systems is subjected to intensive usage with very little time for day-to-day maintenance. Thus, it is imperative that the track structure selected for Metro Systems should be long lasting and should require minimum or no maintenance and at the same time, ensure highest level of safety, reliability and comfort, with minimum noise and vibrations.

Keeping the above philosophy in view, two types of track structures are proposed for this corridor. The normal ballasted track is planned inside the Depot (except inside the Workshops, inspection lines and washing plant lines). The ballastless track is planned on Viaducts as the regular cleaning and replacement of ballast at such locations will not be possible.

From the considerations of maintainability, riding comfort and also to contain vibrations and noise levels, the complete track is proposed to be joint-less and for this purpose, even the turnouts will be incorporated in LWR/CWR.

The track will be laid with 1 in 20 canted rails including on the turnouts and the wheel profile of Rolling Stock should be compatible with the rail cant and rail profile. Turn backs and CBTC systems shall be designed for the operational frequency of 2 minutes to accommodate any upside in the demand.

### 0.4.3 Geo Technical Investigation

The Geotechnical investigations were carried out to find out the geological strata and to arrive at the foundations. In addition, soil investigation reports for various flyovers and underpasses already conducted along this route have also been studied.

Field investigations have been carried out along the Outer Ring Road corridor at 51 locations with borehole exploration. The geo- technical investigation data containing bore log details is provided in **Chapter 5.**

### 0.4.4 Viaduct Structure

The choice of Superstructure has been made keeping in view the ease of constructability and the maximum standardization of the form-work for a wide span ranges. Accordingly, the following type of superstructures are considered.

i. Precast segmental box girder with post tensioning. Similar to the superstructure adopted in Phase 1 and Phase 2 of BMRCL.

ii. Precast Pre tensioned U-Girder superstructure.

0.4.4.1 Precast segmental box girder with Post Tensioning.

This essentially consists of pre-cast segmental construction with post tensioning and joints glued and is by far the most preferred technique in fast track projects. In such construction, the pre-stressing cables are placed in the conduits inside the structural concrete which are grouted with non-shrink cement slurry. The match cast joints at the interface of two segments are provided with shear keys for maintaining the correct line and level of the superstructure.

0.4.4.2 Precast Pre tensioned U-Girder superstructure.

Superstructure with single unit of U Girder for the span to accommodate one track is another method of construction of Metro structures. There will be two Girders for each

span to cater for the two tracks. The U Girders are Pre tensioned, Pre cast, transported to site and erected on the spans using road cranes.

Since these units are erected as a single unit per span, the speed of construction of Superstructure becomes very fast compared to the segmental construction. Since, the Pier cap will have to accommodate two U Girders, it has to be wider and hence, is made as a precast prestressed unit. This feature also facilitates faster construction. However, the internal width of U Girder is generally kept as 4m and hence this type of superstructure can be adopted for spans on curves of radius only upto 300m. For spans on curves of sharper radius and for cross over spans, different superstructure such as precast I Girders with cast-in-situ deck slab have to be used.

### 0.4.5 Station Locations and Planning

0.4.5.1 As per the configuration of alignment, all the stations would be elevated and the details of location and inter-station distances are as shown in the table below.

**Table 0.3 List of Stations Planned for Phase 2A**

| Sl. No | Name of Stations | Chainage (in m) | Inter-Station Distance (in m) | Remarks |
|---|---|---|---|---|
| | Start of the Corridor | 0.000 | | Elevated |
| **1.** | Central Silk Board | 413.840 | 413.840 | Elevated |
| **2.** | HSR Layout | 1485.363 | 1071.523 | Elevated |
| **3.** | Agara | 2817.116 | 1331.753 | Elevated |
| **4.** | Ibbalur | 5121.234 | 2304.118 | Elevated |
| **5.** | Bellandur | 7165.144 | 2043.910 | Elevated |
| **6.** | Kadubeesanahalli | 8117.297 | 952.153 | Elevated |
| **7.** | Kodibisanahalli | 9970.612 | 1853.315 | Elevated |
| **8.** | Marathahalli | 11416.461 | 1445.849 | Elevated |
| **9.** | ISRO | 12688.210 | 1271.749 | Elevated |
| **10.** | Doddanekundi | 13585.838 | 897.628 | Elevated |
| **11.** | DRDO Sports Complex | 14867.153 | 1281.315 | Elevated |
| **12.** | Mahadevapura | 15906.210 | 1039.057 | Elevated |
| **13.** | K.R Puram | 17133.392 | 1227.182 | Elevated |
| | End of the Corridor | 18363.941 | | Elevated |

