

METROS IN ITALY

(Robert Schwandl/Claudio Brignole)

BERGAMO

Bergamo (117,000 inh.; approx. 390,000 in the metropolitan area) is an old and well-preserved city in northern Italy, some 45 km northeast of Milan. The historical centre, still surrounded by a city wall, is located on a hill (Città Alta), while the newer parts extend mostly south and east of it (Città Bassa).

The idea of building a tramway into Bergamo's valleys was born back in 1988, but almost 12 years passed before the construction contract was signed in December 2000. The project envisaged the implementation of some sort of guided mass transit system on a reserved alignment along the Bergamo-Albino and Bergamo-Almè corridors. This would be achieved by resuscitating the disused railway routes into the Val Seriana for line T1 and the Val Brembana for line T2. Opened in 1884 to Albino, the Val Seriana railway was extended to Ponte Selva in 1885 (34 km), but was never electrified; it was followed by the line into the Val Brembana, which reached San Pellegrino in 1906 and San Martino de' Calvi in 1926 (40 km). Within Bergamo, the two lines ran parallel along the first 1.7 km stretch. The newer of the two lines, which had been electrified in its early days, was completely abandoned in 1966, and one year later the 'Ferrovia della Valle Seriana' was, too. Though without service for over 40 years, the railway right-of-way remained the property of the State and was not redeveloped; it was thus available for the construction of the newly proposed light rail system.

The publicly owned company TEB SpA (Tramvie Elettriche Bergamasche) was founded in 2000 to plan, build and operate the new routes. The railway infrastructure had to be built from scratch as a double-track line, the six previously existing stations were rebuilt to modern light rail standard, and ten new stops were added, all equipped with shelters for passengers. Regular service on line T1 was launched in 2009. There are plans to extend it from Albino to Cene, Gazzaniga and Vertova (9.2 km). The current rolling stock consists of 14 four-section low-floor Sirio trams designed by Pininfarina and manufactured by AnsaldoBreda, with a distinctive yellow stripe on an otherwise grey livery. Each vehicle is 29.9 m long and 2.4 m wide, with a floor height of 30 cm to provide full accessibility.

Incorporating the disused right-of-way of the former 'Ferrovia della Valle Brembana', line T2 is currently at an advanced stage of planning; in the first phase it will run to Villa d'Almè, but eventually it will continue to San Pellegrino Terme (27.4 km). While lines T1 and T2 reach out into the neighbouring towns and valleys, line T3 will have a more urban character. It is planned to run on a 5.6 km corridor between Redona (T1) in the east to Nuovo Ospedale (a new hospital complex) in the west via the city centre. In the long term, an 84 km tram-train network is planned for the Bergamo region.

Besides the new tram system, Bergamo has two funicular railways: 1) the **Funicolare di Bergamo Alta**, which has linked the Città Bassa to the Città Alta since 1887 (240 m, climbing 85 m from 271 m to 356 m above sea level); 2) the **Funicolare di Bergamo – San Vigilio**, which runs from the opposite end of the upper town to the Castello di San Vigilio. It opened in 1912, is 630 m long and climbs 90 m up the hill. Whereas the first is an important part of the urban transport system, the latter is more of a tourist attraction as it provides a splendid view of the city.

BRESCIA

The city of Brescia is located in Lombardy, some 80 km east of Milan and some 45 km southeast of Bergamo. The city proper has a population of 192,000, with some 450,000 in the entire region.

The history of the 'Metrobus', as it was initially known, began in 1986 with the first feasibility study for an integrated transport system. The plan, which defined a number of priority corridors, led to a lively debate on which system should be implemented: an automatic metro (on rubber or steel wheels) or a more conventional system, like a low-floor rapid tram on an exclusive right-of-way and with underground sections in the city centre. After nearly two decades of planning and debating, the construction of the first metro line was started in 2004 by the municipal company Brescia Mobilità. The current prediction is that the system will open in December 2012.

Though initially planned to become a French VAL metro like that in Turin, in the end an Italian option was chosen in the form of the Ansaldo light metro already in operation in Copenhagen, and currently also under construction in Milan (M5) and Rome (line C). The metro line runs north-south through the city centre before turning eastwards to Sant'Eufemia, all within the Brescia city boundaries. The total length of the line will be 13.1 km (9.7 km underground) and there will be 17 stations (13 underground). The northernmost stretch from the terminus Prealpino to Europa is being built by cut-and-cover, while the tunnel through the city centre and beneath the railway station was excavated using a TBM (tunnel-boring machine) with a diameter of 9.1 m; the TBM drive from Volta to Ospedale was finished in March 2009. Between Brescia 2 and Lamarmora, provisions have been made for a future 3.5 km branch towards the Fiera (fairgrounds). All the underground stations are being built by cut-and-cover to create pleasant areas with daylight coming down to platform level. East of Volta station, the metro trains will emerge from the tunnel and continue at grade to Poliambulanza and San Polo Parco, then return into a shallow tunnel at San Polo Cimabue before reaching the terminus at Sant'Eufemia-Bufalora on a viaduct. The depot and control centre will be located beyond the southern terminus.

A northern extension to Gardone in the Valle Trompia has been considered from the beginning; this may add some 14 km (11 stations) to the initial line, partly underground and partly elevated.

The trains built by Ansaldo for Brescia are very much like those already in service in Copenhagen. The 18 three-car trainsets are 39 m long and 2.65 m wide, and run on standard-gauge (1435 mm) tracks. The initial fleet will be able to transport 8,500 passengers per hour and direction at a headway of 3 minutes (minimum headway - 90 seconds). The first car was presented in Brescia in 2009.

CAGLIARI

Cagliari is located in the south of the island of Sardinia, of which it is the capital city. With a population of 160,000 it is also the biggest city on the island, while its entire metropolitan area is home to some 350,000 people.

Analogous to the slightly older Metrosassari, the tram line in Cagliari is referred to as Metrocagliari, but unlike its northern counterpart, it can be classified as 'light rail' or 'metrotranvia': the entire 6.3 km between Repubblica and Monserrato-Gottardo lies on a former railway alignment, and is thus separate from road traffic, though with several level crossings. The line is double-track between Repubblica and

Gennari, as well as between Centro Commerciale and Caracalla, and has passing loops at most stops, thus allowing a 10-minute headway. Trams run from 06:00 to 22:30, and like the Sassari system they are operated by Ferrovie della Sardegna (FdS). At the Monserrato terminus, located next to the depot, interchange is provided with connecting FdS trains to Isili, which were curtailed there when the tram service was introduced in 2008. In the next step, the 4 km interurban route to Settimo will be electrified and the tram service extended there. Also planned is a 1.7 km extension from Gottardo to Policlinico (also referred to as line 2). The current master plan, approved in 2008, includes several new lines to link Cagliari to every part of the metropolitan area.

Metrocagliari is served by nine Škoda 06 T vehicles; they are 29.5 m long (5 sections), 2.46 m wide, 65 % low-floor (350 mm), bidirectional and, like the rest of the FdS network, run on narrow-gauge (950 mm) tracks.

CATANIA

With some 300,000 inhabitants, the city of Catania on the east coast of Sicily is the centre of a larger metropolitan area extending to the south of the volcano Etna with a population of approximately 650,000.

Catania boasts a small metro system of 6 stations with a total length of just 4 km. It only operates on workdays, every 15 minutes from 07:00 to 20:45.

The 'Metropolitana di Catania' is part of the Ferrovia Circumetnea (FCE) network, although now it is a physically separate line. The Circumetnea, which as its name suggests runs around Mount Etna from Catania to Riposto (located on the coast some 30 km north of Catania), was opened in stages between 1895 and 1898 as a narrow-gauge (950 mm) railway with a total length of 115 km. Within Catania, trains used to run through the rather narrow streets down to the harbour (Porto) up until the 1990s, when a scheme was launched to put the urban section underground and convert it into a metro service. To make it compatible with the Italian national railway network (especially for freight service), the underground section was built with standard-gauge tracks and is thus separated from the remaining FCE route, which now terminates above ground at Borgo.

The metro service was launched on the 2.3 km underground route in 1999, when the four underground stations were opened. Beyond Galatea, trains continue on the 1.7 km single-track surface route running alongside the mainline tracks, with a simple stop on the far side of the Catania Centrale station and a two-track terminus at Porto, at present the closest station to the city centre. The metro service was launched with three vehicles purchased from the Ferrovia Centrale Umbra, which were replaced in 2001 by four new units of class M.88 produced by Firema (a fifth was added to the fleet later); they are 39.5 m long and 2.85 m wide. The line is electrified at 3000 V dc.

A branch from Galatea to Giovanni XXIII (on the northern side of Catania Centrale station) and Stesicoro in the heart of the city is currently under construction. Also in an advanced stage of construction is the completely underground Borgo – Nesima section, while further extensions are planned. As the metro grows towards the western suburbs, the old FCE will be cut back as its present surface route is perceived as a barrier in those areas. In the long run, the entire FCE line may be upgraded and reconnected to the metropolitan section. A more direct metro route from the west towards the city centre, thus creating a circular route, has been proposed.

While the short metro line is being expanded to become the proper backbone of urban transport, the existing RFI line is being doubled and new stops are being added to introduce a metropolitan service on the Messina-Siracusa line between Cannizzaro and Bicocca. There are plans to put the existing Catania Centrale station underground.

FLORENCE

Florence (in Italian 'Firenze') is the capital of the Toscana region. The city proper has a population of 370,000, while some 600,000 live in the metropolitan area (incl. e.g. Scandicci).

On 14 February 2010, trams finally returned to the streets of Florence, the first-generation tramway system having been abandoned back in 1958. The last of the old lines in operation had been line 17 which had connected Via de' Pecori in the city centre to Cascine.

Funding for the recently opened first modern tram line had already been approved by the Italian government back in 1996 when it was included in an ambitious national scheme to improve urban transport in the country's major cities. But several years passed before construction finally started, and many more were required to complete this typical modern tramway line, with dedicated lanes mostly separated from road traffic by a slightly raised right-of-way. The most significant infrastructure built for the tram is an exclusively used bridge across the Arno River, an underpass between Talenti and Federiga, as well as a viaduct between Aldo Moro and the Greve River. The initial line is part of a planned 3-line network, and runs from the railway station Santa Maria Novella in the city centre (some 600 m from the famous cathedral) to the neighbouring municipality of Scandicci. The 14 stops along the route are served by Sirio trams supplied by Ansaldo. The depot is located near the Scandicci terminus. Line T1 operates from 05:00 to 24:00, with a tram every 3.5 minutes during peak hours and every 6 minutes at other daytime hours (12 min in the late evening).

After heavy protests against the proposed alignment past the cathedral, which even led to a referendum, the future of the planned lines T2 and T3 is unclear. In the next stage, only the sections outside the historical centre might be built. Line T2 is designed to link the present railway station to the future high-speed railway station and the airport. For the route through the old city centre, a power supply system without overhead wires (like e.g. in Nice or Bordeaux) has been proposed.

GENOA

The city of Genoa (in Italian Genova) is the most important seaport in Italy. With a population of 610,000 (880,000 in the entire province), Genoa is Italy's sixth largest city. The city is located on a narrow 30 km strip between the Ligurian Sea and the coastal mountains (the highest peak within the municipal boundaries reaches 1183 m above sea level!), which makes transportation rather difficult: the streets are mostly narrow and go up and down a lot, resulting in longer distances between different parts of the city than one would normally find. The city territory also comprises two side valleys, the Val Polcevera and the Val Bisagno, which makes journeys within the city even longer and more complicated. Public transport has therefore played an important role since the 19th century, resulting in the early implementation of pioneering technologies such as funiculars, rack tramways and public elevators to provide access to higher areas of the city. The city also developed a large network of tramway lines, initially horse-powered and later electrified, but unfortunately they were all abandoned during the 1960s and replaced by buses and, more recently, two trolleybus lines. With a large number of stations within the city limits, suburban railways also have an important share of Genoa's transport system.

