

Automated Metro, safer and more efficient

State-of-the-art technology at your service



Transports Metropolitans
de Barcelona



Barcelona, on the road to automation

The Barcelona Metro is on the road to automation. The medium- or long-term perspective is for 43% of the TMB network (70 to 160 kilometres) to be automated.

The new lines, such as the L9/L10, have been conceived as automated lines and some of the existing ones will be progressively converted. Following L9/L10, which was put into operation as an automated line from the outset, L2 will have to be technologically converted and adopt automated operation, as was recently done with L11. This is because, when it is extended to the airport through the Parc Logístic fork, L2 will share part of the infrastructure with L9. The two lines will require compatible trains and systems to operate jointly on the same infrastructure.





The benefits of automation

TMB's commitment to automation is consistent with its desire to provide the best possible service. The introduction of automated metro systems not only provides more safety, reliability and flexibility while adapting the supply to the demand, it also enables more efficient management of the system and an increase in the capacity of the networks. An automated metro system can run with high journey frequencies, complete safety and optimum regularity.

1) More safety

Automation doubles the safety provision on the metro. On the one hand, thanks to the deployment of state-of-the-art technologies in supervising train traffic and reducing the chance of human error. On the other, thanks to the new methods of preventing intrusions onto the tracks. In this respect, the platform doors are an efficient system for physical separation between the platforms and the tracks, which prevents people and objects from accidentally falling onto them. The platform doors, which adjust exactly to the train doors, perform this separation function and are a key safety measure since the trains run without drivers.

2) More passengers in less time

Automation enables more passengers to be transported in less time using the same infrastructure. Thanks to their sophisticated control and monitoring systems, trains can run during peak times at shorter intervals, under two minutes, with safety totally guaranteed.

3) Leading role of the control centre

The control centre acquires supreme importance in the management of automated metro systems. Being the brain of the network, it is provided with more technical and human resources, with specialists in the various aspects of the operation—safety, public protection, information—who provide support to the line staff.

The operators in the control centre monitor the trains at all times by remote control. They can see the interior by means of video cameras that transmit in real time, they can send and receive messages to and from passengers by public address and intercom, and they can even perform remote assistance tasks. Constant surveillance of the network status is also carried out from the control centre, so that the service provision can be adapted to any pickup in demand by adding more trains whenever necessary





Automated metro systems around the world

The first experiments in automated metro systems date from the beginning of the nineteen-eighties, and since then they have expanded continuously. Today there are automated lines in cities as diverse as Paris, Copenhagen, Singapore and Vancouver, among others.

The automated metro systems include light ones, such as those of Lille and Toulouse in France, and large-capacity or heavy systems such as the Line 14 (or Meteor) in Paris. Line 9/10 under construction in Barcelona is a heavy metro system, while Line 11, adapted for driverless operation, is an example of a light system.

At the moment there are no automated lines in service in Spain outside Barcelona. So Lines 9/10 and 11 are the first to follow an innovative path, although they have now reached a fair level of maturity. To date, over 30 cities in the world have constructed and satisfactorily operate automated light or heavy metro systems, and many more have well-advanced plans to do so.

Automatic lines in the Barcelona Metro network. Target 2015

- L9** Terminal entrepistes Can Zam
- L10** Polígon Pratenc Gorg
- L2** Terminal entrepistes Badalona Centre
- L11** Trinitat Nova Can Cuiàs





The automated operation of L9/L10



L9/L10, the most modern in the Barcelona metro network, has been conceived from the outset to run automatically without drivers, as regards both the infrastructure and the mobile equipment. This means the trains run at the allocated speed and stop at the stations according to a pre-determined schedule, which can vary depending on the day of the week and time of day. However, the control centre can intervene at any time to add or remove trains according to the demand. In the stations, passengers enter and leave through the platform doors, which open and close simultaneously with those of the trains, thus preventing intrusions and falls onto the track.

Other features of automated operation are the mechanisation of ticket sales and the remote control of fixed installations, already installed in the TMB metro network.