0.4.5.2 The proposed stations are either on the middle of the road or partially on the service road or off road as per details below:

a. The elevated alignment generally passes on median of the road and the stations are also proposed above the road with entries planned from both sides of the road beyond the existing service road. The proposed stations will have two side platforms and the access to the platforms is through staircases, escalators and elevators housed in the paid area of concourse.

b. Traffic Integration facility at stations include approach roads to the stations, circulation facilities, pedestrian ways, connecting bridges for Metro and non-

Metro commuters, adequate halting areas for various modes likely to come to Metro stations including feeder buses/ mini buses.

c. Connecting bridge at Concourse level has been planned for crossing the road for the use of non-Metro commuters also through unpaid areas.

d. 7 out of 13 stations have been planned for commercial development for an area of about 1000 Sqm at each Station at concourse level. The area at ground level will be used for intermodal transit and parking.

e. 6m wide service road has been provided around the stations for integration with BMTC buses to ensure last mile connectivity for commuters.

f. A provision for pocket track of 300m length at Kodibeesanahalli station and cross overs at Ibbalur-Bellandur-Kadubeesanahalli and Marathalli-ISRO-Doddenakundi stations are made for facilitating smooth train operations and to help in easy turnaround of trains during emergency.

### 0.4.6 Land Requirement

As the Metro alignment has to be planned on set standards and parameters, apart from alignment, various structures like stations, parking facilities, traction sub stations, communication towers, etc. require large plots of land. The land being scarce, costly and acquisition being a complex process, the alignment is so planned that barest minimum land acquisition is involved.

Land requirement for Phase 2A ORR line is given in table below.

**Table 0.4 Land Requirement for Phase 2A**

| Type of Land | Area | |
|---|---|---|
| | Sqm | Hectares |
| Government/Government Agencies | 18,011.98 | 18.01 |
| Private | 18,772.31 | 18.77 |
| Total | 36,784.29 | 36.8 |

A lumpsum provision of Rs 22.70 Cr is made for land acquisition for RSS at K R Puram and Pocket track at Kodibeesnahalli. Baiyyappanahalli Depot which is functional and serves the East-West Corridor at present will be used for the train maintenance for the ORR line. A train maintenance depot to provide for maintenance facilities for the trains of East-West Corridor is planned at Kadugodinear Whitefield where about 20 Ha (50.00 acres) of Forest land is available. Therefore, the above given land acquisition requirement does not include the Kadugodi (Whitefield) Depot land. However, a lumpsum provision of Rs. 10 Cr is made for compensatory afforestation in lieu of the Forest land being acquired at Kadugodi (Whitefield). Once, the Depot at Kadugodi is developed, the existing Baiyappanahalli Depot with additional stabling lines and required remodelling will be utilised exclusively for the ORR Metro line and for the proposed Airport Metro line. The cost of land acquisition for the project is estimated at

Rs.559.10 Cr at the prevalent market value and as per land acquisition norms approved by the State Government.

## 0.5 Multimodal Integration & First and Last mile connectivity

No one mode can operate in isolation if it is to play a role in an integrated network. As each mode is suitable for different journey types, trip length, a combination of modes and complementary services is essential for seamless and effective mobility.
"The City Wide Multi-Modal Integrated Transport Plan can be defined as an approach for integration of institution, transportation & information structure for the unified transport network to provide the first mile and last mile connectivity both by private & public mode."

First and last mile connectivity can be defined as delivering connectivity from home to work and work to home with different modes of transport. The details for Multimodal Integration and first and last mile connectivity planned for this corridor are given in **Chapter 7** of this Report.

## 0.6 Environmental Impact Assessment/Environmental Management Plan

Ministry of Environment and Forests (MoEF), Government of India, has issued various notifications on Environmental Impact Assessment since 1994 with the latest being in 2009. According to those notifications, 32 types of projects under Schedule-I require environmental clearance from MoEF while Rail projects are exempted. The proposed project being rail based does not require Environmental Clearance and it does not create any major adverse environmental impact.

However, this report tries to identify environmental and social impacts and their mitigation measures and the details are dealt in **Chapter 14**.

