3. The Barcelona’s metro

3.1. Introduction

Barcelona, unlike Copenhagen, has a big metro network for more than 80 years. This metro, together with suburban railways, bus service and the new tram provides Barcelona with a great public transport network to move through the Metropolitan region. However, the increase of population, work places and the development of private transport need to offer a better public service, with better connections between different transport modes to compete directly with the private transport, such as cars and motorbikes.

For that reason, in 1997, the Metropolitan Transport Authority (ATM) was created in order to plan the public transport infrastructures in the Barcelona Metropolitan Area. Aside from that, ATM acts as a mediator between the public Administrative and the different operators that take part in the public transport.

Hence, ATM created the Infrastructure Master Plan for public transport 2001-2010 (PDI), which basically describes the development of the public transport in the Barcelona Metropolitan Region within the next years. That means the improvement of the actual network, enlarging the existing lines, putting new rolling stock, etc, or creating new ones to fulfil the demand. But also ATM is responsible to plan and coordinate the services, define an integration fare system and manage the mobility.

One of the most important infrastructure within the PDI and improvement in the public transport will be the new metro line, L9, the largest in Europe, which will connect the Barcelona’s airport with L’Hospitalet de Llobregat, the northern part of Barcelona, Santa Coloma de Gramenet and Badalona, as well as The Zona Franca, which is the largest industrial area in Spain.

At the moment, the new line is under construction and it should be finished at 2007. It will have connection with all the metro and railways lines, at least once in its layout, and thanks to L9, some districts that now are weakly connected will have a good connection with the rest of the city, helping the development of the neighbours in terms of mobility and increasing their quality of life.

Although the new line will be an essential instrument to improve the mobility through Barcelona and surrounding areas, not everybody is for the infrastructure and there are several points of discussion about the layout, the stations, the construction costs, the estimations for the future and so on.

Next chapters will deal with the actual metro lines, their characteristics and improvements in a future according to the PDI, as well as the planning process of the new L9 with all these conflict points laying emphasis on the stations, specially the Campus Nord station, and explaining the benefits that new line will give to the industrial estate of Zona Franca, to the airport and to some forgotten districts around Barcelona in terms of public transport.
3.2. History and existing lines

Barcelona has a large metro network through the city and its surroundings with a total of nine lines, operated by two different companies: “Transports Metropolitans de Barcelona” (TMB) and “Ferrocarrils de la Generalitat de Catalunya” (FGC). The first one was created in the sixties in order to manage the metro lines, together with urban bus network and the Montjuïc’s funicular. TMB is owned by the city council. On the other hand, FGC is owned by the Autonomous Region of Catalonia and is in charge of some suburban railways going from Barcelona city center to surrounding cities like Sabadell, Terrassa, etc. Hence, the urban stretches of these lines inside Barcelona are used as a metro, due to the improvement of the trains’ frequencies some years ago.

Thus, the lines can be recognized by different colours and their short s are numbers. L1, L2, L3 and so on until L11.

The first metro was opened in 1924 between Catalunya square and Lesseps. This line was called “Gran Metro de Barcelona”. Lately, there were two different branches. One was going from Liceo to Aragon and another one going from Jaume I to Correos, which nowadays takes part of the L4. In 1975 the stretch Zona Universitària – Paral·lel was opened to give a better access to the university area in the northern part of Diagonal street. However, this stretch was running independently, as it had third rail power supply, different from the first branch, which had an overhead wire. Finally, in 1982, L3 (green line) was defined linking the two different stretches. This line is crossing Barcelona from north to south with a Y shape (see next figure) and it is one of the most used by the tourists, as it passes through the oldest part of the city in “Les Rambles”.

The second oldest line was opened in 1926 known as “Ferrocarril Metropolitano Transversal de Barcelona” between Catalunya square and La Bordeta. This stretch was constructed due to the World Fair in 1929 and its aim was to link the main train stations in the city with the new fairground in Espanya square. At the present time, this line is the largest in Barcelona, with 20.7 km and is known as the red line (L1). It is going from Bellvitge hospital to Fondo stations, crossing all Barcelona from L’Hospital de Llobregat to Santa Coloma de Gramenet. Some important stations are Espanya square, Catalunya square, Clot and Sagrera, which will be the new station of the High speed train (AVE).

L4 and L5 were opened in the 60’s. The first one, known as the yellow line, contains the stretch between Passeig de Gracia and Barceloneta, which was part of the Gran Metro. L4 has a C shape through the city, linking the northern part of the city in Trinitat Nova station with Sant Adrià de Besós and Badalona cities in the south-east of Barcelona. In 2002, the stretch between La Pau and Pep Ventura station was joined to the L2. However, new stations of the L4 were created in 2004 in order to give a better access to the Universal Forum of Cultures.

On the other hand, L5 (blue line), is crossing Barcelona from west to east linking Cornellà de Llobregat with Horta district. As the L3, the best feature of this line is the connection with Sants, which is the main train station in the city. Both lines, L4 and L5, are running with the oldest trains of the network, but they are updating progressively.
The newest metro line, except for L11, is the purple one (L2), which was inaugurated in 1995. Although the tunnels were bored in the 60’s from Horta to Universitat square, the stretch between Horta and Sagrada Familia stations was joined to L5. Hence, the other stretch was not used until the investment done for the Olympic Games in 1992, even though it was opened three years later. Finally L2 is ending in Badalona, taking advantage of the stretch between La Pau and Pep Ventura stations, which was part of the L4 before 2002. Passeig de Gràcia and Clot are two of the most important stations of the line, as they are also RENFE stations.

