

## Executive Summary

Delhi Metro Rail Corporation Limited (DMRC) is a joint venture with equal equity (50:50) contribution from Government of India (GoI) and Government of National Capital Territory of Delhi (GNCTD). Delhi Mass Rapid Transit System Project Phase-I covering 65 km was conceptualised (September 1996) and completed (November 2006) by DMRC. This was followed by Phase-II (124.93 km during 2006-2011), Phase-III (160.75 km during 2011-2019) and Phase-IV covering 103.93 km which is under implementation and scheduled to be completed by December 2024. The Performance Audit of Phase-I was taken up in March 2007 and completed in July 2008. Compliance Audit of Airport Metro Express Line was taken up under Phase-II and included in Report No 13 of 2013. Performance Audit of Delhi Mass Rapid Transit System Phase-III was taken up to assess implementation of the project in terms of economy, efficiency, and effectiveness due to public interest in the project, growing transport requirement of Delhi, substantial cost involved, and delay in completion of the project.

The objectives of the Performance Audit were to examine whether (i) effective planning was done to ensure economic viability and selection of the most appropriate technologies; (ii) implementation in terms of project execution and contract management was done with due care, economy, and in a timely and transparent manner; and (iii) an adequate mechanism was in existence to monitor the project to ensure timely completion and conformity of works executed with laid down specifications, and (iv) the operation and maintenance were efficient, and the planned benefits were achieved after commercial operation of Phase-III.

The Performance Audit covered the 13 corridors<sup>1</sup> and outcome of the activities of Phase-III project for the period since inception (April 2011) to March 2020. A total of 93 (four more contracts added during audit) out of 259 contracts valued above ₹5 crore relating to civil, rolling stock, track, electrical, signalling & telecom, property development and operation & maintenance were covered during the audit. The coverage in terms of number of contracts was 36 *per cent*. In terms of monetary value, the audit coverage was ₹25,616 crore out of sanctioned cost of ₹48,565.12 crore which amounts to 53 *per cent*. The Indian Institute of Technology, Delhi (IIT Delhi) provided technical consultancy during review of the technical aspects of the Phase-III project.

A summary of the main audit findings is given below:

### Policy, Planning and Selection of Technology

- National Urban Transport Policy 2006, stipulated that GoI contribution shall not exceed 20 *per cent* of the capital cost of the project (including equity, subordinate debt and grant etc.) excluding the cost of land and Rehabilitation and Resettlement. The funding pattern of Dwarka-Najafgarh, Mundka-Bahadurgarh and Badarpur-Faridabad extensions envisaged GoI contribution of more than 20 *per cent* leading to additional contribution of ₹421.34 crore by GoI.

(Para 2.1.1)

<sup>1</sup> *Jahangir Puri to Badli (Line-2 Extension), Mukundpur (Majlis Park) to Yamuna Vihar (Line-7), Janak Puri West to Kalindi Kunj (Line-8), Badarpur-Faridabad Extension (Line-6), Maujpur to Shiv Vihar (Line-7 Extension), Kalindi Kunj-Botanical Garden (Line-8 Extension), Dwarka-Najafgarh, Mundka-Bahadurgarh, Escorts Mujesar (Faridabad)-Ballabhgarh, Najafgarh to Dhansa Bus Stand extension, Noida City Centre-Noida Sector -62, Central Secretariat-Kashmiri Gate and Dilshad Garden-New Bus Adda, Ghaziabad*

- There was no minimum Financial Internal Rate of Return criteria for approval of a metro corridor before 2013. This resulted in sanctioning of two corridors (Badarpur-Faridabad and Shiv Vihar extension) with negative Financial Internal Rate of Return. After Ministry of Housing and Urban Affairs instructions (August 2013), for minimum eight *per cent* Financial Internal Rate of Return, Detailed Project Report of (i) Dilshad Garden to Ghaziabad, New Bus Adda, (ii) Noida City Centre to Noida Sector-62, (iii) Kalindi Kunj to Botanical Garden, (iv) YMCA Chowk to Ballabgarh corridors were revised (up to October/ December 2014) to make them viable and higher Financial Internal Rate of Return of 12.23 *per cent*, 8.63 *per cent*, 9.85 *per cent* and 11.01 *per cent* were computed as against the earlier 4.02 *per cent*, 2.03 *per cent*, 1.11 *per cent* and 4.50 *per cent*, respectively. Increased Fare Box Revenue ranging from 111 *per cent* to 175 *per cent* has been considered to attain the Financial Internal Rate of Return of eight *per cent* or more for sanctioning the projects.