The likely number of trees affected due to this line are enumerated. Of the likely total of 1218trees, 758 trees are planned to be trans-located and hence, 460 trees are getting affected.10 times the number of trees affected are going to be planted and nourished as Compensatory Reforestation.

## 0.7 Train Operation Plan

Since, Phase- 2A corridor will be extended up to Airport terminal station (Phase-2B corridor), train operation plans and train frequency of Phase-2A corridor have been integrated for the entire corridor from Central Silk Board to Airport Terminal Station so that every third train starting from Central Silk Board will be extended to Airport terminal station. The detailed train operation plan is provided in **Chapter 8**.

**0.7.1** Considering the present inter-station distance, sections with straight and curve alignment, dwell time at stations etc., detailed simulation was carried out and average speed of 34 Kmph is planned to be achieved between Central Silk Board junction to KR Puram.

**0.7.2** For the purpose of planning, the Peak hour peak direction traffic (PHPDT) demands for the Phase-2A corridor is indicated below:

**Table 0.5 Peak Hour Peak Direction Traffic for Phase 2A**

| Corridor | Year | | |
|---|---|---|---|
| | 2024 | 2031 | 2041 |
| Silk Board to KR Puram | 15411 | 20668 | 30909 |

### 0.7.3 Train formation

To meet the above projected traffic demand, running trains with composition of 6 Car trains has been planned with different headway.

Composition

| | | |
|---|---|---|
| DMC | : | Driving Motor Car |
| MC | : | Motor Car |
| TC | : | Trailer Car |
| 6 Car Train Compositions | : | DMC - TC -MC - MC - TC – DMC |

## 0.8 Rolling Stock

**0.8.1** The important criteria for selection of Rolling Stock for BMRCL are mainly reliability, low energy consumption, lightweight and high efficiency leading to lower annualized cost of service. Also, the train should have high rate of acceleration and deceleration.

**0.8.2** The proposed Rolling Stock for Phase-2A corridor is identical in dimensions with the Rolling Stock of Phase-1 to ensure interchangeability and continuity in service and compatibility of the same with Baiyapanahalli depot which has already been constructed under Phase-1. Train of Phase-2A corridors will be maintained at Baiyapanahalli depot after remodelling. Schedule of Dimensions (SOD) of Airport Link Metro corridor will be same as Schedule of Dimensions of Phase-1 and Phase-2.

**0.8.3** The size of the coach for Phase-2A corridor shall be in accordance with Schedule of Dimensions (SOD) of Phase-2. Proposed Coach Dimensions are as below:

**Table 0.6 Proposed Coach Dimensions for Phase 2A**

| | Length* | Width | Height |
|---|---|---|---|
| Driving Motor Car (DMC) | 21.05 m | 2.88 m | 3.8 m |
| Trailer car (TC)/Motor Car (MC) | 20.8 m | 2.88 m | 3.8 m |

**0.8.4** Coaches will have longitudinal seats with seating capacity of 43 persons per coach and the exceptional dense crush capacity (AW4) of 43 seated, 273 standing thus a total of 316 passengers for a Driving Motor Car and 50 seated, 293 standing thus a total of 343 for a trailer and motor car is envisaged. It is recommended to procure Rolling Stock for the ORR Metro line and the Airport Metro line with maximum axle load of 15 T. It is also proposed to consider the maximum design speed of train at 90 Kmph.

**0.8.5** There is requirement of 16 six -coach rakes for Central Silk Board junction to K R Puram line to cater traffic requirement for the year 2024.

## 0.9 Power Supply System of Traction

**0.9.1** The existing traction system in BengaluruMetro is 750 V DC third rail. Since the Central Silk Board junction to K R Puram line is a spread out of R V Road to Bommasandra and Baiyappanahalli to Whitefield line, the same traction system of 750 V DC third rail bottom current collection system is proposed to achieve the seamless integration and operational flexibility.

**0.9.2** Incoming power supply is proposed to be received from grid substation of KPTCL at 220/66 KV and by UG cable through double feeder for each proposed RSS. Since, 220/33 kV RSS at Central Silk Board part of Phase 2, catering RV Road to Bommasandra (Reach-5) Line, which also planned to feed ORR Line, one RSS of 66/33 kV, 2x25 MVA at KR Puram is required to be constructed for the line.