L11 is a new and particular metro line. Actually is a light rail situated in the northeast of Barcelona, following the L4 line to give access to the population living in Ciutat Meridiana and Can Cuiàs, in Montacada i Reixac town. This part of the city, which has a difficult accessibility due to its complex orography, was weakly connected with public transport before the construction of the L11. The main characteristics of this line are: single track with double track only in Torre Baró station to allow train crossing, automatic train operation, platform screen doors, short stretches between stations and low frequencies due to the low demand. (Ref: www.urbanrail.net) L1, L2, L3, L4, L5 and L11 are operated by TMB.

FGC operates three metro lines under the short of L6, L7 and L8. Although these lines were not considered from the metro system, the increases of the frequency, together with new zonal fare system implemented by ATM, have made the increasing of the metro network.

L6 and L7 depart from Catalunya square going to the northern part of Barcelona, but in Gràcia station they split up in two different lines. L6 goes to Reina Elisenda, following the oldest railway line opened in 1863, which connected Barcelona with different towns such as Gràcia, Sarrià and Sant Gervasi. These towns are nowadays districts of Barcelona, due to the expansion of the city at the beginning of the 20th century with the Eixample designed by Ildefons Cerdà.

On the other hand, L7 is going to Tibidabo Avenue and is running all the way under Balmes Street.
Finally, the L8 line is running between Espanya square and Molí Nou station in Cornellà de Llobregat. Other trains go further to Igualada, Manresa, etc, which is known as the Baix Llobregat line. The feature of this line is the one meter track gauge.

Some of the characteristics of these metro lines are shown in the next table:

<table>
<thead>
<tr>
<th></th>
<th>Length (Km)</th>
<th>Number of stations</th>
<th>Travel time (min)</th>
<th>Gauge (mm)</th>
<th>Power supply</th>
<th>Trains</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>20.7</td>
<td>30</td>
<td>35</td>
<td>1668</td>
<td>Rigid overhead</td>
<td>4000</td>
</tr>
<tr>
<td>L2</td>
<td>13.1</td>
<td>17</td>
<td>24</td>
<td>1435</td>
<td>Rigid overhead</td>
<td>2000, 2100 and 5000</td>
</tr>
<tr>
<td>L3</td>
<td>16.6</td>
<td>24</td>
<td>27</td>
<td>1435</td>
<td>Rigid overhead</td>
<td>3000, 2100 and 5000</td>
</tr>
<tr>
<td>L4</td>
<td>16.7</td>
<td>22</td>
<td>27</td>
<td>1435</td>
<td>Rigid overhead</td>
<td>1100</td>
</tr>
<tr>
<td>L5</td>
<td>16.7</td>
<td>23</td>
<td>30</td>
<td>1435</td>
<td>Rigid overhead</td>
<td>1000 and 5000</td>
</tr>
<tr>
<td>L6</td>
<td>7</td>
<td>9</td>
<td>14</td>
<td>1435</td>
<td>Rigid overhead</td>
<td>111</td>
</tr>
<tr>
<td>L7</td>
<td>7</td>
<td>7</td>
<td>10</td>
<td>1435</td>
<td>Rigid overhead</td>
<td>111</td>
</tr>
<tr>
<td>L8</td>
<td>12</td>
<td>10</td>
<td>20</td>
<td>1000</td>
<td>Rigid overhead</td>
<td>213</td>
</tr>
<tr>
<td>L11</td>
<td>2.1</td>
<td>5</td>
<td>4</td>
<td>1435</td>
<td>Rigid overhead</td>
<td>500 (light rail)</td>
</tr>
</tbody>
</table>

Table 7. Characteristics of the metro network. (Ref: www.trenscat.com)

Due to the age of some lines, the train units are also really old, like trains 1000 of the L5, which are the oldest trains in service. For that reason, new trains with serial number 5000 are fit recently in the network improving the headway times. Hence, it permits a higher frequency and a better service in rush hours.

The metro network is improving little by little and there are some projects to enlarge these existing lines. Actually, some new stretches are already in construction and they will be very useful to fulfil the demand. Aside from enlarge the actual lines and create new ones, it is necessary to improve the actual stations to allow a better access for disabled people. That means lifts in every station and line up the platforms with the trains to minimize the gap between them. All these projects and improvements will be explained in the next chapter, when talking about the ATM and its role within the Infrastructure Master Plan for public transport 2001-2010 (PDI).
3.3. The Metropolitan Transport Authority

The Barcelona Metropolitan Transport Authority (ATM) is a voluntary consortium created by all the administrative titulars of public transport service in the Barcelona Metropolitan Area. Transport modes such as metro but also bus service, tramway, suburban railways, etc.

This organization was created in 1997 and there are different bodies taking part of the ATM. The Generalitat of Catalonia, with 51% and the local administrations with 49% like Barcelona City Council, the Metropolitan Transport Body (EMT) and the Association of Municipalities with urban transport services of the Barcelona Metropolitan Area (AMTU). The Central State Government acts as an observer between these different administrative organizations.

