Underground activities

The opening of the London Underground 150 years ago marked the first step in the development of an urban transport system that has had huge success worldwide. Siemens has contributed to this success story with its pioneering spirit and innovative technology.

Some call it the metro, others the underground or the subway, and in Germany and Austria it's called the U-Bahn – but in principle they all mean the same thing: a public rail transport system that is primarily underground, free of intersections and operated independently from other urban transport systems. Metro systems provide mobility for people in over 150 cities around the world. With the advance of urbanization and the constant influx of new people into cities, the space for transport is becoming scarce, which leads to growing numbers of underground rail lines.

Underground trains have a long tradition, with examples stretching back over 160 years. In the booming district of Brooklyn in 1850, the oldest remaining U.S. railroad company, Long Island Rail Road, builds a stretch of its line under Atlantic Avenue using the cut-and-cover method. Although this urban railway tunnel is closed just a few years later, the idea catches on – including in the capital of the British Empire, which is plagued by massive congestion problems. Since the Royal Commission of Railways will not approve any overground railway lines in central London, the routes heading to London end at terminus stations outside of the city – and soon a growing number of shuttle coaches and horse-drawn buses is clogging up the streets.

London goes underground

So underground is the way to go. On January 10, 1863, the Metropolitan Railway, which preceded today's London Underground and gave its name to the metro transport system as a whole, opens an entirely underground line from the terminus station Paddington via Euston and Kings Cross to Farringdon Street in the city – the world's first subway.

The route is constructed as a subsurface line using the cut-and-cover method, like in Brooklyn: a trench is excavated and roofed over, then a road is laid on top. In London the tracks of the subsurface lines going in each direction are built next to one another, around 5 meters under the surface, in a tunnel with a diameter of around 7.6 meters. However, thanks to technological advances such as tunneling shields, it soon becomes possible to quickly and economically dig tunnels through London's clay soil at a depth of 20 to 30 meters. This method is first used to build the Tower Subway beneath the River Thames in 1870. The diameter of these tunnels is less than half that of the subsurface lines, though the track gauge remains the same, and each track has a separate tunnel. These narrow tunnels give the entire London system its nickname, the Tube. The two partial networks remain separate from one another to this day – only on the overground line from Rayners Lane to Uxbridge do subsurface and deep-level trains run directly alongside one another.

In 1897 Siemens Brothers delivered the world's first multiple unit train with gearless drive axles in the bogies – the ancestor of today's metros.

Hurdles on the way to electrification

At first the underground trains are powered by steam locomotives – this remains the leading technology until the mid-19th century. Today it's hard to imagine the experience of these 28,000 daily passengers, with steam and soot filling the tunnels. This only changes after the Berlin entrepreneur Werner Siemens develops a workable electric drive system. At the Berlin Industrial Exposition of 1879 he presents the first electric locomotive, and in 1881 he opens the world's first electric tramline in Lichterfelde, Berlin. He also plans an electric rapid transit network, but the Prussian bureaucracy resists the project for another two decades.

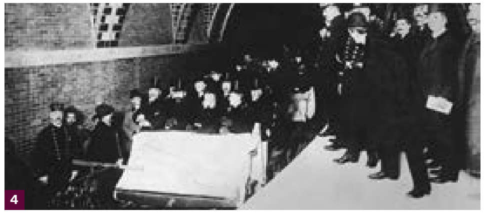
In England the family is represented by Siemens Brothers & Co., owned by the Siemens brothers Werner, Carl and Wilhelm (later known as Sir William). They also present the locomotive from the Berlin exhibition at Crystal Palace in London in 1882. Although the Tube gets its first electric power from Siemens generators in 1890, its first electric locomotives are supplied by an English company. However, the powerful Siemens drives soon outstrip the competition: in 1891 Siemens Brothers supplies its first two electric locomotives to the London Underground, followed in 1897 by the world's first multiple unit train with gearless drive axles in the bogies – the ancestor of today's metros, rapid-transit trains and high-speed trains. By 1908 the Tube is fully electrified.

