

METRO & TRAM ATLAS SPAIN

(Robert Schwandl)

Introduction

While first-generation tramways have survived in most major cities in central and eastern European countries, Spain followed the international trend set by France and the UK, and by the mid-1970s, virtually every tramway system had been abandoned. In Madrid and Barcelona, metro construction was accelerated instead, whereas public transport in the other Spanish cities henceforth relied on diesel buses, and in a few cities also on trolleybuses. Just two lines escaped the general wave of system closures, namely the 'Tramvia Blau' in Barcelona and the 'Tramvia de Sóller' in Mallorca, which have always been more of a tourist attraction.

The first modern tramways had been implemented in France in the mid-1980s (Nantes, Grenoble), and with the new low-floor technology, this type of transport was also resurrected on the south side of the Pyrenees. In 1994, Valencia became the first city in Spain to open a modern tramway. It was developed as a side project together with the upgrading of the former suburban railway network to a metro system. Subsequently, nearly every city in the country started planning its tram network, which led to some premature births (see Vélez-Málaga, Jaén), while other projects were eventually shelved as a result of the financial crisis which struck several years later (e.g. León, Burgos). Although some of the new systems, notably in Zaragoza, Tenerife and Vitoria-Gasteiz, have been very successful, Spain has the world's greatest concentration of aborted, deferred and sometimes poorly executed tram routes, mostly due to hasty planning or never-ending local political disputes. Systems like those in Jaén and Bahía de Cádiz, or the interurban route from Sevilla to Alcalá de Guadaira, are included in this atlas as there is some hope that they may start operation in the medium term, while others like the interurban route from Manacor to Artà in Mallorca, or the line to the UPV campus near Bilbao, are only briefly mentioned.

While the tramway systems in the two major cities of Madrid and Barcelona are still limited to the outer districts and suburbs, their respective metro systems have continued to grow over the past 20 years. By the time the financial crisis was starting to dominate day-to-day politics, Madrid's metro expansion had achieved a level of saturation, and thus there are currently no unfinished urban rail construction projects. In Barcelona, however, an ambitious project to build the driverless L9/L10 literally got stuck halfway. In Sevilla, where the world's first low-floor metro with platform screen doors is in operation, the present line will probably remain the only one for many years to come, while Palma will have to continue to put up with the title of "most useless metro in the world". In the two other metro cities, Valencia and Bilbao, which had developed their underground systems by integrating old suburban railways, expansion continues slowly. At the same time, the second largest city in the Basque Country, Donostia/San Sebastián, is also gradually developing a kind of metro line by upgrading an existing suburban railway.

Apart from the country's only trolleybus line in Castellón, which features a dedicated busway along most of its route, the new fashion of 'Bus Rapid Transit' (BRT) or 'Bus à haut niveau de service' (BHNS) has not yet arrived in Spain.

ALICANTE

Like Valencia's metro, Alicante's tramway is operated by the Valencian Railways 'Ferrocarrils de la Generalitat Valenciana' (FGV). The entire autonomous region of Valencia is bilingual, although within the city of Alicante, Spanish place names are mostly used.

The urban rail network is branded the TRAM, and consists of the proper urban lines L2-L4 and the electrified interurban line L1 to Benidorm. The as yet non-electrified FGV route from Benidorm to Dénia is operated with DMUs as the L9.

The Cercanías network in the Alicante region is rather modest: Line C-1 runs approximately every hour to Murcia, uses DMUs and requires a change of direction at Sant Gabriel station. Line C-3 also runs approximately once an hour on the electrified route between Alicante and Sant Vicent del Raspeig.

Lines L2-L4 lie completely within fare zone A, where a single ticket costs €1.35, although multi-ride tickets are also available (Bono 10 for €7.60). A single trip to Benidorm (Zone D) costs €4.85. Using a TAM Mòbilis card (€2), passengers can transfer to city buses (€1.45/8.70) for a small additional charge. For visitors, the AlicanteTouristCard is on offer (24h-€13, 48h-16 €, 72h-€18, incl. bus, tram and sightseeing tour).

The history of the TRAM goes back to the year 1914, when the first section of the Alicante – Dénia metre-gauge railway opened as far as Altea. By 1915, the entire 93 km route to Dénia was operational. Originally built by a private company, the railway was transferred from the national narrow-gauge railway company FEVE to the regional FGV on 1 January 1987.

A 'tram-train' network incorporating the Dénia railway line was planned in the late 1990s. As the original terminus La Marina was located some distance from the city centre, a 700 m single-track extension was built to a new terminus at Puerta del Mar on the Esplanada. At the same time, the existing route was electrified up to La Isleta (then Albufereta – 2.8 km), enabling trial operation with the Combino prototype from Siemens to be launched on 17 March 1999. At the end of May, this vehicle was replaced with a tram from Valencia. On 26 August 1999, the hourly trial service was extended to Lucentum.

With the trial operation successful, construction work on a larger network began in late 2001, now advertised as 'TRAM Metropolitano de Alicante'. Between Lucentum and Costa Blanca, the route was realigned further north. The following section along the beach was doubled and lined with palm trees to integrate it into the esplanade. South of Fabraquer station, the coastal road is crossed on a viaduct, and between Pla Barraques and just before El Campello, a grade-separated alignment was achieved by putting the line into a partly covered cutting. On 15 August 2003, tram operation between Puerta del Mar and El Campello started with four additional vehicles of class 3800 transferred from Valencia. Since these are single-ended cars, a turning loop was built 700 m north of the new terminus. At the city end, drivers had to use the auxiliary driving console to reverse the trams via a loop at the old La Marina station. The regional trains to Benidorm and Dénia were cut back to El Campello, so mixed operation with trams and DMUs was no longer necessary.

On 10 May 2007, after three and a half years of construction and the delivery of the first Flexity Outlook vehicles (the class

3800 trams were returned to Valencia), the first section of the underground city centre route opened up to the centrally located station Mercado. Most of this first tunnel runs below Benacantil mountain. East of MARQ station, the trams emerge from the tunnel and cross Av. de Dénia on a viaduct. The following grade-separated junction for line L2 was built at the same time. Some 750 m northeast of Sangueta, the new route merged with the old route, which at the time still ran directly alongside the coastline. The direct connection between La Marina and Sangueta was only established on 18 June 2010, when the extension to Luceros came also into operation. Between Puerta del Mar and Sangueta, shuttle line 4L was introduced to allow line L4 to use the new tram tunnel, too. By that time, the TRAM was supposed to continue to the main railway station, but since its reconstruction has been delayed by several years, it is currently uncertain when the construction of the underground tram station on the south side of the ADIF station will start.

On 15 June 2007, shortly after the commissioning of Mercado station, the first section of the loop into the Cabo Huertas area opened to Av. Naciones. This route features a typical modern French-style tramway alignment. On 30 July 2007, line L1, now with new tram-train vehicles from Vossloh, started running to Creueta. Since 2 June 2008, the route has been fully electrified all the way to Benidorm. The L4 loop around Playa de San Juan was eventually completed on 18 December 2009.

Line L2 to Sant Vicent del Raspeig (6.9 km) was already fully operational in 2011, but the financial crisis delayed the opening of the university line until 4 September 2013. After diverging from the trunk route in a grade-separated junction, line L2 stops at La Goteta before disappearing into a roughly 400 m long tunnel. The rest of the route lies on a dedicated right-of-way, which is often covered with lawn and lies either in the middle of or alongside the wide city streets.

To eliminate the single-track bottleneck between Sangueta and La Isleta, the construction of a new tunnel under the Serra Grossa mountain range started in 2010, but due to a lack of funds, work has been suspended for several years. This tunnel will eventually allow denser headways on lines L3 and L4. Another victim of Spain's austerity measures was the under-used shuttle line 4L, which was discontinued on 30 June 2013. With all the workshops having been moved to the depot at El Campello, the old station La Marina is no longer needed. Given the uncertainty regarding the completion of the extension to the ADIF railway station, a western TRAM extension towards the airport cannot be expected in the foreseeable future.

BARCELONA

... will be covered in the mid-term future in a dedicated book, *U-Bahn, S-Bahn & Tram in Barcelona*

BILBAO

The largest city in the Basque Country and the capital of the Bizkaia/Vizcaya province is a paradise for railway enthusiasts: in addition to the metro and tram, Bilbao (in Basque also Bilbo) offers two other narrow-gauge train operators, EuskoTren and FEVE, the broad-gauge Cercanías network run by Renfe, as well as several funiculars, inclined and vertical lifts, and last but not least, the transporter bridge across the Ría de Bilbao.

Despite or because of this variety of transport modes, Greater Bilbao has no real fare integration, and the 'Consorcio de Transportes de Bizkaia' plays merely a coordinating role. In every form of transport (incl. Bilbobus and Bizkaibus), however, the respective fare can be paid with the common rechargeable stored-value Barik card, which can be purchased for €3.00. The metro has a 3-zone fare structure, with a single journey charged at €1.50, €1.70 or €1.75, respectively; if paid with the Barik card, it is just €0.82/0.99/1.10. A day pass exclusively for the metro is available for €4.60 (valid in all zones). Similar rates apply for Euskotren, Renfe and FEVE within Greater Bilbao. A tram ride costs €1.50 (with Barik €0.73), and a day pass just for the tram €4.40! When transferring from one operator to another, no discount is granted.

Metro Bilbao

20 years ago, Bilbao became the fourth metro city in Spain. Unlike the classic metros in Madrid and Barcelona, Bilbao's metro has its origins in an old suburban railway, much like in Valencia. Its history goes back to 1887 when a private company built a narrow-gauge line from Bilbao to Areeta (Las Arenas). This railway followed the right bank of the River Nervión, which in its lower reaches is usually referred to as Ría de Bilbao. In 1893, another line was added, connecting Areeta to Plentzia. Later, more metre-gauge routes appeared, for example, from Lutxana to Mungia via Sondika and from Bilbao to Lezama via Ola (see Euskotren p.52). By 1929, the route to Plentzia had been electrified, and in 1947, it became part of the FTS network (Ferrocarriles y Transportes Suburbanos). It was integrated into FEVE, but only from 1977 until 1982, when most of the narrow-gauge routes in the Basque Country were merged in the newly-founded company 'Eusko Trenbideak - Ferrocarriles Vascos S.A.' (ET/FV), now simply known as 'Euskotren'.

During the 1970s, the idea of a metro in the Greater Bilbao region had developed to a point where the 'Consorcio de Transportes de Bizkaia' was founded in 1975. This body, which would be responsible for construction, approved a basic network two years later. A Y-shaped network with two lines was the obvious choice due to the high population density on either side of the River Nervión. After several years of delays due to the end of the Franco regime and the subsequent democratisation and regionalisation of Spain, the first construction contracts were only awarded in the mid-1980s. Since the new metro was to take over the existing line from Lutxana to Plentzia, the metre gauge was maintained, but the new vehicles nevertheless boast a generous width of 2.80 m. In the first stage in 1988, the stop in Erandio was rebuilt below ground, and a year later, the construction of the underground city centre route began, too. Thanks to the stable soil in the Bilbao region, the modern mining method NATM (New Austrian Tunnelling Method) was able to be used on most sections, even for the majority of the underground stations. The two river crossings, however, required some special solutions. Between San Mamés and Deusto, two 86 m caissons were sunk into the riverbed, while between Abando and Casco Viejo, the riverbed had to be consolidated by means of jet grouting before the tunnel could be excavated underneath. The

tunnel between Sarriko and the junction at San Inazio was built by cut-and-cover. The proven NATM was later also used in the construction of line 2, both on the northern branch, including the river crossing, and in the Ariz/Basauri area, where rather deep stations were inevitable due to the hilly terrain and densely built-up neighbourhoods. Also for topographic reasons, the section around Ansio station was constructed from the surface, while a viaduct spans the Galindo Valley and the Cercanías tracks in the area of Urbinaga station (a Cercanías station was planned in this area, but has not materialised). On the southern leg in Etxebarri, the River Nervión is crossed three times on bridges. This above-ground section takes advantage of a former railway link between Matiko and Ariz.