Some basic aims of ATM are: (Ref: www.atm-transmet.org)

- The planning of public transport infrastructures.
- The planning of services and operating programmes.
- The definition of an integrated fare system.
- The managing of the operating costs.
- Define the distribution between operators of the rates’ income.
- Analysis of mobility.
- Advertising, information and user relations.

First of all, the planning of public transport infrastructures is an important tool to make progress in terms of mobility through the region. Hence, it is necessary to define the main characteristics of the territory and know the shortcomings of the actual network to improve in an efficient way the public transport service for the population. From here on, the control of the new investments and the supervising of the projects to fulfil the planning objectives are essential. For that reason ATM created the Infrastructure Master Plan (PDI) which contains all these projects and improvements of the network.

Secondly, all the companies and operators that take part of the public transport within the ATM have to coordinate between them to plan the services and set up the operating programmes. This is necessary for each company to know its fields and respect the others’ work catchment areas. Aside from that, the analysis of the evolution of public transport in terms of travels is really important to compete against private transport. Thus, it is also necessary to follow mainly the behaviour of cars and motorbikes.

When ATM was created 9 years ago, the Barcelona Metropolitan Region (RMB) was not divided in zones, and there was any integrated fare system. One of the aims of ATM was to create a common framework of fares. This would be useful in a future to control the coverage of costs coming from fares, but also this integrated system would help the passengers to get great discounts in the travel ticket, as it makes possible to use different transport modes in the same journey within the RMB extended to the limits of the local rail services.

The integrated fare system was a reality in 2001. RMB is divided in six semi-circle zones. The sixth area is the furthest one, with cities like Vic, Manresa, Igualada, El Vendrell, etc, which are almost 80 kilometers from Barcelona.

Metro is within the zone 1. This zone is not only Barcelona city and its adjacent municipalities, but also some stretches going out to Montgat, Montcada or Castelldefels. Of course, the further you go, the more you pay for the ticket.
Planning system of metro networks. Comparison between Copenhagen and Barcelona

ATM is also in charge to manage the deficit of the operating costs and the services. Hence, it is funding agreements with the public administrations to face this deficit. However, the integrated fare system has been very useful for a better control of the income coming from rates’ travel tickets. Moreover, it permits a better distribution to the different operators according to their market shares.

One of the more important tasks of ATM is the analysis and studies of mobility in RMB. This function is really important to know how the market share changes when there is a new transport mode, there are some improvements in the network, etc. ATM carries out studies based on surveys to the population in order to get these data. For example, the modal distribution between public and private transport, and the analyses of the main corridors and accesses to Barcelona city and also the internal mobility through the city.

Another analysis is the Everyday Mobility Study, which allows obtaining real data and adapting the transport services to the real demand. Actually, this is an official survey carried out every 5 years. Hence, these data are useful to find out the weaker points in the network, so they are essential for the development of the public transport. How to carry out these surveys and what is the contribution of the data will be explained later on.

All these studies and projects to improve the infrastructures are unnecessary if population do not make aware of the importance to use the public transport. For that reason, ATM is also in charge to advertise and inform of all the advantages and promote a sustained mobility using the public transport all along RMB.

ATM carries out different campaigns claiming the use of public transport and explaining the negative points of a massive use of private transport, such as congestions, pollution and a progressive dispersion of the citizens to the surrounding areas. All these factors mean a higher cost for the population but also for the authorities and governments, as they have to build better road accesses to the city. Moreover, such a private transport means a higher by-unit occupation of public land per traveller transported, higher energy consumption, more air pollution and less safety for passengers.
However, the transport system overall, including private and goods transport, together with the public transport within the RMB and considering the relations between residential areas and economic activities has three main functions:

- To support the efficiency of the economic system, avoiding flow congestion.
- To improve citizens’ quality of life, ensuring optimal quality and safety of their journeys at a minimum time and cost.
- To guarantee the integration of the metropolitan space, allowing it to work as a single system with different polarities.

In this global transport system, traveller public transport systems target guaranteeing mobility, a key element in personal autonomy, for all citizens, at a minimum cost and based on environmental sustainability criteria. (Ref: PDI)

Hence, the basic aims for the metropolitan public transport system are:

- To increase the participation of public transport in metropolitan mobility.
- To obtain the maximum economic and social efficacy of public resources assigned for the public transport system via the integrated planning of the SMTPC.

In short, the strategic objectives of the two points above that ATM wants to get are shown in the next figure:

<table>
<thead>
<tr>
<th>To increase the participation of the TPC in metropolitan mobility</th>
<th>To obtain the maximum economic and social efficacy of public resources earmarked for the transport system via the integrated planning of the SMTPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>To increase the spatial coverage of the public transport network; to increase and spread accessibility and facilitate access of people to the network.</td>
<td>To reduce the overall costs of travel by public transport in the RMB and more particularly in the central conurbation.</td>
</tr>
<tr>
<td>To improve the internal accessibility of the RMB and its connection with the outside.</td>
<td>To boost the intensive use of existing high-capacity TPC infrastructures.</td>
</tr>
<tr>
<td>To increase the frequency of public transport in periods of heaviest demand.</td>
<td>To boost the use of the most efficient means of transport for each demand.</td>
</tr>
<tr>
<td>To manage the shared use infrastructure rationally: give priority to the commercial speed of public transport.</td>
<td>To promote the complementariness and coordination of public transport services making it easier, physically and economically, to change modes.</td>
</tr>
<tr>
<td>To increase the network effect of the SMTPC: to coordinate and facilitate exchanges between networks, make changing modes easier.</td>
<td>To minimise the impacts of the transport system on the environment.</td>
</tr>
<tr>
<td>To guarantee the mobility of the captive population of public transport in conditions of social equality.</td>
<td>To adapt fares to spatial areas regardless of who the operator is.</td>
</tr>
<tr>
<td>To improve the quality and comfort of travel in public transport.</td>
<td>To propose funding formulas that guarantee regularity of resources and guarantee, at the same time, a given coverage via income from fares.</td>
</tr>
<tr>
<td>To create brand loyalty among travellers in the use of public transport via a fare policy which boosts use.</td>
<td>To guarantee the economic equilibrium of public transport operators.</td>
</tr>
</tbody>
</table>

Table 8. Finalities and objectives of the ATM within the SMTPC. (Ref: PDI)

Although the Catalan Government is also carrying out television’s campaigns for the benefits of the public transport, is not easy to change the mentality of a culture, where everyone has a vehicle and people want to get their destination by car, thinking that is the most convenient way even though is more expensive than public transport.
3.3.1. The Infrastructure Master Plan 2001-2010

Before the creation of ATM in 1997, there were different proposals of planning documents in terms of public transport in the RMB, but any of them was approved. One of the most recent backgrounds in the planning of public transport infrastructures was the Preliminary Intermodal Transport Plan launched in 1993. However, this plan was not approved by the authorities.

On the other hand, there are planning documents about the infrastructures of each public operator. For example, the Underground Plan 1984 for the metro network, the Master Plan of the state railway network 1993 by RENFE and the three-year Action Plans of the FGC, together with plans of TMB. In a more general context, there are some guidelines of the metropolitan area in the General Territorial Plan of Catalonia from 1995.

However, there was not a common planning of infrastructures for the different public transport modes in the RMB. This would help to develop the network within the same framework between different modes and also it would be easier to funding agreements for the investments of the infrastructures.

Hence, the creation of ATM which is formed by different institutes from the Government, in a local, regional and state level, together with the Metropolitan Transport Organization (EMT), stresses the beginning of a new stage in the infrastructure planning of the RMB. This is based on the planning of public transport infrastructures within a frame of 10 years and it was the point of departure for the development of the Infrastructure Master Plan 2001-2010 of public transport in the Barcelona Metropolitan Region (PDI).

The basic features of the PDI 2001-2010 are, among others, that most of the infrastructure planning of the public transport is based on railways. Moreover, it is complemented with the Services Plan, also developed by ATM.

The PDI treats the whole RMB with the same criteria and it is a flexible plan. That means yearly reports and a revision every five years in order to change some infrastructures or putting new ones if necessary, depending on the results got from the surveys, mobility studies and other territorial analysis.

The main purposes of the PDI are: (Ref: PDI)

- To significantly increase the number of journeys made by TPC and help the public transport to increase its share versus the private vehicle in all areas of the RMB: in the city, its accesses, at connection points between the metropolitan polarities, etc., via a large-volume offer policy.
- To ensure that the availability of TPC with fixed infrastructure is not a limiting factor in metropolitan operation, in the implementation of activities in the RMB, or in Barcelona’s international competitiveness.
- To guarantee greater economic and social efficacy of public investments in the metropolitan transport system by integral planning and adapting the mode of transport to the expected volume of demand.
- To undertake a series of actions to underline the Administration’s determination to boost public transport in the metropolitan region.
In order to develop the PDI was necessary to make a diagnosis of the public transport system in the RMB. Hence, ATM carried out different analysis such as the territorial framework and the demographic and socioeconomic situation, the current mobility, traffic and population forecasts in 2010, the public transport offer, etc. Moreover, they needed two points of view for the diagnosis: an overall view of the whole RMB and divided into smaller zones.

From here on, the PDI’s process of preparation was divided in four phases: (Ref: PDI)

1. Collection and preparation of information which, along with the background and the basic information from administrations and operators, will give a first overview of the state of the metropolitan TPC System.
2. Drafting of the System Diagnosis and Guidelines for the PDI, a document which is put to the Administrations and operators, and then approved.
3. Collection of the proposals for action in infrastructures and priority setting thereof by means of the Methodology of evaluation of investments in public transport also examined and approved.
4. Preparation of the PDI proposal including the revised Diagnosis and Guidelines, the Action programmes and the relevant economic-financial study.

During this process of preparation it can distinguish two types of conditioning factors: Firstly, those related to the uncertainty of future forecasts. The studies of traffic and population for 2010 have two dependent variables, which are the mobility and the distribution between transport modes. As these variables can change rapidly, planners wanted to avoid a rigid PDI and it is necessary to follow-up them. On the other hand, those factors derived from actions by other territorial agents, specially the arrival of the high speed railway line (LAV) in Barcelona. Hence, the ATM’s aims are: (Ref: PDI)
• To guarantee optimal accessibility by TPC to the new LAV stations (the Underground and local trains network must be extended to cover it).
• To leverage the actions scheduled to improve the operation and the urban insertion of the TPC networks.
• To minimise any negative effects on the TPC system of the railway work required.