**0.9.3** Two (02) RSSs of 66/33 kV, 2x25 MVA at Yelahanka and KIAL Depot are planned to be constructed for the Airport Metro line. The third RSS at K R Puram is part of Phase-2A line and is planned with a provision for 10 MVA built-in for K R Puram – Airport line.

**0.9.4** The 66 kV power supply will be stepped down to 33 kV level at the above RSSs of metro authority. The 33 kV power supply drawn from the RSS will be distributed along the alignment through 33 kV ring main cable network for feeding to traction as well as auxiliary loads. These cables will be laid in dedicated ducts/hangers/brackets along the viaduct. Station auxiliary power supply is envisaged from the ASS (33/0.415 kV) located at concourse.

**0.9.5** Total 10 TSSs are estimated and the precise requirement of TSSs to be determined by simulations during detailed engineering stage. The TSS along with Auxiliary Sub-Stations (ASS) will be located at station building itself at concourse level inside a room. Self-cooled, cast resin dry type rectifier-transformer is proposed, which is suitable for indoor application. From the traction sub-stations, 750 V DC cables will be laid up to third rail and return current cables will be connected to running rails.

**0.9.6** Electric Power requirement for this line is likely to be 17.04 MVA approximately in year 2024 and which is likely to increase to 20.00 MVA by the year 2041. All the ASS & TSS of mainline are unmanned and to be SCADA compatible, to be integrated with OCC of Phase 2.

## 0.10 Signalling and Train Control

**0.10.1** Signalling/Train Control System in this section shall be Communication Based Train Control (CBTC) System. The Phase-2 lines (Line5 &6) which is under implementation is also being provided with CBTC Signalling System. Signalling and Train Control System shall be designed to meet the required headway. The proposed Signalling system shall be capable of Unattended Train Operations (UTO).

**0.10.2** The control of train operation will be done from a centralized Operation Control Centre(OCC) and will be supervised by the Traffic Controller(TC) at OCC. The OCC shall have required facilities for setting up of route and clearing of signals and other supervisory and control facilities. The Backup Control Centre (BCC) shall also be provided at suitable location geographically separated from OCC. Since the present OCC cannot accommodate additional line, a new OCC will have to be set up preferably at Baiyappanahalli Depot.

## 0.11 Telecommunication and Fare Collection System

**0.11.1** Telecommunication system shall cater to the needs of system traffic control, features to supplement Signalling system, operational/ maintenance and emergency communication, administrative communication, passenger information system, CCTV surveillance etc. in Metro Network. It shall also provide communication backbone for other systems such as Signalling, Power SCADA, Building Management Systems, Automatic Fare Collection (AFC) systems and administrative IT LAN.

**0.11.2** Further, for efficient and cost effective maintenance of the Signalling & Train Control and Communication network, it is proposed to provide a network management system(NMS), which will help in diagnosing faults from a central location and attending the same with least possible delay. Adequate space for proper installation of Signalling/Train Control and Telecommunication equipment at each stations shall be provided in view of regular testing and maintenance of the equipment/Systems.

**0.11.3 Automatic Fare Collection System (AFC)**

The proposed ticketing system shall be similar as provided for Phase-1 & Phase-2 i.e., of contactless smart token/card type. The AFC system shall support simultaneously ISO 14443 based type- 'A' cards compatible with MiFare and EMV based open loop (National Common Mobility Cards, Rupay, Visa, Master Card etc.) cards. The system shall also be capable of processing and accepting NFC based fare media with the provision of mobile ticketing. The system shall have provision for QR code based mobile ticketing also.

## 0.12 Train Maintenance Depot

**0.12.1** At present, Baiyappanahalli Depot serves the East-West (E-W) corridor catering to the maintenance needs of trains. It is housed with 16 Stabling Bay Lines (SBL), 3 Inspection Bay Lines (IBL) and 4 Repair Bay Lines (RBL). With sanction of Phase 2A ORR line (18.36 Km), it is proposed to switchover Baiyappanahalli Depot to ORR Line after remodeling and in lieu construct a new depot at Whitefield with full facilities to cater for E-W Corridor.