**(Para 2.1.2)**

- DMRC did not have any protocol for scientifically estimating the cost of an upcoming project. They also did not have any approved policy for selection of type of corridor i.e., elevated, at grade or underground; policy for providing interchange between two stations and mode of interchange facility.

**(Para 2.1.3)**

- Gross infirmities and adoption of different assumptions in formulation of Detailed Project Report were noticed. Chapter on Comprehensive Mobility Plan highlighting developing an integrated plan was not included in the DPR. Guidelines/ instruction/ standard operating procedures were not formulated by DMRC for preparation of the Detailed Project Reports. No cost and benefit analysis was conducted for adopted Technologies.

**(Para 2.1.4.1)**

- Detailed Project Reports were inadequate and lacked specific information on the project. There was no information on tunnel details, cut and cover method, tunnelling methods, support system, lining, excavation methods etc. Detailed Project Reports also did not mention about any quick and cost-effective geophysical methods to get the strata condition depth wise along the alignment.

**(Para 2.1.4.4)**

- Memorandum of Understanding was not signed among GoI, GNCTD and DMRC although it was required as per condition of sanction letter of Phase-III Delhi Mass Rapid Transit System project to ensure effective implementation of the project and conditions of sanction.

**(Para 2.2.1)**

- Government of India sanction letter for Shiv Vihar extension required that a Memorandum of Understanding be signed between DMRC and Government of Uttar Pradesh, as some portion of this extension was passing through territory of Uttar Pradesh and required partial

funding by Government of Uttar Pradesh. DMRC utilised ₹63.27 crore from their own funds for construction of the Uttar Pradesh portion. Since the Memorandum of Understanding is not in place, Government of Uttar Pradesh has not released the funds, although construction work has been completed by DMRC and the corridor is operational.

**(Para 2.2.2)**

- As per the Detailed Project Report, Dwarka-Najafgarh metro corridor was not financially viable with assessed negative cash flow of ₹5,178 crore during the horizon period of 33 years. A requirement of 4.03 hectare of land at Najafgarh station for Property Development was, therefore, included in the Detailed Project Report to make the corridor viable. The metro corridor was completed in October 2019, but DMRC had not ensured availability of land for Property Development till December 2020 although Property Development from the land was the only way to make this corridor viable. This section was further extended to Dhansa Bus Stand.

**{Para 2.2.3(i) and 2.2.3(iii)}**

- Since the metro corridor of Mundka-Bahadurgarh was not financially viable, 4 hectare land with 'residential' land use for Property Development at Ghevra (Delhi) and 1.56 hectare in Haryana was envisaged in Detailed Project Report to make it viable. Metro corridor has been completed in June 2018, but as on December 2020, 4 hectare land in Delhi portion has not been acquired by DMRC for Property Development. Further, out of 1.56 hectare land for Property Development in Haryana portion, only 0.8 hectare space is available, which also remained unutilised as of March 2020.

**(Para 2.2.3(ii))**

- The Board of Directors of DMRC approved (February 2011) the Detailed Project Report of Phase-III with nine car operation on new standalone corridors of Phase-III i.e. Line-7 and Line-8. However, DMRC decided (27 May 2011) to change the plan of running nine cars to six cars on Line-7 and Line-8 due to reduction in the train's headway under Communication Based Train Control system. The decision of nine cars to six cars train operations was taken without any cost benefit analysis. This eliminated the possibility and scope for further increase in cars in a rake to cater to increase in ridership in future.

**(Para 2.2.5)**

- DMRC awarded RS-11 and RS-13 contracts at the same time but the clauses of Heating Ventilation and Air-Conditioning, Coefficient of Performance in the two contract agreements were different. This resulted in additional payment of ₹3.24 crore for lower Heating Ventilation and Air-Conditioning, Coefficient of Performance (i.e., 2.3) in RS-11 contract as compared to 2.5 in RS-13 contract.

**(Para 2.3.1.2)**

- After approval of Phase-III project by DMRC, GNCTD and GoI, DMRC decided to adopt Unattended Train Operation/ driverless technology on all new lines of Phase-III i.e. Line-7, Line-8 and Line-9 without preparedness and cost-benefit analysis.

**(Para 2.3.1.3)**

- Quality issues of rails and wheels of rolling stock were noticed. Comparison of hardness as specified in contracts and actuals were different. There was higher vibration and noise level in the trains and stations. Lubricant waste on the track, and maintenance issues were also noticed.