After the approval of the planning document in 2001 by the Executive Council of the Autonomous Government of Catalonia, the PDI includes 4 action programmes:

1. Extension of the network
2. Improvement and modernisation of the existing network
3. Changeovers
4. Actions in the state railway network

When talking about the metro network there are a lot of improvements within the PDI along the 9 lines that exist at the moment. Besides, the construction of the new L9 is the most important action of the PDI.

Next chapter will deal about L9 and all its characteristics, but in short, its main objectives are the coverage of the territory of high density of mobility developed in the top part of Barcelona and Barcelonès Nord, as well as the increase of the network effect, with a total of 14 new changeovers. It will connect El Prat Airport, Barcelona, Santa Coloma de Gramenet and Badalona through 46 stations and 42.6 kilometres. Finally, it is expected to reach a demand of 90 million passengers per year.

The improvements of the actual metro network are based on the coverage of high density residential territory that now is not connected by metro. Besides, some lines are enlarged in order to connect them with the new L9. Next table shows these improvements: (Ref: PDI)

<table>
<thead>
<tr>
<th>Extensions of the actual metro network within the PDI 2001-2010</th>
<th>Investment (M €)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1 From Feixa Llarga to El Prat Plaça Catalunya (L9)</td>
<td>132,283</td>
</tr>
<tr>
<td>From Fondo to Badalona Centre (L2)</td>
<td>128,857</td>
</tr>
<tr>
<td>L2 From Pep Ventura to Badalona Centre (L1) and Morera.</td>
<td>146,887</td>
</tr>
<tr>
<td>From Sant Antoni to the new fairground Montjuïc 2 (L9)</td>
<td>120,202</td>
</tr>
<tr>
<td>L3 From Canyelles to Trinitat Nova (L4)</td>
<td>86,786</td>
</tr>
<tr>
<td>L4 From La Pau to Sagrera LAV station (L9)</td>
<td>80,115</td>
</tr>
<tr>
<td>L5 From Horta to Vall d’Hebron (L3)</td>
<td>138,533</td>
</tr>
<tr>
<td>L6 No imminent plans</td>
<td>-</td>
</tr>
<tr>
<td>L7 No imminent plans</td>
<td>-</td>
</tr>
<tr>
<td>L8 From Plaça Espanya to Plaça Francesc Macià and Gràcia/Provença</td>
<td>159,629</td>
</tr>
<tr>
<td>L11 No imminent plans</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 9. PDI’s Projects of the actual metro network. (Ref: PDI)
3.4. L9

3.4.1. Background of the new line

Although the extensions of the actual metro network to improve the connectivity through public transport are really important, there are still some districts of Barcelona and surrounding areas where the population are weakly served. Moreover, a city like Barcelona, with more than 4 million people in its Metropolitan region, needs a fast connection to the airport. However, this link is only possible by suburban railways and buses. That means few stations to catch the suburban railway to the airport even though is a fast mode. On the other hand, the bus service is determined by the road traffic, which is normally very congested. Hence, the idea to build a new metro line passing through these areas came up many years ago. Actually, the first backgrounds came from the Metro Plan of 1971 and 1974, which emphasized the necessity of a metro in areas like Zona Franca and Besós. However, these ideas did not carry out until some years ago.

The new metro line is the most important project of the PDI 2001-2010 and is the most expensive investment ever done by the Catalan Government. It costs around 2000 million euros. Thus, there are a lot of determining factors to construct a good infrastructure.

One of them is the layout of the line. The connection between Barcelona and the Prat Airport seems the best feature, but without forget the great service that this metro will give to the population living in some districts that now are dissatisfied due to the poor connections with public transport. Areas like the northern part of Barcelona and cities like Badalona and Santa Coloma de Gramenet. Besides, the industrial area of Zona Franca situated in the southwest of the city needs a better and fast connection, as there are a lot of people working there every day.

For that reason when planning the infrastructure, different mobility analyses were carried out in order to figure out the neediest zones. Besides, it was necessary to study the metro network as a whole to provide good connections between different lines and transport modes. However, one of the weak points of the final layout is that there is not a direct connection between the city center and the airport, and even though it is expected to reach a demand of 90 million passengers during the first year of operation, the layout of the L9 has created a lot of controversy.

Another important determining factor of the new L9 is the construction process. The costs have been raised up due to the complexity, as the stations are very deep, down to 70 meters in some places. Moreover, the 12 meter tunnel diameter is unusually big, and it has been necessary to use the biggest tunnel boring machine ever constructed. The construction of the new line started in 2002 and is expected to finish in 2007. Hence, the success of the construction of the L9, which will be largest metro line in Europe, is a challenge for everybody, both for authorities, planners, builders, and even for population.

The main features of the line will be explained within the next chapters, specially the layout of the route. It will be dealt about some location of the stations and some areas, as well as the characteristics of the line and the advantages that L9 will give after its inauguration. However, not everybody is in favour of the L9 and it will be discussed later on, when talking about the pros and cons of this new line.
3.4.2. Layout and stations

The new line will connect the west part of Barcelona with the east part, passing through the city’s districts situated in the northern part. Actually both sides of the line are split up into two different branches, which are called L9 and L10.