There is a requirement of 19 rakes for Central Silk Board junction to KR Puram line to cater to the traffic requirement in the year 2041 with 4 min headway. These trains are planned to be stabled and maintained at Baiyappanahalli Depot. Further, Phase 2B from KR Puram to Kempegowda International Airport is sanctioned for a length of about

38.44 Kms. Phase - 2B corridor being longer in length, the depot facilities are necessary at either end of the corridor to ensure seamless operation during any eventuality. Hence, to ensure feed from KR Puram end to Airport line it is proposed to provide additional stabling and inspection facility at Baiyappanahalli depot duly planning remodeling of the facility. Similarly, one more depot has been considered at Airport end to meet combine O&M requirement of Phase-2A & 2B. Details of modification and augmentation at Baiyappanahalli depot is brought out in **Chapter 13.**

The required Financial provision for full-fledged Whitefield Depot and Baiyappanahalli Depot remodeling and modification work related to Phase - 2A has been made in the DPR.

## 0.13 Metro-cum-Road Infrastructure

The traffic congestion on common section of ORRand Old Madras Road (OMR) between K R Puram and Kasthuri Nagar is causing lot of hardship to road user travelling to their work places and residences in Whitefield, ITPL, Marathahalli, Sarjapur etc., The traffic from 5 directions, namely from Hebbal, OMR, Marathahalli, Whitefield and Hoskote having major economic activates and residential areas converge at the common segment of ORR and OMR and seek passage to their destinations. This common road segment is carrying lot of through traffic along the ORR towards Marathahalli and Kasthuri Nagar. Also, there is a through traffic towards Whitefield and Hoskote. Apart from the heavy through traffic, there are certain cross movements taking place in this portion of road causing heavy congestion.

Various proposals like construction of additional flyovers, construction of clover leaf flyover etc., which involve large extent of land acquisition and construction of additional structures are under consideration by the Government of Karnataka to decongest the traffic on ORR especially at K R Puram and Tin Factory junctions.

With the approval for implementation of Metro line from Central Silk Board junction to K R Puram along ORR (Phase 2A) and the Airport line from K R Puram to KIA, construction of additional flyovers/ Clover leaf flyover for decongestion of road traffic may not be feasible as the Metro alignment between K R Puram and Kasthuri Nagar is passing through common segment of ORR and OMR.

Hence, it is planned to construct Metro-cum-Road flyover between Mahadevapura and Ramamurthy Nagar. This infrastructure will have combined Viaduct for Metro and Road between K R Puram and Kasthuri Nagar which will carry the through traffic on ORR and will result in effective decongestion of road traffic at K R Puram and Tin Factory junctions. It is also planned to provide the link from Hoskote road to ORR towards Marathahalli.The detailed construction feasibility of the structure will however be examined in consultation with BBMP.

No major land acquisition is involved except for the ramps at both the ends of the flyovers as the land requirement for Metro Viaduct is already finalised and the road

way will come on the same Piers of Metro Viaduct. The additional estimated cost of the flyover due to clubbing of road with Metro structure is about Rs. 330 Cr excluding the cost of land acquisition and this cost is not included in this DPR. The additional cost of land acquisition and construction of flyover for road has to be borne by the Government of Karnataka.

## 0.14 Security

Provision has been made for Security arrangements to be provided during operation of the Project. The Cost and other details are available in **Chapter 16** of this Report.

## 0.15 Cost Estimates

### 0.15.1 Summary of Capital Cost Estimate

The summary of capital cost of the project for ORR lineprepared at September 2018 prices, is given in the table below. The additional cost of land acquisition and construction of flyover for road has to be borne by the Government of Karnataka which is not included in this estimate. The Estimated Cost may however vary along with FIRR and EIRR estimates at appraisal stage of the DPR.

**Table 0.7 Summary of Capital Cost Estimate for Phase-2A**

| Sl. No. | Item | Basic Cost |
|---|---|---|
| 1 | Land | 559.10 |
| 2 | Alignment and Formation | 831.28 |
| 3 | Station Buildings and Architectural Finishes | 571.35 |
| 4 | Permanent- Way (Ballasted and Ballastless) | 225.89 |
| 5 | Depot | 307.97 |
| 6 | Miscellaneous (Utility shifting & Multimodal integration) | 198.60 |
| 7 | Traction & Power Supply - incl., Third rail, ASS, | 335.67 |
| 8 | E&M Works | 205.37 |
| 9 | Rolling Stock (SG) | 787.20 |
| 10 | Signalling and Telecom | 253.72 |
| 11 | Road Restoration | 44.00 |
| 12 | Security-Capital Cost | 5.88 |
| 13 | **Total (1 to 12)** | **4326.03** |
| 14 | Price Variation (PV) during Construction | 568.62 |
| 15 | Taxes | 432.24 |
| 16 | **Total incl., PV & Taxes (13 to 15)** | **5326.89** |
| 17 | Contingency @ 3% ( excl., land) | 125.98 |
| 18 | D&G charges @ 5% ( excl., land) | 194.65 |
| 19 | Interest During Construction (IDC) | 347.40 |
| 20 | **Grand Total (16 to 19)** | **5994.9** |