In Santurtzi, an underground funicular was built to link the metro station to the higher-lying district of Mamariga, while the Casco Viejo metro station features a lift up to the district of Begoña, which requires a metro ticket. An inclined lift is available outside the paid area at Aiboa station.

British architect Sir Norman Foster was hired to create a distinctive design for the stations, resulting in a very simple and elegant, albeit rather uniform look with spacious vaults dominated by bare concrete. His design concept was pursued to the very last station opened at Kabiezes, and has also been implemented on the new line 3 (see page 53). The stations taken over from EuskoTren and the other above-ground stations, however, feature a slightly different style, and the cut-and-cover metro stations Sarriko, San Inazio and Ansio as well as the lowered stations at Areeta and Algorta also deviate from the standard type. At the surface, besides the metro logo, the entrances, popularly known as 'Fosteritos', have become the most distinctive element of the metro.

While the stations located in the important town centres of Areeta and Algorta were put underground during the line's upgrade to metro standard, further measures were later implemented on the former Euskotren route, in particular to eliminate the numerous level crossings. The most recent measure was the commissioning of a tunnel north of Bidezabal in 2012. But only with the lowering of the route around Urduliz station (543 m), which was started in mid-2015, will the Metro become completely grade-separated. The section between Urduliz and Plentzia, which is only served every 20 minutes, will remain single-track. Between Bidezabal and Berango, the three-track Ibarbengoa-Getxo station was inserted in 2009/10, but due to a lack of development in the area, it has not yet opened.

The first section of the Metro was opened on 11 November 1995, 10 days after the cessation of Euskotren operation, and by 2014 as planned, the Y-shaped network had been completed in various stages, so that today two lines are available. On the shared cross-city section, they provide a 2½-minute headway during peak hour service. The walk-through vehicles from CAF were initially made up of four cars, but starting in 2009, some were extended with a fifth car. The trains operate on the left side in semi-automatic ATP/ATO mode. 1500 V DC is supplied via an overhead line.

TRAM

Seven years after the opening of the first metro line, Bilbao also launched its first modern tram line. Today, the network still consists of just a single line operated by the Basque railway company Euskotren: Initially branded 'EuskoTran', it is now known as 'Euskotren tranbia'.

The tram route starts single-track outside Euskotren's terminal railway station in the Atxuri district, just south of the old town. It then follows the right bank of the River Nervión to Teatro Arriaga, the only stop with a passing loop, before crossing the river on the Areatzako Zubia. The stop Abando is located within walking distance of ADIF's two terminal stations (Renfe and FEVE). After a right turn, it runs down to the river, where the route finally becomes double-track. Up to Euskalduna, the tramway now takes advantage of the former Renfe route, which was abandoned in 1999. Instead of a railway corridor through an industrial riverfront, the tramway now features lawn-covered tracks along a new esplanade, and serves the Guggenheim Museum and the redevelopment area at Abandoibarra. Next to the San Mamés soccer stadium, the trams reach an important transfer hub which includes Metro, Cercanías and coach stations. The stop Ospitalea/Hospital is located close to FEVE's Basurto Hospital station, which is now also underground. The tram route terminates for the time being at La Casilla, but it was actually supposed to continue a further 700 m south to the district of Errekalde. A link between La Casilla and Abando to create a circular route, including the double-tracking of the Abando – Pío Baroja section, has also been proposed.

The CAF Urbos vehicles in service in Bilbao are a forerunner of the trams used in Vitoria-Gasteiz. In Bilbao, they have just three sections with only 70% low floor. Only car no. 408, the prototype for Vitoria-Gasteiz, boasts a continuous low floor.

In addition to the city centre tramway, several other tram routes were planned for the Bilbao region, but none have materialised. The project that had made the most progress was a line from Leioa metro station to the campus of the UPV (Universidad del País Vasco), where the construction of a depot had already started in 2010. In the second phase, the Ría de Bilbao was to be crossed on a bridge for which an architectural competition has already been held, and the line was to be extended to Urbinaga metro station.

From the terminus at Atxuri, repeated proposals suggested extending the tramway on existing Euskotren tracks south to Etxebarri, as these tracks are likely to become redundant once the Euskotren services have been connected to metro line 3, which is now under construction.

Given the current economic situation and several projects which need to be completed first, the implementation of any further tram projects is currently uncertain.

EUSKOTREN

In the Greater Bilbao region, Euskotren (short for Eusko Trenbideak - Ferrocarriles Vascos S.A.) operates not only Bilbao's tramway, but also several narrow-gauge suburban railway lines.

Today's *Línea del Txorierri* is all that remains of a larger suburban rail network which lost its busiest line when the San Inazio – Plentzia route was handed over to the Metro in 1995. The remaining portion of the Plentzia line, i.e. the section between San Inazio (about 500 m east of the metro station of the same name) and San Nicolás (now Casco Viejo/Zazpi Kaleak), was connected to the Bilbao – Lezama line in 1996 via a short new tunnel. A lack of demand caused the San Inazio – Deustu section to be

abandoned in 2000. To allow for the construction of metro line 3, the operation between Deustu and Casco Viejo was curtailed at Matiko on 15 May 2010, while a half-hourly service between Casco Viejo and Lezama was maintained. The Txorrieri route is mostly single-track, and the trains used to change direction at Sondika station. Between 2009 and 2012, a new double-track tunnel (1875 m) was partially built under the Artxanda mountain, but the construction start on the access routes was delayed until 2015. In the medium term, Euskotren services are to serve the airport in Sondika, too. On 1 June 2015, the link between Lutxana and Sondika, a depot access which had been without passenger service since 1996, was reactivated and trains from Lezama were rerouted to Lutxana, which has finally allowed Casco Viejo station to be rebuilt for the new metro line 3. Until further notice, the Loruri-Ciudad Jardín – Sondika section is being served by a shuttle train.

From Atxuri, regional trains depart 3-4 times an hour. At Amorebieta, some 20 km east of Bilbao, a branch to Bermeo diverges from the main route to Donostia/San Sebastián. Suburban services around Bilbao are partly operated with older EMUs of class 200 and 300, but like in Donostia, some new class 900 trains are also used.

Construction work on **Metro Line 3** started in summer 2009. This line was conceived to connect the higher parts of the city with the city centre. The look of its deep stations at Uribarri, Zurbaranbarri, Txurdinaga and Otxarkoaga closely resembles the design developed by Sir Norman Foster for lines 1 and 2. For a long time, it was not clear who would become the operator of this line, but in the end, Euskotren was chosen, enabling the new 5.9 km rail tunnel between San Antonio de Etxebarri and Matiko to be integrated into the existing suburban network. This will enable regional trains to run directly into the city centre. On the metro section, a 7½ minute service is planned to start in December 2016 at the earliest. From Matiko, trains will continue through the new Artxanda tunnel every 15 minutes to terminate at Lezama. In the long term, regional trains may serve the airport, too. From San Antonio de Etxebarri station, two 250 m parallel inclined lifts will connect the higher neighbourhoods of Kukullaga and San Antonio.

The future of the railway line between Atxuri and Etxebarri, opened in 1882, is still uncertain. If railway operations are completely withdrawn from Atxuri station, the line could be connected to the tramway instead.

In July 2014, Euskotren ordered twelve three-car units of class 900 from CAF to provide metro service on line 3. A fourth car can be inserted if required. It is intended to replace the older trainsets with a further 16 units.

RENFE & FEVE

In the Bilbao area, Renfe operates three Cercanías lines on broad-gauge ADIF tracks. The northern lines C-1 to Santurtzi and C-2 to Muzkiz run every 30 minutes during daytime hours, and every 20 minutes during peak hours. As there are no other passenger trains on these lines, the stations are equipped with high platforms to allow stepfree boarding. The southern line C-3 follows the main line to Madrid, with trains to Llodio every 10 minutes in peak times, and otherwise 3-4 times an hour.

Until 4 March 1999, the northern lines C-1 and C-2 used to run along the riverfront to arrive at La Naja, a station which was located below the plateau in front of the FEVE station. In conjunction with an ambitious urban redevelopment project, this route was dismantled and the suburban trains were redirected to the terminal station Abando via the existing link railway. Following the covering of part of this urban section, new stations opened at Zabaltzuri, Ametzola, Autonomía and San Mamés.

In the early 1990s, when Metro line 2 was planned to be built along the left bank of the Ría de Bilbao, the closure of the parallel Renfe line had been considered. But although the Metro serves most town centres directly, the Cercanías lines, which run close to the river, survived because of the steep slopes in those towns.

On line C-3, La Peña station was inserted on 25 January 2005, and the underground station Miribilla on 18 December 2008, which increased the urban character of the Cercanías lines in Bilbao.

All three lines continue to be served by class 446 rolling stock from the 1990s.

Since 2013, the national narrow-gauge railway company FEVE (Ferrocarriles de Vía Estrecha) has been integrated into Renfe, while the railway infrastructure is maintained by ADIF (Administrador de Infraestructuras Ferroviarias). The FEVE brand name, however, is still used for a number of narrow-gauge lines, in particular along the Cantabrian coast in northern Spain. On the electrified section between Bilbao-Concordia and Balmaseda, FEVE operates regional trains approximately every half an hour. The route within Bilbao has seen some changes in recent years: on 29 May 1998, the underground station Ametzola, where interchange with Cercanías lines C-1 and C-2 has been provided since 1999, was opened at the western portal of the tunnel leading to the historic Concordia terminus. Starting in 2007, the following section was put underground and Basurto station was relocated about 200 m further north. Since 25 January 2010, FEVE trains have traversed the entire built-up area in tunnel.

Miscellaneous

In addition to the railways already described above, Greater Bilbao has a number of other curious transport items to explore:

The **Puente Colgante** [the hanging bridge], officially called Puente Vizcaya/Bizkaiko Zubia, is a transporter bridge which spans the 160 m wide Ría de Bilbao between Portugalete and Areeta. Opened in 1893, the structure even allows large ships to enter the estuary. It still plays an important role as a link between the two river banks for both pedestrians (€0.35) and cars. The gondola glides back and forth almost continuously. For €7.00, a lift takes visitors to the footbridge, which lies 45 m above the river.

[www.puente-colgante.com]

In the municipality of Getxo, which includes Areeta, there are also two outdoor **inclined lifts**, one of which connects the beach promenade to the town centre of Algorta (€0.20), while the other makes it easier to reach the entrance to Aiboa metro station.

A bit out of the way in the municipality of Valle de Trápaga-Trapagaran, Euskotren operates the 1198 m long **Funicular de Larreineta**. Opened in 1926, this railway negotiates a difference in altitude of 342 m with its horizontal cars, providing a splendid view of the entire region around the mouth of the Nervión. It operates every half an hour and a ticket costs €1.75 (with Barik card €0.89).

A must for every visitor to Bilbao is a ride on the **Funicular de Artxanda**, as from the mountain you can enjoy a wonderful view

of the city. The funicular starts in an underground station located almost directly below the (future) Matiko metro station. Emerging from the tunnel just above the Euskotren stop Loruri-Ciudad Jardín, it reaches the upper station after 770 m without any intermediate stops. The difference in altitude is 226.5 m. This funicular was opened in 1915, and is currently operated every 15 minutes by the Bilbao city council. A ticket costs €0.95, and with a Barik card just €0.58.

Due to the hilly topography of the city, Bilbao has not only the lift up to the district of Begoña mentioned in the Metro chapter, but no less than 17 other public lifts, all free of charge. However, the historic “Ascensor de Begoña”, which from its observation deck even afforded a view into Euskotren’s Casco Viejo station, has been out of service since July 2014.

BAHÍA DE CÁDIZ

The capital of the Andalusian province of Cádiz lies on a peninsula, which naturally leads to bottlenecks for modern road and rail traffic. The city has been served by trains via an isthmus since 1861. Between Cádiz and Jerez de la Frontera, this route is served by the region’s only Cercanías line at least once an hour, with extra trains in peak times. The branch between Las Aletas and Universidad, however, labelled C-1a, only has six trains a day, all of which continue to Jerez. The line is operated by Renfe with Civia class 463 rolling stock. At the southern end of the peninsula, Cortadura station was added in 1998, and by 2002, the tracks which for decades had divided Cádiz had been placed in a tunnel on a 2.5 km long section, with Avenida Juan Carlos I now running on top. In December 2013, an underground section through Puerto Real was also put into operation.

