**Delhi Metro Rail -an Overview**

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**Delhi Metro**

The Delhi Metro is a rapid transit system serving Delhi, Gurgaon, Noida and Ghaziabad in the National Capital Region of India. The network consists of six lines with a total length of 189.63 kilometres (117.83 mi) with 142 stations of which 35 are underground. It has a combination of elevated, at-grade and underground lines and uses both broad gauge and standard gauge rolling stock. Four types of rolling stock are used: Mitsubishi-ROTEM Broad gauge, Bombardier MOVIA, Mitsubishi-ROTEM Standard gauge and CAF Beasain Standard gauge.

Delhi Metro is being built and operated by the Delhi Metro Rail Corporation Limited (DMRC). As of November 2010, DMRC operates around 2,700 trips daily between 6:00 and 23:00 running with an interval of 2 minutes 30 seconds between trains at peak frequency. The trains are mainly of four coaches, but due to increase in passengers numbers, six-coach trains are also added on the Red Line (Dilshad Garden to Rithala), Yellow Line (Jahangirpuri to HUDA city centre), Blue Line (Dwarka sec −21 to Vaishali/NOIDA city centre) and Violet Line (Central Secretariat to Badarpur).4578 The power output is supplied by 25-kilovolt, 50 Hertz alternating current through overhead catenary. The metro has an average daily ridership of 1.8 million commuters, and, as of July 2011, had carried over 1.25 billion commuters since its inception. The Delhi Metro Rail Corporation has been certified by the United Nations as the first metro rail and rail-based system in the world to get “carbon credits for reducing greenhouse gas emissions” and helping in reducing pollution levels in the city by 630,000 tons (630 Gg) every year.

**Background**

The concept of a mass rapid transit for New Delhi first emerged from a traffic and travel characteristics study which was carried out in the city in 1969.11 Over the next several years, many official committees by a variety of government departments were commissioned to examine issues related to technology, route alignment and governmental jurisdiction.12 In 1984, the Delhi Development Authority and the Urban Arts Commission came up with a proposal for developing a multi-modal transport system, which would consist of constructing three underground mass rapid transit corridors as well augmenting the city's existing suburban railway and road transport networks.

While extensive technical studies and the raising of finance for the project were in progress, the city expanded significantly resulting in a twofold rise in population and a fivefold rise in the number of vehicles between 1981 and 1998.13 Consequently, traffic congestion and pollution soared, as an increasing number of commuters took to private vehicles with the existing bus system unable to bear the load.11 An attempt at privatising the bus transport system in 1992 merely compounded the problem, with inexperienced operators plying poorly maintained, noisy and polluting buses on lengthy routes, resulting in long waiting times, unreliable service, extreme overcrowding, unqualified drivers, speeding and reckless driving.14 To rectify the situation, the Government of India and the Government of Delhi jointly set up a company called the Delhi Metro Rail Corporation (DMRC) on March 5, 1995 with E. Sreedharan as the managing director.

**Construction**

Physical construction work on the Delhi Metro started on October 1, 1998.16 After the previous problems experienced by the Kolkata Metro, which was badly delayed and 12 times over budget due to "political meddling, technical problems and bureaucratic delays", the DMRC was given full powers to hire people, decide on tenders and control funds.17 The DMRC then consulted the Hong Kong MTR on rapid transit operation and construction techniques.18 As a result, construction proceeded smoothly, except for one major disagreement in 2000, where the Ministry of Railways forced the system to use broad gauge despite the DMRC's preference for standard gauge.

The first line of the Delhi Metro was inaugurated by Atal Behari Vajpayee, the then Prime Minister of India on December 24, 200220 and thus it became the second underground rapid transit system in India, after the Kolkata Metro. The first phase of the project was completed in 200621 on budget and almost three years ahead of schedule, an achievement described by Business Week as "nothing short of a miracle".