### 0.15.2 Operations and Maintenance Cost

The O & M cost for the year 2023-24 is **Rs. 147.33** Crores for the new line of 19.45 Kms with 13 stations, for running 6 coach train sets. Possibility of outsourcing

maintenance activities for Rolling Stock, Signalling & Telecommunication, Power Supply and Traction, Station Buildings as service contracts will be explored to economise on the cost.

**0.15.3** Detailed Cost estimate is given in **Chapter 16.**

## 0.16 Financing Plan and Financial Analysis

### 0.16.1 Financing Plan

The highly capital intensive Metro projects are a public utility with huge positive economic externalities but typically very low financial returns. Domestic commercial borrowings are not a viable option for financing as not only the cost of funds is on the higher side, but the tenures are also not long enough to match the long pay back periods which characterise a long gestation infrastructure project. Therefore, there is the need to explore avenues of financing with moderate rates, long tenures and a long enough initial moratorium. This requirement is fulfilled by the sovereign loans extended by Multilateral and bilateral development banks such as JICA, ADB, AFD, EIB etc. Therefore, in addition to the Equity and Subordinate Debt contribution from the Central and State Government, the Senior debt is proposed to be contracted through sovereign borrowing. In addition, public private partnerships for station naming rights, direct access to stations, advertising and commercial area rights, are expected to help finance Capital expenditure to the extent of Rs 500 crores.

**Table 0.8 Revised Funding pattern ( Equity sharing model) for Phase-2A**

| **Sources** | **Amount (Rs) (In crores)** | **(% of Share)** |
|---|---|---|
| GOI – Equity | 827.8 | 13.8% |
| GOI - Sub-debt | 216.1 | 3.6% |
| **GOI Share sub total (1)** | **1,043.9** | **17.4%** |
| GOK – Equity | 827.8 | 13.8% |
| GOK - Sub-debt | 216.1 | 3.6% |
| GOK - Sub-debt ( Land Cost ) | 559.1 | 9.3% |
| Reimbursement of SGST ( Grant) | 216.1 | 3.6% |
| **GOK Share sub total (2)** | **1,819.1** | **30.3%** |
| **Innovative Financing (3)** | **500.0** | **8.3%** |
| **Senior Debt ( Sovereign/Non -Sovereign Loans) (4)** | **2,631.8** | **43.9%** |
| **Total Sources ( 1) to (4)** | **5,994.9** | **100.0%** |

### 0.16.2 Financial Analysis

Financial analysis is done based on estimated Capital inflows on account of equity, subordinate debt and borrowings as well contribution from innovative financing and Capital outflows are comprised of expenditure during construction and IDC. The inflows from Fare and Non fare Box revenue comprise the Revenue inflow and the revenue expenditure on operations and Operational, staff and energy cost as well as finance cost constitute the Revenue outflow. The FIRR is derived as 5.25% in the Most

Likely scenario for estimated Ridership for a 30-year time horizon and Sensitivity Analysis has been carried out for an optimistic scenario with 10% increase in ridership and pessimistic scenario with 10% reduction in ridership coupled with a 1-year time over run and a 10% cost overrun.

**Table : 0.9 Summary of Sensitivity Analysis and FIRR results**

| SL No | Ridership Scenarios | Pax per day | Capital Outflow including IDC (Rs in crores) | Net cash inflow (after redemption of borrowings) (Rs in crores) | FIRR | Reference (Chapter 18) |
|---|---|---|---|---|---|---|
| **1** | Most Likely scenario | 2,18,000 | (5,995) | 11,582 | 5.25% | Annexure 18.1 |
| **2** | Optimistic scenario (Pax 110% of Most likely scenario) | 2,39,800 | (5,995) | 15,037 | 6.34% | Annexure 18.2 |
| **3** | Pessimistic Scenario (Pax 90% of Most likely scenario with one year time overrun + CAPEX increase by 10% ) | 1,96,200 | (6,663) | 8,925 | 3.92% | Annexure 18.3 |

## 0.17 Economic Analysis

The benefits that the metro projects provide are more important from the government's economic and social point of view compared to the financial benefits that accrue from implementing the project. The proposed system will provide a variety of benefits to the city and society, viz. savings in fuel consumption, vehicle operating costs, travel time, reduction in road accidents and air pollution etc. These economic benefits would overweigh the financial benefits and hence assessing the same would also be of more significance.