At the beginning of the millennium, in order to improve connections between the provincial capital and the growing cities around the Bay of Cádiz, a real tram-train of the Karlsruhe type was proposed, here generally referred to as ‘Tren-tranvía’. Since the existing railway line in the region has Iberian broad gauge (1668 mm), this also had to be used for the new sections to be constructed. The regional government, the Junta de Andalucía, designed a network with two lines. The first line will connect Cádiz with San Fernando and Chiclana. Of the total length of 24.5 km, 10.3 km corresponds to ADIF’s Sevilla-Cádiz line through Cádiz and across the isthmus, while the remaining 14.2 km consists of new urban tram routes through San Fernando and Chiclana, as well as an interurban route between these two towns. On the interurban section and the ADIF line a top speed of 100 km/h is envisaged.

The first construction work began in early 2007 at La Ardila, where the tram route diverges from the ADIF line in a grade-separated junction. Soon after, construction was also launched on the section through San Fernando, where a long section of the main street Calle Real was pedestrianised. To reduce the space occupied by the trams, some sections were built with interlaced tracks. In the Chiclana area, however, construction activity did not get into full swing. While tracks have been lying on the southern section for several years now (single-track along Av. Reyes Católicos), the widening of the bridge over the River Iro and the construction of the route through the northern part of town along Calle Mendizábal and Travesía Alameda de Solano only started in early 2015.

In November 2014, a few days after the northern track had been connected to the ADIF network, the first test runs were carried out between La Ardila, in the west of San Fernando, and Pinar de los Franceses, in the north of Chiclana. Just west of the junction, where the new line joins the ADIF route, a station called Río Arillo is planned to allow transfer to trains heading to Jerez.

Trial operation on part of the line could start before the end of 2015, but the opening date is yet to be determined, especially as it is not yet clear who will operate the service. Initially, Renfe was to become the operator in order to optimise train coordination on the shared route. On the entire route, a 15-minute headway is envisaged.

The decision to implement a tram-train also required some special parameters for the vehicles to be procured. In March 2009, CAF was chosen to manufacture seven three-section tram-train vehicles to run on 1668 mm gauge tracks. They had to be able to operate both under the ADIF catenary at 3000 V DC as well as on tram routes electrified at 750 V DC. In order to stop at both low platforms (400 mm) in urban areas and high platforms (760 mm) on railway routes, the trains feature two doors for each access height on each side, making the vehicle low-floor only in part of the two end modules. To enable wheelchair users, for example, to board from a high platform and get off at a low platform, a lift was installed inside the vehicle.

Before the Andalusian regional elections in March 2015, the Junta confirmed its intention to implement the second line, too. Starting from the railway station in Cádiz, it would cross the bay on the new Puente de la Pepa and link up with the short Cercanías branch which runs from the university to Las Aletas, from where the tram-trains could continue on ADIF tracks to El Puerto de Santa María and the airport at Jerez de la Frontera (220,000 inh.).

Inside Cádiz, an extension in the style of a tramway has been proposed to take passengers further into the city centre, either to Plaza de España or to circle the old town.

DONOSTIA/SAN SEBASTIÁN

The capital of the Basque province of Gipuzkoa is known by two official names, Donostia in Basque and San Sebastián in Spanish. Although the coastal city itself is not big enough for a metro system, the metropolitan area, most of which extends eastwards up to the French border, has a population of almost half a million. For over 100 years, this densely populated corridor has been served by two railway lines running largely parallel to each other. The broad-gauge ADIF route, on which Renfe operates Cercanías line C-1, is part of the Paris – Madrid rail corridor. Between the border stations Irún and Hendaye, there are mainline tracks with both 1668 mm broad gauge and 1435 mm international gauge. Parallel to them, the border river Bidasoa is also crossed by the metre-gauge line, which is now gradually being upgraded to become the **Metro Donostialdea**. Popularly known as “Topo” [mole] due to its numerous tunnels, the line is part of the rail network operated by the Basque railway company ‘Eusko Trenbideak - Ferrocarriles Vascos S.A.’ (ET/FV), or simply ‘Euskotren’. The entire length of the line from Lasarte-Oria to Hendaia is served at least every 30 minutes throughout the day, though mostly every 15 minutes. On part of the western leg, there are additional trains heading for Zumaia and Bilbao.

Although Euskotren’s fares are not integrated with the urban bus lines operated by Dbus, the same rechargeable stored-value

card called Mugi can be used on both. With the card, a single train fare costs €1.00 (€1.25 € to Irun or Hendaia), while cash fares are €1.60 and €1.85, respectively. A day ticket for €5.00 is only available at Hendaia! All stations are equipped with access gates.

While the narrow-gauge line from Bilbao had reached San Sebastián in 1901, the eastern route, electrified from the start, was completed to Irun in 1912 and to Hendaia in 1913. Until 1954, the Topo trains used to run into the city centre using the urban tram tracks.

Since the narrow-gauge network east of Bilbao was handed over from FEVE to ET/FV in 1982, the system has continuously been modernised and upgraded in order to gradually develop an urban metro line modelled on the metro lines in Valencia, although mixed operation with regional trains will continue on the western leg. The first milestones were: in 1993, an underground station at Anoeta; on 9 October 1998, a single-track elevated branch from Errekalde to Lasarte-Oria; on 10 March 2005, the double-tracking of the route west of Amara station, including a 1.8 km tunnel and Lugaritz station; on 5 March 2011, a new elevated route between Erreterria and Oiartzun; on 4 October 2012, a new double-track tunnel between Loiola and Herrera with the 45 m deep Intxaurreondo station and the lowered Herrera station; in 2012, a new alignment including a 955 m tunnel between Añorga and Errekalde. In July 2016, the underground branch from Herrera to Altza is scheduled to open, and a further extension via Pasaia to Galtzaraborda is planned. At the intersection with Renfe's Cercanías line, an interchange called Riberas de Loyola has been proposed.

The most important project in Donostia is the long-awaited underground cross-city route, which will make reversing at Amara unnecessary, and bring passengers directly into the city centre and to the university campus in Benta Berri. After some delays due to a change of government in the Basque Country, construction is currently due to start in 2017, with completion set for 2020/21. The tunnel will be excavated using mining methods to reduce disruption in the central area. In the future, the Metro Donostialdea is planned to run every 7½ minutes between Lasarte-Oria and Oiartzun.

Whereas in the Bilbao area some older trains can still be seen, on Euskotren's Lasarte-Oria – Hendaia line (for a long time shown as line 2) only new four-car trains of class 900 are in service. They are suitable for suburban as well as metro operation. The Topo line is operated on the left side, using a 1500 V DC overhead line.

GRANADA

Granada, the capital of the homonymous Andalusian province and famous for its Arab fortress Alhambra, decided in 2005 to build a light rail line. Although it is mostly referred to as 'Metropolitano de Granada', it is a typical French-style modern tramway, although with a central 2.4 km tunnel section which actually skirts the city centre on its western side. The main axis through the old town, however, has been served every few minutes by the special bus line LAC (Línea de Alta Capacidad) since June 2014. The three underground tram stations feature 68 m island platforms, and the surface stops, which have mostly side platforms, were also designed with this length to allow the use of coupled trams.

The construction of the northern section began in 2007. The route starts in the centre of the northern suburb of Albolote and follows the main road (Calle Motril/Camino de Albolote) to the next suburb, Maracena. On the southern edge of this town, the trams leave the road alignment to dive under motorway A-44 and the railway line towards Linares-Baeza and Almería. Just south of this structure, the tracks from the depot join the line. After that, the trams take a detour via some new housing estates before reaching the coach station, which opened in 1995. From here, they continue in the median of the wide city streets to Caleta, the temporary terminus near the ADIF railway station, whose planned reconstruction in conjunction with the arrival of the new standard-gauge railway from Antequera contributed significantly to the delays suffered in the construction of the tramway. Work on the Caleta –

Universidad section had therefore hardly started by mid-2015.

After stopping at the university, the trams will disappear in the tunnel, which was mainly built by cut-and-cover along Camino de Ronda. From Recogidas station, the shopping street of the same name leads directly into the heart of the old town. After the third underground station, Alcázar Genil, on the south bank of the river, the trams will emerge from the tunnel on a 150 m long ramp and continue in the median of the wide boulevards through new neighbourhoods with major sports facilities, educational institutions and the new university hospital. Via another short section in a cutting, the line then passes once again under motorway A-44 before finally reaching the neighbouring town of Armilla. While up to this point, the route boasts a dedicated right-of-way, the space available to the west of the stop Fernando de los Ríos is rather limited. A single track was therefore embedded in the mostly pedestrianised street Calle Real de Armilla to lead the trams to the last stop in the town centre at Plaza Poniente. A trip from Albolote to Armilla is expected to take 47 minutes.

The 15 trams Granada ordered are rather similar to those in service in Málaga. While the first was already delivered from CAF-Santana's plant in Linares (Jaén) in September 2012, the others remained in the factory for a while. The second came in October 2014, followed by the third in February 2015, allowing trial runs to begin on the northern section. By the end of June 2015, nine vehicles had arrived in Granada, with the remaining six due to be delivered by the end of the year.

JAÉN

With just over 100,000 inhabitants, Jaén is not an obvious candidate for a modern tramway considering the density of Spanish cities. Nevertheless, in December 2008, the Andalusian government approved the construction of a 4.7 km north-south route, which would connect the old town with the railway station, the university, a major hospital complex and an industrial area. Construction began promptly in early 2009. The entire route was built on a dedicated track alignment in the style of a modern French tramway. The first of five vehicles originating from the surplus of Madrid's Metro Ligero was delivered by Alstom at the end of 2010, with the other four following soon after. Test runs on the entire route began in February 2011, and the new tram line was handed over to the city on 19 April 2011.

A free trial service with passengers was launched on 3 May 2011, but it already had to be stopped on 19 May 2011 as the owner

of the bus franchise, Castillo, successfully filed a lawsuit against the tram operator for unfair competition. Despite Castillo's withdrawal, the dispute is yet to be settled, and the city council is not in the financial position to assume the costs of daily operation. On 26 July 2013, Jaén's mayor therefore symbolically returned the depot keys to the Andalusian government, which refused to subsidise the operation. The future will show whether the Tranvía de Jaén, which has been ready to start operation for four years, will ever provide a useful service to the local population.

MADRID

From the Spanish capital, high-speed trains (AVE) now head in every direction. But the autonomous region called 'Comunidad de Madrid', which includes not only the city proper, but also many neighbouring towns and rural areas all the way up to the Sierra de Guadarrama, also boasts an extensive railway system with busy suburban trains (Cercanías) as well as one of the densest metro networks in Europe and worldwide. In the suburbs, there are also four tram or light rail lines. Madrid, which lies at an altitude of 655 m above sea level, also offers a little bonus, an aerial cable car (Teleférico de Madrid) from the Parque del Oeste over the valley of the Manzanares River to Casa de Campo, the city's recreation area.

Public transport in the entire Comunidad de Madrid is planned and coordinated by the 'Consorcio de Transportes de Madrid'. Although for several decades, overall fare integration has been a reality for holders of personal season tickets ('Abono Transportes', now in the form of the contactless smartcard 'Tarjeta Transporte Público'), occasional riders cannot change between buses and metro for free, for example. The special 'Billete Turístico' is therefore recommended for visitors. This is available for 1, 2, 3, 5 or 7 days and costs from €8.40 to €35.40 for Zone A (Madrid) and from €17.00 to €70.80 for Zone T, which covers the entire region. For single trips on the Metro only, basically a 2-zone tariff applies, with one zone costing from €1.50 to €2.00 and two zones €3.00. A variety of reduced price 10-ride tickets is also available. At the two airport stations, a surcharge of €3.00 is payable.