**Network**

The Delhi Metro is being built in phases. Phase I completed 65.11 km (40.46 mi) of route length, of which 13.01 km (8.08 mi) is underground and 52.10 km (32.37 mi) surface or elevated. The inauguration of the Vaishali\*–Barakhamba Road corridor of the Blue Line marked the completion of Phase I on October 27, 2006.21 Phase II of the network comprises 128 km (80 mi) of route length and 79 stations, and is fully completed, with the first section opened in June 2008 and the last line opened in August 2011.23 Phases III (112 km) and IV (108.5 km) are planned to be completed by 2015 and 2021 respectively, with the network spanning 413 km (257 mi) by then.24

[**Red Line**](http://delhimetrorail.info/line/Red_Line)

The Red Line was the first line of the Metro to be opened and connects Rithala in the west to Dilshad Garden in the east, covering a distance of 25.09 kilometres (15.59 mi).26 It is partly elevated and partly at grade, and crosses the Yamuna River between Kashmere Gate and Shastri Park stations. The inauguration of the first stretch between Shahdara and Tis Hazari on December 24, 2002, caused the ticketing system to collapse due to the line being crowded to four times its capacity by citizens eager to have a ride.3031 Subsequent sections were inaugurated from Tis Hazari – Trinagar (later renamed Inderlok) on October 4, 2003,32 Inderlok – Rithala on March 31, 2004, and Shahdara – Dilshad Garden on June 4, 2008.

[**Yellow Line**](http://delhimetrorail.info/line/Yellow_Line)

The Yellow Line was the second line of the Metro and was the first underground line to be opened. It runs for 44.36 kilometres (27.56 mi) from north to south and connects Jahangirpuri with HUDA City Centre in Gurgaon. The northern and southern parts of the line are elevated, while the central section through some of the most congested parts of Delhi is underground. The first section between Vishwa Vidyalaya and Kashmere Gate opened on December 20, 2004, and the subsequent sections of Kashmere Gate – Central Secretariat opened on July 3, 2005, and Vishwa Vidyalaya – Jahangirpuri on February 4, 2009. This line also possesses the country's deepest Metro station at Chawri Bazaar, situated 30 metres (98 ft) below ground level.[35][36] On 21 June 2010, an additional stretch from Qutub Minar to HUDA City Centre was opened, initially operating separately from the main line. However, Chhatarpur station on this line opened on August 26, 2010. Due to delay in acquiring the land for constructing the station, it was constructed using pre-fabricated structures in a record time of nine months and is the only station in the Delhi metro network to be made completely of steel.[37][38] The connecting link between Central Secretariat and Qutub Minar opened on September 3, 2010.[39] Interchanges are available with the Red Line at Kashmere Gate station, Blue Line at Rajiv Chowk Station, Violet Line at Central Secretariat, and with the Indian Railways network at Delhi and New Delhi railway stations. New Six Coach trains are also introduced for convenience for passengers

[**Blue Line**](http://delhimetrorail.info/line/Blue_Line-Dwarka_Secter-21__to_Nodia_City_center)

The Blue Line was the third line of the Metro to be opened, and the first to connect areas outside Delhi.42 Partly overhead and partly underground,43 it connects Dwarka Sub City in the west with the satellite city of Noida in the east, covering a distance of 47.4 kilometres (29.5 mi).42 The first section of this line between Dwarka and Barakhamba Road was inaugurated on December 31, 2005, and subsequent sections opened between Dwarka – Dwarka Sector 9 on April 1, 2006, Barakhamba Road – Indraprastha on November 11, 2006, Indraprastha – Yamuna Bank on May 10, 2009, Yamuna Bank – Noida City Centre on November 12, 2009, and Dwarka Sector 9 – Dwarka Sector 21 on October 30, 2010.33 This line crosses the Yamuna River between Indraprastha and Yamuna Bank stations,29 and has India's first extradosed bridge across the Northern Railways mainlines near Pragati Maidan.44 A branch of the [Blue line](http://delhimetrorail.info/line/Blue_Line-Yamuna_Bank_to_Vaishali), inaugurated on January 8, 2010, takes off from Yamuna Bank station and runs for 6.25 kilometres (3.88 mi) up to Anand Vihar in east Delhi.45 It was further extended up to Vaishali which was opened to public on July 14, 2011.4647 A small stretch of 2.76 kilometres (1.71 mi) from Dwarka Sector 9 to Dwarka Sector 21 was inaugurated on October 30, 2010.4849 Interchanges are available with the Yellow Line at Rajiv Chowk station,43 and with the Indian Railways network at the Anand Vihar Railway Terminal.