Metropolitana

As a result of the aforementioned topographical difficulties of moving within the city, the construction of a metro system was first proposed in as early as the beginning of the 20th century. Between 1907 and 1972, many projects were put on the table, but generally for financial reasons, they all failed to prosper. In 1980, the ambitions were therefore reduced, and the incorporation of some unused tunnels was envisaged to create a light rail line with both underground and surface sections to link the Val Polcevera to the city centre.

The 1761 m Certosa tunnel between Brin and Dinegro was inaugurated as a dedicated tram tunnel on 23 May 1908. After tram operation had ceased in 1964, the tunnel was rebuilt and re-opened as a bus tunnel in 1967. It was closed again in 1982 to allow for its integration into the new metro line, which eventually opened on this section in 1990. The width of the existing Certosa tunnel limited the choice of the future metro rolling stock to that with a width of only 2.2 m.

In 1983, Ansaldo Trasporti was awarded the contract to build the first section from Brin to Dinegro, which was to become the first segment of a future cross-city line linking the major railway stations at Principe and Brignole via the city centre. The metro line was designed for light rail vehicles, both to keep costs down and to use the maximum amount of the existing tunnel infrastructure: besides the Certosa tunnel, this included storage space below Via Buozi (which now accommodates Dinegro station and sidings) and the Grazie railway tunnels (the section between a point south of San Giorgio station and a point close to the future Corvetto station), resulting in the curved alignment of the current metro line. The low-budget approach of the metro project is also visible in the station platforms, which are only 80 m long; the design of the stations from Brin to San Giorgio was commissioned to the famous Italian architect Renzo Piano, who decided to use modular and standardised elements. Different solutions were later chosen for the newer stations at Sarzano/Sant'Agostino and De Ferrari, resulting in a greater variety of station architecture. Between De Ferrari and Brignole, a station had also been planned at Piazza Corvetto, but to reduce costs its construction was postponed indefinitely. The future Brignole station, now under construction, will have a rather functional design: it will lie on the surface and provide cross-platform interchange with the urban rail line, as well as convenient transfer to regional and long-distance services and several bus lines, thus forming part of a real transportation hub.

The construction of the metro line has been very slow, and despite the use of some previously existing infrastructure, its total length has only reached 5.2 km with 7 stations after 25 years of construction. In 2012, when the extension to Brignole is scheduled to open, the line length will increase to 6.8 km. At the time of writing, no decisions have been taken about future extensions beyond Brin and Brignole. An extension from Brin to Canepari is still likely, while a previously envisaged terminus at Rivarolo with an interchange to the existing railway line was shelved. The 130 m viaduct beyond the Brin terminus, which is now used for reversing, was prepared for the future extension, which will carry the metro onto the western side of the freight rail line. A once-planned eastern extension from Brignole into the Val Bisagno will be built as a tram line, while a metro extension to the huge Ospedale San Martino is still an option for the future.

The metro line starts on a viaduct at Brin station, at present the only surface station, and soon disappears in the Certosa tunnel. After a very tight curve with a radius of just 40 m, the metro trains reach Dinegro. From here, they continue through an area previously occupied by port warehouses before they enter Principe station. This is the beginning of the two single-track tube tunnels excavated with TBMs. Principe, as well as the stations Darsena and San Giorgio, has an island platform. Just before arriving at San Giorgio, there is a large cave which accommodates a scissors crossover: until the extension to Brignole has been completed, trains will continue to De Ferrari on alternating tracks as there are no crossovers at the current terminus. This kind of operation leads to the minimum headway of six minutes, although theoretically the line is designed for a 2-minute interval. Illuminated signs indicate to passengers which track will be used by the next train in each respective direction. Shortly after San Giorgio, the metro trains enter the upgraded Grazie tunnels, which were formerly used by freight trains to and from the seaport. Sarzano/Sant'Agostino station is the deepest at 29.2 m, and currently also the least frequented as it is located close to the terminus at De Ferrari, which lies right in the heart of the city.

The Genoa metro operates every 6-7 minutes, from 06:30 until 21:00. It is fully integrated with the city's public transport system (including buses, funiculars and urban trains), and single tickets (90 minutes) are available at € 1.20, 24-hour tickets at € 3.50. The metro line is part of the AMT (Azienda Mobilità e Trasporti) network, which is now managed by the French RATP.

The standard-gauge metro fleet comprises two different types of trains, which were both manufactured by Firema (car bodies and mechanical parts) and Ansaldo (electrical equipment):

1) six first-generation light rail vehicles entered service in 1990: these articulated cars are 25 m long and 2.2 m wide, and have four doors on each side.

2) twelve second-generation vehicles (T67A) were built between 1991 and 1995: they are also 25 m long and 2.2 m wide, but besides the four double-leaf doors, they have two additional single-leaf doors next to the driver's cabs.

Both train types have a floor height of 850 mm to match the height of the platforms. Power (750 V dc) is supplied via an overhead line. In normal operation two units are coupled together. When the extension to Brignole opens, triple units will be used and the fleet will be complemented by seven new third-generation articulated units (with an option for seven more), which have been ordered from Ansaldo and will be 39 m long. The metro control centre is located at the Brin terminus.

Funiculars, Rack Tramway and Lifts

As the residential areas that surround the old city centre climb to 200 m above sea level, convenient ways to negotiate the steep streets had to be found in the early days of electric traction. Today, Genoa boasts two funiculars, one rack tramway, one peculiar hybrid lift/funicular and several public lifts, all of which form part of the integrated transport system.

The most important mountain transport is the **Funicolare Zecca-Righi**; it was built between 1895 and 1897 as two separate funiculars, which were connected in 1963. This line is 1428 m long and has 7 stops; it starts at Largo Zecca and runs underground for the first 700 m, but emerges from the tunnel at the intermediate stop San Nicolò where the two carriages cross. The maximum gradient is 35 %, with the mountain terminus Righi located at 292 m above sea level.

The **Funicolare di Sant'Anna** was brought into service in as early as 1891; it was initially powered by water ballast, but was eventually rebuilt into a conventional funicular in 1980. Its route from Piazza Portello to Via Bertani near Corso Magenta is only 357 m, but with a difference in altitude of 54.8 m and an average gradient of 15 %, it is also an essential transport option for many residents.

The **Ferrovia Principe-Granarolo**, opened in 1901, is a single-track rack tramway, which due to urgently needed repair work, has been limited to a short section since 2003. The full length of the line is 1136 m; with a maximum gradient of 21.4 % it negotiates a difference in altitude of 194 m.

The **Ascensore Castello d'Albertis-Montegalletto** seems to be unique in the world, as it combines a horizontal funicular (i.e. a cable-hauled cabin) with a vertical lift. When the lift opened in 1929, passengers had to walk some 300 m into the mountain before being carried up some 70 m. The old elevator closed in 1995 to be re-opened in December 2004 with completely new technology developed by Poma Italia.

Starting from the street entrance, the cabin is pulled by a cable on an almost horizontal line. After it has reached the bottom of the lift shaft, it is automatically transferred to the vertical mechanism and lifted up, while the cabin in the opposite direction continues like a train towards the city centre exit.

The list of mountain transport is complemented by several public lifts, among them the **Ascensore di Castelletto Levante**, the most popular and that with the best view.

Suburban Rail

The RFI mainline railway La Spezia – Genoa – Ventimiglia runs along the entire Ligurian coast and thus right through the city of Genoa. Between Nervi and Voltri, a half-hourly service is provided with 12 intermediate stops, although many trains continue beyond these points. The lack of dedicated suburban tracks, however, makes an exclusive urban service impossible at the moment. A similar service, but with some timetable gaps, is operated on the Val Polcevera line. On the route to Acqui Terme there is a train only about every two hours.

In the first attempt to create a dedicated metropolitan service, the underground station Principe Sotterranea was added to Genova-Piazza Principe station in 1993.

In 2005, two new stations were built within the city boundaries, Via di Francia in the central area and San Biagio in the Val Polcevera, while Pra was rebuilt on a new alignment. The city's busiest stations, Piazza Principe, Brignole and Sampierdarena, are currently being refurbished. In the near future, suburban traffic will be separated from long-distance traffic on the Voltri – Brignole section, thus allowing the introduction of a real metropolitan service with five new stations, one of them serving Genoa's airport.

Besides the Trenitalia trains on RFI routes, yet another railway operates from Genoa, the **Ferrovia Genova-Casella** (FGC), a single-track narrow-gauge (1000 mm) line which connects Piazza Manin in Genoa with Casella, some 25 km further north, on a scenic and winding route which climbs from 93 m above sea level in Genoa to 410 m in Casella. Like the Italian mainline railways, it is electrified at 3000 V dc. With only 10 trains a day in each direction, its role in the urban and suburban transport system is rather limited.

MESSINA

With the first-generation tram system having been closed down in 1951, modern trams started regular service in Messina in April 2003 after five years of construction, making Messina the first city in Italy to bring back its tramway. Messina has a population of 244,000 and is an important harbour in the east of the island of Sicily, and the gateway for all Sicilians travelling towards mainland Italy.

Oddly, Messina's only tram line carries the number 28, which it inherited from the bus line which had served the same corridor prior to the re-introduction of the tram. The line is 7.7 km long and has 18 stops. Running parallel to the coast, it serves all the important parts of the city. After a temporary single-track terminus had been used for many years, the permanent southern terminus at Bonino was finally brought into service on 23 Sept 2009, providing interchange with several bus lines. The entire route is on a reserved right-of-way, with priority at traffic lights. The tracks were mostly laid on prefabricated concrete elements embedded on a rubber layer to reduce noise and vibration.

The Messina tram fleet comprises 15 bidirectional five-section Cityway vehicles (22.5 m long and 2.4 m wide; standard-gauge) built by Alstom, similar to those in service in Turin. The depot is located near the Curv. Gazzi stop. The tram line is operated by Azienda Trasporti Messina (ATM), which also runs urban buses.

MILAN

... will be covered in a dedicated book in the mid-term future (U-Bahn, S-Bahn & Tram in Milano)

NAPLES

With a population of 965,000, Naples (Napoli in Italian) is the biggest city in southern Italy and the centre of a metropolitan region with some 3.5 million inhabitants, extending from Caserta in the north to Sorrento in the south. Naples is a major tourist destination – besides the city proper, there are many world-famous sights to see in the area, such as Ischia, Capri, the volcano Vesuvius and the Roman site of Pompeii. Naples is the capital of the region of Campania. Naples is one of the most densely populated cities in the world and therefore ideal for urban mass transportation.

For the urban rail enthusiast, Naples is without doubt among the most exciting cities in Europe, thanks to the large diversity of railways operating in and around the city, ranging from funiculars and trams, to a metro, to various kinds of suburban railways with a metro-like service. The city extends from the beautiful Gulf of Naples up to the surrounding hills, which adds even more fun to an already thrilling experience.

Within Italy, Naples has often been a railway pioneer: in as early as 1839, the first Italian railway was opened between Naples and Portici, after which, in 1842, it was extended to Castellammare di Stabia. In 1925, Naples became the first Italian city to inaugurate a 'Passante', i.e. an underground cross-city link with a metropolitan service on its urban stretch. Naples' real metro, however, became the fourth in Italy after Rome, Milan and Genoa when it started service in 1993.

All the different modes of transport, rail lines and buses, are fully integrated into the UnicoCampania fare system. For visitors, a 3-day pass for the entire region of Campania is available at only € 20.00. UnicoNapoli tickets are valid in Naples and all the adjacent municipalities: a 90-minute ticket costs € 1.10, and a day ticket € 3.10 (2010). Overall maps with clear zone borders are, however, non-existent, and ticket vending machines do not issue the complete range of tickets.