Metro

With a total length of approximately 280 km (official sources quote 294 km, including non-revenue sections), Madrid's Metro plays in the world's premier league. In addition, the city boasts a large Cercanías network, with some routes offering a metro-like schedule. Apart from the shuttle line R, the Metro lines are numbered from 1 to 12, although there are actually 16 lines, as on three lines (L7, L9 and L10) the outer sections are operated separately with shorter trains and often longer intervals. On these sections, as on L12, zone B fares are required.

Like in London, the Metro network consists of two subnetworks, although here we find a small-profile network which is older (L1 to L5), and a large-profile network (L6 to L12) which has been built since the early 1970s. Although Madrid's Metro was originally designed following the parameters of the Paris Metro with predominantly vaulted stations built below ground, it has never used a third-rail power supply, but always an overhead catenary with 600 V DC (on newer lines now 1500 V). From the old tramways, the Metro took not only the power supply system, but also the rare track gauge of 1445 mm.

As in Barcelona, until the mid-1990s most metro tunnels were excavated using classic mining techniques (Método tradicional), while cut-and-cover was only used for short sections. For the massive expansion of the network from 1995 to 2011, when 40-50 km of new routes were being completed every four years, tunnel boring machines were mainly used, which enabled construction to proceed rapidly in Madrid's soft ground. The newer metro stations, however, were all excavated by cut-and-cover. The stations, both the older vaulted type as well as the newer box-shape type with their varying coloured panels, feature standardised designs, but to add a little variety, many are enhanced with a large mural, with a theme generally inspired by the station's surrounding. While all the Metro stations opened since 1998 have been equipped with lifts from the very beginning and many have been retrofitted in recent years, numerous stations are still not yet fully accessible for disabled people.

Every Metro line runs from 06:00 in the morning until 02:00 at night, providing a 15-minute service after 23:00. The lines are all operated in ATO mode, which limits the driver's duties to closing the doors and giving the command for departure. Lines L1 and L6 plus the eastern part of L7 are additionally equipped with the new CBTC system (Communications-Based Train Control). The Madrid Metro is operated on the left.

L1

The oldest metro line dates back to 1919, making Madrid the ninth city in Europe to have an electric underground railway, after London, Budapest, Glasgow, Paris, Berlin, Liverpool, Athens and Hamburg. Like the following lines, the original north-south route was initially built with platforms just 60 m long. Only in the 1960s, they were extended to 90 m to allow the use of 6-car trains. Due to the short distance to the neighbouring stations, Chamberí station was closed on this occasion, and since 2008, this well-preserved underground station has been open to the public as a museum. The typical vault clad in white tiles is visible here. The accessible platform is separated from the trains running through the station by a glass wall.

L1 has been extended in both directions over the decades, and in the south it has reached the edge of the built-up area. The Metro station Atocha Renfe was inserted in 1988 after Madrid's main railway station had been moved further south. In the north, L1 ends at the Pinar de Chamartín hub: the L4 tracks lie on the same level, and comfortable cross-platform interchange between L1 and L4 is usually provided. Two levels higher up, the Metro Ligero departs for Sanchinarro.

L2

Madrid's second metro line followed only a few years after the first, but due to its short platforms, it has only ever been possible to operate it with 4-car trains. Traditionally, the so-called 'Ramal', which goes from Ópera down to the former Estación del Norte (now Príncipe Pio), is considered a part of L2. Until the early 1990s, long-distance trains heading to the north and northwest of the country used to depart from the old Estación del Norte. Although the steep 1 km line was built as a branch off L2, it was never served by any through running trains.

Line 2, however, had a real branch from 1932 until 1958, when the Goya – Diego de León section was connected to L4 instead. From 1964, L2 trains used to continue from Ventas to Ciudad Lineal, until this section became part of the new L5 in 1970. After L2 had been traversing the 1.4 km section between Quevedo and Cuatro Caminos nonstop for nearly 70 years as L1 already served this area, the intermediate station Canal was added in 1998 to provide interchange with the new L7. L2 received a major extension eastwards to Las Rosas just a few years ago.

L3

The sharp bend found on the alignment of line 1 south of the interchange station Sol is an indication of the original plan to build a branch off the first line, but later, a separate line was designed instead. The construction of this still rather busy line suffered a delay of several years because of the Spanish Civil War (1936-39). While the line saw just a few short sections added over the following years, it doubled its length in 2007 with the opening of the southern extension to Villaverde Alto. Prior to that, the platforms in the older stations had been extended from 60 m to 90 m between 2004 and 2006, so 6-car trains can now also be used on this line. At the same time, the stations were all retrofitted with lifts. The only underground station which already had 90 m platforms, namely Moncloa, was closed and built anew parallel to the L6 station in order to allow the construction of an underground bus terminal. A planned extension to El Casar in Getafe (3.3 km) was postponed due to budgetary constraints during the financial crisis.

L4

In the 1940s, line 4 completed the originally designed basic network of three radial lines and one tangential route along the so-called 'Bulevares'. The former L2 branch from Goya to Diego de León, however, was only connected to L4 in 1958. From the late 1960s, the line was gradually extended towards the district of Hortaleza in the northeast, passing through the hub at Avenida de América, where interchange between four metro lines is now provided. On L4, even the newer stations only have 60 m long platforms. None of the stations opened before 1979 are fully accessible yet.

L5

Line 5 emerged in the second half of the 1960s as the last line to be built with traditional small-profile tunnels. This enabled L5 to take over the L2 section from Ventas to Ciudad Lineal on 20 July 1970, a few years after it had been completed. The four stations on this section had already been fitted with 90 m platforms like the rest of L5, thus allowing the use of 6-car trains. While the line was later extended in two stages at the eastern end (a further extension to the airport has often been proposed), its southwestern terminus was initially at Carabanchel, where interchange with the 'Suburbano' (see L10) was provided. In conjunction with the construction of Renfe's underground line (now C-5), L5 took over the Suburbano's route to the new hub at Aluche on 29 October 1976. On this stretch a few years later, Eugenia de Montijo station was inserted directly at the tunnel portal. Since 22 October 2002, L5 has continued to the new interchange Casa de Campo, while L10 has been extended to the southwest. L5 now terminates on a single track between the L10 tracks, thus offering a comfortable transfer in both directions. The second L5 track, however, lies hidden under the southern, now widened island platform.

L6

The circular L6 is one of the busiest lines on the Madrid Metro. In the absence of proper termini, the directions are indicated as 'Andén 1' [platform 1] for anticlockwise and 'Andén 2' for clockwise. The grounds of the 'dent' on the western side of the ring line are occupied by the vast recreational area known as Casa de Campo.

Conceived in the 1970s, L6 differs from the older lines through its deep alignment, which reaches down to 45 m at Cuatro Caminos station and results in transfer corridors which are often long and inconvenient. In provision for large crowds of passengers, some stations were equipped with three platforms, an island platform (in theory for alighting passengers) and two side platforms (for boarding). At Príncipe Pio, cross-platform interchange is possible between L6 and L10 in the same direction.

L7

In 1974, line 7 became Madrid's first large-profile line, i.e. with tunnels wide enough for 2.8 m instead of just 2.4 m wide trains, while the standard platform length was also fixed at 115 m instead of the previous 90 m.

L7 acted as a feeder line, serving only the eastern districts of the city for 23 years until it was extended to become a long diameter line in the late 1990s. However, it still suffers today from the fact that it does not come close to the historic city centre.

During the last major phase of expansion, L7 was extended east beyond the city limits to the neighbouring cities of Coslada and San Fernando de Henares. This new section, which is also referred to as 'MetroEste', provides headways similar to those operated on the original L7, but only 3-car trains, which stop at 90 m long platforms, are used. At Estadio Olímpico, a change of trains is necessary anyway due to the different fare charged for the outer section; ticket gates were therefore installed in the middle of the wide island platform.

L8

Today's L8 is not to be confused with the previous line 8, which in 1982 (on the occasion of the Football World Cup) started running between Nuevos Ministerios and Fuencarral. On 23 December 1986, the line was linked via a 1.4 km single-track spur to the Avenida de América hub, but this spur lost passenger service when the original line was finally connected with L10 on 22 January 1998 to become a long diameter line. Since 6 December 1997, the old line 8 had therefore been temporarily adapted to allow the use of small-profile rolling stock.

The now free line number and line colour were transferred to the new express metro line to the exhibition centre at Campo de las Naciones after just a few months. A year later, L8 reached the old airport terminal. Initially, it was operated with small-profile

class 2000 trains, and removable boards were therefore fixed to the platform edges. Prior to the extension to Nuevos Ministerios, where check-in desks had been installed, the line was switched to operation with large-profile rolling stock. The class 8000 trains initially had a special compartment for the transport of checked baggage, but the city check-in only remained in service for four years.

Line 8's most distinctive feature is the long distances between stations. Although the full length of every platform is furnished and accessible, so far only 4-car trains have been used.

L9

Today's L9 consists of two very different parts which are also operated separately. While the Paco de Lucía — Puerta de Arganda section is a typical metro line, the Puerta de Arganda — Arganda del Rey section to the south is rather similar to a suburban rail line, lying above ground and with long distances between stations. The construction and operation of this section was awarded to the private company 'Transportes Ferroviarios de Madrid S.A.' (TFM). For this reason, different fares are charged, and passengers have to change trains at Puerta de Arganda. The TFM-section is operated with short trains of class 6000 running every 8-10 minutes during daytime hours. Two years after the opening of the TFM line, a 1.6 km section through Rivas was covered and a park laid out on top.

Until the middle section had been completed, the real L9 was operated as two separate lines from 1983 to 1986, with the northern section shown as line 9B. As on L6, some L9 stations lie very deep, e.g. Sainz de Baranda is 43 m below ground. With hardly any network expansion having taken place in recent years due to the financial crisis, the only extension was to L9 in two stages from its northern end. Adjacent to the new terminus Paco de Lucía, named after the famous guitarist who died in 2014, a Cercanías station will be completed by the end of 2015.

L10

The history of today's L10 begins in the late 1940s, when the idea of a rapid transit line from Chamartín to Carabanchel first came up. In the mid-1950s, in addition to numerous Metro lines, 'Ferrocarriles Suburbanos' were also planned to connect the less densely populated areas; these were supposed to run both underground and above ground. In 1961, the southern section of this diameter line opened from Plaza de España to Carabanchel. However, it was not operated by the 'Metropolitano', but by the state company EFE (Explotación de Ferrocarriles por el Estado). The parameters of the route and rolling stock were similar to those used on the Metro. The platforms were 90 m long, and the distances between stations outside the city centre significantly greater than on the existing Metro lines. To save costs, the route was not aligned along Paseo de Extremadura, but along the edge of Casa de Campo park. On 29 October 1976, the Suburbano had to cede the Aluche — Carabanchel section to L5. Eventually in 1981, when the Suburbano was extended from the 35 m deep Plaza de España station further into the city centre to Alonso Martínez, it was fully integrated into the metro network as line 10.

Shortly after the closure of the gap on the circular line L6, the L10 section between Lago and Plaza de España was completely rebuilt to take it to the new hub, Príncipe Pio. With two single-track tunnels under the Manzanares River, the best possible L6/L10 interchange was created. In 1998, the once-envisioned north-south cross-city route was finally achieved by connecting the old line 8 (Fuencarral — Nuevos Ministerios) to L10. Until 2002, L10 had been operated as a small-profile line because the older sections between Alonso Martínez and the new interchange Casa de Campo still had to be rebuilt accordingly. Since 2003, L10 has functioned as the primary link between the ring line MetroSur (L12) and the city of Madrid.

In 2007, L10 saw a 16 km long, completely underground extension north from Fuencarral to Alcobendas and San Sebastián de los Reyes. The northern section is operated separately from the main L10 and therefore requires a change of trains at Tres Olivos. On the northern section, referred to as 'MetroNorte', the platforms are just 90 m long, and 3-car trains only run every 4-5 minutes even during peak hours, whereas on the main section they operate twice as often. Since fare zone A extends to Ronda de la Comunicación station, the increased fare is checked at all the exit gates on the outer section.