Technology for maximum safety

L9/L10 represents a qualitative leap in the way a metro line is run. Basically this leap has been brought about by the technology employed, which enables the **remote control of existing resources and infrastructures** (trains, stations, etc.) on the line, such as:

- Supervision of the status of the train systems and of their interiors
- Supervision and control of the fixed installations, such as lifts, escalators, ticket vending machines and toll lines
- Automation of station opening and putting into service

Remote control can also be used to synchronise all these elements in order to optimise operation according to the needs of the service.

To make this possible, L9/L10 has a **wireless broadband network** which enables **transmission of data and images between the control centre and the interior of the trains**. This technology admits the sending of information and videos in real time between the trains running automatically and the control centre supervising all the operations.

Broadband enables multimedia content to be transmitted for reproduction on the screens inside the trains, immediately and efficiently, meaning that users can be informed at all times.

The remote control and monitoring of the mobile equipment is an **innovative system**, which enables the various devices integrated into each of the trains to be managed, and to have all the information about the trains available in the control centre.

The absence of the employee in the train cabin in fact symbolises access to a new technological stage, the logical consequence of a process which began a few years ago with the introduction of the automatic train protection (ATP) systems and those of assisted train operation (ATO).



Automatic trains, the maximum expression of safety

Automation increases the technical safety of the Metro and makes it easy to provide answers to public mobility

Platform doors

Synchronised with the train doors, they prevent intrusions and falls onto the tracks

Control centre

24-hour supervision of the processes by the specialised staff



Public address

Permits the Control Centre to provide passengers with information and instructions

TV monitors

Continuous visual information for passengers

Video-surveillance

Transmits images in real time to the Control Centre

Intercoms

Enable passengers to communicate with the Control Centre

Radio

Diagnosis of the train's equipment via radio in real time



Travelling experience

The absence of a cabin gives passengers a privileged view from the front of any train

Emergency resources

Door unlocking devices, front evacuation doors

Automatic driving

ATC

Automatic control of trains which sets the routes and stops, thus optimising travelling time

Remote controls

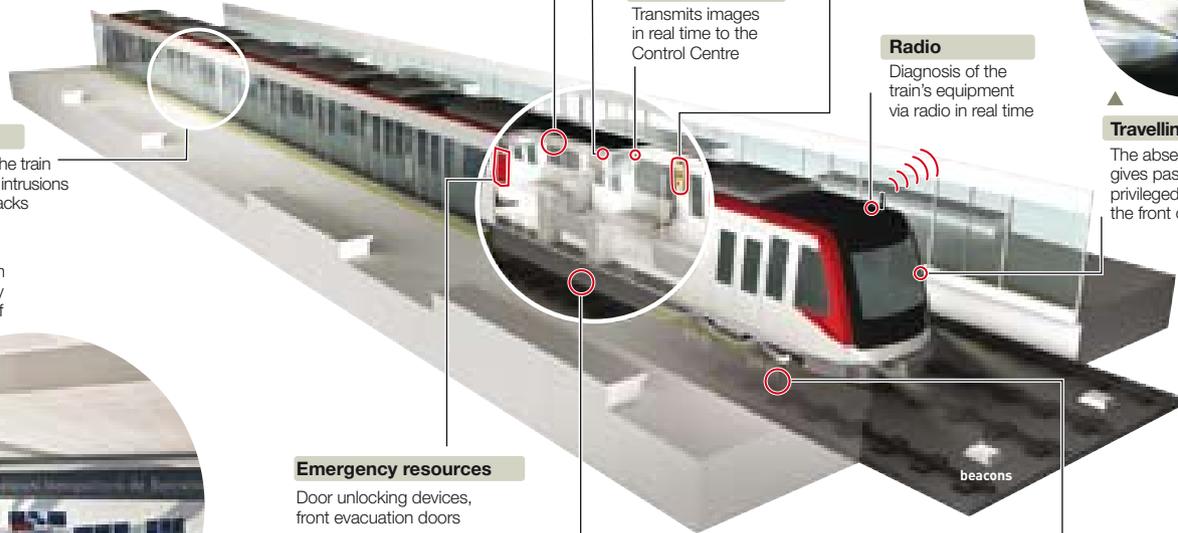
Enable commands to be given to the mechanisms of the train from the Control Centre

Redundant equipment

Comes into action in case of failure of main equipment

Distance measurement

Continuously determines the train's position on the track together with the beacons



Automated trains for a better service

The trains used on the L9/L10 are **automated**, or driverless, and are **located, controlled and programmed from the Metro Control Centre (CCM)** at La Sagrera. The system locates the trains with the aid of radio stations and beacons and measures the distance between them.