All the transport services are provided by public companies, although different civil administrations are responsible for them. The trams and most buses within Naples are operated by the municipal ANM (Azienda Napoletana Mobilità); buses running between Naples and the surrounding province are in the hands of CTP Napoli (Compagnia Trasporti Pubblici di Napoli) or EAV Bus, two companies owned by the Province of Naples; Metronapoli SpA (mostly owned by the City of Naples) is responsible for metro lines 1 and 6, as well as the four urban funiculars; three formerly independent companies are now under the control of the Ente Autonomo Volturno, the transport administration of the region of Campania:

- 1) Ferrovia Circumvesuviana s.r.l. operates an extensive narrow-gauge suburban network on the eastern side of Naples;
- 2) S.E.P.S.A. (Società per l'Esercizio di Pubblici Servizi Anonima) runs the Ferrovia Cumana and Ferrovia Circumflegrea on the western side of the city;
- 3) Metrocampaia Nordest is in charge of two regional rail line rail lines and a suburban one (Alifana).

And last but not least, line 2 (Metropolitana FS) is part of the Trenitalia network, Italy's national railway company.

In early 1997, the Napoli city council approved an ambitious plan to create a comprehensive metro network by integrating all the existing urban and suburban rail lines into a single system. Although none of the deadlines proposed for completion have been met, many projects are currently underway – they are described in detail in the corresponding sections of this book. Apart from these, line 9 has been proposed to run between Museo and Colli Aminei via Capodimonte (3.6 km), and line 10 from Museo to the new railway station at Afragola on the high-speed line to Rome (intersecting with line 1 at Di Vittorio; ~11 km). Outside the city of Naples, the existing and new suburban lines will provide a metro-like service, with many routes being doubled and new stations added. With the completion of the high-speed Rome – Naples rail link in December 2009, the old cross-city link is now exclusively used by urban and suburban trains, and a kind of RER/S-Bahn service is gradually being introduced.

Metropolitana Linea 1 (Metro Collinare)

Today's line 1, also known as the Metro Collinare [Hill Line], runs from Dante in the city centre to Piscinola in the north, passing through the Vomero district some 200 m above the city centre. This area has long been linked by a total of three funiculars (see p. 126), but with more residential areas being built and car traffic increasing steadily, additional transport options had to be found. A fourth funicular was proposed in the mid-1960s, but it was soon discarded as its capacity would have been insufficient, and its required length would not have been operable with funicular technology. A 4.5 km rack railway between Piazza Bovio and Colli Aminei via Piazza Medaglie d'Oro with 12 stops was then proposed, but its limited coverage of the area was heavily criticised. Still vacillating between a conventional rail line and a rubber-tyred solution, the final alignment eventually emerged in the mid-1970s. In 1976, the necessary funds were approved for the mountain route as well as its extension through the city centre terminating at Piazza Garibaldi, next to the railway station Napoli Centrale. The 'Società Metropolitana di Napoli', which had been founded in 1972 and received support from the 'Metropolitana Milanese SpA', launched construction between Vanvitelli and Medaglie d'Oro in December 1976, but the works did not advance as expected. With a northern surface extension having been added to the project to link the emerging neighbourhoods of Piscinola and Scampia, and just as construction on the initial section finally seemed to get into full swing, the Naples region was shaken by an earthquake on 23 November 1980; as a consequence, the whole metro project had to be revised to make it earthquake-proof, thus delaying its completion once again. Step by step, the funding problems with the different administrations involved were overcome, and the Metro Collinare finally started regular service in 1993 between Vanvitelli and Colli Aminei, i.e. in the upper part of the city. At Vanvitelli, passengers had to change to one of the funiculars to reach the city centre proper. Although Vanvitelli station is already located at 174 m above sea level, trains still have to negotiate gradients of up to 5.5 % to reach the highest point of the line at Policlinico (232 m), from where they descend towards Colli Aminei (225 m). The following 4.8 km surface section, which lies mostly on a viaduct, was opened two years later. Apart from providing a fast service to the populous northern districts, it was needed to access the metro depot established near the Piscinola terminus (initially with the appendage 'Secondigliano'). At the elevated terminus, an underground shell was built to provide convenient interchange with the Alifana Railway, which eventually re-opened in 2005 in the form of the Metrocampaia Nordest line (see p. 117).

With the first two sections in operation, construction continued in the second half of the 1990s on the steep climb from the city centre up to the Vomero area. In order not to exceed the permitted maximum gradient of 5.5 %, the line has taken such a long loop that it crosses itself near Medaglie d'Oro station, the only place in the world where this happens to a metro line. Due to a lack of track crossovers between the single-track tunnels, initially only a 30-minute shuttle service was introduced between Vanvitelli and Museo in April 2001; this was extended to Dante in March 2002. Through service between Dante and Piscinola finally started in December 2002. The opening of the intermediate station at Materdei eventually completed line 1 as it exists today.

All the stations were built with 110 m platforms, long enough to accommodate 6-car trains. Most stations lie rather deep, with Rione Alto the deepest at 42 m below the surface. The distance between stations varies from 464 m between Rione Alto and Policlinico to 1687 m between Chiaiano and Piscinola. Great effort has been put into attractive station designs, with many works of art on display, especially in the stations built or refurbished since the year 2000.

Except for a short 1.2 km section between Vanvitelli and Piazza Muzji (north of Medaglie d'Oro), which was constructed by the cut-and-cover method and which includes an encased bridge across Via S. Gennaro ad Antignano, all the underground sections were excavated below ground as single-track tunnels.

Line 1 has overhead power supply at 1500 V dc. Trains are equipped with ATP and ATO systems for semi-automatic operation, but they are now operated in manual mode. The metro cars operate in permanently coupled pairs (2x17.8 m long; 2.85 m wide), and form 4-car or 6-car trains (106 m). The 45 pairs were manufactured by Fiore and SOFER (car bodies), and Ansaldo and Metalmeccanica Lucana (electrical equipment).

Since 2001, Line 1 has been operated by Metronapoli S.p.A., a municipal company. Trains run from 06:00 to 23:15, every 7 minutes during peak hours, and every 10-12 minutes during off-peak hours.

Line 1 Future

The 1997 master plan (revised in 2001) included some ambitious extensions to line 1. Previously, a northeastern extension from Piscinola towards the Afragola railway station on the new high-speed line had been envisaged. The new project, however, considered the construction of a circular metro line by incorporating the section between Piscinola and Garibaldi, which was to be served by the rebuilt Alifana railway. The Alifana line was then planned to terminate at Piscinola, but eventually the metro and the Alifana line (now renamed Metrocampaia Nordest) will share tracks between Piscinola and the city centre. Line 1 will therefore directly link all the important points in the city: the railway station, the airport, the harbour, the historical city centre, the Vomero and the largest hospital complex.

The section through the city centre from Dante to Piazza Garibaldi (Napoli Centrale) had already been included in the initial project, but it was slightly modified in 1998 to take a detour via Municipio (City Hall), where an interchange with line 6 is now under construction; the original project envisaged a more direct curve between Piazza Carità (Toledo) and Piazza Bovio (Università). Though initially meant to be built by cut-and-cover along Corso Umberto I, the city centre section is now being excavated by tunnel-boring machines to reduce disruptions at the surface. Many archaeological finds encountered during the construction of the stations in the city centre are now on display in a special section of the Museo Nazionale, directly accessible from Museo station.

Similar to what had previously been done on the Vanvitelli – Dante section, a shuttle service will be launched in June 2010 to link Dante to Università station, without any intermediate stops, while the rest of the line is being completed. Other sections may be brought into service in stages as they are finished, with the entire circular route planned to be in operation in 2015 at the earliest, as construction between Garibaldi and the airport had not started yet in 2010.

Linea 6

Like line 1, Naples' line 6 is operated by the municipal Metronapoli S.p.A. With a current length of only 2.3 km, line 6 is among the shortest metro lines in the world, but by the time it has reached Municipio station in the city centre in a few years, it will have grown to 5.8 km.

Line 6 is the successor of an abandoned project designed in the 1980s, in which a Linea Tranviaria Rapida (LTR) was planned to cross the city from east (Ponticelli) to west (Piazza Tecchio/Mostra). The line was to be similar to a German Stadtbahn, i.e. running partly in metro-style tunnels and partly on the surface on conventional, though mostly separated tram routes. The LTR, developed jointly with the Genoa Metro and hence the small train profile, was supposed to open in time for the 1990 Football World Cup, as Naples' municipal stadium San Paolo is located at the western end of the proposed line. For various reasons, only a short stretch was finished, and with the Football World Cup over, the project fell into slumber. It was eventually included in the 1997 master plan, but as a small-profile metro line (metropolitana leggera) rather than the previously envisaged metroltramvia.

The four initial stations, Mostra, Augusto, Lala and Mergellina – all enhanced with works of art – finally opened on 4 February 2007, with trains operating from 06:00 to 21:20, every 8 minutes during daytime and every 16 minutes in the evening. As can be seen on the map, the present route runs through an area already served by several stations on line 2 as well as the Ferrovia Cumana, so line 6's real value will only be felt when the extension into the city centre opens, too, and interchange will be provided to line 1. The section between Mostra and Lala was built by cut-and-cover, while the eastern part between Lala and Mergellina, which runs below the Posillipo hill and has a maximum gradient of 5.5 %, was excavated using mining techniques.

The six articulated light rail units (T67) currently in service on line 6 were delivered by Firema in 1990; they are 23.6 m long and only 2.20 m wide, and similar to those in service on the Genoa Metro.

In 2008, a western extension was added to the line 6 project, to replace a loop previously planned for line 8 (Cumana) to serve the new developments of BagnoliFutura on the terrain of Italsider, a former steel factory.

Metropolitana Linea 2 (Metropolitana FS)

Line 2 is the new designation for what used to be known simply as 'Metropolitana', i.e. the urban service along the mainline cross-city rail link. Line 2 is currently 14.5 km long and runs from Gianturco on the eastern side of Napoli Centrale station to Pozzuoli-Solfatara, an old town west of Naples, serving a total of nine intermediate stations. Trains run underground between Piazza Garibaldi (railway station) and Mergellina, calling at four underground stations. There are two more tunnels west of Mergellina due to the hilly topography of the area. During off-peak hours, there are 6-7 trains per hour, but at somewhat irregular intervals. Until December 2009, when the high-speed line from Rome to Naples was completed, the cross-city tunnel was still used by some long-distance trains, but it is now exclusively available for urban and suburban services. Some trains continue north to Villa Literno or Formia, northeast via Cancelli to Caserta or Capua, and south to Salerno. For the future, an RER-style service is planned, with trains operating through the central tunnel every few minutes. The capacity of the cross-city tunnel is limited, however, by the rather short underground stations (100 m).

Line 2 is mostly operated with rolling stock of class Ale 724 (with Le884 intermediate trailers), delivered in 1983/84. These EMUs form four-car trains with a total length of 98 m. These trains are rather inadequate for a metro service as the steep steps and the limited number of doors require several minutes for each station stop. To increase capacity, half of the seats have been removed from the trains used exclusively on the metropolitan service (see p.116 ®). The line 2 service is provided by Trenitalia, the national rail operator, although between 2001 and 2005 it was also operated by Metronapoli SpA, in which Trenitalia (then Ferrovie dello Stato - FS) was a shareholder.

The urban service on the cross-city link was introduced in 1925, although some stations were added at a later date (see table). The construction of a new line between Rome and Naples (the 'Direttissima') had started in 1909, but was delayed due to World War I. It became fully operational in 1927. The urban section (in fact from Garibaldi to Villa Literno) was initially electrified at 650 V with third rail power supply, and long-distance trains were hauled through the urban tunnels by special locomotives. The original power supply was replaced in 1935 by the nationwide overhead system with 3000 V dc.

Until 1960, Piazza Garibaldi was an uncovered station in a cutting within the mainline station complex, but when the Napoli Centrale station building was relocated further east, the Metropolitana station was covered, and a large square was laid out in front of the new station building (which is currently undergoing major refurbishment). Gianturco station used to have two through and three stub tracks, but in 2007 it was rebuilt to become a 4-track railway junction.

By the end of 2010, line 2 will have been extended from Gianturco to San Giovanni-Barra, where the existing station is currently being rebuilt to accommodate dedicated tracks for terminating trains.