[**Green Line**](http://delhimetrorail.info/line/Green_Line-Indrlok_to_Mundka)

Opened in 2010, the Green Line was the first standard-gauge corridor of the Delhi Metro.27 The fully elevated line connects Mundka with Inderlok, running for 15.1 kilometres (9.4 mi) mostly along Rohtak Road.51 An interchange with the Red line is available at Inderlok station via an integrated concourse. This line also has the country's first standard-gauge maintenance depot at Mundka.

[**Violet Line**](http://delhimetrorail.info/line/Violet_Line)

The Violet Line is the most recent line of the Metro to be opened, and the second standard-gauge corridor after the Green Line. The 20.2 km (12.6 mi) long line connects Badarpur to Central Secretariat, with 9 km (5.6 mi) being overhead and the rest underground.28 The first section between Central Secretariat and Sarita Vihar was inaugurated on October 3, 2010, just hours before the inaugural ceremony of the 2010 Commonwealth Games, and connects the Jawaharlal Nehru Stadium which is the venue for the opening and closing ceremonies of the event.54 Completed in just 41 months, it includes a 100 m (330 ft) long bridge over the Indian Railways mainlines and a 167.5 m (550 ft) long cable-stayed bridge across an operational road flyover, and connects several hospitals, tourist attractions and a major industrial estate along its route.28 Services are provided at intervals of 5 min.54 An interchange with the Yellow Line is available at Central Secretariat through an integrated concourse.28 On January 14, 2011, the remaining portion from Sarita Vihar to Badarpur was opened for commercial service, adding three new stations to the network and marking the completion of the line.

[**Airport Express**](http://delhimetrorail.info/line/Orange_Line)

The Airport Express line runs for 22.7 km (14.1 mi) from New Delhi Railway Station to Dwarka Sector 21, linking the Indira Gandhi International Airport. The line is operated, by the Delhi Airport Metro Express Pvt. Limited (DAMEL), a subsidiary of Reliance Infrastructure, the concessionaire of the line. Constructed at a cost of 2,885 crore (US$575.56 million),56 the line has six stations (Dhaula Kuan and Delhi Aerocity became operational on August 15, 2011), with some featuring check-in facilities, parking and eateries.57 Rolling stock consists of six-coach trains operating at intervals of ten minutes and having a maximum speed of 135 km/h (84 mph).57 Originally scheduled to open before the 2010 Commonwealth Games, the line failed to obtain the mandatory safety clearance, and was opened on 24 February 2011, after a delay of around 5 months.

**DMRC Project:**

Delhi Metro was planned to be built in phases spread over around 20 years as with each phase having a target of five years and end of one phase marking the beginning of another. Phase I (65 km) and Phase II (125 km) were completed in 2006 and 2011, respectively, and Phase III and Phase IV are scheduled for completion in 2016 and 2021, respectively. Work on Phase III has already started while planning for Phase IV has begun. Ex-chief of DMRC hinted that by the time Phase IV is completed, the city will need Phase V to cope with rising population and transport needs.

**Present Routes:**

**Phase I of Delhi Metro Rail project consists of the following three lines:**

\_ Line No.1- Shahdara-Tri Nagar-Rithala

\_ Line No.2- Vishwa Vidyalaya-Central Secretariat

\_ Line No.3- Indraprastha-Barakhamba Road-Dwarka Sub City

**Phase II of Delhi Metro Rail project consists of the following lines:**

\_ Shahdara – Dilshad Garden

\_ Indraprastha – Noida Sector 32 City Centre

\_ Yamuna Bank – Anand Vihar ISBT

\_ Vishwavidyalaya – Jahangir Puri

\_ Inderlok – Kirti Nagar -Mundka

\_ Central Secretariat – HUDA City Centre

\_ Dwarka Sector 9 to Dwarka Sector 21

\_ Anand Vihar – KB Vaishali

\_ Central Secretariat – Badarpur

\_ Airport Express Line

**Technologies used in the project**

1. Prestressed concrete blocks and specially designed Viduct techniques was used.
2. For tunneling heavy TBM (Tunnel Boring Machines) was used.
3. Stations roofs, railyards, sheds are made using pre-engineering structure techniques.
4. Special types of signaling system to run the trains at 2.5 mins intervals are secured.
5. Escalators, elevators, WiFi are being installed at every station

**Phases Involved in Project**

After the successful completion and commissioning of 190 kilometres of Metro lines across the National Capital Region (NCR) spanning two different construction phases, the Delhi Metro Rail Corporation has now started the construction work for another 120 kilometres of Metro which will enhance connectivity of the entire NCR tremendously.