In the long term, the Chamartín — Hospital Infanta Sofía section could become a new line 14 if L10 is extended north from Chamartín to Puerta del Norte to serve the redevelopment area along Paseo de la Castellana. At Chamartín, the necessary metro platforms have already been built. At the southern end, a L10 extension to Móstoles is a long-term option.

L11

Line 11 is the 'Unfinished Symphony' of the Madrid Metro. Its long-term route across the entire city has been fixed since the mid-1990s: from Chamartín (the respective platforms were built together with the L1 extension) via Arturo Soria (L4), Ciudad Lineal (L5), Ascao (L7), La Elipa (L2), Sainz de Baranda (L6, L9), Atocha railway station and southwest to Carabanchel Alto. The southern section was in fact completed in stages between 1995 and 2010, but despite the massive network expansion of the last 20 years, the rest of the line never gained a high enough priority. L11 is thus only connected to the circular line L6, so passengers have to change lines twice to reach the city centre. Due to low demand and a rolling stock shortage on the other large-profile lines, L11 was operated with small-profile trains from 2000 until 2010, during which time the platforms were temporarily widened. Today, 4-car trains of class 8000 run on L11 every 6-8 minutes during daytime hours.

L12

In record time, the 40.5 km circular line L12 was implemented during the metro expansion programme of 1999-2003. The line was designed to connect five cities south of Madrid with each other, namely Alcorcón, Móstoles, Fuenlabrada, Getafe and Leganés, which together have a population of about a million. Despite some undeveloped areas between these cities, an underground alignment was chosen throughout. On the one hand, this allowed uninterrupted construction with tunnel boring machines, while on the other hand it prevented the Metro line from obstructing any future urban development. In addition to the 28 completed stations, provisions were also made for five additional stations, particularly with respect to a horizontal and straight alignment.

Lagging slightly below expectations, L12 is currently operated every 7½ minutes during daytime hours and every 5 minutes

during peak hours, using 3-car trains of class 8000. The entire MetroSur route lies in fare zone B, and fare gates were therefore installed between L10 and L12 at the interchange station Puerta del Sur. In addition to L10, MetroSur is also connected to Madrid via four frequently served Cercanías routes. An L3 extension from Villaverde Alto to El Casar is also planned.

Metro Ligero

The expansion programme for the 2004-2007 period included not only numerous extensions to existing metro lines, but also the construction of three tram or light rail lines in the outer areas. These are officially known as 'Metro Ligero', i.e. 'light metro'. While 'Metro de Madrid' operates line ML1, which on its way through the new neighbourhoods of Sanchinarro and Las Tablas in the north of Madrid establishes a link between three metro lines, the two lines west of Madrid are run by the private operator 'Metro Ligero Oeste, S.A.'. All three lines were built in the style of a modern French tramway, although ML1 runs in a tunnel on 3.3 km of its total length of 5.4 km, serving five underground stations; this line was therefore equipped with an ATP (Automatic Train Protection) system. The western routes, however, remain mostly on the surface, with ML3 running through some undeveloped areas, but still featuring several underpasses and viaducts. While ML3 to Boadilla del Monte is only underground at the shared departure station Colonia Jardín, line ML2 has two rather simple subsurface stations in the municipality of Pozuelo de Alarcón. Since travel speeds are rather low due to some tight curves, even on the interurban sections, and the transfer options to continue towards the city centre are limited, especially on the western lines, the success of the Metro Ligero has remained below expectations, and the government has therefore refrained from building any additional lines. However, the Comunidad de Madrid had already ordered a total of 70 low-floor Citadis trams from Alstom, of which only 35 are needed today. Some of the surplus trams were able to be transferred to other tram systems, notably in Jaén, Murcia and Adelaide. Nine of them are in service in Parla, to the south of Madrid (see page 104). Unlike the Metro, the Metro Ligero's track gauge is 1435 mm.

Service frequency on the ML lines is highly dependent on the time of day, running every 5-13 minutes during daytime hours, but only half-hourly on Sundays on the western lines. Whereas metro fares for zone A apply for ML1, the other two lines require a zone B ticket, although with single tickets no free transfer between the two lines is granted!

Cercanías

Besides the Metro, the suburban trains operated by Renfe also play an important part in the urban rail system. While the branches south of the main railway station Atocha have had the same line numbers for many years, the numbers in the north have repeatedly changed. Except for line C-5, all the trains run underground between Atocha in the south and the second main railway station Chamartín in the north. They use either the older connection via Recoletos from 1967, the so-called 'Túnel de la Risa' ('Tunnel of laughter' because of its long construction time – C-1, C-2, C-7, C-8, C-10), or the second Cercanías tunnel opened via Sol on 10 July 2008 (7.4 km; C-3 and C-4, with Sol station in operation since 27 June 2009). On each route, there is thus a train between the two railway stations every few minutes, with all trains calling at Nuevos Ministerios. The route of line C-7 may appear somewhat confusing as it runs through the same tunnel twice. Line C-2 is usually jointly operated with line C-8. Except for the outer branches of line C-8, every route is served at least twice an hour, although usually more often. The most frequent lines are C-4 and C-5, which have a daytime headway of 10 minutes, with line C-5 even running every 4 minutes during peak hours. The Cercanías network also includes the metre-gauge mountain railway C-9 in the Sierra de Guadarrama.

Despite the four standard-gauge high-speed routes radiating from Madrid, the Cercanías trains still have to share their broad-gauge tracks (1668 mm) with some regional and long-distance trains. The western C-5 leg, however, half of which is underground, was exclusively built for Cercanías services: 1976 Aluche – Móstoles; 1983 Móstoles – El Soto; 1984 Aluche – Laguna; 1989 Laguna – Embajadores, and finally in 1991 Embajadores – Atocha. In 1989, the 8.8 km mostly underground route from Atocha to Villaverde Alto opened exclusively for C-5. Despite these dedicated routes and the metro-like operation with ATO, no high platforms for full stepfree access like in Bilbao are available.

The connecting route between Atocha and Príncipe Pio, which dates back to the 1860s, was put into a tunnel up to Delicias when the former Estación del Norte was rebuilt and integrated into the Cercanías network in 1996.

In 2001, the cities of Alcobendas and San Sebastián de los Reyes in the north were linked to the Cercanías network. This was followed by a 15.3 km long branch in the southeastern region from Pinto to San Martín de la Vega in April 2002 to provide rail service to a new theme park. Due to low ridership, however, the route was shut down exactly ten years later. The most recent addition to the Cercanías network was the tunnel route to the airport terminal 4, opened on 23 September 2011. This branch diverges from the bypass line, which during rush hour is used by the so-called CIVIS express trains between Guadalajara and Chamartín.

The Madrid Cercanías system is operated with class 446 and 447 EMUs, double-deck trains of class 450, as well as many newer trainsets of class 465 (Civia). The latter feature stepfree boarding at the centre door.

MÁLAGA

The urban rail system opened in Andalusia's second largest city in 2014 after several years of delays can be classified as "light rail", and in many aspects it resembles the 'Metro do Porto' in Portugal. Of its total length of 11 km, just 2.3 km at the western end of line 1 lies on the surface, while the rest was built underground. But the use of low-floor tram vehicles and some rather tight curves in the tunnels give the impression of an underground tramway rather than a proper metro. The underground sections, however, are operated semi-automatically in ATO mode just like many modern metros. Unlike in Sevilla, the platforms were not equipped with platform screen doors.

At present, the two lines start at some distance from the old town, on the north side of the main railway station María Zambrano at the two-level underground station El Perchel. In the future, this station will provide cross-platform interchange between the two lines. Until further notice, the two lines will continue to be operated jointly, and the trams therefore change

direction at this station. To make this continuous service possible, a complex junction had to be built to the west of El Perchel.

Via two sharp bends, **line 1** reaches La Unión station, which has superimposed platforms due to the limited space available below a narrow road. Besides El Perchel, this is the only metro station which deviates from the standard station layout. Only after the next tight curve do the two tracks run on the same level. From Barbarela, all the underground stations on line 1, just like those on line 2, feature island platforms. West of Ciudad de la Justicia, the trams emerge from the tunnel via a ramp. Having arrived at Universidad, the drivers switch from semi-automatic to manual operation. A fence prevents passengers from crossing the tracks at this stop, and the side platforms are only accessible from the western end. The other surface stops also have side platforms, and are in a partly undeveloped area where more university facilities are planned. The depot is located approximately 1 km west of the terminus Andalucía Tech, while another stop has been prepared shortly before the depot entrance.

After departing from El Perchel, **line 2** reaches La Isla station via two tight curves, from where it boasts a rather straight alignment southwest through the densely populated district of Carretera de Cádiz. With construction having begun in early 2006, the La Isla – Palacio de los Deportes section was ready in 2011, but with the connection to the old town still missing, the city decided to postpone its opening until line 1 had been completed, too. Construction on line 1 had only begun in 2009. All the underground sections except for the tunnel under the railway tracks to the west of the main railway station were built by cut-and-cover using diaphragm walls. The underground stations were all designed as spacious structures with large mezzanines. Contrary to the original draft, which envisaged a different colour theme for each station, the final station design is rather sober, similar to that applied on the Sevilla Metro, with the Andalusian national colour green dominating. All the stops and stations were built with a platform length of some 66 m, allowing the use of double tramsets, and they are fully accessible for disabled people.

According to the original plans, both lines were to be extended east below the central Alameda Principal to terminate at the bullring in the district of La Malagueta, from where a surface tram was to continue further east. Given the economic situation, a shortened underground solution with a terminus at Atarazanas (1.2 km from El Perchel) was eventually chosen, after the above-ground alternative preferred by the city council failed to gain support. Instead, the Andalusian government agreed to finance a surface branch to the Hospital Civil, which is to be served by line 2. The Metro is expected to reach Guadalmedina by the end of 2016, and Atarazanas in the historic centre in 2017/18. To save space and reduce costs, the last station will be built single-track.

A single ride on the Metro Málaga costs €1.35, and with a stored-value card (*tarjeta monedero*) just €0.82. If a prepaid card from the Consorcio de Transportes is used, a discount is granted when changing to a local bus. Unfortunately, no day passes are available.

The five-section, 100% low-floor vehicles from CAF have a floor height of 350 mm, which allows stepfree boarding. They are equipped with an air-conditioning system. The entire network is fitted with a 750 V DC overhead line.

Cercanías

In addition to the new Metro, Málaga also boasts a busy suburban rail system. While line C-2 only runs hourly to Álora (38 km) along the old main line to Córdoba, C-1 trains on the coastal line to Fuengirola (31 km) operate every 20 minutes. They serve seven underground stations (lying off the map shown on page 108/109, Torremolinos and Fuengirola are also underground). The single-track underground extension to Málaga Centro-Alameda was built in as early as 1976. Victoria Kent station was opened in 2009 in conjunction with the construction of the high-speed line and the covering of the broad-gauge tracks. To allow for the expansion of the airport with a second runway, a longer section of the railway was put below ground, resulting not only in the underground station Aeropuerto, but also Guadalhorce station, which lies in the middle of an industrial area. South of the airport, the S-Bahn route is mostly single-track with passing loops at most stations. An extension to Marbella is planned in the medium term. The Cercanías service is provided by Renfe with Civia EMUs.

Vélez-Málaga

In March 2003, **Vélez-Málaga** (78,000 inh.), a town just 30 km east of Málaga, surprised the urban rail world with the start of construction of a tram line designed to connect the old town with the seaside resort of Torre del Mar on a 4.8 km route. Three Urbos low-floor vehicles (31 m long, 2.65 m wide) like those used on the Sevilla Metro were ordered from CAF. When it opened in 2006, it became the first modern tramway in Andalusia, but as it was not integrated into the local bus fare system, it was unable to compete with the existing bus service. Economically unsuccessful, service was discontinued in June 2012, even before a completed 1.3 km northern extension to the former railway station could be brought into service. Together with a car from Sevilla's Metro, the vehicles were shipped to Sydney in mid-2013, where they were supposed to remain in service until the new CAF vehicles had been delivered, but by late 2014 they had already been returned home. Service may resume one day if a financial contribution from the Andalusian government can be achieved.