The trains running on the L9/L10 belong to the 9000 series and are characterised by their **light structure, advanced technology and high energy saving**. Also, the duplication of their equipment multiplies reliability and the ability to communicate constantly with the control centre.

The trains in the 9000 series are 85.860 metres long and consist of five coaches, four of which are motor-driven, with the fifth being towed. They are distinguished by their box-type structure produced using standard aluminium profiles. Steel is used in the other parts of the structure subject to greater stresses, such as the headstock or the pivot crossbar.

Their design is **modern** and **adapted to the demands of metropolitan public transport: great capacity, comfort and safety**. The coaches are connected by a worm-type communication gangway. Every coach has four access doors on each side, equidistant throughout the length of the train to permit closure of platforms.

Each train has a maximum capacity of 959 passengers (112 seated, 845 standing, with space for two passengers with reduced mobility). The end coaches have **areas adapted for people with reduced mobility** and there is also space for bicycles, etc.

The trains run automatically without drivers (ATC-S), but can run on other conventional lines with a driver (ATP-ATO). The driver's desk folds away and is integrated into the design of the cabin.

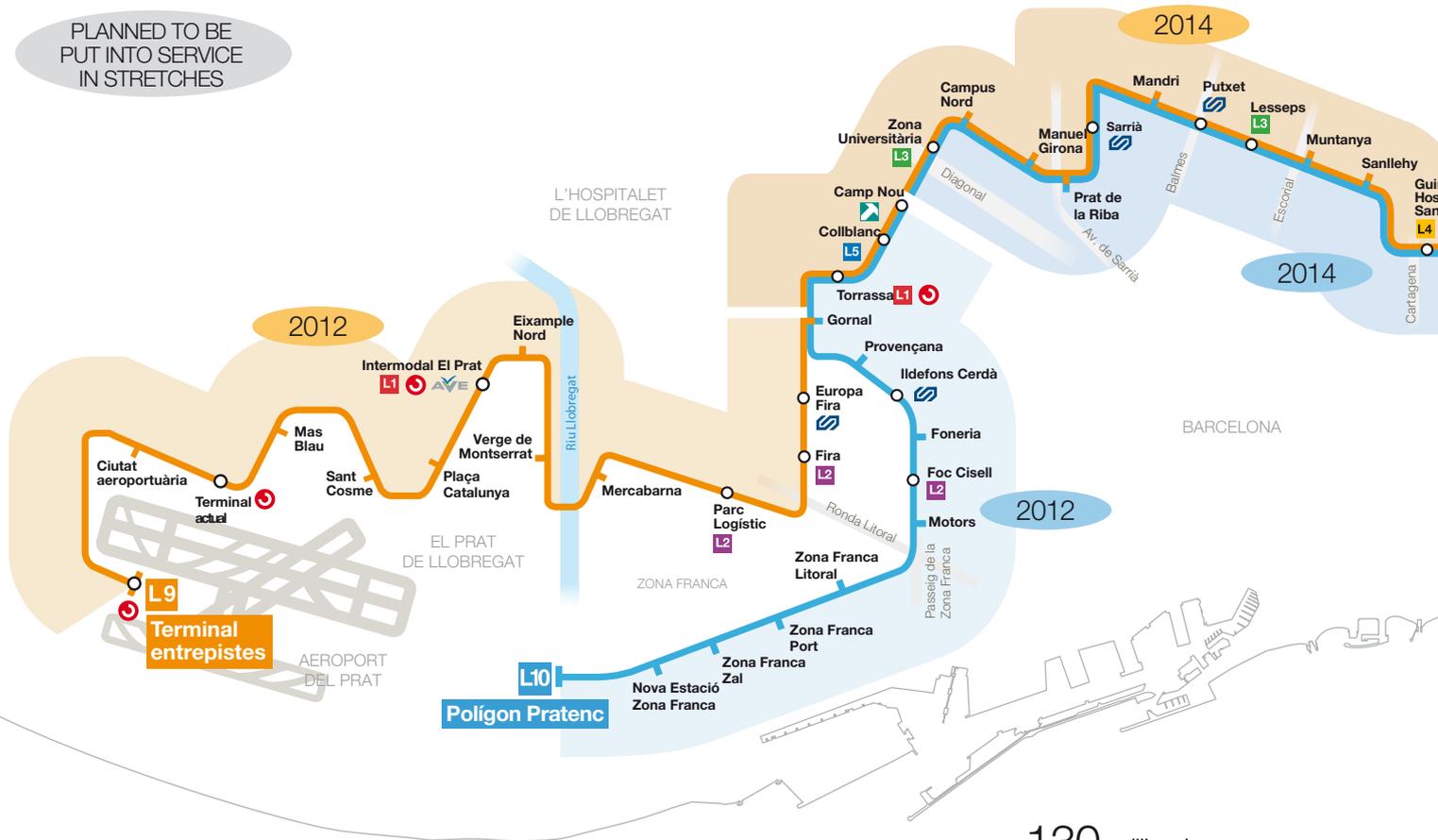
The coaches have double sliding fitted doors which operate electronically and ensure the passengers' stability and safety. Each coach has four doors per side, with an access width that enables fast, safe evacuation in any circumstances.