**(Para 2.3.1.5)**

- With the same specifications for train control and signalling system and common Pre-Qualification tender, DMRC awarded two separate tenders for Line-7 and Line-8. Due to deficiency in tender evaluation of not comparing the per km cost, DMRC incurred an avoidable expenditure of ₹23.97 crore.

**(Para 2.4.1)**

- Communication Based Train Control system had the deficiency of reduced reliability due to wireless connections of access points, excess values of mean time between hazardous events, mean time to repair and mean time between failures and vulnerability to interference and jamming in Communication Based Train Control system.

**(Para 2.4.2(ii))**

- The capacity and design of the Traction Transformer on Line-7 and Line-8 was planned for nine car and 90 seconds headway operation, however, DMRC decided to have six car operations on Line-7 and Line-8. DMRC procured Traction Transformer and Auxiliary Main Transformer of higher size and location of Receiving Substation was predefined rather than the optimal placement.

**(Para 2.5)**

- DMRC did not carry out any detailed study on installation of Platform Screen Doors during Phase III. Resultantly, DMRC did not consider full height Platform Screen Doors which would have ensured not only improved climate control within the station but also energy saving.

**(Para 2.6.1)**

**With reference to Audit findings on Policy, Planning and Selection of Technology, Audit recommends that:**

- 1. DMRC should ensure at the project planning stage itself that Detailed Project Reports are prepared with realistic assumptions for computation of Financial Internal Rate of Return to ensure economic viability of the corridor.*
- 2. DMRC may formulate a policy for selection of type of corridor, interchange between two stations, and mode of interchange facility, which would benefit future Mass Rapid Transit System projects in the country. Also, the policy document may clearly define the circumstances under which deviations from the stated policies are allowed.*
- 3. DMRC may consider preparing Guidelines/ Standard operating Procedures for formulation of the Detailed Project Reports for future metro rail projects/ expansion. The revised Detailed Project Reports may be approved by the Board of Directors before submission to Government of India and Government of National Capital Territory of Delhi.*

4. *A Guideline/ criteria for selection of mode of transport for different scenarios like Light Metro, Bus Rapid Transit system based on viability and alternative analysis may be formulated.*
5. *DMRC should ensure timely availability of land for Property Development which is of paramount importance to make the project financially viable.*
6. *DMRC may consider optimising the sizing of Traction Transformers in Receiving Sub Stations instead of putting transformers of uniform capacity across all Receiving Substation on a Line.*
7. *DMRC may consider full height Platform Screen Doors including evaluation of its effect on Heating, Ventilation and Air Conditioning requirements in the under-ground station design studies.*

### **Contract and Project Management**

- DMRC prepared cost estimates of CC-26 R on the basis of awarded rates of civil contracts awarded in the year 2006 by adding @ 5 per cent p.a. escalation (i.e. 34 per cent) to obtain the estimated rate as on February 2012 instead of taking completed rates having actual escalation (i.e. 11.02 per cent). This has resulted in higher cost estimation by 23 per cent. There is no practice of preparing a justified cost estimate to know the reasonable cost to execute the given project.

**(Para 3.1.1 and 3.1.2)**

- DMRC released special advance of ₹555.69 crore to 13 civil contractors beyond contractual provisions. There were two instances where outstanding advances availed by the contractor was more than balance work to be executed.

**(Para 3.3)**

- Social Impact Assessment study and Detailed Project Report of Phase-III was silent on relocation of Project Affected Persons of Trilokpuri. During the execution, DMRC frequently changed the relocation site thereby delaying the completion of Mayur Vihar Pocket-I to Trilokpuri section. This further led to delay in awarding of revenue contracts, cost escalation of the balance work, and under-utilisation of Rolling Stock and depot facilities.

**(Para 3.5)**

- DMRC envisaged at grade metro station at Majlis Park (earlier Mukundpur) without ensuring land availability from Delhi Police. Resultantly, DMRC had to construct elevated Majlis Park station after incurring extra expenditure of ₹72.73 crore without exploring the possibility of construction at grade station on the vacant PWD land available under the existing elevated alignment, which could have saved ₹39.01 crore to DMRC.

**(Para 3.6)**

- DMRC on the request of Delhi International Airport Limited extended passenger subway from Terminal 1C to Terminal 1D and to the new terminal building with its own fund.