Under this phase, many new areas, which, hitherto, were not connected by the Metro will become a part of the network. Delhi's two arterial roads – the Ring Road and Outer Ring Road will get new Metro corridors and the satellite city of Faridabad in Haryana will also get Metro connectivity with the national capital.

The work on the Central Secretariat- Kashmere Gate corridor, a vital extension in Central and Old Delhi, has already been started and the first Tunnel Boring Machine (TBM) of the stretch has been inserted for tunneling work between Central Secretariat and Janpath.

The construction work for Metro's expansion to Faridabad has also begun last month. On all the other corridors planned under the new phase, the preliminary preparatory works such as floating and finalization of tenders, acquiring of land etc are in progress. All the above mentioned corridors are scheduled to be completed by the year 2016.

Having completed two phases of Metro construction in a highly populated and congested city like Delhi within the allocated time and budgetary limit, the DMRC has now gained tremendous experience and expertise in the field of Metro Railway construction. Therefore, now we are also guiding the other upcoming Metro projects in the country as consultants. In fact, in Jaipur, we have been assigned the responsibility of constructing the Metro corridor also besides providing the consultancy.

Based on our observations made during the construction of the preceding phases, this time we have tried to further improve our construction methods with special focus on safety at the sites. This time, safety training has been made absolutely mandatory for every individual involved in the construction work irrespective of his rank or position. There are many batches of labourers, maintainers and other staff of the contractors who have already been provided safety training by DMRC's safety team.

More than 40 kilometres of underground lines will also be laid under this new phase which will be a major construction challenge for DMRC. At four different points, we will pass below our already operational underground corridors. Successfully completing the construction work at these points where we will go about 22 m below the surface without hampering train movement on the tunnels above will be very challenging but I am confident that our competent engineers will come out with flying colours.

Another major step that we are going to introduce to further improve our underground tunnels is the installation of Mass Spring Systems (MSS) on the tracks to prevent any kind of vibration from reaching the structures above these tunnels.

MSS is a solution which helps mitigating vibrations generated by the passing trains at the source itself. MSS elastically separates the tracks slabs in the tunnels or on the viaducts from the supporting structure. The material used for isolation is a microcellular Polyurethane Elastomer. Use of MSS helps in minimizing the transmission of vibrations (structure-borne noise) to the surrounding establishments in the vicinity of tracks.  In addition, MSS also effectively reduces the development of audible secondary airborne noise, which is caused by the vibration of buildings and other infrastructure components.

About 25 tunnel boring machines will be put to use for the tunneling drives across the city. It is indeed rare to find so many TBMs working within a city's territory. In Phase 2 also, we had used about 14 TBMs for our tunneling works. In order to monitor the performance of the tunnel boring machines in the sensitive areas, a centralized control centre shall be set-up with connectivity through GPS to all the tunnel boring machines.

For other underground works such as construction of subways and underpasses, we are exploring the use of technologies such as the box pushing technology as we want to avoid adopting the traditional cut and cover method which involves large scale excavation and diversion of traffic, demolition of buildings etc.

The management of traffic during construction work is another major challenge in a city like Delhi in which about 4.5 lakh vehicles get registered every year. This time, we have hired professional consultants to advise us on scientific traffic diversions. We are also focusing a lot on adequate deployment of traffic marshals, proper installation of signage, blinkers etc at all the sites where we have to carry out diversions or road blockades.