They have **active information systems for passengers**: interior public address, illuminated line indicators at all the doors, train number indicator and an emergency communication device. All units incorporate a **visual information system** by means of LCD screens with brightness control, as well as fire detection and video-surveillance systems. The trains also have integrated air-conditioning and optimum interior soundproofing.

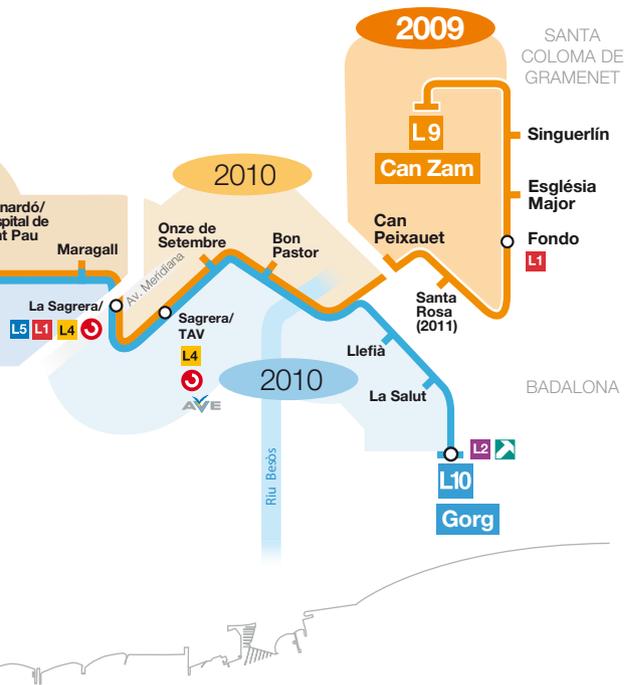
As an innovation, we would like to point out the incorporation of an evacuation ramp at the front of the trains.

L9/L10, the longest automated metro line in Europe

PLANNED TO BE PUT INTO SERVICE IN STRETCHES



130 million journeys per year
350.000 validations per day



47,8 km long

0-70 m deep

52 stations

20 interconnections

Once totally completed, L9/L10 will be **the longest automated metro line in Europe**, at 47.8 kilometres, with 52 stations in five municipalities of Barcelona metropolitan area and a demand estimated at 165 million travellers per year in 2020.

Developing an infrastructure of this magnitude and which **has a total budget of 6.5 billion euros** requires firm, cohesive organisation. The Government of Catalonia has promoted the planning and construction of the line through the Department of Territorial Policy and Public Works. It finances and promotes it with Ifercat (Infraestructures Ferroviàries de Catalunya) and manages and constructs it with GISA (Gestió d'Infraestructures, SAU).