L9 is the part going from Terminal entre pistes to Can Zam stations. On the other hand, L10 is going between Zona Franca ZAL and Gorg stations. Both lines have a common stretch in the central part of the line, from Gornal to Bon Pastor stations.

The fact that the new metro is split up in different lines, it permits to give a better coverage of the zone. Hence, L9 covers the airport and L’Hospitalet de Llobregat in the west part and Santa Coloma de Gramenet in the east.

On the other hand, L10 is in charge to give access to the industrial area of Zona Franca and Badalona in the west and east, respectively.

In the central part, the new metro will serve the university area and the districts of Sarrià, Pedralbes, Sant Gervasi, El Guinardó, La Sagrera, etc.

All along the layout, metro will connect with different transport modes, as well as the other metro lines. At least there is one connection between each line.

Moreover, there will be two changeovers with suburban and regional trains. The most important is at La Sagrera TAV station, which will connect with the new high speed train. The other one is Torrassa station, where a new interchange will be built.

Aside from that, metro will connect with the new fairground and the new judicial city in L’Hospitalet.

When talking about construction process, the line has been divided in three stretches due to the different characteristics of the soil along the 40 kilometers of the layout:

- **Stretch 1:** from Airport to Parc Logístic. This stretch, with 9.8 kilometers, will be composed of a double track tunnel like the actual metro lines.
- **Stretch 2:** the three Zona Franca’s stations are constructed as elevated tracks on viaduct due to the amount of services going underground.
- **Stretch 3:** the rest of the line is constructed with two tracks superimposed in the same tunnel.
Hence, there are different procedures to build the line. The stretch 3 is bored with a big tunnel boring machine (TBM), with 12 meter diameter. Such a big diameter permits to put one track on top the other one separated by one slab. However, both sides are connected in order to evacuate the passengers if necessary. The advantage is that each half acts as an evacuation tunnel.

As Copenhagen’s metro, new L9 will run driverless thanks to the automatic control system. It will permit a high frequency, as trains can run with a lower headway time. Hence, the common stretch will have trains at least every two and a half minutes and it will still be enough when the train goes through the different branches, with frequencies down to five minutes.

This automatic driving system is new in Barcelona’s metro, but the backgrounds of other cities will ensure a good operation. Besides, metros have a big capacity, with almost thousand people per train, which is composed by 5 coaches with a total length of 100 meters. That means large platforms at the stations. However, as they will be built in the same tunnel, they will not have a big impact to the final costs. (Ref: www.gencat.net)

On the other hand, the construction costs are really expensive due to the line’s depth. L9 will run between 0 and 90 meters underground in order to dodge the existing metro and railway lines and avoid the sewer service, as well as the other services, such as water supplying, telecommunications, etc.

Hence, the metro goes deeper than usual and specially the stations’ construction costs have raised a lot due to the great amount of excavated soil and the concrete used to hold up the structure.

In short, the layout is conditioned by several factors: first of all, the demand that new metro will fulfil in a future. Aside from that, the connections with different transport modes are really important to improve the whole network. However, the political reasons and the costs, which are extremely related, are determining factors when deciding the final layout. Next figure shows the route over the city:
The mobility analysis of the population and the different surveys to figure out the neediest areas in terms of public transport, aside from the final political decisions, determines the location of the stations. Hence, the final layout is formed by the stations. Looking at the map above, each station has its significance but probably the most important are:

- **Aeroport**: this station, at the end of L9, will connect the metro with the new terminus of the Prat Airport, which is under construction.
- **Fira**: the new fairground in Gran Via will have a metro station. Moreover, there is a big shopping center next to the fair.
- **Zona Franca**: it is composed by three elevated stations that will serve all the industrial area, where thousands people work everyday. This area will be explained later on.
- **Torrassa**: it will be a new changeover between metro and suburban railways.
- **Campus Nord**: this station will fulfil a lot of students’ demand to go to the university area up to Diagonal Street.
- **Sarrià, Mandri, and El Putxet**: these three stations will cover the north central part of Barcelona and they will help to uncongest the traffic road, especially in the peak hours.
- **Sagrera TAV**: it will be probably the main station of the line, as it will have connection with the high speed train. This station, together with Sants, will be the biggest changeovers in the city.
- **Can Zam and Singuerlin**: these stations, situated in Santa Coloma de Gramenet, will be really useful for the citizens, as now this zone is weakly connected by urban railways.

Although the L9 do not pass through the city center, which is one of the most discussed points, it is expected a capable demand of 90 milion passengers within the first year of operation.
As the layout has been divided in three stretches according to the soil conditions and the construction’s procedure, also the stations are different depending on the depth, the crossings with other metro lines and services and the degree of urbanization. Hence, there are three types of stations: (Ref: www.gencat.net)

- **L9 station:** it is a deep station with a shaft cylinder shape. There are two halls, one on the top, reaching the surface, and one on the platforms. Between them, big capacity lifts are fit in order to access as fast as possible. In total, there are 30 stations like this. As Copenhagen’s metro, the platforms are provided with screen doors to avoid the access to the tracks and to insulate the tunnel.
- **Conventional underground’s station:** this is the typical station of the other metro lines. Situated at little depth, there will be 13 stations.
- **Conventional surface’s station:** these are the three elevated stations at the Zona Franca. They are constructed on a viaduct, with parallel tracks and provided with island platforms.

