The **London Underground** is a metro system serving a large part of Greater London and neighbouring areas of Essex, Hertfordshire and Buckinghamshire in the UK. It is the world's oldest underground railway. It was also the first underground railway to operate electric trains. It is usually referred to as *the Underground* or *the Tube*—the latter deriving from the shape of the system's deep-bore tunnels—although about 55% of the network is above ground.

The earlier lines of the present London Underground network, which were built by various private companies, became part of an integrated transport system (which excluded the main line railways) in 1933 with the creation of the London Passenger Transport Board (LPTB), more commonly known by its shortened name: "**London Transport**". The underground network became a single entity when London Underground Limited (LUL) was formed by the UK government in 1985. Since 2003 LUL has been a wholly owned subsidiary of Transport for London (TfL), the statutory corporation responsible for most aspects of the transport system in Greater London, which is run by a board and a commissioner appointed by the Mayor of London.

The Underground has 270 stations and approximately 400 km (250 miles) of track, making it the longest metro system in the world by route length,[6] and one of the most served in terms of stations. In 2007, over one billion passenger journeys were recorded.

The tube map, with its schematic non-geographical layout and colour-coded lines, is considered a design classic, and many other transport maps worldwide have been influenced by it.

## History

*Main article: History of the London Underground*

Railway construction in the United Kingdom began in the early 19th century. By 1854 six separate railway terminals had been built just outside the centre of London: London Bridge, Euston, Paddington, King's Cross, Bishopsgate and Waterloo. At this point, only Fenchurch Street Station was located in the actual City of London. Traffic congestion in the city and the surrounding areas had increased significantly in this period, partly due to the need for rail travellers to complete their journeys into the city centre by road. The idea of building an underground railway to link the City of London with the mainline terminals had first been proposed in the 1830s, but it was not until the 1850s that the idea was taken seriously as a solution to the traffic congestion problems.

### The first underground railways

In 1854 an Act of Parliament was passed approving the construction of an underground railway between Paddington Station and Farringdon Street via King's Cross which was to be called the Metropolitan Railway. The Great Western Railway (GWR) gave financial backing to the project when it was agreed that a junction would be built linking the underground railway with their mainline terminus at Paddington. GWR also agreed to design special trains for the new subterranean railway.

Construction was delayed for several years due to a shortage of funds. The fact that this project got under way at all was largely due to the lobbying of Charles Pearson, who was Solicitor to the City of London Corporation at the time. Pearson had supported the idea of an underground railway in London for several years. He advocated plans for the demolition of the unhygienic slums which would be replaced by new accommodation for their inhabitants in the suburbs, with the new railway providing transportation to their places of work in the city centre. Although he was never directly involved in the running of the Metropolitan Railway, he is widely credited as being one of the first true visionaries behind the concept of underground railways. And in 1859 it was Pearson who persuaded the City of London Corporation to help fund the scheme. Work finally began in February 1860, under the guidance of chief engineer John Fowler. Pearson died before the work was completed.

The Metropolitan Railway opened on 10 January 1863.[4] Within a few months of opening it was carrying over 26,000 passengers a day.[8] The Hammersmith and City Railway was opened on 13 June 1864 between Hammersmith and Paddington. Services were initially operated by GWR between Hammersmith and Farringdon Street. By April 1865 the Metropolitan had taken over the service. On 23 December 1865 the Metropolitan's eastern extension to Moorgate Street opened. Later in the decade other branches were opened to Swiss Cottage, South Kensington and Addison Road, Kensington (now known as Kensington Olympia). The railway had initially been dual gauge, allowing for the use of GWR's signature broad gauge rolling stock and the more widely used standard gauge stock. Disagreements with GWR had forced the Metropolitan to switch to standard gauge in 1863 after GWR withdrew all its stock from the railway. These differences were later patched up, however broad gauge was totally withdrawn from the railway in March 1869.

On 24 December 1868, the Metropolitan District Railway began operating services between South Kensington and Westminster using Metropolitan Railway trains and carriages. The company, which soon became known as "**the District**", was first incorporated in 1864 to complete an Inner Circle railway around London in conjunction with the Metropolitan. This was part of a plan to build both an Inner Circle line and Outer Circle line around London.