MetroCampania NordEst

Lying mostly outside the Naples municipality, the new line which runs north from the line 1 terminus at Piscinola to Aversa was not assigned any number in the 1997 master plan, although it is the most metro-like line of all the suburban routes. The section currently in operation is fully underground, and was built to the same parameters as line 1 to allow the two lines to share the same tracks between Piscinola and the city centre; at the time of writing, the definitive terminus has not yet been determined. Instead of a number, the MetroCampania NordEst line was soon nicknamed 'Linea Arcobaleno', the Rainbow Line, thanks to each station being designed in a different colour.

In 2005, the company 'Ferrovia Alifana e Benevento-Napoli' changed its name to 'MetroCampania NordEst' (MCNE). Apart from the Piscinola – Aversa line, MCNE operates two regional services, which enter Napoli Centrale station on RFI tracks, one to Benevento via Cancelli, and the other to Piedimonte Matese via Santa Maria Capua Vetere; the latter line used to have a direct route to Naples via Aversa and Secondigliano. It opened on 30 March 1913 and terminated in Naples at Piazza Carlo III. While the outer non-electrified section from Santa Maria Capua Vetere to Piedimonte was rebuilt to standard gauge in 1963, the inner section (Alifana Bassa) remained narrow-gauge and electrified at 11,000 V ac (25 Hz) until 20 February 1976, when it was 'temporarily' closed for upgrading. In various stages, its southern terminus had already been relocated from the city centre to Secondigliano a few years earlier.

The new Linea Arcobaleno had originally been planned to return to Naples' central station, but this alignment was later given to the circular line 1, instead. Eventually, a combined solution was found, and now the MCNE line will share the metro tracks.

Construction began in 1984, but was later suspended. The northern section between Santa Maria C.V. and Teverola was to remain single-track and on the surface, while the rest was to be built underground by cut-and-cover. The underground station at Piscinola was built together with the line 1 extension to create a convenient interchange. The first 3.2 km section between Piscinola and Mugnano was finally brought into service in 2005; the line was extended to Aversa Centro in 2009 (without Melito station). The start of the construction of the missing underground section from Aversa to Teverola is not yet in sight. While the northern surface route closely follows the old alignment of the Alifana line, the southern underground part runs further east on a more direct route.

Trains now run every 15 minutes (10 min during morning peak hours) between Piscinola and Aversa. The rolling stock in service consists of 15 modernised class MA 100 cars purchased from the Rome Metro.

Ferrovia Circumvesuviana

The Ferrovia Circumvesuviana is a dense electrified narrow-gauge suburban rail network (950 mm; 1500 V dc) in the region east of Naples. Two of the lines embrace the volcano Vesuvius, hence the name of the railway company. The sections within Naples have been upgraded and constitute lines 3 and 4 in the overall master plan for an integrated metro network, although these line numbers are currently not used in passenger information. In fact, on line 4 no trains serve only the urban section, while the line to Torre Annunziata has a rather metro-like character anyway. The current service consists of six lines (clockwise):

- 1) Napoli – Acerra: every 60 minutes (plus hourly shuttle from Pomigliano to Acerra)
- 2) Napoli – Baiano: every 30 minutes
- 3) Napoli – S. Giorgio a Cremano (Line 3): every 30 minutes
- 4) Napoli – Cercola (Line 4) – Sarno: every 30 minutes
- 5) Napoli – Pompei – Poggioreale: every 30 minutes
- 6) Napoli – Sorrento: every 30 minutes

with some extra trains during peak hours. Trains to Sorrento skip some stations on the route from Naples to Torre Annunziata. All trains depart from Porta Nolana (opened in 1893), the 13-track terminus some 700 m from Napoli Centrale.

The Circumvesuviana, formerly operated by SFSM (Strade Ferrate Secondarie Meridionali), first started to run steam trains from Naples to Ottaviano on 18 November 1890. In 1904, this line was extended to Sarno, and a second line was built on the southern side of Vesuvius via Pompeii, joining the original line at Poggioreale. Electric service was introduced in 1905, although the electrification of the entire network took until 1926.

Plans for the expansion of the network were interrupted by World War I, which is why the first section of the branch line to Sorrento, up to Castellammare di Stabia, only opened in 1934. Damaged not only in World War II but also by the eruption of the volcano in 1944, the railway had to be rebuilt, while the ultimate extension to Sorrento, which included several mountain tunnels, was only completed in 1948.

Prior to World War II, however, the Circumvesuviana network had grown considerably by acquiring the 38 km narrow-gauge line from Naples via Nola to Baiano, which had opened back in 1884. Until 1936, the Baiano line had its terminus north of the current Napoli Centrale station at Corso Garibaldi/Via Casanova.

Between 1948 and 1975, the line to Torre Annunziata was doubled and put mostly into an open cutting to eliminate level crossings. At the same time, all the platforms have been raised to match the height of the train floors.

In 1977, a branch with two underground stations was added to the Baiano line to improve access to the Alfa Lancia factories. On 2 February 2005, this branch was further extended, partly underground, to Acerra.

The mostly underground link between Botteghe/Volla on the Baiano line and San Giorgio a Cremano on the route to Torre Annunziata was opened in two stages: in 2001, with a link between Volla and San Giorgio a Cremano, and finally in 2004, the curve between Botteghe and Madonnelle completed what is to become metro line 3 (which with a train every 30 minutes cannot really be classified as a metro line, though). In the future, a branch will be built from Volla to the new railway station at Afragola.

In 2008, the Ottaviano branch was doubled up to Cercola, and in 2009, the section between Torre Annunziata and Pompei was too, with Boscoreale and Boscoreale stations being put underground.

The Circumvesuviana lines are served by EMUs of class FE220 (1970s), T21 (1990s), and the new CVS (ETR 200) 'Metrostar' trains delivered by Ansaldo/Firema since 2008.

Ferrovie Circumflegrea & Cumana (SEPSA)

The two standard-gauge SEPSA lines both depart from Montesanto in the centre of Naples. While the older Ferrovia Cumana runs along the coast to Torregaveta, the Ferrovia Circumflegrea reaches the same destination via a hinterland route. On the Cumana, there is a train every 20 minutes to Torregaveta, although the headway is reduced to 10 minutes between Montesanto and Bagnoli, except during the summer months; on the Circumflegrea, trains run to Licola every 20 minutes, with only a few trains continuing to Torregaveta (every 40 minutes during the summer). Like the RFI (national) railway lines, the SEPSA lines are electrified at 3000 V dc.

The 1997 municipal master plan included the upgrading of the Circumflegrea between Montesanto and Pianura to become line 5 (mostly by doubling the line), while the Cumana is the future line 8, although with some modifications: initially, it was planned to run in a long curve between Campi Flegrei/Mostra and Bagnoli to serve the new developments in that area with several stations. More recent plans are for this area to be mainly linked by an extended line 6, while the line 8 section through Bagnoli will be put underground and slightly diverted southwards before joining line 2 at Campi Flegrei (with possible through service to Piazza Garibaldi or beyond). The present Cumana section between Montesanto and Zoo/Edenlandia, however, will become line 7, which will continue on a new 5.7 km underground route to Monte Sant'Angelo before joining the Circumflegrea at Soccavo on its way back to Montesanto. The section between Mostra and Zoo/Edenlandia will be completely covered, too. The Soccavo – Monte Sant'Angelo section has been under construction since 2000! An extremely deep station (~100 m) is being built at Cileia/Quattro Giornate on the existing Circumflegrea route to provide interchange with line 1 (the initially planned underground corridor between Montesanto and Dante stations has been shelved).

The 20 km Ferrovia Cumana was built back in 1889; it was put underground in the Fuorigrotta area in 1940, and has since been completely double-tracked except for a 5 km stretch through Pozzuoli – a cavern-like underground station at Baia is still under construction. The 27 km Ferrovia Circumflegrea, however, was only opened in 1962. In the course of the upgrading to metro standard, a second tunnel was excavated between Montesanto and Piave, and the surface section to Pianura was doubled (except for the unfinished second tunnel through La Trencia). The 4-track terminus at Montesanto was completely refurbished in 2008.

The SEPSA lines are currently operated with rolling stock dating from the 1960s, 1970s and 1990s (13 units of class E82); all the trains are

equipped with retractable steps, although many stations now have raised platforms (850 mm). 12 new 50 m ALFA3 trains were ordered from AnsaldoBreda and Firema in 2006.

Funiculars

Even more than Genoa, Naples would not function without its funiculars. Three of the four lines link the historical city centre to the Vomero district, which lies some 200 m above sea level (Piazza Vanvitelli).

The oldest is the **Funicolare di Chiaia**, which connects Piazza Amedeo (near the line 2 station) to Piazza Vanvitelli. Opened in 1889, it was completely modernised in 2003. Initially steam-powered, the Funicolare di Chiaia was eventually electrified in 1900.

At 1290 m, the **Funicolare Centrale** is the longest and also the busiest; its lower terminus is located near the famous Galleria Umberto I and the Municipio (City Hall), and the upper terminus lies near that of the Funicolare di Chiaia, both of which are linked underground to Vanvitelli station on line 1. Every 30 minutes, it provides a non-stop express service.

The third funicular that climbs up to the Vomero is the **Funicolare di Montesanto**, which terminates some 300 m east of Piazza Vanvitelli. The lower terminus is located adjacent to the Cumana/Circumflegrea terminus, and is a short walk from the line 2 station. To improve access to the Castel Sant'Elmo, a fourth stop is planned.

During daytime hours, the three funiculars to the Vomero operate every 10 minutes.

The **Funicolare di Mergellina** links the Mergellina port area to the Posillipo hill. The Mergellina line, which was modernised in 2008, operates every 12 minutes. Like on line 1 and line 6, service on all funiculars is provided by Metronapoli.

Tram

Naples' present tram network consists of three lines with a total length of only 10 km:

- 1 Poggioreale — Piazza Vittoria
- 2 Poggioreale — San Giovanni
- 4 Piazza Vittoria — San Giovanni

While line 1 operates every 10 minutes, and line 4 even every 7 minutes, line 2 runs rather sporadically every 36(!) minutes. Like the urban buses, the standard-gauge tram lines are in the hands of the ANM (Azienda Napoletana Mobilità), a municipally owned company which emerged in 1995 from the former ATAN (Azienda Tranvie Autofilovie Napoli). The ANM also operates six trolleybus routes.

The first horse-drawn trams appeared in Naples in 1876 along Riviera di Chiaia. The network gradually expanded, with electric service starting in 1899. The first shrinking process took place in the mid-1950s, when private car ownership was increasing rapidly. In recent years, the coastal line was cut back from Bagnoli to Piazza Tecchio (Mostra) in 1998, and then to Piazza Vittoria in 2000, to be replaced by the new metro line 6. The tram will eventually return to Piazza Sannazzaro (2.2 km).

The small network is currently being extended from Poggioreale to Stadera (1.6 km); new routes are planned along Corso Arnaldo Lucci, Corso Novara, Via Arenaccia, Via S. Alfonso Maria dei Liguori to Piazza Carlo III; and towards Ponticelli in the eastern districts. An isolated light rail line may be built between Piscinola and Villaricca (northwest of Mugnano), partly re-using the old, abandoned Alifana railway alignment.

The current tram fleet comprises 30 four-axle vehicles from the 1930s (rebuilt in the 1970s) and 22 low-floor Sirio trams (class 1100 – 20.2 m long) manufactured by AnsaldoBreda. The tram depot is located at the San Giovanni terminus.

PADUA

Padua (Padova in Italian), some 25 km west of Venice, is a city in the Veneto Region with a population of 213,000 in the city proper, and more than 400,000 in the metropolitan area.

The transport system in Padua is officially referred to as 'Tram di Padova', although it is actually what is known in France as 'tram sur pneu', i.e. a rubber-tyred tram, the Translohr system developed by the French company Lohr. Padua is the third city in the world to implement this innovative technology, the other two being Clermont Ferrand in France and Tianjin in China, with a fourth system currently being built in nearby Venice (Tram di Mestre). When the project was launched in 1990, a total of three conventional tram lines were planned, but after strong opposition which argued that a steel-wheel system would be detrimental to the historical city centre, the choice was made for this innovative system.