![Fig. 38. Illustration of a L9 station (left). (Ref: www.gencat.net)](image1)

![Fig. 39. Circular shape of L9 station at the beginning of the construction. (Right)](image2)

### 3.4.2.1. Campus Nord

When planning the layout of L9, the stretch between Collblanc and Sarrià stations was discussed. The main point analyzed was the connection of the L9 with the L3. Hence, there were two possibilities:

On one hand to connect the new metro in Zona Universitària station, on the other hand the connection between L9 and Maria Cristina station. Both have their pros and cons.

The first option is more favourable to the students, as the line would have three stations in the main campus: Campus Sud, Zona Universitària and Campus Nord. Moreover, these stations would connect the university area with the northern part of Barcelona, which nowadays remains poor connected by public transport.

However, the situation of Maria Cristina station seems better for its location, as it is a great point of shopping possibilities and business activities with a lot of offices.
The studies carried out by ATM showed that passengers’ estimations were favorable to Maria Cristina alternative. Other analyses carried out by UPC showed that the differences between alternatives were not as important as the ATM analyses (See chapter 4).

Finally, the future improvements in the university area with the construction of other research institutes, as well as the changes of lifestyles and some geological problems in Maria Cristina were the deciding factors for the politicians and the Barcelona’s city council to connect L9 with Zona Universitària (L3).

Next figure shows the exactly layout in this stretch, which goes from Collblanc to Prat de la Riba. Thus, Campus Sud, Zona Universitària, Campus Nord and Manuel Girona are the final stations.

Chapter 4 shows different studies and data about these two alternatives.
3.4.3. Connection between Zona Franca and metro

The Zona Franca is an industrial estate formed in the sixties. It is situated in the southwest part of Barcelona, next to the port and just 7 kilometers away from the airport. Besides, the road communications are optimum, as it connects to the ring roads of Barcelona and to the motorways, and it is next to the main cargo train station. Little by little, Zona Franca was getting importance and thanks to these excellent communications, nowadays is the largest industrial area in Spain and one of the most important in the whole continent. It takes up an area of 600 Ha, which represents the 5% of the total city of Barcelona.

Companies like Seat and Nissan are placed in the Zona Franca, taking a big space, but there are 250 businesses very diversified. Basically, there are three different zones: the industrial estate, the logistics area and the Custom’s Zona Franca. Hence, the whole area generates 45 thousand direct jobs, but more than 275 thousand indirect ones. These 45000 people, which represents the 1,8% of the total Catalan population in active service, are going everyday to the Zona Franca. For that reason, is very important the existing infrastructures to reach this area.

However, the bigger is the industrial area, the more important is a sustained mobility between public and private transport. A survey carried out by El Consorci de la Zona Franca, the Barcelona’s city council and CCOO union showed that most of the workers go to Zona Franca by private transport. (Ref: Guia Zona Franca)

![Market share of the Zona Franca’s workers](Ref: Guia Zona Franca)

Looking at the graphic above it can be observed that 70% of workers use private transport, by car or motorbike. That means a large space in order to park the vehicles. Actually, a quarter of the total surface of Zona Franca is car park. From the rest, only 16 per cent of workers use the public transport. At the moment, there is only bus service acting as public transport. 4 bus lines coming from Barcelona center and one coming from L’Hospitalet de Llobregat are covering the Zona Franca, but it is not enough to fulfil the demand.

Next graphic shows that the office’s space is the same than the car park, approximately of 20 m². However, while the office is a profitable resource, the car’s space is wasted.
However, L10 will arrive at Zona Franca and will complement the bus service. This new transport mode will have two main advantages:

- It will reduce the use of private transport, uncongesting the roads and helping the traffic trade’s mobility. Besides, it will help to create a sustained mobility, which is recently the most discussed question in terms of traffic development.
- The reduction of private transport will reduce the car parks, with the possibility of setting new companies and creating new spaces.

The arriving of the metro, together with different campaigns to reduce the private transport, are great tools to change the actual market shares. For example, inside the industrial area, there are campaigns for the use of bikes or moving on foot. On the other hand, the propaganda about the carsharing and the carpooling can be useful to reduce the number of cars, as well as the use of different transport modes to get the work place.

Moreover, the implementation of Park & Rides in the surrounding areas of Barcelona can be a good solution for the reduction of the road’s congestion, as it happens in some European cities, where these dissuasion techniques have been really useful.

Metro will have three elevated stations in Zona Franca: ZAL, Port and Litoral. Actually they are now under construction. The viaduct will follow the A street. Foneria and Foc Cisell are underground stations situated in the Zona Franca Avenue. Just at the Zona Franca ZAL station, which is the logistics part, it is expected to reach 1725 passengers per day.

Aside from these three elevated stations, the headquarters of the L9 management will be built at the end of the line. Moreover, there will be a depot with a capacity of 20 trains, a maintainance building with more than 35000 m$^2$ and some offices to control the good operation of the metros. (Ref: www.gencat.net)
3.5. The pros and cons of the metro

The new L9 will be really useful for some districts that now are forgotten, specially the northern part of Barcelona. This area does not have a railway line crossing from east to west. Hence, the alternatives are only by public bus or by private transport, but with a high travel time, as the roads are pretty congested, especially in the rush hours.

