METHODOLOGY: PERFORMANCE OF INDIAN METRO RAIL SYSTEMS

The following section provides an overview of the evolution of the case metro systems, their current network details, the financing details and the ridership achieved by the systems.

DELHI METRO

The Delhi metro is considered India's first modern metro rail system. Delhi Metro Rail Corporation (DMRC), a joint venture between Government of India (GoI) and the Government of National Capital Territory of Delhi (GNCTD)[1] formed in 1995, manages the implementation and operation of the Delhi metro. It was conceptualised in 1991 as a 198.5 km network of underground, at-grade and elevated metro to meet Delhi's growing travel demand needs until 2021[2] and was later extended into a wider network. The network was developed in phases with the phase I and II network of 190 km being operational by 2010, and the current length of 389 km and 285 stations after phase III operational by 2021.[3] The development of Phase IV network of 103.93 km has also begun. The network is now spread beyond boundaries of the National Capital Territory (NCT) of Delhi to connect adjacent regional urban centres like NOIDA and Ghaziabad in Uttar Pradesh, and Gurgaon, Faridabad, Bahadurgarh and Ballabhgarh in Haryana.

FINANCING OF THE PROJECT

The main financiers of the project are Central and Delhi government along with Japan International Cooperation Agency (JICA). Table 1 summarises the split of financing for various phases of the Delhi metro. [4]

Table 1: Delhi Metro Phase-wise financing

Phase of development	Network length	Total Cost	Contribution
Phase I	65.1 km	INR10,571 crore* ($142.5bn, €120.4bn)	60% JICA Loan 14% GoI Equity 14% GNCTD Equity

[1] Delhi Metro Rail Corporation Ltd, 2017. About us.
[2] UNEP, 2014. Promoting Low Carbon Transport in India: Case study of Metro Rails in Indian cities.
[3] Global Mass Transit, 2010. Delhi Metro: Setting an example in India.
[4] Delhi Metro. Delhi MRTS: Cost & funding plan for Phase-I, II & III.

			5% interest free subordinate debt towards the land cost 7% property development
Phase II	124.9 km	INR 1,8783 crore ($253.1bn, $213.9bn)	55% JICA Loan (PTA by GoI) 16.4% GoI Equity 16.4% GNCTD Equity 6.6% interest free subordinate debt towards the land cost and central taxes 5% property development and DMRC internal accruals 0.6% grant by HUDA
Phase III	156.5 km	INR 41,079 crores ($553.6bn, €467.8)	48.6% JICA Loan 10% GoI Equity 10% GNCTD equity 31.4% property development by DMRC, land and central tax, and grants

**1 Crore = 10 million*

RIDERSHIP

The ridership realised by phase I of Delhi Metro didn't meet the original projections and was revised several times for the subsequent phases based on the actual ridership realised as summarised in Table 2. The original feasibility study for developing a metro system for Delhi 1995, estimated that the system would handle an estimate of 3.1 million commuter trips per day for phase 1 by 2005, and 12.6 million trips by 2021[5]. This was later reduced to a projected demand of 2.18 million passengers by 2005.[6] The phase II projection in 2005 estimated a daily ridership of 3.09 million by 2021.[7] This was further revised during the projections for Phase III made in 2011 wherein the ridership predicted for 2021 was reduced to 0.7 million for Phase I, 1.8 million for phase II and 2.3 million for the phase III network, i.e., a total of 4.8 million for the entire network. The latest projects from phase I, II and III networks made in 2018 reduced this further to 4.05 million.

By 2019-20 the actual ridership of Delhi metro reached 5.7 million per day, higher than the projected ridership in Phase III and IV reports[8]. However, part of the increase in ridership numbers were due to a change in definition of ridership where in trips made on separate lines of the metro are now counted as separate trips, departing from the earlier definition of the

[5] Advani et al,. 2005. *Evaluation of public transport systems: case study of Delhi metro*.
[6] Mohan, 2008. *Mythologies, Metros & Future Urban Transport*. TRIPP Report Series, WHO Collaborating Centre.
[7] DMRC, 2005. *Environmental Impact assessment for Phase II corridors of Delhi Metro*.
[8] Hindustan Times, 2021. *Avg. daily ridership of Delhi Metro at 10 lakh, down from 57 lakh pre-lockdown.*

entire journey between origin station to the destination station counted as one trip. This change in definition of a trip is estimated to have contributed to 50% increase in the ridership numbers.