The Padua tram started operating on 24 March 2007 on the southern part of the line from a temporary stop in front of the railway station to Capolinea Sud [southern terminus] at Guizza. After the new road bridge across the railway tracks had opened in October 2009, the tram was extended north to Capolinea Nord at Ponte Vigodarzere on 5 Dec 2009. The full length of the first line is 10.3 km, with 24 stops (Assunta/Sacchetti counted as one). Like the urban buses, the tram line is operated by the APS (Azienda Padova Servizi).

The rolling stock comprises 16 Translohr units: the 3-section vehicles are 25 m long, 2.2 m wide and 2.89 m high; they are only authorised to be operated in guided mode as trams, and may not travel detached from the guide rail, as originally proposed by the manufacturer, due to the restrictions imposed by the Italian Highway Code, which, unlike the French, does not allow road vehicles that exceed a length of 18 m. The guide rail is located in the middle of the tram lane; it is grasped by two diagonally arranged wheels, which make derailments virtually impossible. Although this type of tram does not require any conventional tram tracks, a special roadbed is needed to resist the permanent pressure placed on exactly the same surface as a result of the guided system. Electric power is supplied via a catenary, but thanks to special onboard batteries, some sections in the historical city centre can be operated without overhead wires.

In the future, a branch from the railway station to the fairgrounds may be added. Additional lines are currently at the planning stage: line 2 will become a 12.6 km east-west route (Ponte di Brenta - Sarameola), and lines 3 and 4 may one day be operated as a cross-city line from Voltabarozzo in the southeast to the stadium and a new regional hospital in the northwest (12.6+5.4 km).

PALERMO

Palermo is the capital of Sicily and is located on the island's northern coast. It is home to 660,000 people in the city proper and around 1 million in the metropolitan area, which extends along the coast.

At present, Palermo only has a 'Metropolitana F.S.' on offer, i.e. an urban service operated by Trenitalia on mainline tracks. Trains on line A (Palermo Centrale — Punta Raisi/Aeroporto) run every 30 minutes; every second train (Trinacria Express) skips some stops to provide a

faster service to the airport. Line B is an urban shuttle service between Notarbartolo and Giachery which also runs every 30 minutes; passenger service was first introduced on this route in 1990 to serve the football stadium near Imperatore Federico station during the Football World Cup. On the eastern line from Palermo Centrale to Altavilla Milicia, there is a train every 30-60 minutes. The Metropolitana trains are not integrated with the fare system of the urban buses operated by AMAT.

Palermo is currently working on several ambitious projects to create an integrated transport system:

- 1) **Passante Ferroviario** — doubling of the trunk railway route between Brancaccio and Punta Raisi/Aeroporto to allow trains every 10-12 minutes during peak hours, eliminating several level crossings and adding several new stations along the urban section;
- 2) **Railway Circle Line** — construction of an approx. 3 km single-track tunnel between Giachery and Notarbartolo, with a centrally located station at Politeama at the northern side of the historical centre. Once the circle has been completed, trains will run every 5 minutes in one direction only.
- 3) **Tram Network** — three tram lines are presently under construction, two running westwards from Notarbartolo (a long way from the actual city centre), and one (isolated from the other two) running south from Palermo Centrale. The new tram system (totalling 15 km) will be operated by the municipal bus company AMAT with 17 Bombardier Flexity Outlook trams (32 m long and 2.4 m wide). Palermo used to have a first-generation tram system, but it was abandoned back in 1947.
- 4) **Metropolitana Leggera (Light Metro)** — 18 km underground north-south line across the city centre with characteristics similar to the driverless metro under construction in Brescia, or line M5 in Milan. Given the present delays in the construction of the surface tram lines, the realisation of this metro project is not very likely in the foreseeable future.

PERUGIA

With a population of only 166,000 on a territory of 450 km², Perugia, the capital of Umbria, would certainly not qualify for a metro system, but the extreme difference in altitude between the old city centre, which lies some 450 m above sea level, and the rest of the city, which extends around it at a height of 170-280 m, requires special transport solutions. Between 1983 and 2001, several open-air escalators were installed to facilitate access to the city centre and keep cars out.

Minimetrò SpA, a mostly publicly owned company, was founded in 1998 to provide an innovative link between the lower and upper parts of the city. The construction of the peplemover system began in 2002 and took six years. Technologically, the Minimetrò is a funicular with special features. It was designed by Leitner, a north Italian company which specialises in the development of non-standard transport solutions. The Minimetrò is hauled by a continuous 6100 m cable, but unlike a conventional funicular, the cabins grip onto it except when stopping at stations, when they release the cable automatically. While detached from the cable, the cabins are moved by lateral rubber pulleys.

The double-track line is operated with 25 single vehicles (plus two in reserve), each with a capacity of 50 passengers (eight of them seated). The cabins are 5.7 m long and 2.1 m wide. The peplemover can provide a 60-second headway, and is thus able to carry 3000 people per hour up the mountain. A trip from Pian di Massiano, where a large car park was built, to Pincetto in the old town takes 12 minutes, while a difference in altitude of 162 m, from 276 m at Pian di Massiano to 438 m at Pincetto, is negotiated. The seven stops along the 3 km line were all designed by the architect Jean Nouvel and are quite impressive structures; the upper two stops lie underground. For maximum safety, the stations are equipped with platform screen doors. The underground depot and workshop (the cabins are lowered with a lift), as well as the cable tightening mechanism, are located at Pian di Massiano, while the control centre and cable traction motors are found at Pincetto. At the two termini, the vehicles are turned around on a two-track rotating platform. The rubber-tyred cars run on metal beams, mostly on a viaduct but also through a short cut-and-cover tunnel on the lower section, and a 400 m mountain tunnel between Cupa and Pincetto. At Fontivegge, interchange with long-distance and local trains is provided.

There are plans for a second line, which will intersect with the existing line at Pincetto and run from Monteluca to Stazione Sant'Anna, the terminus of the Ferrovia Centrale Umbra.

ROME

With a population of 2.73 million, Rome ('Roma' in Italian) is not only Italy's capital, but also its biggest city. Extending over 1,285 km² (Greater London: 1,572 km²), the large city covers almost the entire metropolitan area, including Lido di Ostia. The Province of Rome is home to some 4 million inhabitants. With only 0.44 km², the Vatican City is surrounded by the city of Rome (the Vatican has its own railway station, although without any regular passenger service). The ancient city of Rome was built on seven hills on the east bank of the Tiber (Tevere) River, some 25 km inland from the Tyrrhenian Sea.

With over 2000 years of history, Rome is without doubt one of the most important tourist destinations in Europe. For the urban rail enthusiast, however, the city may be rather disappointing, although it boasts various kinds of urban rail systems. Only a small part of the once extensive tram network has survived, and the two-line metro system is hardly adequate for a city of its size. Three 'ferrovie urbane' and several 'ferrovie regionali' complement a generally well-integrated system. A 4 km branch for line B and the brand new 25 km line C are currently under construction. The planning of the fourth metro line, D, is at an advanced stage, although no credible dates for its realisation can be given at present. Several extensions to the existing lines are also on the drawing board.

All the different means of transport, i.e. buses, trolleybuses, trams, metro, urban and regional railways can be used with a single ticket, the Metrebus ticket, which is available for Rome only, or for the entire Lazio region (which is divided into zones). At present in 2010, a single ticket (within 75 minutes, including transfer) for Rome is priced at € 1.00, a 1-day ticket costs € 4.00, and a 3-day ticket € 11.00. On network maps, the boundary of the urban tariff is clearly shown.

On 1 Jan 2010, the operation of all urban transport except the FR lines, which continue to be operated by Trenitalia, was integrated in a single municipal company, ATAC. ATAC originally stood for 'Azienda Tranvie ed Autobus del Comune di Roma', and its predecessor was first founded as a municipal transport operator in 1909. The latest merger absorbed the former 'Tramibus' and 'Met.Ro.' (which also operated the Roma-Lido, Roma-Viterbo and Roma-Pantano railways).

Metropolitana Linea A

Metro line A, which links the western districts to the southeastern areas via the city centre, became Rome's second metro line when it opened in 1980. Except for the bridge across the Tiber River, it is completely underground with a total of 27 stations along its 18.4 km

route. During rush hour, trains run every 3 minutes, and during the rest of the day, every 5 minutes. Like line B, operating hours are from 05:30 until 23:30, except on Friday and Saturday evenings, when trains continue running until 01:30.

With Rome's first metro line, the present line B, having opened in 1955, a second line was approved soon afterwards in 1959 to link Prati, the area between the historical city centre and the Vatican, to Anagnina in the southeast, with a possible southern extension to Ciampino, as well as a branch from Colli Albani towards Torre Spaccata. Construction started in 1964, but was soon suspended for several years to make some modifications to the project. On the west bank, the initially envisaged terminus was relocated from Piazza Risorgimento to Ottaviano, and to reduce the impact at the surface, the running tunnels on the central section from Colli Albani to Flaminio were instead to be excavated by means of a tunnelling machine at a depth of 11-30 m, resulting in 5.50 m diameter single-track tubes. The stations from Repubblica to Flaminio were also dug below ground at great depth. As can be expected in an old city like Rome, the excavation brought to light many archaeological finds, some of which are on exhibit inside Repubblica station. The section along Viale Giulio Cesare between the river and Ottaviano, as well as the southern section beyond Colli Albani, were built by cut-and-cover as double-track rectangular tunnels 7.60 m wide and 3.90 m high. On the southern part, however, an approximately 500 m section between Arco di Travertino and Porta Furba, where the line passes below the mainline railway, had to be excavated using traditional mining techniques. All station platforms were built with a length of 120 m. In the early days of the line A project, two branches were planned at the western end: one towards the west as later built, and another towards the north to the Foro Italico area.

The original line A route includes a purpose-built bridge across the Tiber River (Ponte P. Nenni) which accommodates the metro tracks in the middle and two road lanes on either side. The 120 m concrete bridge designed by Luigi Moretti became the 27th river crossing in Rome.

After 14 years of construction, the 14 km route between Anagnina and Ottaviano was finally brought into service in 1980, drastically reducing travel times, especially for residents in the southeast.

Almost 20 years later, line A was eventually extended from Ottaviano to Battistini (4.5 km), thus becoming a real cross-city line. This extension had already been approved back in 1976, but afterwards the northeastern extension of line B to Rebibbia was given priority. Starting from Ottaviano, the line continues in a two-level cut-and-cover tunnel, with the two tracks also lying on top of each other in Cipiro and Valle Aurelia stations (inbound on the lower level). From a point west of Valle Aurelia station up to the present terminus, two single-track 5.7 m diameter tube tunnels were excavated using a hydroshield, although between Cornelia and Battistini, one of the two tunnels was built with a diameter of 9.3 m to accommodate a siding. Due to the hilly topography of the western districts, Baldo degli Ubaldi (a large cavern station) and Cornelia (deep cut-and-cover station with a multistorey car park above the station) had to be built 30-50 m below the surface; Battistini is a shallow cut-and-cover station with side platforms. The five stations on this extension have been fully accessible since the beginning.

At present, there are plans for a further 2-station extension beyond Battistini, while for a southern extension, a light rail alternative is under discussion, too.

To improve passenger flow, the interchange between lines A and B at Termini is currently being rebuilt by adding more stairs and escalators at the ends of the line A platform.

In 1980, service on line A began with 38 trainsets (2x2 cars) from Breda (class MA001-152). The fleet was complemented with 10 trainsets (2x3 cars with gangways) of class MA200 in 1998. The older trains have been replaced by 45 CAF S/300 trains since 2005; the Spanish trains are 108 m long (six cars connected with wide gangways) and 2.83 m wide. The floor height is 1100 mm above the rail top, which matches the height of the platforms exactly. The four middle carriages are motorised. The refurbished MA100 trains have been transferred to the Lido line, as well as to MetroCampania NordEst in Naples. Line A is electrified at 1500 V dc, with power supply via an overhead catenary. Line A's depot and workshops are located near the Anagnina terminus (with the access tracks to the depot diverging north of the terminus).