MURCIA

In the capital of the autonomous region of Murcia, the construction of a 2.1 km demonstration tram line with four stops began in October 2006, pending a final decision on the implementation of a wider tram system. Two redundant Citadis vehicles were leased from the Metro Ligero in Madrid. Free service on the line, which runs along the straight arterial road Avenida Juan Carlos I, started on 29 April 2007 between Juan Carlos I at Plaza Circular and Parque Empresarial (Nuevos Juzgados). The tram thus follows the path of the Murcia – Caravaca railway, which was abandoned in 1971, but whose station building can still be seen at Plaza Circular.

In the second phase, today's Line 1 was built together with shuttle line 1B. The primary objective was not only to connect the city centre with the university campus in Espinardo and the Universidad Católica (UCAM), but also to provide a link from the old town to the industrial areas and major retail centres in the north, as well as to the stadium Nueva Condomina, which resulted in a V-shaped route alignment. In March 2009, construction contracts were awarded to the FCC/Comsa-EMTE consortium, which under the brand name 'Tranvía de Murcia' took over the operation of the system for a period of 40 years. The eastern branch runs

completely in the median of wide roads through new neighbourhoods, like along Avenida Don Juan de Borbón, with the most significant structure being a 200 m bridge over the A-7 motorway between the depot in La Ladera and the terminus Estadio Nueva Condomina. On the western branch, the demonstration track was extended 1 km north along Avenida Juan Carlos I. At the stop Espinardo, the line turns west and reaches Los Rectores-Terra Natura, the transfer point for the shuttle line to the Universidad Católica. Line 1 then crosses the A-7 motorway again before serving the campus of the Universidad de Murcia on an anticlockwise loop, with the track reservation placed in the middle of the road. The branch towards UCAM-Los Jerónimos was built single-track, but the alignment was prepared to allow for future doubling. This includes a 240 m viaduct over motorway A-30 and its access ramps. For the rest of the branch, the trackbed runs alongside a main road called Costera Norte, through a still undeveloped area. The whole of the Murcia tramway thus features dedicated routes.

For lines 1 and 1B, the two leased vehicles plus nine additional unused ones were purchased from Madrid and repainted with a light-green front. The same colour can be seen at the standardised stops, except the four original ones built along the demonstration line, where light blue dominates.

In the initial euphoria of tram planning there were numerous proposals for routes into the surrounding region, especially to the neighbouring town of Molina de Segura in the north. At present, however, planning is concentrated on a cross-city route to link the railway station, an extension which will operate without overhead wires for part of the way.

To ride the tram, passengers need the stored-value card 'Bono Murcia', available for €1.00 and rechargeable with a minimum of €5.00. For each trip €0.70 is deducted, with an additional €0.45 when changing to a local bus. Ticket machines also issue single-ride paper tickets, which cost €1.05 for a ride in the inner area, and €1.40 for a ride on the entire network. Day passes are not available.

Labelled 'Cercanías', older diesel-powered units (DMUs) run approximately every hour from Murcia to Alicante (C-1) and from Murcia to Lorca (C-2).

PALMA

In what came as quite a surprise, the construction of a metro line to connect the campus of the UIB (Universitat de les Illes Balears) to the city centre was announced in the Balearic capital in November 2004. This came shortly after work had started on a project to put the existing SFM railway to Inca underground along its urban stretch. Following the parameters of the existing SFM route, metre-gauge was chosen for the Metro, too.

The construction of the Metro was launched in the summer of 2005, and already on 25 April 2007 a free trial service on the 8.5 km long route started. Shortly after the introduction of regular revenue service, however, heavy rains caused significant damage to the station Son Fuster Vell on 24 September 2007, resulting in the temporary closure of the line until 28 July 2008.

Line M1 starts at the northern edge of the old town, at Plaça d'Espanya, where a 10-track underground railway terminus was built together with a regional coach station. The 1.3 km shared tunnel was laid out with four tracks, and Jacint Verdaguer and Son Costa-Son Fortesa stations thus have two separate island platforms, one for line M1 and the other for regional services and line M2. The continuing underground section of line M1 runs through an industrial area under Gran Via Asima. The Metro then comes to the surface and stops at Son Sardina, next to the Tren de Sóller, whose route it then crosses on a viaduct. The terminus at the university lies underground again at the southern side of the campus.

All the running tunnels and stations were built by cut-and-cover. The platforms are some 75 m long, although normally only 33 m interconnected 2-car trainsets are in service. The line is equipped with a 1500 V DC overhead power supply.

On 13 March 2013, **line M2** was introduced on the inner section of the SFM Inca route between Plaça d'Espanya and Marratxí. It serves all the stations every 20 minutes, while the other trains skip all the stops along this section. On 16 June 2014, Son Cladera/Es Vivero station was added. The railway to Inca dates back to 1875. In 1994 it was transferred from FEVE to the Balearic railway company SFM. The electrification (1500 V DC) of the line finally began in mid-2010. Line M2 was initially operated with three-car class 81 EMUs, but now uses the same class 71 rolling stock as line M1. Three- and four-car trains of class 81 are in service on the regional line via Inca to Enllaç, where passengers still need to transfer to a diesel unit to continue their journey to Sa Pobla or Manacor.

Even before the opening of metro line M1 there had been repeated proposals to build a tramway or light rail line in Palma. Most such proposals included a route along the former city walls (Les Avingudes) as well as a link to the airport and the tourist areas around S'Arenal in the southeast.

While the old railway line from Inca to Manacor was reopened in 2003 after a 25-year interlude, the continuing route to Artà was to be converted into a 'Tram-Tren'. Starting in 2010, construction was well-advanced when the project was suspended in 2012. The six partly low-floor Citylink vehicles (class 91) already delivered by Vossloh for this line are currently used in the morning peak hours, when they can be found running as "Incaexpres" between Palma and Inca.

There is no fare integration between the SFM service (including the Metro) and the urban bus system. A single trip on the Metro costs €1.60. Line M1 is not in service on Saturday afternoons and on Sundays, while the M2 stations are only served by regional trains on weekends.

PARLA

When the Metro Ligero lines ML1 to ML3 were built in the Madrid region, an 8.3 km circular tram line also opened in Parla in 2007. Home to some 125,000 inhabitants, Parla is located about 20 km south of Madrid, and served at least six times an hour by Cercanías line C-4. The suburban railway was brought closer to the city centre in 1994 via a new tunnel. The tram now serves as a distributor for not only the city centre, but also the new housing estates in Parla Este. The once planned Cercanías station Parla Norte has not been realized, and thus the corresponding stop on the tram line has not been built either.

SEVILLA

The capital and largest city in Andalusia boasts three different urban rail systems, namely Metro, tram and Cercanías, but the total coverage of the metropolitan area or full fare integration is far from being achieved.

Although a coordinating body exists in the form of the 'Consorcio de Transporte Metropolitano del Área de Sevilla', and a single stored-value card can be used on all modes (except Cercanías), when transferring between different operators, passengers only receive a discount.

Metro line 1 is operated by 'Metro de Sevilla S.A.', which largely depends on the regional government, the Junta de Andalucía. The Metro has a 3-zone fare system – single rides without transfer cost €1.35/1.60/1.80, respectively, though when paid with prepaid cards just €0.82/1.17/1.37. Exclusively for the Metro, a day pass (Bono de 1 día) is available for €4.50.

The tramway, known as 'MetroCentro', is part of the urban bus network run by TUSSEM. A single journey without transfer costs €1.40, but if paid with a stored-value card just €0.69 (€0.76 including transfer). For the TUSSEM network, 1-day tickets (€5.00) and 3-day tickets (€10.00; both with an additional €1.50 deposit for the card!) are on offer, too.

The Consorcio stored-value cards can also be used as a means of payment at the ticket-vending machines at Cercanías stations, but no discount is granted. Within Sevilla, i.e. on the entire C-2 and C-4 routes, a single ride is charged at €1.80, while a ticket to Camas or Dos Hermanas, for example, costs €2.00.

Metro

Construction work on Sevilla's first metro line started back in 1976, but 33 years passed before the Metro was finally ready for operation. The route then initiated ran from La Plata in the east towards the city centre. But unlike today's L1, it was laid out to continue straight on from Nervión station to reach Puerta de Jerez via the former railway station Estación de Cádiz, before finally turning north into the old town to terminate at Plaza Nueva. In a later stage, it was supposed to continue through Macarena and north towards Pino Montano. While most tunnel segments on the outer section were completed by cut-and-cover, the city centre portion was to be built at great depth (up to 34 m at Plaza Nueva). In the early 1980s, several accidents occurred due to the unstable soil, and both locals and engineers feared for the safety of the historic buildings in the area. Eventually, all construction work was suspended in 1983 and the already completed segments were mothballed. A long-term project, it included a network with three lines, with line 2 running northeast-southwest and line 3 north-south.

In the following decades, there were several proposals on how to use the tunnel completed between Nervión and La Plata, but it was not until the late 1990s that the project was finally revived. At that time, metro construction was not only booming in Madrid and Valencia, but Bilbao had also successfully implemented a modern metro system. Construction contracts were awarded in the spring of 2003. Instead of a real metro, however, a light rail system was now planned, with underground sections through the city centre, but surface routes with level crossings on the outer sections. While the tunnel between Nervión and La Plata could be adapted to the new requirements, a new alignment was chosen for the section west of Nervión. In this way, not only could the tunnel be excavated under the wide streets, but also because Renfe's station San Bernardo (formerly Estación de Cádiz) had moved south to an area where major redevelopment work was taking place. To avoid the sensitive old town, L1 was extended west from Puerta de Jerez to Triana, and then further into the suburban municipalities of San Juan de Aznalfarache and Mairena del Aljarafe on the west bank of the new Guadalquivir riverbed. While the Nervión – San Bernardo section was built by cut-and-cover, the single-track tubes between San Bernardo and Parque de los Príncipes were excavated using a tunnel boring machine. The short tunnel in San Juan was driven by traditional mining techniques. The decision to build the entire line completely grade-separated only came in the course of construction, and the stations were even equipped with platform screen doors to allow semi-automatic operation in ATO mode. Not counting the historic Földalatti in Budapest, Sevilla's L1 thus became the world's first low-floor metro line. To the south of the old tunnel section, the Metro surfaces at a station called Cocheras [Depot] to cross the ring motorway SE-30, the River Guadaira and the orbital line C-4 (provisions were made for an interchange station here) on a viaduct before reaching the neighbouring municipality of Dos Hermanas. In the end the alignment through the Montequinto area was modified in favour of an underground alternative, and it was therefore completed several months later. Unlike the rest of the underground stations, which all feature a mezzanine, the island platforms at the two Montequinto underground stations lie just below the road surface, with the entrance building housing the access barriers. While the city centre stations along the section built with TBMs also have island platforms, those already built in the early 1980s feature side platforms. The stations all have a functional but spacious design, and as in Málaga the Andalusian national colour green is predominant.

Metro line 1 is now operated with 21 vehicles of type Urbos 2 from CAF, four of which (101-104) had originally been delivered to the MetroCentro tramway. Vehicles of the same type were also previously in use in Vélez-Málaga. The five-section air-conditioned cars are just over 30 m long, which is relatively short for a metro, but the stations are structurally designed for double units. The floor height is 350 mm above the top of the rail, which is reduced to 307 mm at the doors by means of gentle ramps. On the tunnel sections, the 750 V DC overhead line is installed as a rigid catenary. The maximum speed is 70 km/h, but the actual speed is determined by some very tight curves. In ATO mode the driver's tasks are limited to the closing of the doors and giving the command to move by pushing a button.

As a result of the metro operation eventually implemented, a network of surface feeder lines was designed for the metropolitan region. Several lines of the so-called 'Tranvía Metropolitano' were to cover the 'comarca' of Aljarafe to the west of Sevilla. In the southeast, one line was proposed to connect more areas in Dos Hermanas, while a second was to run from the Metro station Pablo de Olavide to Alcalá de Guadaira. The latter was actually mostly completed on the outer portion of what would become a modern, 12 km interurban line, featuring a 385 m long viaduct on the northern side of Alcalá and a 200 m long bridge structure over the Carretera Sevilla-Alcalá. In December 2011, however, construction was stopped as a result of the Spanish financial crisis, and it only resumed in mid-2015.