A fierce rivalry soon developed between the District and the Metropolitan. This severely delayed the completion of the Inner Circle project as the two companies competed to build far more financially lucrative railways in the suburbs of London. The London and North Western Railway (LNWR) began running their Outer Circle service from Broad Street via Willesden Junction, Addison Road and Earl's Court to Mansion House in 1872. The Inner Circle was not completed until 1884, with the Metropolitan and the District jointly running services. In the meantime, the District had finished its route between West Brompton and Blackfriars in 1870, with an interchange with the Metropolitan at South Kensington. In 1877, it began running its own services from Hammersmith to Richmond, on a line which had originally opened by the London & South Western Railway (LSWR) in 1869. The District then opened a new line from Turnham Green to Ealing in 1879[9] and extended its West Brompton branch to Fulham in 1880. Over the same decade the Metropolitan was extended to Harrow-on-the-Hill station in the north-west.

The early tunnels were dug mainly using cut-and-cover construction methods. This caused widespread disruption and required the demolition of several properties on the surface. The first trains were steam-hauled, which required effective ventilation to the surface. Ventilation shafts at various points on the route allowed the engines to expel steam and bring fresh air into the tunnels. One such vent is at Leinster Gardens, W2.[10] In order to preserve the visual characteristics in what is still a well-to-do street, a five-foot-thick (1.5 m) concrete façade was constructed to resemble a genuine house frontage.

On 7 December 1869 the London, Brighton and South Coast Railway (LB&SCR) started operating a service between Wapping and New Cross Gate on the East London Railway (ELR) using the Thames Tunnel designed by Marc Brunel, who designed the revolutionary tunnelling shield method which made its construction not only possible, but safer, and completed by his son Isambard Kingdom Brunel. This had opened in 1843 as a pedestrian tunnel, but in 1865 it was purchased by the ELR (a consortium of six railway companies: the Great Eastern Railway (GER); London, Brighton and South Coast Railway (LB&SCR); London, Chatham and Dover Railway (LCDR); South Eastern Railway (SER); Metropolitan Railway; and the Metropolitan District Railway) and converted into a railway tunnel. In 1884 the District and the Metropolitan began to operate services on the line.

By the end of the 1880s, underground railways reached Chesham on the Metropolitan, Hounslow, Wimbledon and Whitechapel on the District and New Cross on the East London Railway. By the end of the 19th century, the Metropolitan had extended its lines far outside of London to Aylesbury, Verney Junction and Brill, creating new suburbs along the route—later publicised by the company as Metro-land. Right up until the 1930s the company maintained ambitions to be considered as a main line rather than an urban railway.

### The first tube lines

Following advances in the use of tunnelling shields, electric traction and deep-level tunnel designs, later railways were built even further underground. This caused much less disruption at ground level and it was therefore cheaper and preferable to the cut-and-cover construction method.

The City & South London Railway (C&SLR, now part of the Northern Line) opened in 1890, between Stockwell and the now closed original terminus at King William Street. It was the first "deep-level" electrically operated railway in the world. By 1900 it had been extended at both ends, to Clapham Common in the south and Moorgate Street (via a diversion) in the north. The second such railway, the Waterloo and City Railway, opened in 1898. It was built and run by the London and South Western Railway.

On 30 July 1900 the Central London Railway (now known as the Central Line) was opened, operating services from Bank to Shepherd's Bush. It was nicknamed the "Twopenny Tube" for its flat fare and cylindrical tunnels; the "tube" nickname was eventually transferred to the Underground system as a whole. An interchange with the C&SLR was provided at Bank. Construction had also begun in August 1898 on the Baker Street & Waterloo Railway. However work on this railway came to a halt 18 months after it began when funds ran out.

### Integration

In the early 20th century the presence of six independent operators running different Underground lines caused passengers substantial inconvenience; in many places passengers had to walk some distance above ground to change between lines. The costs associated with running such a system were also heavy, and as a result many companies looked to financiers who could give them the money they needed to expand into the lucrative suburbs as well as electrify the earlier steam operated lines. The most prominent of these was Charles Yerkes, an American tycoon who secured the right to build the Charing Cross, Euston and Hampstead Railway (CCE&HR) on 1 October 1900. In March 1901, he effectively took control of the District and this enabled him to form the Metropolitan District Electric Traction Company (MDET) on 15 July. Through this he acquired the Great Northern & Strand Railway and the Brompton & Piccadilly Circus Railway in September 1901, the construction of which had already been authorised by Parliament, together with the moribund Baker Street & Waterloo Railway in March 1902. On 9 April the MDET evolved into the Underground Electric Railways of London Company Ltd (UERL). The UERL also owned three tramway companies and went on to buy the London General Omnibus Company, creating an organisation colloquially known as "the Combine" which went on to dominate underground railway construction in London until the 1930s.