The economic analysis for Central Silk Board junction to KR Puram Line has been carried out within the broad framework of EIRR (Economic Internal Rate of Return) based on Appraisal Guidelines for metro rail projects taken from website of Ministry of Housing & urban affairs.

The Economic Analysis is based on the incremental costs and benefits and involves comparison of project costs and benefits in economic terms under the various Sensitivity Scenarios. In the analysis, the cost and benefit streams arising under the above project scenarios have been estimated in terms of market prices and economic values computed by converting the market prices using appropriate factors. The annual

streams of project costs and benefits have been compared over the entire analysis period to estimate the net cost/ benefit and to calculate the economic viability of the project in terms of EIRR. Effectively 30 years of operations from the start of services from the year 2023-24 has been considered for economic evaluation for the project.

EIRR for 30 years has been computed to be16.51%. The details are in **Chapter 19.**

## 0.18 Implementation Strategy

### 0.18.1 Legal Cover for Implementing the Project

Implementation of proposed Central Silk Board junction to K R Puram line of Bengaluru Metro Rail Project will be done under "The Metro Railways (construction of works) Act 1978"and "The Metro Railways (Operation and Maintenance) Act 2002" as amended by "The Metro Railways (Amendment) Act 2009".

### 0.18.2 Implementation Schedule

The project is proposed to be implemented as Phase-2A for Bengaluru Metro in a period of 45 months from financial closure i.e. between April 2020 and December 2023. A suggested project implementation schedule is given in table below. Activity 6 i.e., commencement of piling in April 2020 will be the effective physical start of works and the Activities 1 to 5 will be the time required for approvals and preparatory works.

**Table 0.10 Activities showing start date, end date & duration for implementing Phase 2A**

| Activity | Description | Start | End | Duration in Months |
|---|---|---|---|---|
| Activity 1 | Land Acquisition for Viaduct & Stations | 0 | 8 | 8 |
| Activity 2 | Approval by GoK | 0 | 3 | 3 |
| Activity 3 | Approval by GoI | 4 | 6 | 3 |
| Activity 4 | Financial Closure by at least 50% Senior Debt | 7 | 12 | 6 |
| Activity 5 | Award of civil works contract | 4 | 12 | 8 |
| Activity 6 | Piling & Pile cap | 15 | 27 | 12 |
| Activity 7 | Pier & Pier cap | 18 | 30 | 12 |
| Activity 8 | Segment Launching | 22 | 40 | 18 |
| Activity 9 | Station works | 15 | 42 | 27 |
| Activity 10 | Station finishing works | 35 | 50 | 15 |
| Activity 11 | Track works | 35 | 50 | 15 |
| Activity 12 | System works (Traction, E & M and S&T) | 30 | 54 | 24 |
| Activity 13 | Integrated Testing | 54 | 57 | 3 |

## 0.19 Compliance to Metro Rail Policy 2017

The proposed ORR Metro line meets the objectives and norms set out in the Metro Rail Policy 2017. The proposed line seeks to provide efficient, effective sustainable mode of mass public transport for the business corridor having economic activities for 12% the country's IT exports.

This DPR has been prepared in accordance with the standard and specifications issued by MoHUA from time to time. The proposed line is part of the Comprehensive Mobility Plan 2019 for Bengaluru city. It has been subjected to the alternative investment analysis for mass public transport systems, and is assessed to be the appropriate mode for the mobility needs on the corridor.

The city has a draft Transit Oriented Development Policy with some of the proposed measures already being at the stage of legal and regulatory approvals.

The state has a fully functional Directorate of Urban Land Transport. A bill for setting up Bengaluru Metropolitan Land Transport Authority has been prepared and is likely to be placed before the State Legislature shortly for enactment.