Table 2: Revision of ridership projections for Delhi Metro

Year of estimation	Phase of metro network	Horizon year for Projections	Projected Daily Ridership (millions)	Source of data
1995	Phase I	2005	3.10	RITES [6]
		2021	12.6	
2003	Phase I	2005	2.18	Sreedharan[6]
2005	Phase I	2005	1.50	Mythologies, Metro Rail Systems and Future Urban, Dinesh Mohan[6]
2005	Phase II	2021	3.09	DPR of Phase II, RITES[7]
2006	Phase I+II	2021	5.41	Social Cost-Benefit Analysis of Delhi Metro[9]
2011	Phase I	2021	0.69	EIA For Phase III corridors of Delhi Metro[10]
	Phase II	2021	1.84	
	Phase III	2021	2.30	
2018	Phase I, II, III	2021	4.05	SIA For Phase IV corridors of Delhi Metro [11]

MUMBAI METRO

The Mumbai Metro was originally conceptualised as a part of the city's master transport plan published by the Mumbai Metropolitan Regional Development Authority (MMRDA) in January 2004. It was envisaged as a 146km network to augment public transport capacity in the city and to relieve congestion on the sub-urban commuter rail system which is the mainstay of mass mobility in the city.[12] MMRDA awarded the project to Reliance Infrastructure to implement the project on Public-Private-Partnership model (PPP) in 2007.[13] This was the first Metro project awarded in the country on a PPP basis and entailed design, financing, construction, operation and maintenance. A special purpose vehicle, namely, Mumbai Metro One Private Limited (MMOPL) was incorporated for the implementation of the project. The first phase of the project included a 11.40km fully elevated line with 12 stations, completed in 2014. It connects two suburban railway lines running parallel to each other (North-South) at Ghatkopar and Andheri, improving East-West connectivity.

[9] Dhavala et al,. 2006. *Social Cost-Benefit Analysis of Delhi Metro*. Institute of Economic Growth.
[10] DMRC, 2011. *EIA for Phase III Corridors of Delhi Metro*.
[11] DMRC, 2018. *Social Impact Assessment for Phase IV corridors of Delhi Metro*.
[12] Shirke et al,. 2017. Transit Oriented Development and Its Impact on Level of Service of Roads & Metro: A Case Study of Mumbai Metro Line-I. Transportation Research Procedia, Volume 25.
[13] Reliance Mumbai Metro One. *About us.*

The Mumbai region under MMRDA also has upcoming network of 326km including 13 metro rail lines, of which 6 lines are under construction. MMRDA has established a public sector undertaking organisation - Maha Mumbai Metro Operation Corporation Limited (MMMOCL), responsible for the operation and maintenance of all these metro lines across the MMR region. Mumbai Metro Rail Corporation Limited (MMRC) is the nodal agency responsible for the implementation of Mumbai Metro Line–3 (MML-3) project.

FINANCING OF THE PROJECT

The project was financed by a consortium of banks led by Syndicate Bank. The other banks in the consortium were Indian Bank, State Bank of Hyderabad, Bank of Maharashtra, IDBI Bank and India Infrastructure Finance Company (UK)[15]. The project cost, which was originally estimated as INR 2,356 crore, faced a 70% cost escalation to INR 4,321 crore ($582m, €492) due to growing inflation which led to increase in input costs of raw materials, delays on account of right of way clearances, and shifting of utilities, etc[14]. The project had INR 2,000 crore ($270m, €228m) of bank loans, INR 650 crore ($88m, €74m) as viability gap funding from the government of Maharashtra, and balance of around INR 1,350 crore ($182m, €154m) were put in by Reliance.

RIDERSHIP

The Metro DPR for Phase I corridor of Mumbai metro rail predicted a daily ridership of 0.43 million per day in 2011, and 0.67 million per day in 2021. The metro system however opened in 2014, and by 2018 had the average daily ridership of 0.34 million per day and 0.45 million per day by 2019.[15]

BANGALORE METRO

The Bangalore metro rail as an idea was formed when the Central Road Research Institute in 1963 carried out a study for improving the road network and traffic management system of the city and proposed a rail network of 26km. More studies and reports like Government Study Group report (1982), feasibility report by Metropolitan Transport Project an organisation of Indian Railways (1983), and World Bank aided study (1988) for Bangalore Urban Transport Project (BUTP) carried out by RITES, proposed a grade separated suburban services for the city. Thus, Bangalore Mass Rapid Transport limited (BMRTL) was incorporated in 1994 by the State Government to implement a Mass Rapid Transport System. BMRTL, in turn, asked IL&FS to carry out a feasibility study for an LRT system on Public - Private Partnership basis. The study suggested an elevated LRT system on six routes, however the project was not taken up due to financial and street space constraints. Because of worsening traffic woes for the city, the State Government asked DMRC to step in and propose a metro system on two busy corridors for implementation as a fast-track project. Hence, a Special Purpose Vehicle (SPV)-Bangalore Metro Rail Corporation Limited (BMRCL) was formed based on a joint venture of Government

[14] Jog, 2014. *Before Mumbai Metro hits tracks, a fare controversy*. Business Standard
[15] Mehta, 2019. *Versova-Ghatkopar Metro One crosses 60 Crore ridership in 5 years*. The Times of India.

of India and Government of Karnataka for planning and implementation of the Bangalore metro rail project[16]. The primary purpose of the metro rail in Bangalore was to enable the commuters to travel across the Central Business District areas of the city with ease[17]. This was the first Metro rail project in India commissioned with 750V DC Third Rail on Standard Gauge[18].