With the financial backing of Yerkes, the District opened its South Harrow branch in 1903 and completed its link to the Metropolitan's Uxbridge branch at Rayners Lane in 1904—although services to Uxbridge on the District did not begin until 1910 due to yet another disagreement with the Metropolitan. By the end of 1905, all District Railway and Inner Circle services were run by electric trains.

The Baker Street & Waterloo Railway opened in 1906, soon branding itself the Bakerloo, and by 1907 it had been extended to Edgware Road in the north and Elephant & Castle in the south. The newly named Great Northern, Piccadilly and Brompton Railway, combining the two projects acquired by MDET in September 1901, also opened in 1906. With tunnels at an impressive depth of 200 feet below the surface, it ran from Finsbury Park to Hammersmith; a single station branch to Strand (later renamed Aldwych) was added in 1907. In the same year the CCE&HR opened from Charing Cross to Camden Town, with two northward branches, one to Golders Green and one to Highgate (now Archway).

Independent ventures did continue in the early part of the 20th century. The independent Great Northern & City Railway opened in 1904 between Finsbury Park and Moorgate. It was the only tube line of sufficient diameter to be capable of handling main line stock, and it was originally intended to be part of a main line railway. However money soon ran out and the route remained separate from the main line network until the 1970s. The C&SLR was also extended northwards to Euston by 1907.

In early 1908, in an effort to increase passenger numbers, the underground railway operators agreed to promote their services jointly as "the Underground", publishing new adverts and creating a free publicity map of the network for the purpose. The map featured a key labelling the Bakerloo Railway, the Central London Railway, the City & South London Railway, the District Railway, the Great Northern & City Railway, the Hampstead Railway (the shortened name of the CCE&HR), the Metropolitan Railway and the Piccadilly Railway. Some other railways appeared on the map but with less prominence than the aforementioned lines. These included part of the ELR (although the map wasn't big enough to fit in the whole line) and the Waterloo and City Railway. As the latter was owned by a main line railway company it wasn't included in this early phase of integration. As part of the process, "The Underground" name appeared on stations for the first time and electric ticket-issuing machines were also introduced. This was followed in 1913 by the first appearance of the famous circle and horizontal bar symbol, known as "the roundel",[12] designed by Edward Johnston.

On 1 January 1913 the UERL absorbed two other independent tube lines, the C&SLR and the Central London Railway. As the Combine expanded, only the Metropolitan stayed away from this process of integration, retaining its ambition to be considered as a main line railway. Proposals were put forward for a merger between the two companies in 1913 but the plan was rejected by the Metropolitan. In the same year the company asserted its independence by buying out the cash strapped Great Northern and City Railway. It also sought a character of its own. The Metropolitan Surplus Lands Committee had been formed in 1887 to develop accommodation alongside the railway and in 1919 Metropolitan Railway Country Estates Ltd. was founded to capitalise on the post-World War One demand for housing. This ensured that the Metropolitan would retain an independent image until the creation of London Transport in 1933.

The Metropolitan also sought to electrify its lines. The District and the Metropolitan had agreed to use the low voltage dc system for the Inner Circle, comprising two electric rails to power the trains, back in 1901. At the start of 1905 electric trains began to work the Uxbridge branch and from 1 November 1906 electric locomotives took trains as far as Wembley Park where steam trains took over. This changeover point was moved to Harrow on 19 July 1908. The Hammersmith & City branch had also been upgraded to electric working on 5 November 1906. The electrification of the ELR followed on 31 March 1913, the same year as the opening of its extension to Whitechapel and Shoreditch. Following the Grouping Act of 1921, which merged all the cash strapped main line railways into four companies (thus obliterating the original consortium that had built the ELR), the Metropolitan agreed to run passenger services on the line.

The Bakerloo line extension to Queen's Park was completed in 1915, and the service extended to Watford Junction via the London and North Western Railway tracks in 1917. The extension of the Central line to Ealing Broadway was delayed by the war until 1920.

The major development of the 1920s was the integration of the CCE&HR and the C&SLR and extensions to form what was to become the Northern line. This necessitated enlargement of the older parts of the C&SLR, which had been built on a modest scale. The integration required temporary closures during 1922—24. The Golders Green branch was extended to Edgware in 1924, and the southern end was extended to Morden in 1926.