Metro is booming – in Europe and America

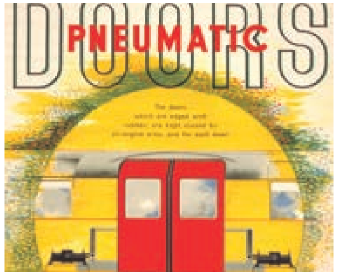
The principle of underground rail also arouses interest elsewhere. The year 1875 sees the opening of the "Tünel" line on the European side of Istanbul, an underground funicular railway from the terminus of the Orient Express to the district of Beyoğlu. Aside from people, it also transports horses and carriages, and it is therefore not a metro in the usual sense. For this reason, the Budapest Metro, which begins operation in 1896, is considered the world's second-oldest subway line – and the first electrified underground rail system with regular service in continental Europe.

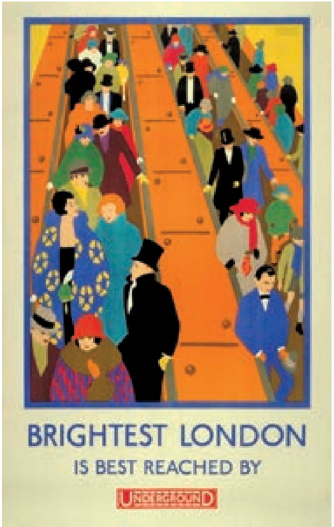
It is worth noting that the approval authorities in Budapest make precisely the inverse objection to those in Berlin: they refuse to let the two transport companies build a tramline over the boulevard Andrássy út, yet they are in favor of an underground line. And so it comes to pass that Werner von Siemens completes his metro project in Hungary's capital, rather than in his home city of Berlin.

In the major U.S. cities the idea of an independent rapid transit system also prevails in the late 19th century.

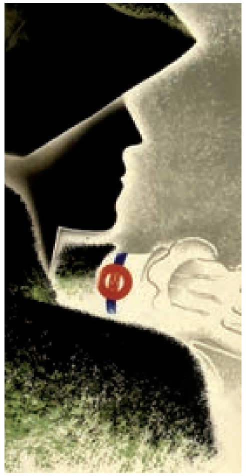


1 The first electric locomotive was presented in 1879
2 A broad tunnel profile: the London Underground in the first years
3 Small-profile train on the Berlin elevated railway at the Görlitzer station
4 Opening of the New York Subway in 1904
5 Metró Budapest is the world's second-oldest rail network
6 London Underground: escalators and magnificent design
7 Latin America's first metro opened in 1913 in Buenos Aires





Poster Art 150: until January 2014, the London Transport Museum is presenting a Siemens-sponsored exhibition of posters from the Tube's 150-year history.



An elevated railway opens in Chicago in 1892, and in 1987 Boston opens an underground streetcar line – an idea that would be rediscovered 70 years later in the light rail systems of numerous cities. New York follows in 1904 with its Subway system. Four years later a second suburban railroad opens in New York, the Port Authority Trans-Hudson (PATH), which runs under the Hudson River from Manhattan to the neighboring state of New Jersey via two tunnels. This line still exists today and is currently undergoing extensive modernization using Siemens technology: radio-based train control will shorten the train headways, enabling up to 290,000 passengers to use the service each day, with no alterations to the line itself required.

After years of debate Berlin also finally opens a regular metro line on February 15, 1902: the electrically driven underground and elevated railway operated by Siemens & Halske. It runs between the stations Stralauer Tor and Zoologischer Garten. Most of the line runs on a viaduct, but later extensions through the city center and wealthy districts run underground. Berlin is also where the term "U-Bahn" comes from – to distinguish it from Berlin's urban, circle and suburban lines operated by Deutsche Reichsbahn, which have been collectively known as the "S-Bahn" since 1929.