DMRC did not recover ₹40 crore from Delhi International Airport Limited for this connectivity.

**(Para 3.7)**

- DMRC appointed General Consultant on nomination basis in violation of Detailed Project Report recommendations. Further, DMRC constructed Sadar Bazar cantonment and Shankar Vihar stations without the approval of GoI and GNCTD and the flawed design of Hauz Khas interchange station resulted in inconvenience to the commuters.

**(Paras 3.2, 3.8 and 3.13)**

- Environmental clearance was not obtained by DMRC for the Phase-III project even though it had constructed four car maintenance depots<sup>2</sup> each having built up area of more than 20,000 sqm. DMRC did not conduct water audit though it was required under the National Water Policy, 2012 and DMRC Water Policy. No details and records were maintained either by DMRC or by the contractors for water extracted, consumed or loss of water during Phase-III.

**(Para 3.15)**

- There were discrepancies in tree cutting estimation in Detailed Project Report and Environment Impact Assessment study, and estimation of cost of compensatory plantation. There was no monitoring of compensatory afforestation locations and disposal of wood as per permit letters. DMRC deposited an excess amount of ₹14.20 crore in advance with Forest Department, GNCTD as the number of trees cut was less than the permission granted.

**(Para 3.16)**

**With reference to Audit findings on Contract and Project Management, Audit recommends that:**

- 8. DMRC may ascertain cost estimates of projects on the basis of scientific method; establish a cell to study the cost aspects of various contracts and may consider formulating a schedule of rates like Delhi Schedule of Rates for metro projects.*
- 9. DMRC may formulate a policy on grant of special advances to the contractors.*
- 10. DMRC should ensure efficient planning and timely completion of rehabilitation and resettlement activities for smooth completion of project.*
- 11. DMRC may ensure adherence to relevant environmental requirements of obtaining environmental clearance, carry out water audit, maintain records for water consumption and prepare Water Management Plans for future projects.*

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<sup>2</sup> Mukundpur (45,686 sqm), Kalindi Kunj (29,310 sqm), Vinod Nagar (32,104 sqm) and Badli (46,063 sqm)

## **Project Monitoring**

- DMRC failed to complete the corridors within stipulated time-period due to various impediments like delay in land acquisition, Rehabilitation and Resettlement activities, slow progress of work by contractors etc., resulting in foregoing of Fare Box and Non Fare Box Revenue. Besides, the Board Sub Committee on Project Management did not meet at regular intervals to monitor the progress of work and suggest measures to expedite the projects.

**(Paras 4.1.2 and 4.1.3)**

- Absence of a proper formwork<sup>3</sup> system of civil structure at Hauz Khas and other metro stations were noticed. Non-optimisation of quantities of construction materials, lack of uniform project Quality Management Plan were also noticed.

**(Paras 4.2.1, 4.2.2, 4.2.3 and 4.2.4)**

- DMRC had Building Management System for controlling and monitoring the building's mechanical and electrical equipment such as Heating Ventilation and Air Conditioning, lighting, power systems, fire systems, and security systems. But, in the absence of real time performance monitoring, Building Management System is of not much value. No record was maintained on the actual fresh air being introduced or the CO<sub>2</sub> levels maintained inside the coaches and the energy consumption of the air-conditioning unit.

**(Paras 4.2.5 and 4.2.8)**

- The method of duct designing was based on equal friction instead of better optimisation methods which can help in minimisation of space, material or operating cost savings. For Heating Ventilation and Air Conditioning load calculations, DMRC adopted outdated carrier method in comparison to the well-established state of the art hourly load calculation methods using software such as Hourly Analysis Programme, Trane etc.

**(Para 4.2.7)**

**With reference to Audit findings on Project Monitoring, Audit recommends that:**

- 12. DMRC may strengthen the monitoring mechanism by ensuring periodic review by the below Board level Sub Committee on Project Management and follow up thereon, to ensure timely completion of the projects.*
- 13. DMRC may formulate a template for (i) Quality Management Plans and (ii) specifications for the system of formwork.*
- 14. DMRC may ensure optimal utilisation of Building Management System for better monitoring of the ambient conditions at the metro stations to achieve anticipated energy savings, and to render maximum comfort to the commuters.*
- 15. DMRC may adopt latest method of load calculations for Heating Ventilation and Air Conditioning for simulation and better estimations.*

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<sup>3</sup> *Formwork is the term used for the process of creating a temporary mould into which concrete is poured and formed under civil construction*

**16. DMRC may consider real time monitoring and data logging of parameters relating to Rolling Stock Heating, Ventilation and Air Conditioning.**

**Operation & Maintenance and Revenue Management**

- As per sanction letters, and instructions of GoI and GNCTD, DMRC had to ascertain line-wise operation profit and loss, and in case of operational loss, if any, necessary claims are to be made with the respective State Governments. While DMRC did not maintain line wise operational loss/ profit statements till 2019-20, it decided (January 2021) to apportion operating loss from 2020-21. However, it remained silent on recovery of past years' operational loss, if any.