The Watford branch of the Metropolitan opened in 1925 and in the same year electrification was extended to Rickmansworth. The last major work completed by the Metropolitan was the branch to Stanmore which opened in 1932.

By 1933 the Combine had completed the Cockfosters branch of the Piccadilly Line, with through services running (via realigned tracks between Hammersmith and Acton Town) to Hounslow West and Uxbridge.

### London Transport

In 1933 the Combine, the Metropolitan and all the municipal and independent bus and tram undertakings were merged into the London Passenger Transport Board (LPTB), a self-supporting and unsubsidised public corporation which came into being on 1 July 1933. The LPTB soon became known as "**London Transport**" (LT).

Shortly after it was created, LT began the process of integrating the underground railways of London into one network. All the separate railways were given new names in order to become lines within it. A free map of these lines, designed by Harry Beck, was issued in 1933. It featured the District Line, the Bakerloo Line, the Piccadilly Line, the Edgware, Highgate and Morden Line, the Metropolitan Line, the Great Northern & City Line, the East London Line and the Central London Line. Commonly regarded as a design classic, an updated version of this map is still in use today. The Waterloo & City line was not included in this map as it was still owned by a main line railway (the Southern Railway since 1923) and not LT.

LT announced a scheme for the expansion and modernisation of the network entitled the New Works Programme, which had followed the announcement of improvement proposals for the Metropolitan Line. This consisted of plans to extend some lines, to take over the operation of others from main-line railway companies, and to electrify the entire network. During the 1930s and 1940s, several sections of main-line railways were converted into surface lines of the Underground system. The oldest part of today's Underground network is the Central line between Leyton and Loughton, which opened as a railway seven years before the Underground itself.

LT also sought to abandon routes which made a significant financial loss. Soon after the LPTB started operating, services to Verney Junction and Brill on the Metropolitan Railway were stopped. The renamed "Metropolitan Line" terminus was moved to Aylesbury.

The outbreak of World War II delayed all the expansion schemes. From mid-1940, the Blitz led to the use of many Underground stations as shelters during air raids and overnight. The authorities initially tried to discourage and prevent this, but later supplied bunks, latrines, and catering facilities. Later in the war, eight London deep-level shelters were constructed under stations, ostensibly to be used as shelters (each deep-level shelter could hold 8,000 people) though plans were in place to convert them for a new express line parallel to the Northern line after the war. Some stations (now mostly disused) were converted into government offices: for example, Down Street was used for the headquarters of the Railway Executive Committee and was also used for meetings of the War Cabinet before the Cabinet War Rooms were completed; Brompton Road was used as a control room for anti-aircraft guns and the remains of the surface building are still used by London's University Royal Naval Unit (URNU) and University London Air Squadron (ULAS).

After the war one of the last acts of the LPTB was to give the go-ahead for the completion of the postponed Central Line extensions. The western extension to West Ruislip was completed in 1948, and the eastern extension to Epping in 1949; the single-line branch from Epping to Ongar was taken over and electrified in 1957.

### Nationalisation

On 1 January 1948 London Transport was nationalised by the incumbent Labour government, together with the four remaining main line railway companies, and incorporated into the operations of the British Transport Commission (BTC). The LPTB was replaced by the London Transport Executive (LTE). This brought the Underground under the remit of central government for the first time in its history.

The implementation of nationalised railways was a move of necessity as well as ideology. The main line railways had struggled to cope with a war economy in the First World War and by the end of World War Two the four remaining companies were on the verge of bankruptcy. Nationalisation was the easiest way to save the railways in the short term and provide money to fix war time damage. The BTC necessarily prioritised the reconstruction of its main line railways over the maintenance of the Underground network. The unfinished parts of the New Works Programme were gradually shelved or postponed.

However the BTC did authorise the completion of the electrification of the network, seeking to replace steam locomotives on the parts of the system where they still operated. This phase of the programme was completed when the Metropolitan Line was electrified to Chesham in 1960. Steam locomotives were fully withdrawn from London Underground passenger services on 9 September 1961, when British Railways took over the operations of the Metropolitan line between Amersham and Aylesbury. The last steam shunting and freight locomotive was withdrawn from service in 1971.[14]

In 1963 the LTE was replaced by the London Transport Board, directly accountable to the Ministry of Transport.