Metropolitana Linea B

Metro line B links the southern districts to the northeastern areas via the city centre with 22 stations on its 18.2 km route. During peak hours, trains run every 4 minutes, and during the rest of the day, every 6 minutes.

Italy's first metro line opened in Rome in 1955, 13 years later, however, than initially scheduled. In the late 1930s, at the height of Mussolini's reign, a World Fair, the 'Esposizione Universale Roma' (E.U.R.), had been planned to be held in 1942 on terrain to be developed in the southern part of the city. To provide convenient transport from the city centre, a metro line had been designed. It runs underground from Stazione Termini, Rome's central railway station, to Piramide, from where it continues parallel to the existing Lido railway alignment south to Magliana, before returning underground to serve the E.U.R. area. Although tunnel construction began in 1938, both Expo and metro projects were disturbed by the ongoing world war (some completed tunnel sections served as air raid shelters), and the Expo never took place.

Metro construction work was resumed after World War II, and single-track trial operation began on the section south of Piramide on 28 June 1953 during the 'Esposizione Internazionale dell'Agricoltura'. Regular service on the entire 11.3 km line was launched in February 1955. On the Lido line, a new station was added at EUR Magliana, including a track link between the line to the coast and the line to the Expo area: until 1989, when the original line B was upgraded before its extension to Rebibbia in 1990, some trains ran directly from Termini to Lido di Ostia. This was possible as they had the same track gauge of 1435 mm, the same power supply (1500 V dc via overhead line), and the same train width (3.05 m). The southern terminus of line B, Laurentina, was initially a single-track surface station linked to the previous station by a single-track line, as it was not actually meant to become a passenger station, just a freight yard for the Expo; some trains therefore terminated at EUR Fermi. Prior to line B's northeastern extension, the southern end of the line was doubled, and Laurentina became a covered station with a large bus terminal built on top; the reversing sidings beyond the station remain in the open air.

The old 3.7 km tunnel in the city centre was excavated using conventional mining techniques between Termini and Colosseo (resulting in vaulted tunnels) and cut-and-cover from Colosseo to Piramide; it runs close to historical sites such as the Colosseum and the Circus Maximus. Ancient Rome was built on some gentle hills, resulting in Termini underground station actually lying 46 m above sea level, which is 39 m higher than the surface station at Piramide. Unlike the 120 m platforms later built for line A, the original line B platforms are 156 m long.

The 1.9 km underground route through the EUR area was dug from the surface at a shallow depth as the area was still undeveloped at that time (it later became an important business and administrative centre), with EUR Fermi and EUR Palasport stations being open towards the southern side and having separate entrances for each direction. On the 5 km section which runs alongside the Lido railway, Marconi station was added in 1994; the station formerly known as 'EUR Marconi' was then renamed 'EUR Palasport'. In conjunction with the line upgrading in 1990 (in preparation for the Football World Cup), Garbatella station had been relocated some 200 m further north. Although it had been a line B station from the beginning (before 1990 called San Paolo Basilica), the adjacent station at Basilica San Paolo for the Lido line was only added in 1998.

After the completion of the most important part of line A in 1980, it was finally time for line B to be extended northeast to convert what was really a radial line into a more balanced cross-city line. Construction on the 7.9 km extension was launched in 1982, with different excavation methods used depending on the section: the first segment from Termini to Piazza Lecce (between Policlinico and Bologna stations) was built with TBMs as single-track tube tunnels with a diameter of 5.7 m. From Piazza Lecce to Bologna, a two-level cut-and-cover tunnel was realised to allow for a future grade-separated junction east of Bologna station. From Bologna to Quintiliani, excluding Tiburtina station, the running tunnel was driven using conventional mining techniques, resulting in a double-track vaulted tunnel. The remaining section beyond Quintiliani was built at a shallow depth by cut-and-cover, except for the stretch around Ponte Mammolo, which was laid out on a viaduct across the Aniene River. While Castro Pretorio and Policlinico are deep-level stations, the others were built by cut-and-cover. Ponte Mammolo station was only brought into service in 1997 as a major bus/rail interchange point for the eastern suburbs, and has a large park-and-ride facility. Quintiliani station was placed in a rather undeveloped area in provision for an interchange with the once-planned line D, which was to run north-south through the eastern districts; with this tangential line no longer pursued, Quintiliani station eventually opened in 2003. All the stations were built with 150 m platforms, thus allowing the use of 8-car trains on the entire line. The northeastern extension created an additional interchange with the mainline rail network at Tiburtina, which has since been further developed into a second main station, with some high-speed services from northern to southern Italy only to call at this station in the future, thus avoiding the need to reverse at Roma Termini.

The next metro section to open in Rome will be the 3.6 km B1 branch from Bologna to Conca d'Oro, the construction of which began in autumn 2005. Initially planned with four stations, Nomentana station (between Bologna and Annibaliano) was cancelled in 2007, and instead a further extension to Jonio (the future interchange with line D) was added, although the construction of this 1 km route only began in November 2009. While the single-track running tunnels are being excavated by means of tunnelling machines from Conca d'Oro towards Bologna, the spacious stations are being built by cut-and-cover with diaphragm walls. Conca d'Oro – Jonio will be a double-track tube tunnel at a depth of 25 m. While the B1 branch to Conca d'Oro is currently scheduled to open at the end of 2011, the additional section to Jonio may follow a year later. A further B1 extension north is planned, as is an eastern extension to the Rebibbia branch.

Line B is currently served by 31 trainsets of class MB100 (3x2 cars; 35.7 m long, 2.85 m wide), which were introduced in 1990 when the extension to Rebibbia opened, replacing the original Stanga/TIBB vehicles. The basic fleet is complemented by refurbished MA200 trains transferred from line A, all manufactured by Ansaldo. In Nov 2009, eight new trains were ordered from CAF for line B. The depot for line B is located south of EUR Magliana station, while the control centre for both lines is found at Garbatella.

Ferrovie Urbane Roma-Laziali – Giardinetti & Metropolitana Linea C

The present narrow-gauge (950 mm, 1650 V dc) line from Roma-Laziali, a terminus located on the western side of Termini station, to Giardinetti has its origin in a regional line opened in 1916/17 to Frosinone via Fregene and Alatri. Within Rome, it had a short branch from Centocelle to Piazza dei Mirti, which had been added in 1927 but was closed in 1982. The Roma terminus, which used to be on the square in front of Termini station, was relocated some 800 m south in 1950, thus necessitating a long walk for passengers wanting to change to other transport services. After a long period of decline, the section beyond Pantano was abandoned in 1984, while the remaining stretch was integrated into the urban rail system and became known as the Roma-Pantano line.

In the mid-1980s, when ambitious plans for metro expansion were developed, the Pantano line was chosen to be integrated into a new cross-city metro line. Without any details of the line's route through the historical city centre having been approved, the outermost stretch began a 10-year upgrading process in 1996 by doubling the line between Grotte Celoni and Pantano and building several new stations ready to be used for future metro operation, i.e. fully segregated and with 120 m long platforms. Some sections were put on viaducts and Finocchio station was covered. To enable the existing rolling stock to remain in service, a short section of each platform was kept low to allow boarding into vehicles equipped with steps. Re-opened up to Grotte Celoni in 2002 and Pantano in 2006, service on the Giardinetti – Pantano section ceased on 7 July 2008 to allow for its definitive upgrading to metro standard: regauging to standard gauge and equipping the stations with platform screen doors, among other measures.

At the time of writing, the future of the remaining Laziali – Giardinetti section is not clear yet. Running almost completely on its own right-of-way, the Laziali – Centocelle section ought to be maintained in some way. Its conversion to standard gauge and subsequent connection to the urban tramway system has been proposed.

In the early 1990s, the alignment for line C, which is currently being constructed, was slowly taking shape. At that time, the entire route east of Alessi was to be maintained, while at Piazza Venezia the line was to turn north towards Flaminio, going all the way up to Vigna Clara and Tor di Quinto. Since then, the project has undergone many modifications, with construction finally being launched in summer 2006 after archaeological studies, which will continue for the rest of the excavation, had been carried out. The deep-level tunnels (on average, some 30 m below street level) are being excavated by means of four tunnelling machines as single-track tube tunnels 18-25 m apart and with a diameter of 5.80 m, while stations outside the city centre are being built by cut-and-cover. On the route through the city centre, the distance between the two tubes is 30-40 m and the tube diameter is 8.80 m, large enough to accommodate a track and a station platform. There will now be a total of 30 stations (of which 9 are on the surface), after a station called Argentina in the historical city centre was deleted from the plans. At San Giovanni, provisions were made for an intersecting line when line A was built, but to avoid major disruptions to the present line A service, line C will not run above line A at this point as initially planned, but the TBM will pass below the existing line. At Teano, the platforms are located on top of each other as this station was initially planned to become a junction for a branch C1 diverging north towards Ponte Mammolo, which was later shelved. On the western section, the construction of which is scheduled to start in late 2010, San Pietro station will have a special design as it is located below the Tiber River, with exits on the side of the historical city centre as well as next to the Castel Sant'Angelo.

In 2004, the decision was taken to design the new line for driverless operation, and AnsaldoBreda won the competition held to provide the required rolling stock and operation system. Line C will thus be similar to the Copenhagen Metro, which was also developed by the Italian train manufacturer, as well as the Brescia Metro and Milan's line M5, both currently under construction. Each of the 30 trains will be made up of six permanently coupled carriages, with a total length of 107 m. The trains will reach a maximum speed of 80 km/h. For driverless operation, the stations are being equipped with platform screen doors.

Apart from intersecting with the two existing metro lines (San Giovanni and Ottaviano with line A, and Colosseo with line B), line C will also provide interchange with the busy FR1 line at the future Pigneto station, which will be added on the railway line between Tiburtina and Tuscolana, as well as with various tram lines. Once the entire 25 km line has been completed, a train frequency of three minutes is planned on the core section between Clodio-Mazzini and Alessandrino, with trains continuing to Grotte Celoni every six minutes, and to Pantano every 12 minutes. A ride on the entire route between Clodio-Mazzini and Pantano will take 45 minutes. The depot will be located next to

Graniti station.

In a later stage, line C may be extended north from Clodio-Mazzini to Grottarossa (9 km with 7 stations).

Ferrovia Roma – Lido

Starting at Porta San Paolo, adjacent to the line B Piramide station and just north of the RFI station Ostiense (FR1, FR3 and FR5), the Lido line runs south alongside metro line B before it diverges at EUR Magliana station to head southwest to Ostia Antica and Rome's beaches at Lido di Ostia, some 25 km from the city centre but still within the municipal boundaries.

The Lido line (sometimes proposed to become line E) is completely segregated from road traffic with no level crossings. The 150 m platforms are raised and thus allow level boarding. The line is 28.4 km long and has 13 stations, with additional stations planned to be added, e.g. at Acilia Sud. The Lido trains normally run every 15 minutes, and every 10 minutes during peak hours.

The construction of this standard-gauge line began in 1920, and although it had been designed as an electric line from the beginning, it started service in August 1924 with a steam locomotive. Regular electric service (at that time 2400 V dc) on the double-track route was finally launched on 21 April 1925. The original terminus Marina di Ostia was located slightly to the west of today's Lido Centro station. After World War II, the terminus was pushed back some 300 m, while the line was extended to Stella Polare in 1948 and Castel Fusano in 1949. The stub terminus was replaced in 1951 by the through station Lido Centro on the extension line. The line eventually reached its current terminus at Cristoforo Colombo in 1959 (second track from Castel Fusano brought into service on 28 Aug 1960).

In 1955, Rome's first metro line was opened between Termini and Laurentina, running alongside the Lido railway line between Porta San Paolo and EUR Magliana. At the latter, a convenient interchange was built for the two lines, with cross-platform interchange for passengers travelling from the EUR area towards Lido di Ostia. A track link even allowed through service from Termini to Lido, which lasted until 1989. Between 1989 and 1998, the line was cut back to EUR Magliana to allow for the reconstruction of the Porta San Paolo terminus.