**(Para 5.2.1)**

- As against the projected ridership of 20.89 lakh in 2019-20 from initially sanctioned Phase-III four corridors, the actual ridership in 2019-20 was 4.38 lakh only, which is 79.02 *per cent*, less than projected ridership. Similarly, in case of National Capital Region/other extension, the actual ridership on these corridors were 15.12 *per cent* to 87.63 *per cent* lower than projected ridership. The total ridership of entire DMRC network (Phase-I, Phase-II and Phase-III) in the year 2019-20 was estimated as 53.47 lakh. Against this, the actual ridership of DMRC was 27.79 lakh (2019-20) i.e. 51.97 *per cent* of projected ridership.

**(Para 5.2.2)**

- DMRC utilises only 174 buses, out of 400 buses (43.5 *per cent*) for providing last mile connectivity to metro commuters. Due to shortage of buses, DMRC was operating buses on only 32 out of 73 approved routes (44 *per cent*). Since January 2021, even these 174 Midi feeder CNG Non-AC buses are not operating on the 32 routes and the operators have requested for termination of contracts.

**(Para 5.2.3)**

- While calculating operating ratio, which indicates operational efficiency, DMRC excluded the depreciation & amortisation expenses and interest cost as part of the operating expenses, thereby reducing the operating expenses. Thus, DMRC was suffering operational loss instead of earning operating profit. Even without considering the depreciation and interest expenses, there has been a consistent increase in the operating cost ratio, from 48.99 *per cent* in 2011-12 to 80.55 *per cent* in 2019-20, which indicates inefficient operational performance of DMRC.

**(Para 5.2.4)**

- DMRC did not keep the provision for additional land areas required for implementation of complete Multi Modal Integration. Non-implementation of all the components of Multi Modal Integration at metro stations resulted in denial of seamless interchange between various modes of transport to the daily commuters, non-availability of safe pedestrian crossing facilities near metro stations, absence of traffic calming measures, improved access and last mile connectivity, safety, improved short term parking and drop off facilities, Non- Motorised Vehicle lanes, bus shelters, public toilets etc.

**(Para 5.2.5)**



- As against consolidated targeted earning of ₹2,505 crore (from Phase-II & Phase-III) from Property Development as per sanction letters issued by GoI, DMRC could generate only ₹657.13 crore (26.23 per cent) from Property Development till 31 March 2020.

**(Para 5.3.1)**

- DMRC constructed Property Development area of 44,751 sqm on Badarpur-Faridabad-Ballabhgarh metro corridor at a cost of ₹151.49 crore, out of which 40,071 sqm area remained idle as DMRC has not been able to lease them out till date.

**(Para 5.3.2)**

- For Phase-III and extensions, revenue from Property Business during 2016-17 to 2019-20 was estimated at ₹1,917.25 crore. DMRC generated only ₹76.06 crore during 2016-17 to 2019-20 from Property Business.

**(Para 5.4.1)**

**With reference to Audit findings on Operation & Maintenance and Revenue Management, Audit recommends that:**

17. *DMRC may prepare line-wise profit and loss account and claim operation losses, if any, from respective State governments.*
18. *DMRC may also ensure last mile connectivity for augmentation of ridership through various modes including planned feeder bus services.*
19. *DMRC may enhance its efforts to increase operating efficiency by reducing the operating ratio and also estimate more realistic ridership for future DPRs.*
20. *DMRC may ensure implementation of a complete Multi Modal Integration (MMI) as per extant guidelines with integrated planning of land use and various modes of transport.*
21. *A structured and approved Property Development and Property Business manual may be formulated for ensuring uniformity and consistent decision making. DMRC may also consider preparing a road map to accomplish targeted Non-Fare Box Revenue on the basis of combined experience of Phase-I, Phase-II & Phase-III.*
22. *There should be a member/expert with marketing skill in Board for efficient dealing with Property Development and Property Business related activities.*