**GLC Control**

On 1 January 1970, the Greater London Council (GLC) took over responsibility for London Transport. This period is perhaps the most controversial in London's transport history, characterised by staff shortages and a severe lack of funding from central government. In 1980 the Labour-led GLC began the 'Fares Fair' project, which increased local taxation in order to lower ticket prices. The campaign was initially successful and usage of the Tube significantly increased. But serious objections to the policy came from the London Borough of Bromley, an area of London which has no Underground stations. The Council resented the subsidy as it would be of little benefit to its residents. The council took the GLC to the Law Lords who ruled that the policy was illegal based on their interpretation of the Transport (London) Act 1969. They ruled that the Act stipulated that London Transport must plan, as far as was possible, to break even. In line with this judgement, 'Fares Fair' was therefore reversed, leading to a 100% increase in fares in 1982 and a subsequent decline in passenger numbers. The scandal prompted Margaret Thatcher's Conservative Government to remove the Underground from the GLC's control in 1984, a development that turned out to be a prelude to the abolition of the GLC in 1986.

However the period saw the first real post-war investment in the network with the opening of the carefully planned Victoria Line, which was built on a diagonal northeast-southwest alignment beneath Central London, incorporating centralised signalling control and automatically driven trains. It opened in stages between 1968 and 1971. The Piccadilly line was extended to Heathrow Airport in 1977, and the Jubilee line was opened in 1979, taking over part of the Bakerloo line, with new tunnels between Baker Street and Charing Cross. There was also one important legacy from the 'Fares Fair' scheme, the introduction of ticket zones, which remain in use today.

### London Regional Transport

In 1984 Margaret Thatcher's Conservative Government removed London Transport from the GLC's control, replacing it with London Regional Transport (LRT) on 19 June 1984 - a statutory corporation for which the Secretary of State for Transport was directly responsible. The Government planned to modernise the system while slashing its subsidy from taxpayers and ratepayers. As part of this strategy London Underground Limited was set up on 1 April 1985 as a wholly owned subsidiary of LRT to run the network.

The prognosis for LRT was good. Oliver Green, the then Curator of the London Transport Museum, wrote in 1987:

*"In its first annual report, London Underground Ltd was able to announce that more passengers had used the system than ever before. In 1985-86 the Underground carried 762 million passengers - well above its previous record total of 720 million in 1948. At the same time costs have been significantly reduced with a new system of train overhaul and the introduction of more driver-only operation. Work is well in hand on the conversion of station booking offices to take the new Underground Ticketing System (UTS)...and prototype trials for the next generation of tube trains (1990) stock started in late 1986. As the London Underground celebrates its 125th anniversary in 1988, the future looks promising."*[15]

However cost-cutting was not without its critics. At 19:30 on 18 November 1987 a fire swept through King's Cross St Pancras Undeground station, the busiest station on the network, killing 31 people. It later turned out that the fire had started in an escalator shaft serving the Piccadilly Line, which was burnt out along with the top level (entrances and ticket hall) of the deep-level tube station. The escalator on which the fire started had been built just before World War II. The steps and sides of the escalator were partly made of wood, meaning that they burned quickly and easily. Although smoking was banned on the subsurface sections of the London Underground in February 1985 (a consequence of the Oxford Circus fire), the fire was most probably caused by a commuter discarding a burning match, which fell down the side of the escalator onto the running track (Fennell 1988, p. 111). The running track had not been cleaned in some time and was covered in grease and fibrous detritus. The Member of Parliament for the area, Frank Dobson, informed the House of Commons that the number of transportation employees at the station, which handled 200,000 passengers every day at the time, had been cut from 16 to ten, and the cleaning staff from 14 to two.[16] The tragic event led to the abolition of wooden escalators at all Underground stations and pledges of greater investment.

In 1994, with the privatisation of British Rail, LRT took control of the Waterloo and City line, incorporating it into the Underground network for the first time. This year also saw the end of services on the little used Epping-Ongar branch of the Central Line and the Aldwych branch of the Piccadilly Line after it was agreed that necessary maintenance and upgrade work would not be cost effective.

In 1999 the Jubilee line extension to Stratford in London's East End was completed. This plan included the opening of a completely refurbished interchange station at Westminster. The Jubilee line's old terminal platforms at Charing Cross were closed but maintained operable for emergencies.