Since 2005, the older rolling stock on the Lido line has been replaced by a total of 19 refurbished MA100 trains previously used on metro line A, as well as six new MA300 trains built by CAF, similar to those now in service on line A. The present fleet is complemented by class 500 trains built by FIAT Ferroviaria in 1987, and MR600 trains manufactured by Firema in 2000 with old, used parts.

Ferrovia Urbana Roma – Viterbo (Roma-Nord)

The Roma – Viterbo line, also known as Roma-Nord (and possibly the future line F), has two rather different sections, namely the urban line proper, which extends from Flaminio to Montebello, and the regional line, which continues all the way to Viterbo via Castelnuovo and Civita Castellana (102 km).

On the 12.7 km urban section there are 15 stops and trains operate every 8-12 minutes, while only a few trains run through to Viterbo (these trains skip some stops along the urban section) – this town can be reached hourly on the FR3 line from Roma-Ostiense in 1h55 min, as opposed to 2h40 on the Roma Nord line.

The Roma Nord line has standard gauge; it is double-track up to Montebello, but only single-track from there to Viterbo. It starts underground at Piazzale Flaminio, where interchange is provided to metro line A, and leaves the city centre via a 2 km tunnel.

The predecessor of the present line was an interurban narrow-gauge tramway line which had its terminus at Piazza Libertà (across the river from Flaminio), from where it ran from 1906 onwards on city streets on the west bank of the Tiber River towards Tor di Quinto, and north alongside Via Flaminia to Civita Castellana (50 km). The line was then extended to Viterbo in 1913 on a more railway-style alignment. While the urban section used 550 V ac (25 Hz), the outer section was electrified at 6500 V ac (25 Hz).

To improve the line's overall performance, it was rebuilt after World War I. A more direct route was built between Tor di Quinto and the city centre, including the present 2 km tunnel below the Parioli hills and the underground terminus at Flaminio, which opened on 28 Oct 1932. At the same time, the line was doubled up to La Celsa, while the entire route was regauged, now with 1435 mm standard gauge, and electrified at 3000 V dc, the standard on Italian mainline railways. In 1958, Euclide station was added to the underground section. A dedicated urban service was launched in 1981. In 2006, the double-track section was extended to Montebello, now the terminus of the urban service. In recent years, the urban section has seen some upgrading, with La Giustiniana, Saxa Rubra, Tor di Quinto, Monte Antenne, Euclide stations having been refurbished, while Campi Sportivi is currently under reconstruction.

The urban service on the Roma – Viterbo line is operated with two batches of class 100 EMUs delivered by Firema-Casaralta-OMS in 1987 and 1994 respectively, while the class 300 EMUs produced by CostaRail and Alstom between 2000 and 2008 are mostly used on the regional service. To allow boarding from both high and low platforms, the trains are equipped with retractable steps.

Ferrovie Regionali (FR) – Regionalbahn | Regional Railway

On RFI tracks (Rete Ferroviaria Italiana), the national operator Trenitalia (FS) operates several regional rail (FR) lines which are integrated into the Lazio fare system. While lines FR1 and FR3 offer a frequent suburban service with trains every 15 minutes on the inner sections (FR1 Fiumicino Aeroporto – Fara Sabina; FR3 Ostiense – Cesano), other lines like the various branches of the FR4 only run hourly. The FR1 is the only cross-city line, although it actually by-passes the city centre, obliging passengers to change to the metro at Tiburtina, Tuscolana (Ponte Lungo) or Ostiense (Piramide). The dense headway on the Fiumicino line was made possible thanks to a direct route for the FR5 between Maccarese-Fregene and San Pietro via Aurelia, which was brought into service in 1990. The northern section of line FR1 uses the original Roma – Firenze line (1865), which has been without long-distance services since the southern stretch of the Direttissima opened back in 1977.

In recent decades, the inner section of the Viterbo line (FR3) has been upgraded. After several new stations had been added within the urban area in the early 1970s – Balduina 1968, San Filippo Neri 1970, Ottavia and Pinetta Sacchetti 1971 (since 1999 'Gemelli') – the line, which was first opened in 1894, was doubled up to Cesano and electrified all the way to Viterbo in the years before the Millennium celebrations, with lengthy sections through the built-up area being covered and new stations added (Appiano 1999, Valle Aurelia and Ipogeo degli Ottavi 2000). The newest station within Rome is Quattro Venti, which opened on 15 Oct 2006.

On the eastern side of the city, the urban section on the route to Tivoli (FR2) and Pescara was upgraded in conjunction with the construction of the high-speed Roma – Napoli line, which was completed along this section in 2005. Initially opened in 1888, the section between Prenestina and Salone was quadrupled and new stations were added (Serenissima, Palmiro Togliatti, La Rustica Città – 2006) for the urban service, with some parts now covered to improve the noise protection. At present, the urban service provides trains between Tiburtina and Lunghezza every 30 minutes.

The construction of an orbital railway line has been planned for many decades. While about three quarters of the ring actually exists, the northwestern part is still missing. The first attempt was made in 1913 but was interrupted by World War I, and in the 1930s, the

envisaged alignment was given to a road project instead (the *Via del Foro Italico*). After World War II, a new project with a revised route via *Tor di Quinto* was launched, but in 1955 after several kilometres of tunnels had been excavated, construction was abandoned. For the Football World Cup held in Italy in 1990, the section between *San Pietro* and *Vigna Clara* was temporarily brought into service, with an improvised underground stop being established inside the tunnel (by converting one track into a platform) to provide access to the Olympic Stadium for a total period of 8 days, after which the line returned to slumber.

The latest addition to Rome's urban rail system is a short branch to *Val d'Ala*, which opened on 13 Dec 2009 with four trains in the morning and four in the evening to and from *Tiburtina* (skipping *Nomentana*).

TRAM

Rome's present tram network consists of six lines with a total length of 30.7 km:

- 2 *Flaminio* – *Mancini*
- 3 *Piazza Thorwaldsen* – *Stazione Trastevere*
(temporarily operated by buses)
- 5 *Piazza dei Cinquecento (Stazione Termini)* –
Piazza dei Gerani
- 8 *Casaleto* – *Argentina*
- 14 *Piazza dei Cinquecento (Stazione Termini)* – *Togliatti*
- 19 *Risorgimento* – *Piazza dei Gerani*

On a route similar to that of the present line 2, the first horse trams started operating in Rome in 1877 between *Piazzale Flaminio* and *Ponte Milvio*. By the mid-1890s, the private company *SRTTO* (*Società Romana Tramways Omnibus*) had built several additional lines. In 1892, the same company opened the first electric tramway line (550 V dc) between *Termini* and *San Silvestro* right in the heart of the city. The entire network was subsequently electrified by 1904.

From 1909, the *AATM* (*Azienda Autonoma Tranviaria Municipale*) began building the city's own lines, and gradually also took charge of some of the *SRTTO* lines. In 1929, the *AATM* became the *ATAG* (*Azienda Tranviaria del Governatorato*), while the network reached its maximum expansion with some 140 km of routes and a total of 58 lines. But soon after, a network restructuring process began, with two circular lines (inner and outer circle) as the backbone, and 24 radial lines, while all the routes within the inner circle were closed down. After World War II, *ATAG* became *ATAC* (C for *Comune*), a name that is still used today. But during the 1950s, more lines were abandoned, among them the inner circle and the route along *Via Flaminia*. By 1973, only four lines were still in operation! In 1983, the outer section on *Via Flaminia* (now line 2) re-opened, and on the occasion of the Football World Cup in 1990, trams returned to *Piazzale Flaminio* at the northern side of the historical centre. The latest addition to the still rather modest tram network was line 8 on 23 March 1998, which brought trams back into the heart of the city at *Argentina*, although the extension initially planned from there along *Via Nazionale* to *Termini* station has not been built yet.

The present tram fleet comprises some older articulated vehicles (*TAS*) manufactured by *Stanga* in the late 1940s and modernised in the 1980s, as well as 41 newer *Socimi* trams (21 m), which began service in 1990 and are partly low-floor. For service on the new line 8, 28 *Cityway I* trams were delivered from *FIAT Ferroviaria* in 1998, followed by a second series of 50 *Cityway II* trams (33 m – plus two 41.5 m vehicles which have never entered service!), the first 100 % low-floor vehicles. Since 2000, the older vehicles have been repainted in the new dark and light-green livery instead of orange.

SASSARI

Sassari (130,000 inh.) lies in the north of the island of *Sardinia*, some 12 km inland.

The city boasts a short tramway line (4.3 km), which it proudly calls '*Metrosassari*' or '*Metropolitana leggera di Sassari*'. The narrow-gauge (950 mm) 2.5 km urban route is single-track with an intermediate passing loop at the *Cliniche Universitarie* stop. Trams therefore only run every 20 minutes (07:00-21:00) and only serve the southern parts of the city, actually bypassing the historical centre.

Since 2009, the trams have continued their journey on the existing railway tracks of the *Sassari-Sorso* line (opened in 1930) to the present terminus *Santa Maria di Pisa*. This is the first example in Italy of a tram-train operation, with both trams and local trains being operated by *Ferrovie della Sardegna* (*FdS*). While local trains to *Sorso* use diesel traction, the four bidirectional, air-conditioned low-floor *Ansaldo Sirio* trams (27 m long, 2.4 m wide, three sections) are powered by 750 V dc from an overhead wire. The tram service is integrated into the bus fare system.

In the future, the tram-train operation may be extended over other existing *FdS* tracks, notably on the line to *Alghero*, which would also create a link to the *Fertilia* airport. A newly-built route may carry the trams from *Santa Maria di Pisa* to *Li Punti*.

TRIESTE

The harbour city of *Trieste* (205,000 inh.) has preserved an old tramway line which is unique in the world. The 5.2 km *Tranvia di Opicina* was opened in 1902 as a rack railway, but rebuilt in 1928 as a conventional tram line with an 800 m section where the tram cars are pushed or slowed down by means of an auxiliary vehicle, which clutches to the traction cable like on a funicular railway. In this way, the maximum gradient of 26 % can be negotiated.

TURIN

Turin (*Torino* in Italian) is the capital of *Piedmont*, and after *Milan*, the second largest city in Northern Italy and the fourth in Italy by population, with 910,000 inhabitants in the city of *Turin* proper, and 1.5 million in the contiguously built-up area. An industrial city and the historical capital of the automobile (e.g. *FIAT*), *Turin* was once the capital of the *State of Savoy*, and – although only for a very short time from 1861 until 1865 – the first capital of the emerging Italian State. The city centre has a very regular grid layout with broad avenues and arcaded squares built over the Roman city of '*Augusta Taurinorum*'.

Since the early days of public transport, Turin has maintained an extensive tram system. Trams, buses, the metro as well as the rail lines to Ceres, Pont Canavese and Chieri are operated by the GTT (Gruppo Torinese Trasporti). The GTT network is complemented by a regional rail service, operated by Trenitalia, which is currently undergoing major upgrading to create a proper metropolitan service on the north-south axis between Stura and Lingotto (Passante Ferroviario). A day pass for the urban GTT network currently costs € 3.50. Unlike other major Italian cities, the GTT network is not fully integrated with the Trenitalia service, although special 'Cityrail' tickets and 'Formula' passes allow combined GTT/Trenitalia journeys.

Metropolitana

The first proposals for a metro were made in Turin back in 1936. During the fascist regime, construction began on Via Roma, but after 300 m of tunnels had been excavated, the project was abandoned. In 1960, a premetro system like that planned in Antwerp and Brussels was proposed, including a total of 7.2 km of underground routes in the city centre to be used by trams. In 1962, a project for a monorail system was presented: the elevated line was to run along the embankment of the Po River. The political debate became very intense: the futuristic monorail system versus a premetro network which would emerge from the already extensive tram network. In 1968, the working group 'Società per la metropolitana' (SMT) was established with the objective of designing an underground link between the Fiat Mirafiori factories and the workers' neighbourhoods. The working group, however, did not produce any results and was dissolved in 1975.