With Metro line 1 finally in operation, three other lines were soon to follow: line 2 from east to west, without intersecting with L1; line 3 north-south and intersecting with the existing line at Prado de San Sebastián; and the circular line 4, which will require

an additional station on the eastern part of line 1 to create an interchange. Due to higher priorities in times of empty coffers, the Junta de Andalucía has not started any of these projects yet. The northern section of line 3 to Pino Montano, which largely corresponds to the northern leg of the originally planned metro line, is considered the most urgent to be built.

MetroCentro

The idea of a city centre tramway emerged following the decision to keep the Metro out of the old town. Instead, a short surface route was built to function as a feeder for the Metro, hence the name 'MetroCentro'. Due to the delays in the construction of the Metro, five vehicles destined for it were instead delivered to TUSAM, allowing tram operation to start between the central Plaza Nueva, where Sevilla's City Hall is located, and the hub at Prado de San Sebastián on 28 October 2007. With the route passing right next to the cathedral, the black poles which supported the catenary were heavily criticised. Conflicts also arose during the annual Easter processions, when the overhead wires even had to be removed on some sections. A catenary-free solution was found in CAF's newly-developed supercapacitor system ACR (Acumulador de Carga Rápida), which is also employed in Zaragoza. For its implementation, the original cars were replaced with narrower vehicles in spring 2011. Between Plaza Nueva and Prado de San Sebastián, however, the trams also raise the pantograph at the intermediate stops for about 20 seconds. The original, just 1.3 km route was extended to San Bernardo on 15 April 2011, increasing the total length to 2.1 km. A long planned extension to the main railway station Santa Justa, however, has been repeatedly postponed like many other projects.

Cercanías

Sevilla has a suburban rail network with five lines. Lines C-1 and C-4 (a circular line only in a clockwise direction which uses the bypass route on the eastern side of the city) run about every half an hour, lines C-2 and C-5 about every hour, and line C-3, on a non-electrified route, just 4-6 times a day. Except for line C-3, Renfe uses EMUs of class Civia 465 as well as older vehicles of class 446.

Santa Justa, the main railway station, was built in 1991 in preparation for Expo 92 and the arrival of Spain's first standard-gauge high-speed line. At the same time, the tracks south of Santa Justa were put underground, and the former railway station San Bernardo (Estación de Cádiz) was moved some 650 m to the south, where interchange between Cercanías, Metro and tram is now provided.

SÓLLER

Since 1912 (and from 1929 with electric traction), the 'Tren de Sóller', which is especially popular among tourists, has connected the capital of Majorca with Sóller, a town with some 14,000 inhabitants located 25 km north of Palma. Port de Sóller, some 4 km away, is linked to Sóller by an interurban tramway. The mostly single-track line was built in 1913 and is one of the few surviving first-generation tramways in Spain. Although it is now mainly a tourist attraction, the tram is also used by locals. Service is provided with heritage vehicles from the early days of the Tramvia de Sóller (cars nos. 1-3 and 5-6), as well as cars nos. 20-24 from Lisbon, whose track gauge of 900 mm had to be adapted to the local 914 mm. In 1954, some open trailers were taken over from Palma's tramway. In preparation for the tramway's 100th anniversary, the waterfront in Port de Sóller was redeveloped.

The trams run hourly from 08:00 to 19:00 all year round, with extra trams on busy days. A single ride costs €5.50, while locals pay just €2.00. A combined ticket, the 'Tren+Tranvía' (a day return from Palma) is available for €30.00.

TENERIFE

The capital region in the northeast of the Canary Island of Tenerife includes the island's capital, Santa Cruz de Tenerife, and the former capital and university town San Cristóbal de La Laguna, in short La Laguna. While the old town of Santa Cruz rises slowly from the port towards the west, La Laguna lies 545 m above sea level, so line 1 of the 'Tranvía de Tenerife' has to negotiate a significant difference in altitude on its 12.5 km journey between the two city centres. Opened in 2007, the tram was modelled on the modern French systems, i.e. it features a dedicated right-of-way throughout and is well-integrated into the urban environment. Intersections with road traffic are mostly safeguarded by traffic lights, even at the numerous roundabouts the tram has to traverse. Most sections have grooved rails and are covered with lawn.

Line 1 starts outside the old town at the transport hub Intercambiador, where all regional bus routes and numerous city bus routes end. In the future, a railway line may lead from here to the south of the island. The old town is served by the stops Fundación, Teatro Guimerá and Weyler, with the route lying parallel to the pedestrianised shopping street Calle del Castillo. At the stop Puente Zurita, the tram crosses the Barranco de Santos, which separates the old part of the city from the newer urban areas. The trams continue their ascent before reaching the first underground junction at Taco, already part of the municipality of La Laguna. Since 2009, line 2 has diverged westwards from here to Tincer, from where it may be extended further to the new residential areas in La Gallega. Just after the northern tunnel exit, the head office and depot of 'Metropolitano de Tenerife' can be found. The trams then pass under motorway TF-5 on the only downhill section on their way up towards La Laguna. The following junction was also built underground to avoid interference with the busy surface traffic. From here, line 2 continues straight and relatively flat to the district of La Cuesta. Line 1, however, keeps climbing, overcoming some considerable gradients before it finally reaches the last stop La Trinidad close to the historic town centre of La Laguna. From here, a 3.4 km extension with four stops is planned to the airport Tenerife Norte. Running through narrow streets, it will have interlaced tracks on some sections.

On 24 January 2011, the stop Padre Anchieta was moved from the northern to the southern portal of the short tunnel in La Laguna, in order to facilitate access to the new bus station.

In addition to the expansion projects mentioned above, a third line is planned from the north pier of the port into the old town,

running along Calle Méndez Núñez. At Plaza Weyler, interchange with line 1 will be provided. After serving the modern city, the congress centre as well as the Auditorio, the route, now coming from the south, will be connected to the existing line at Intercambiador. However, due to the ongoing economic crisis, there is as yet no schedule for the realisation of these projects.

Most stops are equipped with island platforms, but side platforms can be found, too. The stops all have ticket machines, information boards and electronic next-tram indicators.

The tram system is only partly integrated into the island-wide bus network operated by TITSA. Single tickets (€1.35) and day passes (€4.50) sold on the tram are not valid on buses, although season tickets and shared stored-value cards are available. In addition to the traditional magnetic stripe cards, smartphone tickets (Vía Móvil) are also widely used.

Access into the 100% low-floor Alstom trams is absolutely stepfree, although the considerable gradients of some platforms might be challenging for wheelchair users. If necessary, the five-section Citadis 302 trams can be expanded with two additional modules. The entire line is equipped with a 750 V DC overhead power supply.

VALENCIA

In the province of Valencia, the Valencian railway company 'Ferrocarrils de la Generalitat Valenciana' (FGV) operates a metre-gauge rail network with a route length of approximately 156 km, branded the 'Metrovalencia'. While many new sections have been built in the urban area in recent decades, the outer branches still have to be classified as regional railway lines. These two faces are clearly visible both in the timetable and the standard of each section. However, the through operation of regional services over the urban metro sections brings significant benefits for passengers. After all, the metro emerged from an extension of the first metre-gauge regional lines into and through the city centre.

Within the city of Valencia, the use of Valencian (i.e. Catalan) place names prevails, unlike in some neighbouring towns where Spanish dominates.

Tickets for the metro and tram are sold according to the number of zones travelled through (4 fare zones). Zone A includes the extended urban area, and a single ticket costs €1.50. The airport lies in Zone D (A-D €3.90). There is also a range of combined tickets for EMT buses and FGV trains. Visitors can choose from several passes for zone A (24/48/72 hours for €4.00/6.70/9.70 + €2.00 for the card). Slightly more expensive but more flexible is the ValenciaTouristCard (24/48/72h for €15/20/25, valid in all FGV zones, incl. the airport and EMT zone A).

METRO

North-South Route

The history of the Valencia Metro dates back to 1888, when the route from Valencia (Marxalenes) to Llíria was opened. Three years later, the branch to Bétera was added. In 1892, Pont de Fusta on the north bank of the old Túria River became the new terminus, while a line to the port at El Grau was also built. In 1893, a fourth branch to Rafelbunyol completed the northern network, which, besides some additional stops and some track doubling, remained unchanged for almost a century. The network was electrified between 1919 and 1928.

Almost simultaneously, a line was built in stages from the terminal station Jesús (near today's underground station of the same name) through the southern Horta: in 1893 to Torrent, in 1894 to Picassent, in 1895 to Alberic, and finally in 1917 to Villanueva de Castellón (52.4 km). The electrification of this route was only carried out in 1947. Between 1912 and 1957, the southern network also included a link from Jesús via Natzaret to the port at El Grau. However, after the 1957 floods, which caused the relocation of the Túria River, this line was not rebuilt.

Early plans for a link between the southern and northern lines already appeared in the 1930s, but it was only in the 1980s, under the direction of the national narrow-gauge railway company FEVE, that such a project was launched. A 6.4 km tunnel between Empalme and Safranar (formerly Hospital) was built by cut-and-cover, including eight simple underground stations, each with 96 m long side platforms. On 8 October 1988, through operation under a 1500 V overhead line began, with the narrow-gauge network having been transferred from FEVE to the newly founded FGV on 1 January 1987. Line 1 operated between Bétera and Villanueva de Castellón, and line 2 from Llíria to Valencia Sud or Torrent. The former approach line to the old terminal station at Pont de Fusta became the new line 4 (Empalme – El Grau), while the Pont de Fusta – Rafelbunyol route was now called line 3, with both still electrified at 600 V DC.

From 1998, the two north branches were merged as line 1, with the line number "2" only returning in 2015. Since the opening of the north-south tunnel, several upgrades have been carried out on the connected routes: On 12 March 2001, a new station was opened at Empalme, some 150 m south of the original site; on 22 September 2004, the partly underground section from Torrent to TorrentAVINGUDA (1.4 km) was added; on 3 October 2005, the infill station Bailén was opened on the western side of the main railway station València Nord on the now double-track connecting tunnel route between Colón and Jesús; and since 15 May 2011, line 2 trains have been running through the 1.2 km tunnel, which includes new underground stations at Benimàmet and Les Carolines-Fira.

While on the central section between Empalme and Torrent a dense metro service is provided (L1 and L2 each run every 15 minutes, plus L7 on the southern section), the outer termini can be reached on partly single-track routes only every 30 (Bétera and Llíria) or 40 minutes (Villanueva de Castellón).

East-West Route

While line 4 was resurrected as a modern tram line in 1994, the old line 3 from Pont de Fusta to Rafelbunyol was gradually upgraded and extended to become the second metro trunk route. In the first step, starting in 1992, a 2.8 km tunnel was built by cut-and-cover between Alameda and Machado. On 5 May 1995, this tunnel was connected to the existing line at Alboraya-Palmaret, a station inserted on 9 May 1989. Designed by Santiago Calatrava, Alameda station, which lies under the old riverbed of the Túria,

was laid out with four tracks to become a future junction for the main east-west line 5, which was planned to run from the airport to Cabanyal railway station. For the new line 3, Valencia's first walk-through trains of class 3900 were purchased. Initially consisting of three cars, they were extended with a fourth one in 2001.

The central part of the east-west route was excavated with a tunnel boring machine to minimise disruption at the surface. All the stations from Colón to Av. del Cid, however, were built by cut-and-cover. Xàtiva features superimposed platforms, thus allowing a grade-separated junction for what is now L7, which uses the connecting tunnel via Bailén. Av. del Cid station has three tracks, so it can function as an intermediate terminus. On 16 September 1998, L3 started running to Av. del Cid or via Jesús to Torrent. Just a few months later, on 20 May 1999, the Metro reached the neighbouring town of Mislata, terminating at Mislata-Almassil on the east bank of the new Túria River. Until 1968, suburban trains to Riba-roja used to operate on the same alignment. On this section, the tunnel was once again constructed by cut-and-cover, and large colourful stations were created.