The Phase-I of Bangalore Metro Rail Project (started construction in 2011, fully operational since 18th June 2017) constitutes the network length of 42.3 Kms across two lines i.e., North-South and East-West comprising of 33 elevated and 7 Underground Stations. A 6.4km extension to the previous north-south network opened in January 2021 marking the start of Phase-II of the project. The total network length now stands at 48.7km. Additionally, about 120km of network is currently under development as a part of phases II, IIA and IIB.

FINANCING OF THE PROJECT

The financing for the Phase-I of the project was secured from the Central and State government (59%) and remaining was borrowed from domestic and foreign financial institutions like JICA, HUDCO, ADB, French Development Agency (AFD) and KUIDFC. The cost of the 42.3km of Phase I totals to INR13,845 crore[19] ($186.6bn, €157.7bn). The project cost was revised four times since the announcement of the project. Starting from INR 6,395 crore ($862m, €728m) for 33km, it was revised to INR 8,1580 crore for 42.3km ($109.9bn, €929m), and further revised to INR13,845 crore ($186.6bn, €157.7bn) in 2015. Therefore, the per-km cost of the system increased from INR 197 crore per km to INR 327 crore per km, a 70% increase from the DPR stage to actual execution of the project over a period of 14 years.

RIDERSHIP

The ridership for the project was estimated to be 0.82 million per day during 2007 at the start of the project, increasing to 1.6 million per day by the year 2021. The peak ridership achieved during the year 2019-20 was approximately 0.4 million per day[20].

CHENNAI METRO

The Chennai metro rail was proposed as a part of the Chennai Comprehensive Transportation Study (CCTS) 2010 to arrest the growth in personal vehicles and reduce traffic growth on the road network[21]. Following this, the Government of Tamil Nadu created Chennai Metro Rail Limited (CMRL), a Special Purpose Vehicle (SPV) to implement the project[22]. CMRL prepared the Detailed Project Report (DPR) for six corridors in the city in 2003 of which two corridors were approved for phase 1[23]. At present, Chennai has 54.15km operation rail network with 32

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[16] BMRC, 2021. About us.
[17] BMRC, 2020. *Annual Report '19-20*.
[18] Linxon, 2021. *Urban mass rapid transit system in Bangalore, India.*
[19] Menezes, 2017. *Cost and time overrun marks Bengaluru metro phase-1*. The Economic Industry.
[20] BMRC, 2020.
[21] Sekar and Karthigeyan, 2010. *Chennai Metro – Will it be Boon for Development of Chennai City*. Urban Transport Journal Institute of Urban Transport (India), Vol. 9. No 2.
[22] CMRL, 2021. About CMRL.

stations. Three new corridors under the Phase 2 of the project were approved in 2017 in addition to the existing network and will be implemented by 2026.

FINANCING OF THE PROJECT

The 45.04km Phase I project was implemented and operated under a SPV, owned by Government of India (GoI) and Government of Tamil Nadu (GoTN). It is financed by GoI (25%), GoTN (16.5%) and Japan International Cooperation Agency (JICA) (58.5%). The total project cost was estimated to be INR11,667 million ($156.5bn, €132.2bn).

RIDERSHIP

The ridership for the Chennai metro Phase 1 was projected as 0.78 million per day by the year 2016 (within 2 years of start of operation) and 1.29 million per day by 2026. The average daily ridership in 2019-20 was observed to be 0.12 million per day.

LONDON

London is the world's first underground railway which opened in 1863 to reduce on-street congestion, then known as the sub surface lines using steam engine trains. Londoners have nicknamed this underground rail as the Tube. Safe tunnelling technology of tubes was later developed in 1870, and successful tube railway was made possible after electric power and safe lifts were perfected in the late 1880s. Later supported by American financiers, new tube links were developed and opened in 1906-07 completing the core of the modern tube system. In 1908, several companies started working to promote the system which gradually merged, and the network expanded. In 1933, all of London's public transport – buses, trams, and trolleybuses, as well as the Underground railways were nationalised and integrated into a single body, the London Passenger Transport Board.

In 2003, London Underground became a wholly owned subsidiary of Transport for London (TfL) which is an integrated transport authority responsible for all modes of transport in London. The operating divisions of TfL include the Underground and Elizabeth line rail systems, buses, street charges (including congestion charges and Ultra Low Emission Zone- ULEZ charges), regional rail, other operations, major projects, properties, media and central items.
The London Underground currently has 11 lines covering 402km and serving 270 stations, handling up to five million passenger journeys a day[24,25]. It has also been awarded several times for its operational efficiency and connectivity.