**Phase III:**

Out of 2 new lines and 10 route extensions proposed for Phase III, cabinet approvals have

been obtained for 2 new lines and 5 line extensions totaling 140 km, with an estimated cost of

350 billion (US$6.4 billion). Construction has already begun on many of these. These

approved lines are:

\_ Yellow Line extension: from Jahangirpuri to Badli

\_ Violet Line: from Central Secretariat-Kashmere Gate-Badarpur-YMCA chowk to Faridabad

\_ Blue Line branch: from Dwarka to Najafgarh

\_ Green Line: from Mundka to Bahadurgarh

\_ Inner Ring Road Line (Line 7): from Mukundpur to Shiv Vihar

\_ Outer Ring Road Line (Line 8):from Janakpuri West to Botanical Garden

**Phase IV:**

Phase IV has a 2021 deadline, and tentatively includes further extensions to Sonia Vihar,

Reola Khanpur, Palam, Najafgarh, Narela, Ghazipur, Noida Sector 62, extensions of Violet

line, Green line, Line 8, having a total length of over 100 km. There might be some changes in

plan before actual construction starts on these lines. Apart from these lines in Phases I to IV, plans have been mooted to construct a new line from Noida Sector 62 to Greater Noida which will intersect Indraprastha – Noida Sector 32

line. The Ghaziabad Development Authority is planning to extend Delhi Metro lines deeper

into Ghaziabad through extension of the Blue Line from Vaishali to Mehrauli viaIndirapuram.

The independently operated Gurgaon Metro, work on which is going on and has a deadline of

2013, will also interchange with the Delhi Metro at Sikandarpur station on Yellow line. For

the year 2012-13, Authority has allocated Rupees 7021 crore for Noida,out of which Rs 3,000 crore has been kept for development and infrastructure, while Rs 500 crore for Metro

extension.

**Expansion Plans**

The line is planned to be extended beyond Dwarka Sector 21 to IFFCO Chowk in

Gurgaon.]The 12km extension will have a 1.5km long underground section, while the rest will be elevated. Commuters will be able to travel between Gurgaon and Shivaji Stadium in 30 minutes. Gurgaon to the Airport would be 14 minutes.The cost of the 12km extension is Rs 1830 crore. HUDA will pay for 80% of the cost and New Delhi will pay the remaining 20%.

**Infrastructure**

Siemens Mobility is providing Signalling, Power Transmission, Baggage Handling System

enabling passenger to check-in with baggage at the New Delhi Railway Station and Shivaji

Stadium, with check -in 1200 passenger per hour capacity. The €34 million was expected to be

completed by 2010 in time for the Commonwealth games but could not manage to meet the deadline. Alcatel is supplying the communications systems. Indra Sistemas is providing the ticket machines. Faiveley is providing the platform screen doors.BLUESTAR / Honeywell is

the Control & Automation Provider for Station Management System (SMS).Bluestar is the

main BEMS system provider.

The line will be the first line in the country to be mapped on Geographic Information System to enhance safety, maintenance and traffic regulation and will help in mobilising emergency services in case of an accident.

**Rolling stock**

Eight 6-car trains supplied by CAF Beasain were imported from Spain. CAF holds 5% equity in the DAME project, Reliance Infrastructure holds the remaining 95%. The trains on this line are of a premium standard and have in-built noise reduction features for a noise-free ride with padded fabric seats. The coaches are equipped with LCD

screens for entertainment of the passengers and also provide flight information for convenience of air travelers. The trains are fitted with an event recorder which can withstand high levels of temperature and

impact and the wheels have flange lubrication system for less noise and better riding comfort. Based on the consultancy by MTR, the interior design of the rolling stocks are highly similar

to that of Airport Express line in MTR Hong Kong which also uses CAF trains.

**Tracks**

To ensure safety the tracks are fitted with RHEDA-2000 signaling technology, which

theoretically allows trains to travel at up to 350 km/h (nearly three times the actual maximum speed of current trains). The entire 22.7 km route is ballast-less track, which costs 40–50% more than normal train tracks, but does not take longer to lay than traditional tracks. The rails rest on rubber pads on the concrete sleepers for less noise. The 7 km elevated section from Buddha Jayanti Park to Mahipalpur has been built with 25m

long girders for the first time in India. The 504 girders weigh 120 tons each and are being cast in Mahipalpur and transported on 35m long trailers with 64 tyres.

**Conclusion**

The metro project has proved to be a best facility which ensures a speedy, safe, comfortable and environment-friendly transport. The DMRC has taken up construction of new lines and expansion of existing lines to meet the increasing population needs.