To this day, like the London Underground, the U-Bahn has a small and a large tunnel profile with the same track gauge (1,435 mm), and two vehicle types: the early small profile lines – now known as U1 to U4 – are built for trains with a "tram width" of 2.30 meters. The later large profile lines are designed for a train width of 2.65 meters.

Decades of car dominance

As early as 1920 it becomes apparent that cities will be shaped by car and motorcycle transport in the decades to come. In the years between the two world wars only a few metro systems go into operation: in Spain's capital Madrid in 1919, in Barcelona five years later, and Asia's first metro in Tokyo in 1927. The first underground rapid transit train in Moscow opens in 1935. It features stations built particularly deep underground and splendidly decorated as "working class palaces" – though these can also serve as air raid shelters.

In Western countries the focus in the 1950s is on mass motorization. Train passenger numbers are constantly on the decline; the private car sets the standard for travel. Urban planners in West Germany, Western Europe and the United States redesign car-friendly city centers with plenty of space for traffic and parking while dismantling many urban rail lines. In the Soviet Union and other Eastern European states, on the other hand, the number of private cars remains relatively limited and numerous metro operators are established. Leningrad gets a new subway in 1955, followed by Kiev, Tbilisi, Baku and several other major Eastern cities. The metro system in Budapest is expanded, adding two modern lines. Aside from the subways there are tram networks such as the MetroTram in Volgograd.

At the end of the 1960s, however, Western Europe also starts to think differently: the growth of individual mobility has led to urban sprawl, ever-larger space requirements for traffic, a dependence on oil, and increasing environmental pollution due to emissions and noise. In many cities the freedom of the automobile now simply means the privilege of sitting in traffic in your own car. Now transport planners develop light rail as an alternative model, using simpler, tram-like vehicles. These usually have their own tracks, but can go underground to bypass the traffic in city centers and also make use of existing tramlines. In 1966 Stuttgart opens the first tunnel section of its underground tram, forming the core of its current light rail system. Soon Frankfurt and Cologne follow suit.

The only other German cities to build full U-Bahn systems are Munich and Nuremberg. The Bavarian capital departs from the existing concept of an underground tram and opts for a full U-Bahn, which begins operation in 1971, in the run-up to the Olympic Games. While many vehicles from this initial period are still in use today, since 2002 Siemens has supplied modern "C-car" trains.

The youngest German U-Bahn begins operation in Nuremberg the next year – this city had also originally planned a tram network. In 2008 Germany's first fully automatic U-Bahn goes into service on Nuremberg's U3 line. As part of the RUBIN Project, Siemens enables a type of operation on a shared stretch

The Crossrail Project: a train station beneath the streets of London

An extraordinary kind of rail transport project is taking shape in London's underground: a 21-kilometer tunnel is to connect the current terminus station Paddington in west London with Stratford station in the east. Five new Tube stations will provide convenient links to existing underground lines and, according to the planners' estimates, increase the capacity of the London Underground network by 10 percent. The tunnel is the centerpiece of a long-distance service that, from 2018, will run 24 trains per hour.

Siemens is delivering the control and communication systems for the control center and stations, plus the trackside equipment to connect the new local transport line to the national rail network. The special feature here is that the long-distance route to the west will have the European Train Control System (ETCS) Level 2 installed, while the eastern direction will use the local Train Protection Warning System (TPWS). In the Crossrail Tunnel itself the trains will be controlled via radio using Communications-Based Train Control (CBTC). Siemens will deliver its proven Trainguard MT system for this purpose. Dynamic switching between the three control systems will ensure that the different lines are smoothly integrated.

of the U2 line that has not been seen anywhere in the world before: driverless and conventionally driven trains run alongside one another. This continues until 2010, when the U2 vehicles are also fully automated. The major benefit of this approach is that the trains can be upgraded while service is still running.

Metro boom in Asia

In the emerging nations of Asia, with their rapidly growing metropolitan regions and megacities, the only way to cope with the constant influx of people is with high-performance rail systems that are independent from road traffic. For instance, in December 1999 Bangkok opens the two lines of its "Skytrain" elevated rail system, and Bangkok's largely underground metro system goes into operation in July 2005. Both systems are equipped with Siemens technology.