Along with the underground, the Docklands Light Railway (DLR) also serves the passengers with its 37km network.

[24] TfL, 2019. *Tube trivia and facts*.
[25] London Transport Museum, 2021. *A very short history of the underground*.

HONG KONG

The Mass Transit Rail (MTR) Corporation was established in 1975 as a government-owned enterprise to build, operate, and maintain a mass transit railway system for Hong Kong's public transport needs[26]. MTR constructed capital intensive rail lines and accumulated debt by 1985. As a result, it became publicly traded to cover and cut some of the company's project costs without raising fares and by arranging government land grants for rail and property development. The Rail + Property (R+P) programme helped MTR Corporation meet this objective, where the Hong Kong rail acquires the development right along the metro line at greenfield price from government even before the rail is built. The built metro rail then elevates the land value, which is captured by the system, making it profitable. This profit is used for self-financing the future extensions of metro lines[27].

MTR has been the most profitable metro system in the world, with 193km of metro rail. The profitability is also attributed to its integrated rail and feeder bus network. It is currently responsible for heavy and light railway construction, operation and maintenance; property development, rental and management; consultancy and contracting services and providing contacts for Mainland China and international businesses.

SINGAPORE

Singapore has an extensive public transport system including an elaborate rail network integrated with public bus network providing connectivity to all parts of Singapore. The rail network spans about 200km, with over 3 million daily ridership[28]. In addition to the metro, the city has a 28km light rail system with daily ridership over 0.2 million journeys. The train system is currently run by two public transport operators – SMRT Corporation Ltd (SMRT) and SBS Transit (SBS).

The SMRT Corporation Ltd (SMRT) is a public transport service provider responsible for operation and maintenance of the four out of six metro lines in Singapore along with Light Rail Transit system complemented by the bus, taxi and private hire vehicle services. SMRT's rail business includes over 148 km of rail tracks (137 km metro rail and 11km light rail) across 108 stations. The non-rail business includes bus and taxi operations, rental property, advertising, engineering, and other services. In this report, the focus is on SMRT's operations.

METHODOLOGY

The Knowledge Brief undertakes Ridership and Financial Analysis for the case cities.

Within Ridership analysis, the average ridership per day and riders per day per km is calculated. For the Indian cities, the projected ridership during the planning phase of the projects are compared to the actual ridership achieved by the metro systems. A detailed analysis for Delhi metro ridership was undertaken as the projected ridership for the system changed over the years.

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[26] PPIAF, 2015. *Hong Kong mass transit rail corporation*.
[27] Keegan, 2019. *How public transport actually turns a profit in Hong Kong*. The Guardian.
[28] LTA, 2021. Rail Network.

The Financial Analysis of the case metros is carried out from the perspective of their costs and revenues separately and overall financial performance benchmarked against the international peers. For the Indian cases, the "Statement of Profit and Loss" from the Annual Reports of each city has been undertaken for the Financial Year (April to March) 2018, 2019 and 2020. For the international cases, the latest Annual Report available before the COVID-19 pandemic is used. For London, the Statement of Accounts for TfL 2019/20 is taken[29]. For Hong Kong, the annual report for the calendar year 2020 is taken up[30], and for SMRT Singapore, the segment wise performance of business statement is used[31].

The financial statement for the case cities is for integrated system including metro rail and buses, and also including taxi and property development for the international cases. Financial performance of international cases is thus compared to the Indian cases by arranging the income and expenditure distribution under the following categories.

Revenue	**Operational Revenue**
	Other Revenue
	Total Revenue
Expenditure	Operational expenditure
	Non-Operating expenditure
	Total Expenditure
Operational Profit/(Loss)	
Total Profit/(Loss) before tax	
Total Annual Profit/(Loss) after tax	

The financial performance of Indian metros and the international peers are also compared using revenue recovery ratio. Three revenue recovery ratios used are

- Farebox revenue recovery ratio measured as the ratio of fare revenue and operational expenditure
- Operational revenue recovery ratio measured as the ratio of total operational revenue and operational expenditure
- Total revenue recovery ratio measured as the ratio of total revenue and total expenditure

The revenue recovery ratio comparison between different case cities must be taken with caution, as the exact boundaries of costs and revenue may differ in cities due to difference in defining these metrics. More about defining metrics for financial figures can be read in the UITP Report, *A common metric for Public Transport coverage rate?,* available to members.

[29] TfL, 2020. *Annual Report and Statement of Accounts*.
[30] MTR, 2020. *Keep cities moving: Annual report 2020.*
[31] SMRT, 2016. *Announcement full year results*.