## Transport for London

*Main article: Transport for London*

Transport for London (TfL) was created in 2000 as the integrated body responsible for London's transport system. It replaced London Regional Transport. It assumed control of London Underground Limited in July 2003.[21]

TfL is part of the Greater London Authority and is constituted as a statutory corporation regulated under local government finance rules.[22] It has three subsidiaries: London Transport Insurance (Guernsey) Ltd., the TfL Pension Fund Trustee Co. Ltd. and Transport Trading Ltd (TTL). TTL has six wholly-owned subsidiaries, one of which is London Underground Limited.

The TfL Board is appointed by the Mayor of London. The Mayor also sets the structure and level of public transport fares in London. However the day-to-day running of the corporation is left to the Commissioner of Transport for London. The current Commissioner is Peter Hendy.[23]

The Mayor is responsible for producing an integrated transport strategy for London and for consulting the GLA, TfL, local councils and others on the strategy. The Mayor is also responsible for setting TfL's budget. The GLA is consulted on the Mayor's transport strategy, and inspects and approves the Mayor's budget. It is able to summon the Mayor and senior staff to account for TfL's performance. London TravelWatch, a body appointed by and reporting to the Assembly, deals with complaints about transport in London.

## Infrastructure

*Main article: London Underground infrastructure*

### Stations and lines

The London Underground's 11 lines are the Bakerloo line, Central line, Circle line, District line, Hammersmith & City line, Jubilee line, Metropolitan line, Northern line, Piccadilly line, Victoria line, and Waterloo & City line. Until 2007 there was a twelfth line, the East London line, but this has closed for conversion work and will be transferred to the London Overground when it reopens in 2010.

The Underground serves 268 stations by rail; an additional six stations that were on the East London line are served by Underground replacement buses. Fourteen Underground stations are outside Greater London, of which five (Amersham, Chalfont & Latimer, Chesham, Chorleywood, Epping) are beyond the M25 London Orbital motorway. Of the 32 London boroughs, six (Bexley, Bromley, Croydon, Kingston, Lewisham and Sutton) are not served by the Underground network, while Hackney only has Old Street and Manor House on its boundaries.

Zone 1 (central zone) of the Underground (and DLR) network in a geographically more accurate layout than the usual Tube map, using the same style.

Underground trains come in two sizes, larger subsurface trains and smaller tube trains. A Metropolitan line A Stock train (left) passes a Piccadilly line 1973 Stock train (right) in the siding at Rayners Lane

Lines on the Underground can be classified into two types: subsurface and deep-level. The subsurface lines were dug by the cut-and-cover method, with the tracks running about 5 m (16 ft 5 in) below the surface. The deep-level or tube lines, bored using a tunnelling shield, run about 20 m (65 ft 7 in) below the surface (although this varies considerably), with each track in a separate tunnel. These tunnels can have a diameter as small as 3.56 m (11 ft 8 in) and the loading gauge is thus considerably smaller than on the subsurface lines. Lines of both types usually emerge onto the surface outside the central area.

While the tube lines are for the most part self-contained, the subsurface lines are part of an interconnected network: each shares track with at least two other lines. The subsurface arrangement is similar to the New York City Subway, which also runs separate "lines" over shared tracks.

### Rolling stock and electrification

1996 Stock trains at Stratford Market Depot

The Underground uses rolling stock built between 1960 and 2005. Stock on subsurface lines is identified by a letter (such as A Stock, used on the Metropolitan line), while tube stock is identified by the year in which it was designed (for example, 1996 Stock, used on the Jubilee line). All lines are worked by a single type of stock except the District line, which uses both C and D Stock. Two types of stock are currently being developed — 2009 Stock for the Victoria line and S stock for the subsurface lines, with the Metropolitan line A Stock being replaced first. Rollout of both is expected to begin about 2009. In addition to the Electric Multiple Units described above, there is engineering stock, such as ballast trains and brake vans, identified by a 1-3 letter prefix then a number.

The Underground is one of the few networks in the world that uses a four-rail system. The additional rail carries the electrical return that on third-rail and overhead networks is provided by the running rails. On the Underground a top-contact third rail is beside the track, energised at +420 V DC, and a top-contact fourth rail is centrally between the running rails, at -210 V DC, which combine to provide a traction voltage of 630 V DC.

In cases where the lines are shared with mainline trains which use a three-rail system, the third rail is set at +630 V, and the forth rail at 0 V DC.

### Cooling

In summer, temperatures on parts of the **London Underground** can become very uncomfortable due to its deep and poorly ventilated tube tunnels: temperatures as high as 47 C (117 F) were reported in the 2006 European heat wave. Posters may be observed on the Underground network advising that passengers carry a bottle of water to help keep cool.