In the People's Republic of China, in particular, transport planners are placing great faith in underground rail – the country currently has over 25 metro systems in planning, construction or operation. The Shanghai Metro, opened in 1993 with 12 lines, is one of the fastest-growing subway systems in the world. A consortium between Siemens and Adtranz, which built the first two lines, sets the standards for signal and safety technology.

Although the metro of the capital Beijing is the first in the People's Republic of China, until 1977 it is only open to civil servants. Today it has ten lines with a total length of over 450 kilometers and transports up to ten million passengers per day. At 50 kilometers, Beijing's line 10 is the longest metro line in the world equipped with the latest CBTC and Trainguard MT control technology.

New vehicle concepts, smart rail automation

These days metro systems are becoming increasingly important – with modern vehicles as a replacement and supplement for existing fleets or for new routes. A current example is Poland's first underground system, the Warsaw Metro. Its line 1, almost 23 kilometers in length, has been running since 1995 and carries up to 568,000 passengers each day. A second, 32-kilometer line is under construction, and the operator Metro Warszawskie has decided to use 35 six-car trains from the new Inspiro generation of metro vehicles, 15 of which will run on the existing line 1. The trains have been specially tailored for Warsaw's requirements and can carry up to 1,450 passengers at a time. Thanks to their lightweight construction, energy-saving lighting and energy-recovery technology, they are extremely energy efficient and economical.

Siemens is also active worldwide in the technical equipment of rail lines, for example in the creation of the metro system in Algiers. With over three million residents, the Algerian capital is the country's largest city and most important transport hub. Line 1 of this turnkey project, which was led by Siemens and opened in 2011, is considered the first full subway system on African soil. The Cairo Metro, which began operation in 1987, came about as a connecting tunnel under the city center between two suburbs, and it is more comparable to a light rail system.

Algiers Metro line 1 reduced daily traffic in the city almost immediately, and the first expansion is due to go into operation as early as 2015. This new portion will also be equipped with the Trainguard MT control system, which allows train sequencing to be adjusted to the passenger volume while also optimizing operating safety, train reliability and availability. It uses the moving block principle to allow the trains to travel at an optimal distance from one another, while automatic train operation maximizes their efficiency in terms of time and energy.

Similar benefits are expected in Riyadh, the capital of Saudi Arabia. The city of five million people plans to construct a cutting-edge metro network with six lines and a total length of 175 kilometers. Siemens will supply a turnkey metro system for lines 1 and 2. This will include Inspiro trains, electrification, signal and communication technology, and equipment for fully automatic, driverless operation.

Retrofitting is today's global trend

However, new systems are expensive and take many years to build. Particularly in the rapidly expanding megacities of Asia and South America, where modern transport solutions are urgently needed, time and money are often in short supply. For this reason operators are increasingly retrofitting their existing lines with smart control and safety technology. It typically allows twice the number of trains to operate on the same line – an economical and timesaving solution for increasing passenger capacity.

Subways such as those in London, Paris, Istanbul and Madrid have already been upgraded; other metros such as the PATH line between New York and New Jersey are currently planning or implementing modernization measures. Copenhagen, Denmark's capital, is another example. As part of its aim to become a CO_2-neutral city, it is updating the signal technology of its light rail network. Between now and 2019, without interrupting services, Siemens will equip five lines and 135 trains with the Trainguard MT system and deliver Trackguard Sicas interlockings and train supervision technology. Meanwhile, in São Paulo, Brazil, Siemens is helping to modernize metro lines 8, 10 and 11. The three lines carry over a million passengers per day using 136 trains, and again the retrofitting will take place while normal service continues. Here Siemens is delivering the CBTC system SIRIUS, including WESTRACE electronic interlockings, point machines and LED signals.

So the 150-year success story of underground rail is far from over. Metros, with their high capacities, lighten the load on road traffic and help protect the environment – and when it comes to sustainable mobility, this is more important than ever. ■