The new line will cross **Barcelona** and connect **Badalona** and **Santa Coloma de Gramenet** with **l'Hospitalet** and **el Prat de Llobregat**, and provide service to areas with great demand, which until now had no public railway transport connection, such as the districts of Singuerlín, Liefià, Santa Rosa, Bon Pastor, Can Peixauet, Zona Franca, Sant Cosme, Mas Blau, the Logistical Activities Zone (ZAL), the Zona Franca industrial estate, the UB and UPC university campuses, the Trade Fair, the City of Justice and el Prat Airport, among others. Also, twenty of the stations will be inter-connecting, thus enabling mobility in the Barcelona metropolitan area to be improved, as they will connect with other public railway transport systems such as the Local Railway network, TAV and other Metro, FGC and tram lines.

The construction of a new, innovative line

The construction of the L9/L10 of the Metro constitutes **a great challenge as regards subterranean infrastructures in Spain**. The conditions of the terrain, which include all types of soil, from the sands of the Besòs and Llobregat deltas to the rocky terrain of Collserola, make it necessary to employ **the most innovative technologies and designs in this type of construction**.

Most of the L9/L10 route is being constructed with **latest-generation tunnelling machines**, which are designed to cut through terrains of different composition. This construction method ensures the stability and water-tightness of the tunnel, does not affect the surface and minimises the impact on the surroundings.

The tunnelling machines used in constructing the L9/L10 have two different cutting head sizes. From El Prat Airport to l'Hospitalet de Llobregat a tunnelling machine with a **cutting head of 9.4 metres diameter** is being used and the double track is on the same level. On this stretch, **the trains run parallel to each other**.

In the rest of the line, the tunnelling machine being used has a **cutting head with a diameter of 12 metres**, which allows **the trains to run on different levels**, the platforms to be located inside the tunnel and the tracks to be superimposed.

In the Zona Franca part where the line will connect with the port and the ZAL, **the trains will run on a viaduct** at a height of 6.5 metres. The viaduct, which will be 4 kilometres long, is the first of its type to be built in Spain and will help to improve mobility in the Zona Franca.

Workshops and railway yards are also being built in this area. It is a 26,000-square metre building with twelve sidings. It will also have offices. At the other end of the line, in Santa Coloma de Gramenet, there are more workshops and railway yards.

The construction of the L9/L10 stations has three determining factors: the depth of the subsoil, its intersection with the other metro lines and services and the high degree of urban development in the areas through which it passes. Three station models have therefore been designed:

The L9/L10 station types. Thirty stations have been designed in the form of a large, cylindrical well, which have an upper lobby (with access to the outside) and a lower, or pre-platform, lobby (connecting with the platforms) which are connected by means of large-capacity lifts and emergency stairs. In this type of station, the platforms are located within the tunnel section and the trains run superimposed on two levels.

The classic metro station. Seventeen stations are located in shallow stretches and built using screens with open-air excavation. In this case the trains run parallel to each other on the same level.

The outdoor station on the viaduct. Zona Franca has five outdoor stations planned on a viaduct with parallel tracks and a central platform.





L9/L10 stands out for the comfort and safety of its stations. Despite the construction differences, they all have innovative access points and modern safety systems.

To go from the entrance hall to the platform, there are high-speed lifts with an efficient safety system. The lifts are coordinated with the trains' arrival at the platform. The stations are totally accessible and also have lifts adapted for people with reduced mobility and walkways for the blind.

All the stations also have screens separating the platforms from the zone where the trains run. The screens open in coordination with the train doors. This system improves the safety of the platforms.

Several architects work on the design of the stations, and have provided a variety of finishes for groups of stations. Users are thus given a pleasing, different and varied view of the architectural designs, which is indicative at the same time.

The creative experience of artists has also been incorporated in order to introduce art into people's surroundings and create a custom-made ambience for each district. The idea is for the stations to have a distinctive look in each stretch, while at the same time seeking overall harmony and continuity.

The Government of Catalonia has promoted the construction of L9/L10, an ambitious work given its magnitude, the investment involved and above all the benefits it will bring to the hundreds of thousands of people who use public transport in the Barcelona metropolitan area.

The entry into service of the new Metro line is a great step forward, since the line guarantees coverage for an area with a high density of mobility and will greatly extend the provision of public transport to the districts of Barcelona. The Government is firmly committed to working towards extending and improving public passenger transport services, thus providing a response to people's mobility needs at a minimum cost to the community, and in an environmentally sustainable manner.