### Planned improvements and expansions

There are many planned improvements to the London Underground. A new station opened on the Piccadilly line at Heathrow Airport Terminal 5 on 27 March 2008 and is the first extension of the London Underground since 1999.http://en.wikipedia.org/wiki/London\_Underground - cite\_note-28 Each line is being upgraded to improve capacity and reliability, with new computerised signalling, automatic train operation (ATO), track replacement and station refurbishment, and, where needed, new rolling stock. A trial programme for a groundwater cooling system in Victoria station took place in 2006 and 2007; it aimed to determine whether such a system would be feasible and effective if in widespread use. A trial of mobile phone coverage on the Waterloo & City line aims to determine whether coverage can be extended across the rest of the Underground network. Although not part of London Underground, the Crossrail scheme will provide a new route across central London integrated with the tube network.

The long proposed Chelsea-Hackney line, which is planned to begin operation in 2025, may be part of the London Underground, which would mean it would give the network a new Northeast to South cross London line to provide more interchanges with other lines and relieve overcrowding on other lines. However it is still on the drawing board. It was first proposed in 1901 and has been in planning since then. In 2007 the line was passed over to Cross London Rail Ltd, the current developers of Crossrail. Therefore, the line may be either part of the London Underground network or the National Rail network. There are advantages and disadvantages for both.

The Croxley Rail Link proposal envisages diverting the Metropolitan line Watford branch to Watford Junction station along a disused railway track. The project awaits funding from Hertfordshire County Council and the Department for Transport, and remains at the proposal stage.

London Mayor Boris Johnson suggested he may be thinking of extending the Bakerloo line to Lewisham, as South London lacks Underground lines.

## Travelling

The Underground uses TfL's Travelcard zones to calculate fares. Greater London is divided into 6 zones; Zone 1 is the most central, with a boundary just beyond the Circle line, and Zone 6 is the outermost and includes London Heathrow Airport. Stations on the Metropolitan line outside Greater London are in Zones 7-9.[34]

Travelcard zones 7–9 also apply on the Euston-Watford Junction line (part of the London Overground) as far as Watford High Street. Watford Junction is outside these zones and special fares apply.

There are staffed ticket offices, some open for limited periods only, and ticket machines usable at any time. Some machines that sell a limited range of tickets accept coins only, other touch-screen machines accept coins and banknotes, and usually give change. These machines also accept major credit and debit cards: some newer machines accept cards only.

More recently, TfL has introduced the Oyster card, a smartcard with an embedded contactless RFID chip, that travellers can obtain, charge with credit, and use to pay for travel. Like Travelcards they can be used on the Underground, buses, trams and the Docklands Light Railway. The Oyster card is cheaper to operate than cash ticketing or the older-style magnetic-strip-based Travelcards, and the Underground is encouraging passengers to use Oyster cards instead of Travelcards and cash (on buses) by implementing significant price differences. Oyster-based Travelcards can be used on National Rail throughout London. Pay as you go is available on a restricted, but increasing, number of routes.

For tourists or other non-residents, not needing to travel in the morning peak period, the all day travelcard is the best ticketing option available. These are available from any underground station. These cost around £5.50 and allow unlimited travel on the network from 9:30am onwards for the rest of the day. This provides excellent value for money and a huge saving considering one single journey on the network can cost close to £5. Travel cards for multiple days are also available.

#### Penalty fares and fare evasion

In addition to automatic and staffed ticket gates, the Underground is patrolled by both uniformed and plain-clothes ticket inspectors with hand-held Oyster card readers. Passengers travelling without a ticket valid for their entire journey are required to pay a £50 (or £25 if paid within 21 days) penalty fare and can be prosecuted for fare evasion under the Regulation of Railways Act 1889 under which they are subject to a fine of up to £1,000, or three months' imprisonment. Oyster card pre-pay users who have failed to touch in at the start of their journey are charged the maximum cash fare (£4, or £5 at some National Rail stations) upon touching out. In addition, an Oyster card user who has failed to touch in at the start of their journey and who is detected mid-journey (*i.e.* on a train) by an Inspector is now liable to a penalty fare of £50, which is reduced to £25 if paid within 21 days. No £4 maximum charge will be applied to their destination as the inspector will apply an 'exit token' to their card.