The eastern branch to be served by the planned line 5 became somewhat controversial. Instead of serving Cabanyal railway station, the city administration now wanted to create a direct link between the airport and the seaport. The metro route was therefore modified in favour of a more southerly alignment. However, the idea of an underground alignment in the harbour area was soon discarded, and a German-style Stadtbahn solution was proposed instead. High-level platforms on the rather narrow streets were strongly opposed by the local population, leading to the solution we know today: a tram (now L8) connects directly with the Metro inside the underground station. The line number "5" was introduced with the opening of the first section of this branch, Alameda — Ayora (2.1 km, cut-and-cover), on 30 April 2003. The remaining section to Maritim-Serrería followed on 2 April 2007. Until March 2015, the connecting tram line also carried the line number 5.

On 18 April 2007, lines 3 and 5 were extended from Mislata-Almassil to the airport. The stop at Faitanar was only opened on 16 December 2008. For this extension, the old Renfe line from Valencia to Llíria (C-4), which since 1984 had only reached Riba-roja, was cut back to Quart de Poblet in 2005 (and in 2007 to Xirivella-L'Alter), while the outer section was handed over to FGV. Contrary to the initial plan, the new metro route was eventually built completely underground, just below street level and without mezzanines at the stations. Only the outer portion beyond the airport was to remain on the surface and mostly single-track. After some delays in construction due to financial problems, the 9.5 km section was finally brought into operation on 6 March 2015. In Riba-roja, the route now ends temporarily at some distance from the town centre, while the construction of an underground station at the site of the old railway station and an extension to Vilamarxant are on hold. Besides the introduction of the new line 9 from Riba-roja de Túria to Alboraya-Peris Aragó, several other line numbers were changed in March 2015.

The underground station Alboraya-Peris Aragó had been added on 12 December 2010, along with a 1.2 km tunnel extension for line 3, which features a rebuilt underground station at Alboraya-Palmaret.

Metro Rolling Stock

The class 3900 trains acquired for the commissioning of the first tunnel section of line 3 were originally only made up of three interconnected cars, but a fourth segment was added in 2001. Since an upgrade for ATO operation seems too costly, all 18 units are currently on sale. Service on all the metro lines is mostly provided with class 4300 stock, of which there are both 4- and 5-car units. Both types, 3900 and 4300, were manufactured at the plant in Albuixech, just north of Valencia, which is currently part of the Vossloh Group.

TRAM

After the first metro tunnel had opened in 1988, the old line 4 continued to run as a local railway through the densely built-up northern neighbourhoods of Valencia. In order to eliminate this physical barrier, operation on the old line ceased on 31 January 1990 to allow the line to be rebuilt into a modern low-floor tramway. Between Empalme (for a short period called Ademuz) and Pont de Fusta, today's route closely follows the old railway line, except for a short section between Marxalenes and Sagunt. The trackbed is paved with cobblestones, but is not accessible to other road traffic. Next to the old station building at Pont de Fusta, a double-track loop was laid. Until 1995, two railway tracks remained in service here for line 3 to Rafelbunyol.

The eastern leg of line 4, which is now shared with line 6, also features a paved right-of-way, but it runs on the median of wider roads in the style of a typical modern tramway. The current route only diverts from the old railway in the port area, where the tram negotiates a single-track loop through parallel streets. When the 9.7 km tram line 4 opened on 21 May 1994, now with a 750 V overhead power supply, it was Spain's first modern tramway.

On 3 March 1999, line 4 was extended 2.3 km from Empalme to TVV (Televisió Valenciana), crossing line 2 on a viaduct. Later, three short extensions were added at the northwestern end: in September 1999, an 800 m branch to the fairgrounds (Fira), which is only served during special events; on 23 September 2005, a 2.9 km route to Mas del Rosari, including an underpass below the roundabout previously used as a turning loop; and finally on 20 December 2005, the 600 m branch to Terramar. Each of the two northwestern termini is alternately served every 20 minutes. Along its 16 km route, line 4 connects several university institutions. As the older vehicles of class 3800 have only one driver's cab, the line 4 termini (except Ll. Llarga Terramar) all feature turning loops.

Today's line 8 (line 5 until March 2015) was designed as the logical extension of metro line 5. Opened on 2 April 2007, it starts underground at Maritim-Serrería, where transfer to the Metro (L5-L7) is provided on the same platform. It reaches the surface via a ramp, and after only two intermediate stops, terminates at Marina Reial Joan Carles I (initially Neptú). The introduction of this tram line made the initial idea of high-level platforms along this surface route obsolete.

Since 22 September 2007, line 6 has also had its starting point at the metro station Maritim-Serrería. It reaches the line 4 loop via a link, with both lines sharing the next 4.7 km. After the stop Primat Reig, however, line 6 turns north to serve the neighbourhoods of Orriols and Torreíel on a new 2.4 km route, which like line 4 has its own dedicated, mostly paved right-of-way. Since no turning loops were provided, line 6, just like line 8, can only be operated with bidirectional class 4200 trams.

The northern branch served by line 6 was actually supposed to become part of a north-south line T2, which was to pass

underground through the old town and the district of Russafa before running at the surface to Natzaret via the Ciutat de les Arts i les Ciències (CAC). Most of the above-ground section has been completed, but it is not connected to the rest of the network. Tunnel excavation south of Alacant station (on the eastern side of the main railway station) was well advanced when work was suspended due to the financial crisis. In the old town, the construction of the underground station at the central market had also started. It is currently uncertain when the project will be relaunched. Line 6, however, may be extended in the long term to become a circular line.

Cercanías

The historic railway station Estació del Nord on the edge of the old town is the starting point for six Cercanías lines. While lines C-1, C-2 and C-6 run at least twice an hour, there are fewer trains on line C-3. Lines C-4 (10 trains a day) and C-5 (1-4 trains a day), however, provide a rather modest service. Lines C-5 and C-6 stop at the underground station Cabanyal in the east of the city, which was created when the railway line to Barcelona was put underground in 1991. Unlike in Madrid and Barcelona, in Valencia, Renfe's Cercanías trains are not integrated into the urban fare system. While lines C-1, C-2 and C-6 are operated with EMUs of class 447 and 465 (Civia), the other, non-electrified lines use class 592 DMUs. Lines C-3 and C-4, which had been curtailed at Sant Isidre since 2008 due to the construction of the high speed Madrid – Valencia line, will return to València Nord in December 2015, but to do so, they will need to change direction at Fuente San Luis until further notice.

A new underground central railway station has long been planned just south of today's València Nord station. A large park will be laid out on top of the station. From the northern end, a new cross-city tunnel will be built to provide a faster and more direct connection to the route to Barcelona. For the standard-gauge high-speed AVE trains, a temporary terminus called València Joaquín Sorolla was therefore opened in 2010 on the site of the former goods station, which is within walking distance of Bailén and Jesús metro stations.

VITORIA-GASTEIZ

Unlike some other bilingual cities in Spain, the capital of Álava province officially carries a combined Spanish-Basque name. Today, Vitoria-Gasteiz is also the seat of the Basque Government and the Basque Parliament, which has stimulated the enormous growth of the city and its population over the last decades. A 100 years ago, the city was too small to have enjoyed a tramway of the first generation.

In 2008, Vitoria-Gasteiz became the second city in the Basque Country with a tram system, and the experience gained in six years of operating the older tramway in Bilbao was helpful in its implementation. Both systems are operated by the Basque railway company 'Euskotren' using very similar vehicles.

The two tram lines in Vitoria-Gasteiz are not numbered, but instead the three termini of the Y-shaped network can be identified by different colours and a different number of squares shown (see network map on the right), two features also visible on the tower-like minute displays at the tram stops. Both lines start in the shopping area just south of the old town, from where they run on-street to the stop at the Basque Parliament building. Beyond that point, a dedicated right-of-way is mostly available for both lines, with the reservation corresponding to a typical modern French-style tramway, and the track partly paved but mostly covered with lawn. Today's railway station is not served, probably because in conjunction with the construction of the high-speed line from Madrid to Bordeaux, a new underground railway station is planned in the area of the tram stop Intermodal, where a new bus terminal was also opened in 2014. However, according to recent plans, AVE and TGV will initially be diverted via the old railway station.

The two northern branches, which run through large new housing estates, are served alternately every 15 minutes. The eastern branch was opened a year later, and in 2012, a short single-track extension into the centre of the old village of Abetxuko was added. An extension eastwards from the city side terminus at Angulema is intended, but a final decision is yet to be taken.

Unlike those in service in Bilbao, the Urbos 2 vehicles from CAF used in Vitoria-Gasteiz feature five sections and are 100% low-floor. The original plant of Spain's traditional rail manufacturer CAF (Construcciones y Auxiliar de Ferrocarriles) is located in Beasain, 50 km north-east of Vitoria-Gasteiz.

The tramway in Vitoria-Gasteiz is only partially integrated with the urban bus network operated by TUVISA. A single ticket for a tram ride costs €1.35, though just €0.73 if paid with the rechargeable BAT card, which can also be used on buses. And not just for tram enthusiasts, a day pass is available for €4.40 (tram only!).

ZARAGOZA

The new tramway in the Aragonese capital is considered the most successful example of this type of transport in Spain. In 2004, when metro construction was still booming in other Spanish cities, and Sevilla and Málaga launched their light rail projects, even Zaragoza (in English also Saragossa) had ambitions of building a Sevilla-style metro, i.e. in tunnels through the city centre, but with an above-ground alignment through the less densely built-up outer districts. The first route was to become a north-south line, which would be complemented by an east-west line in the second phase.

In the course of the planning process, however, a French-style modern tramway gradually became the preferred option for the north-south corridor, particularly after a solution was found for the route through the city centre. In the French city of Bordeaux, just 350 km further north, modern trams had been running through the city centre without catenaries for several years, and it was decided to take a similar approach in Zaragoza. Instead of the French APS system with its temporarily switched-on power rails, the Spanish company CAF had developed ACR technology (Acumulador de carga rápida – fast-charging supercapacitors). On the one hand, braking energy is recuperated and fed into the energy storage system mounted on the roof, and on the other hand, the

battery is charged at stops by means of contact pads embedded into the ground. This enables the trams to travel up to 1200 m without a catenary. The same technology, now branded 'Freedrive', is in use on the MetroCentro in Sevilla.

In April 2011, after two years of construction, the first line was launched from the city centre to the new southern neighbourhood of Valdespartera where all the streets are named after film classics. Here the tracks follow parallel streets, with the area between 'Singing in the Rain' and 'An American in Paris' largely undeveloped and partly used for recreation. Once the depot is passed, the trams run into the city along the major axis formed by *Vía Ibérica*, *Paseo de Isabel la Católica* and *Paseo de Fernando el Católico* before reaching the original terminus *Gran Vía*. Starting in October 2012, the line was extended in stages through the city centre, now without overhead wires. Even the Ebro River is crossed in battery mode, with the tracks running along the western side on the *Puente de Santiago*. With the pantographs up again, the trams first run through parallel streets on the north bank of the river. The north and southbound tracks meet just before the line passes under the motorway A-2/Z-40, from where it continues through a partly undeveloped area to the new district of *Parque Goya*. Along the first tram line there are several university institutions. Long sections were covered with lawn, and at traffic lights, the trams are mostly given priority. The stops have 68 m long platforms, so double tramsets could be used.

Despite the great success of the first line, the construction of the planned east-west route (L2) has not yet begun. This line will have two eastern branches, although different alternatives are still under discussion. Surprisingly, line 2 will not provide a link to the new railway station *Delicias*.

Zaragoza's tram is well-integrated into the existing transport system. A single ticket (without transfer) costs €1.35, but with the contactless rechargeable card called 'Tarjeta Bus' (which costs €2.00) it is just €0.74, including free transfer to buses within an hour. The 'Zaragoza Card' is designed for visitors and only includes a limited number of trips on buses and trams!