In 1982, the 'Rolando grid' – named after the city councillor who promoted the project – was presented: five light rail lines (1-5) on reserved lanes and with priority at traffic lights were to be built as the trunk routes of the public transport system, complemented by several conventional tram lines to form a kind of grid without any overlapping lines, which would thus allow faster travel speeds.

Of the once ambitious project, however, only a few results are visible today, e.g. on tram line 3, several kilometres along Corso Regina Margherita were protected with curbs, while the northwestern sections along Corso Svizzera and Corso Toscana of that line were mostly fenced off to allow faster operation.

Heavy migration from the city to the metropolitan area resulted in a significant increase in car traffic, which induced the government to reconsider the old projects. In 1995, the metro route from Campo Volo (Collegno) to Porta Nuova was approved, but no contracts were awarded due to a lack of funds. In 1998, Satti, a company which in 2003 merged with the former ATM to form the GTT, was appointed by the City of Turin to manage the planning and construction of the line. For this purpose, the 'Divisione Metropolitana' (since 2003 part of the 'Divisione Infrastrutture e Ingegneria' of the GTT) was founded, which started working on two major fronts: on the one hand, the design and construction of civil works (tunnels, stations and intermediate shafts), and on the other hand, the choice of the adequate technology (trains, tracks, operation and security equipment).

After the Italian government had finally approved its contribution of 60% of the total cost in 1999, construction started on 19 December 2000, with a view to completing the line in time for the 2006 Winter Olympics. The technology chosen was that known as 'VAL' (Véhicule automatique léger), developed by Matra Transport (now Siemens Mobility): both the size of the tunnels as well as the station platforms are identical to those of the prototype system in Lille (France). Internationally, identical VAL systems have also been implemented in the French cities of Toulouse and Rennes, at the Paris airports of Orly and Charles de Gaulle, as well as at Chicago's O'Hare Airport. The VAL system was considered particularly adequate for the characteristics and requirements of the 'Metropolitana Automatica di Torino', in terms of both transport capacity (with a maximum of 15,000 passengers per hour and direction expected) and ease of integration into the urban environment due to the reduced size of the train, which is only 2.08 m wide. The first section from Fermi (Collegno) to XVIII Dicembre (adjacent the old railway station of Porta Susa) was inaugurated on 4 February 2006, a few days prior to the beginning of the XX Olympic Winter Games; regular passenger service started on the following day. On 30 March 2006, the construction of the extension from Porta Nuova to Lingotto (in the southern part of town) began.

The route of Italy's first automatic metro line runs from west to east, linking the town of Collegno to the centre of Turin and to the railway stations of Porta Susa and Porta Nuova.

The large park-and-ride facility at Fermi station, which opened several months after the start of metro operation, allows car drivers who arrive in Turin from the mountain valleys and the western ring road to use the metro.

The excavation of the metro tunnel was mostly achieved by means of tunnel-boring machines (TBM): between 2002 and 2005, three TBMs made their way from Collegno to Porta Nuova along the rather wide avenues Corso Francia, Corso Bolzano and Corso Vittorio Emanuele II. The section between Marconi and Lingotto on the southern extension was also excavated with a TBM (completed in September 2009). For the stations and the short section along Via Nizza between Via Berthollet and Via Baretti the cut & cover method was applied. For the section between Porta Nuova railway station and Marconi, it was not possible to use a 100 m long TBM due to the reduced radius of the curve between Corso Vittorio Emanuele II and Via Nizza. This section was therefore excavated using a mining technique with roadheaders: this tunnel section will accommodate three tracks, with one used for stabling trains at night to start service from there towards Fermi.

The first phase of the initial metro line was completed in 2008 with the opening of the section from XVIII Dicembre to Porta Nuova railway station. Along the route there are 15 stations, 12 of which belong to the standard type, while three have special designs: Porta Susa will provide interchange with services on RFI lines, e.g. the planned local services along the Passante Ferroviario; Porta Nuova, which also connects with Trenitalia trains; and the Fermi terminus, which lacks the otherwise typical landing between mezzanine and platform level. Metrotranvia line 4 was once planned to run underground through the city centre and intersect with line M1 at Porta Nuova, but the currently proposed metro line M2 will cross line M1 at Re Umberto instead.

The metro stations, which are spaced at an average of 550 m, have 60 m platforms; Porta Nuova and XVIII Dicembre stations have slightly wider platforms than the standard. All the stations were designed by Bernhard Kohn & Associés.

The rolling stock for line 1 consists of 23 VAL208 trains. Each train is 52 m long and composed of two 26 m units, which in turn are made of two permanently coupled 13 m cars. The cars are just 2.08 m wide and have an internal height of about 2 m. On each side there are three doors. Each car has a maximum capacity of 31 passengers seated and 49 standees with all folding seats used, or 19 seated and 61 standing when the folding seats are lifted. The overall capacity of a 52 m train is thus up to 440 passengers (calculating 4 pass./m2).

At an average speed of 32 km/h and an average headway of four minutes, the line's capacity is 6,600 passengers per hour and direction. The interval between two trains can be reduced to 2 minutes at peak times.

While the surface network is in service from 04:30 until 01:00, the metro only operates between 05:30 and 23:30. During service disruptions, Metrobus line 101 provides a replacement along the metro route.

In 2006, construction started on the second stage of metro line 1 between Porta Nuova and Lingotto (6 stations), thus linking the central station to the hospital area and Lingotto, an urban area which is currently experimenting major redevelopment, including the historical FIAT plant, which has been converted into a huge shopping mall and art museum. The 4.5 km extension, which is completely underground, will

bring the total length of line 1 to 14.1 km and allow for the complete reorganisation of public transport along one of the city's most important corridors.

For the period 2015-2020 two more extensions are planned: in the west, about 12.5 km through the municipalities of Collegno, Rivoli and Rosta, with 10 stations, most of which will be located on a viaduct; and in the south, from Lingotto along Via Nizza to Bengasi Square, with a terminus located right next to the Turin/Moncalieri boundary (2 stations).

The construction of the automatic Metro is part of a programme to upgrade and improve public transport in Turin. With the rail link to Caselle Airport completed, numerous other projects are being implemented for completion by 2012, like the Passante Ferroviario or the new railway station at Porta Susa, which will become the main public transportation hub in the city.

Metro line 2 is planned as a north-south link that will pass through the city centre (Piazza Castello) and intersect with line 1 at Re Umberto. The line will start at the railway station Rebaudengo, still to be built, and terminate in the area of the Cimitero Torino Sud [South Cemetery], with a possible extension to the town of Orbassano, southwest of Turin. Along the northern stretch, between Corso Novara and Parco Sempione, the abandoned alignment of a former freight railway line will be used for the metro line.

Suburban Rail

At present, there is no regular suburban rail service in Turin and its surrounding region, except on the GTT line to Ceres, where there is a train every 30 minutes to Germagnano via Caselle Airport. Trenitalia's regional services, however, operate a rather irregular timetable.

The first attempt to create a proper suburban service was made for the Football World Cup in Italy in 1990, when the Turin-Ceres line was upgraded: the urban section was put underground, new stations were built at Madonna di Campagna (underground), Venaria Rigola-Stadio (near the Stadio delle Alpi), and at Caselle Airport; the existing station in the village of Caselle was only put underground at the start of the new millennium. This line is currently curtailed at Dora due to the construction of the Passante tunnel, to which it may eventually be connected near Rebaudengo station.

The implementation of a proper suburban rail service is currently underway with the construction of the so-called 'Passante Ferroviario' (cross-city railway): a 12.3 km urban railway route from Stura in the north to Lingotto in the south, including some 8 km of underground sections. With the first tunnel between a point north of Lingotto and a point just south of the new Porta Susa station having been in service since 1999, the western double-track tunnel between Porta Susa and the tunnel portal north of the future Rebaudengo station was brought into service in October 2009, with trains now stopping underground at the partly completed Porta Susa station. On top of the underground railway corridor, a long avenue ('La Spina') is being laid out as the centrepiece of a huge urban redevelopment programme.

Once the eastern double-track tunnel between Porta Susa and Rebaudengo has been completed too, suburban services will be separated from long-distance trains. Similar to the Passante in Milan, the urban route will then be served by five suburban cross-city lines. Trains on each line will operate every 30 minutes (15 minutes during peak hours) on the central segment, and every 60 minutes (30 min peak) on outer segments, resulting, for example, in a train every 10 minutes between Lingotto and Rebaudengo.

Tram

The Turin tram network, which has a track gauge of 1445 mm, currently comprises 8 lines, although two of them (13 & 18) are temporarily being operated by buses due to disruptions caused by metro and Passante construction. The northern part of line 10 is also currently out of service. The branch to the Stadio delle Alpi is only served during special events. Including the temporarily closed sections, the network has a full length of 77.3 km, making it the second largest in Italy (after Milan).

The present system is the result of a new network layout introduced in 1982 and based on the 'Rolando grid' system, which proposed the creation of several upgraded routes branded 'metrotranvia'. Today, only lines 3 and 4 are referred to as 'metrotranvia', as they include long sections of reserved right-of-way. The rest of the network is characterised by conventional on-street tracks, although many sections along the wide avenues are exclusively used by trams, buses and taxis. Line 9, introduced on the occasion of the Football World Cup in 1990, had to be operated by buses for five years due to the disruptions caused by metro construction along Corso Vittorio Emanuele II, but eventually it returned as a tram line in September 2007.

The GTT tram fleet still includes some 90 vehicles of class 2800, manufactured between the late 1950s and the 1980s mostly by rebuilding older stock.

Class 7000 – often referred to as 'ML' (metropolitana leggera) – comprises the tram vehicles produced by FIAT Ferroviaria in the 1980s and purchased by the ATM from 1984 onwards for the planned 'metrotranvia' lines, notably line 3. With a length of 28.2 m and a width of 2.50 m, they were unable to run on the rest of the network due to the often limited curve radii. With their heavy weight of 63 t compared to 39 t of class 2800, they also necessitated the strengthening of the trackbed with concrete slabs. After 35 vehicles had been delivered, production stopped and a new tram type was designed instead.

For the 1990 World Cup, new rolling stock was ordered for tram line 9 which was introduced in that year to serve the new stadium: class 5000, of which a total of 53 vehicles are still in service. These are more similar to the traditional class 2800, and the first partially low-floor trams in Turin. They are 22.2 m long and 2.30 m wide.

Class 6000 – called 'Cityway' – is the latest tram generation in Turin; 55 vehicles were manufactured by Alstom at the former FIAT Ferroviaria plant at Savigliano. The class 6000 cars are 100 % low-floor, 34 m long and 2.44 m wide (thus they cannot run on all the lines); 49 double-ended trams are in operation on line 4, and six single-ended cars can be seen on line 10.

The Sassi – Superga rack tramway (Tranvia a dentiera) is rather unique in Italy. It can be found in the east of Turin where it provides a link to the baroque Basilica di Superga, inaugurated in 1731 at a height of 672 m above sea level.

The tramway was opened on 26 April 1884 as the first funicular railway to use the Agudio system: the train was powered by a stationary engine via a steel cable running parallel to the track and connected to the car via pulleys. But in 1935, the 3.1 km line was converted to become a more conventional rack railway, although it still has a feature which makes it rather unique in the world: unlike the rack tramway in Genoa, its power supply is via a third rail. The track gauge is the same as on the tramway system (1445 mm), and there is a track link between the two systems at the lower terminus (225 m above sea level). The average gradient is 13.5 %, with a maximum slope of 21 % on the uppermost section. During peak periods, long trains made up of a motor car and two trailers climb the mountain, allowing visitors a splendid view of the city with the Alps in the background.

VENICE

A transport system which is technologically identical to that in service in the neighbouring city of Padua, namely a rubber-tyred tram of the Translohr system, is under construction in Mestre, the mainland part of the city of Venice (270,000 inh.). Although construction began in 2004, the first sections from Monte Celo to Cappuccina will only be opened in mid-2010, with the remaining section south to Marghera possibly ready by the end of 2010. The route from Mestre to Venice proper is predicted to take several more years to complete.

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