## 0.20 Salient Aspects of the Project

### 0.20.1 Goals and Objectives

- The project aims to support the goals of Comprehensive Mobility Plan (CMP) for complementing economic activities and increasing the share of public transport to 70% of all motorized trips.
- It also plans to facilitate systemic changes in road usage by incentivizing efficient, equitable and sustainable mobility options through economic and regulatory measures, while discouraging inefficient and unsustainable options through imposition of cost of negative externalities.
- This project will play a key role in mitigating the mobility related binding constraints to IT eco-system in Bengaluru, which accounts for 40% of revenues of IT companies in India.

### 0.20.2 Innovations and Piloting of New Approaches

The Project will implement the following innovations and new approaches due to the advantages of its location and alignment.

- Enhancing efficiency of usage of road as an economic asset & leveraging parking space fees to encourage use of public transport.
- Development of Inter-modal transit hubs for operational and economic integration with other modes.
- Extensive use of non-motorized transport for last mile connectivity.
- Economic integration of fare by common fare card for Metro and public bus system to complement the two important modes of public transport for the convenience of commuters.

- Augmenting road infrastructure by building Metro-cum road flyover in critical locations in the project alignment.
- Use of latest technology, modern construction practices and project monitoring through advanced IT system.

### 0.20.3 Innovations in Financing Leveraging

In order to reduce the dependence on borrowings, the following financing innovations are planned:

- Upfront PPP with major companies to realize about USD 70-100 million to fund capital cost.
- Land Value capture through innovative TOD measures for financing of urban infrastructure.
- Financing plan with long term and moderate cost financing from multilateral and bilateral development agencies to the extent of 45% which can be largely serviced out of revenues of BMRCL.

### 0.20.4 Private Sector Engagement (Financing, Involvement, Provision of Services)

- Upfront PPP with major companies having presence along the metro alignment giving them rights for station naming, direct access for their employees, advisement and commercial spaces for financing capital expenditure on the project.
- Procurement of system maintenance services for Rolling Stock, Signalling & Telecom, Traction, Housekeeping and Security to be outsourced during the operational phase.

### 0.20.5 Climate Mitigation/Adaptation and Stakeholder Involvement

- The proposed project will increase the share of public transport in total intra-city passenger movements and is expected to reduce carbon dioxide emissions and resultant pollution and improve air quality of the city by shifting 0.46 million daily passengers from road to rail-based modes. The project is also expected to assist in orderly densification of the city instead of lateral growth of the urban area.
- Corridor alignments and the proposed station locations have been identified based on extensive consultation and after obtaining feedback from key stakeholders. Involvement of public is to be mainstreamed through stakeholder consultations to minimise traffic constraints during Metro construction. To obtain support of key stakeholders towards the project, BMRCL has taken number of new initiatives e.g. slum dwellers living in acquired land are being provided with a dwelling unit irrespective of status of the slum. BMRCL compensates/ rebuilds parts of schools, hospitals, parks, religious structures, etc. affected by the project.

### 0.20.6 Mainstreaming of Gender

Convenient and efficient mobility option for women is expected to mitigate one of the causes of declining share of women in the work force. The improved access to city centres, commercial hubs, airport and basic social and other services will contribute to improved job opportunity, health and education outcomes, particularly to the poor and marginalized, women and children. Dedicated special coach for women passengers in each train and reserved seats for the elderly, and persons with disabilities are some of the features planned.

### 0.20.7 Outcome of the Project

The project on implementation, will provide major socio-economic benefits to the society particularly in the influence zone of the corridor, such as:

- Provide safe, reliable, affordable and environment friendly public mass transit systems for Bengaluru city, which will improve mobility and benefit about 0.46 million commuters daily and support endeavour for planned urban development in Bengaluru.
- Result in larger share of public transport in meeting mobility needs of the city.
- Lead to enhanced economic productivity of the city and thereby assistance for more job creation.
- Bringing the roads back to the community for social and economic development of the zone.

## 0.21 Recommendations

**0.21.1** The analysis in this Detailed Project Report (DPR) establishes not only the economic viability and desirability of this project but also brings out that construction of a Metro line on this corridor will enhance effectiveness of the Metro network. The cost of construction of this Metro line measuring about 19.45 Kms would be Rs. **5994.9** Crore.

**0.21.2** The work of execution of this project can be entrusted to a Special Purpose Vehicle (SPV) which has the technical and managerial components to execute it. The Bengaluru Metro Rail Corporation Ltd. (BMRCL) is the appropriate agency for execution of this project with their experience of Phase-1 and Phase-2 projects of BMRCL.

**Figure 0.1 Comprehensive Metro Rail Network in Bengaluru**