While the Conditions of Carriage require period Travelcard holders to touch in and touch out at the start and end of their journey, any Oyster card user who has a valid period Travelcard covering their entire journey is not liable to pay a Penalty fare where they have not touched in. Neither the Conditions of Carriage or Schedule 17 of the Greater London Authority Act 1999, which shows how and when Penalty fares can be issued, would allow the issuing of a Penalty fare to a traveller who had already paid the correct fare for their journey.

### Delays

According to statistics obtained under the Freedom of Information Act, the average commuter on the Metropolitan line wasted three days, 10 hours and 25 minutes in 2006 due to delays (not including missed connections). Between 17 September 2006 and 14 October 2006, figures show that 211 train services were delayed by more than 15 minutes. Passengers are entitled to a refund if their journey is delayed by 15 minutes or more due to circumstances within the control of TfL.

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### Accessibility

Westminster station — extensive structures are required to support Portcullis House above.

Accessibility by people with mobility problems was not considered when most of the system was built, and most older stations are inaccessible to disabled people. More recent stations were designed for accessibility, but retrofitting accessibility features to old stations is at best prohibitively expensive and technically extremely difficult, and often impossible. Even when there are already escalators or lifts, there are often steps between the lift or escalator landings and the platforms.

Most stations on the surface have at least a short flight of stairs to gain access from street level, and the great majority of below-ground stations require use of stairs or some of the system's 410 escalators (each going at a speed of 145 ft (44 m) per minute, approximately 1.65 mph (3 km/h)). There are also some lengthy walks and further flights of steps required to gain access to platforms. The emergency stairs at Covent Garden station have 193 steps (the equivalent climbing a 15-storey building) to reach the exit,[40] so passengers are advised to use the lifts as climbing the steps can be dangerous.

The escalators in Underground stations include some of the longest in Europe, and all are custom-built. The longest escalator is at Angel station, 60 m (197 ft) long, with a vertical rise of 27.5 m (90 ft).[1] They run 20 hours a day, 364 days a year, with 95% of them operational at any one time, and can cope with 13,000 passengers per hour. Convention and signage stipulate that people using escalators on the Underground stand on the right-hand side so as not to obstruct those who walk past them on the left.

TfL produces a map indicating which stations are accessible, and since 2004 line maps indicate with a wheelchair symbol those stations that provide step-free access from street level. Step height from platform to train is up to 300 mm (11.8 in), and there can be a large gap between the train and curved platforms. Only the Jubilee Line Extension is completely accessible.

TfL plans that by 2020 there should be a network of over 100 fully accessible stations, consists of those recently built or rebuilt, and a handful of suburban stations that happen to have level access, along with selected 'key stations', which will be rebuilt. These key stations have been chosen due to high usage, interchange potential, and geographic spread, so that up to 75% of journeys will be achievable step-free.

**Overcrowding**

Overcrowding on the Underground has been of concern for years and is very much the norm for most commuters especially during the morning and evening rush hours. Stations which particularly have a problem include Camden Town station and Covent Garden, which have access restrictions at certain times.[41] Restrictions are introduced at other stations when necessary. Several stations have been rebuilt to deal with overcrowding issues, with Clapham Common and Clapham North on the Northern line being the last remaining stations with a single narrow platform with tracks on both sides. On particularly busy occasions, such as football matches, British Transport Police may be present to help with overcrowding.

On 24 September 2007 the entirety of King's Cross underground station was closed due to "overcrowding". Some stations are closed or are made exit-only stations due to overcrowding in peak periods. At other times trains simply don't stop at the overcrowded station and go onto the next closest station, in places where there is another station within walking distance. Overcrowding can also be limited by temporarily disallowing passengers from passing through ticket gates to the platforms at some stations.

According to a 2003 House of Commons report, commuters faced a "daily trauma" and were forced to travel in "intolerable conditions".

### Safety

Accidents on the Underground network, which carries around a billion passengers a year, are rare. There is one fatal accident for every 300 million journeys. There are several safety warnings given to passengers, such as the 'mind the gap' announcement and the regular announcements for passengers to keep behind the yellow line. Relatively few accidents are caused by overcrowding on the platforms, and staff monitor platforms and passageways at busy times prevent people entering the system if they become overcrowded.

Most fatalities on the network are suicides. Most platforms at deep tube stations have pits beneath the track, originally constructed to aid drainage of water from the platforms, but they also help prevent death or serious injury when a passenger falls or jumps in front of a train.