On the other hand, L9 will connect the city with the airport, doing a big progress for the future. Actually, most of the important European cities have a metro connection with the airport.

Finally, the connection of Zona Franca Industrial Estate by metro will help to develop a sustained mobility, reducing the use of private transport.

Although the L9 is still in construction and it is more difficult to find out errors, the layout has been really discussed, specially the fact that the new metro do not have direct connection between the airport and city centre.

Of course, L9 will be great for people living in Sarrià, as they will have direct connection to the airport. Probably they will get the airport in 20 minutes. Now, this travel is 45 minutes long.

On the other hand, they have already a direct connection with the city center through the L6 of FGC.

However, people living in Badalona will have two possibilities. The first one is the actual with the suburban train, connecting Badalona’s train station with the airport in 25-30 minutes. The other option will be the new L9, but it will be longer, as there will be a lot of stops.

Hence, people would not take the metro to go to the airport, but they will have a fast connection with the high speed train station in La Sagrera.

Anyway, the layout of L9 will be against people going from airport to the city center, especially for tourists and businessmen. They will have to change the line in some point, increasing the travel time. Hence, people would choose the suburban train, which is the actual option.

The fact that metro will connect the airport with the high speed train station in La Sagrera passing through the northern part of Barcelona is due to the mobility analysis made by planners and the necessity of these districts, but also due to the political reasons. The cost of the L9 is so high that local and Catalan governments can not pay the whole investment. For that reason, some of the funds are coming from the European Union and the layout is conditioned a little bit for these European funds.

However, the layout of the L9 is not as bad as seems and future developments could improve the whole metro, enlarging some lines and restructuring the network.

For example, the analysis made by Sergio Juárez has different points: (Ref: Juárez)

- After the enlarging of L2 from Sant Antoni to Foc Cisell, where there is a stretch included in the PDI, this line would continue from Foc Cisell to Airport, taking the L9 stretch.
- The possibility to enlarge L3 or L11 from Trinitat Nova to Bon Pastor stations and follow the line to Görg station.
- To take the stretch of L9 between Can Zam and Guinardó and create another crossing line from east to west under Travessera de Gracia Street, which would connect with the tram and the L8.
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- To create a different line in Zona Franca, similar to the actual L11.
- After that, the stretch between Guinardó and Consorci in Zona Franca could be part of a circle line if there was a future extension.

Next figure shows these ideas:

![Diagram of future metro network ideas](image)

Although these ideas are pretty good, not all of them are viable. For example, the enlargement of L11 to Gorg; this line is a light rail with characteristics adapted to the orography between Can Cuiàs and Trinitat Nova. The frequency is lower than usual and the extension of the line would imply different characteristics.

Moreover, the Zona Franca line, connecting with L9, would make no sense being an independent line. People would prefer the car instead using the public transport, as the travel time would be higher. Hence, the aim to have a sustained mobility and reduce the private transport would be an utopia.

On the other hand, the connection of the airport with the city center using L2 and the creation of a circle line around Barcelona are good ideas and they could be a good solution in a future within new Master Plans.

However, L9 has been planned with the last advanced technology in terms of construction, safety and operational procedures. L9 is much more advanced than the existing lines and it could be difficult and too expensive the adaptation of the actual lines to the new L9’s configuration system. L9’s trains are faster and they can run with lower headway times thanks to the driverless system controlled by ATC system.

This automatic operation system will be similar to the Copenhagen’s metro and other European metros.

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Another point of discussion is the configuration of the stations. The metro has to pass really deep in order to avoid the existing metro lines and the public services along Barcelona. That means deep stations until 70 meters. Although they will have big and fast elevators that will be synchronized with the arrival of the metro, the access’ time will be higher than the conventional stations. Hence, depending on the stretch that people have to do, they will prefer to use the buses or other transport modes instead wasting so many time to get and leave the metro’s station. Besides, it is assumed that lifts will work perfectly, but everybody knows that operational problems will come up due to the wear out, the maintenance, etc., as it happens now with several metro’s escalators.

The depth of the stations and the metro line could be a problem if there is any emergency to evacuate the passengers. Although the new line is fitted with the most advanced safety system, people are careful when they have to down 70 meters under the streets. These situations could reduce little by little the catchment area of the stations, when people are fed up of the operational problems. For that reason is really important to have different alternatives and to solve the problems as soon as possible.

Finally, the construction’s process has created some controversy. On one hand, the largest tunnel boring machine ever used, with 12 meters of diameter, seems a strategy to show the government’s power. Was it necessary such a big tunnel? They spent a lot of money to bring the TBM from Germany and they are spending a lot of money now to construct the line, much more than the expected initial budget. On the other hand, the fact that the same tunnel will be used for both directions, one on top the other, questions the success of the train’s operational system, as well as the safety system in case of an emergency.

In short, L9 is pretty good to complement the actual metro network, acting as a mesh. It is a good tool to fulfil the demand in some districts and the transverse direction in the northern part of Barcelona is the main feature of this new line, as well as the Zona Franca’s stretch and the connection to the airport. However, as this line is still under construction, nobody knows its success in a future. The metro’s operational and the estimations of passengers, with 90 milion passengers per year, are a mystery, as well as if the layout and the stations are the best ones or not.