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Railway systems





Light rail represents the evolution of the traditional tramway into a new mode of public transportation that is innovative, accessible, ecological and very safe

Of all the different metropolitan railway systems, trams and light rail systems are the ones that are currently arousing the most interest as regards implementation in medium-sized cities with medium population densities and metropolitan areas.

1.1 Light rail: a cosmopolitan transportation system

Light rail represents the evolution of the traditional tram system into a new mode of public transportation that is innovative, accessible, ecological and very safe.

Light rail travels on a track that is reserved but not exclusive, allowing it to travel overground while sharing traffic with other vehicles. This reserved platform separates it from private vehicles, but allows grade crossings with pedestrians and other traffic, with excellent urban integration. The incorporation of new technologies makes it possible to give priority to light rail vehicles at signals, offer information in real time, and provide better passenger safety.

1.2 The advantages of state-of-the-art transportation

INTEGRATED

Designed to save space in cities and improve quality of life, while recovering space for pedestrians and public transportation.

INTERMODAL

Provides convenient connections to all modes of transportation of the Community of Madrid during their hours of operation from 6 to 1:30 a.m.

PUNCTUAL

Avoids traffic jams and the need to look for a place to park. Also, its priority right of way guarantees high punctuality.

SAFE

Most of the light rail track runs on a separate right-of-way with priority at traffic lights. It is programmed to adapt the vehicle speed to the section over which it is travelling. Operation is monitored and managed from a Central Command Post (CCP).

ACCESSIBLE

Vehicles are adapted to facilitate accessibility and safety, which makes them well-suited for people with limited mobility, baby strollers and bicycles.

ECOLOGICAL

No gas emissions and very low direct pollution. In terms of numbers, a single light rail vehicle transports the same number of people as 170 private vehicles.

ECONOMICAL

All transport passes subject to the Community of Madrid's fare policy are valid on the light rail network at very affordable prices.





Metro Ligero Oeste

as a concessionary company



In July 2006 the company was awarded the public works concession contract for a period of 30 years

Since 2007 Metro Liger Oeste (MLO) has been managing the operation of the entire light rail system in the western section of Madrid.

2.1 The concession

MLO is a concession granted by the Community of Madrid; since July 2007 it has connected the municipalities of Boadilla del Monte, Alcorcón and Pozuelo de Alarcón to the Metro, Commuter train and Urban and Intercity bus networks that are managed and coordinated by the Regional Transportation Consortium of Madrid.

In July 2006, the company was awarded the public works concession contract for the light rail lines between Colonia Jardín - Estación de Aravaca (ML2) and Colonia Jardín - Puerta de Boadilla (ML3) for a period of 30 years.

The MLO network consists of two lines with a total length of more than 22 kilometers, 28 stops and a fleet of 27 vehicles.

Since July 2007 MLO has managed the operation and maintenance of the entire system: works, installations, and rolling stock, with a workforce of 230 people.

The project required an investment of close to 673 million euros in rolling stock, civil works, installations and technical and human resources.

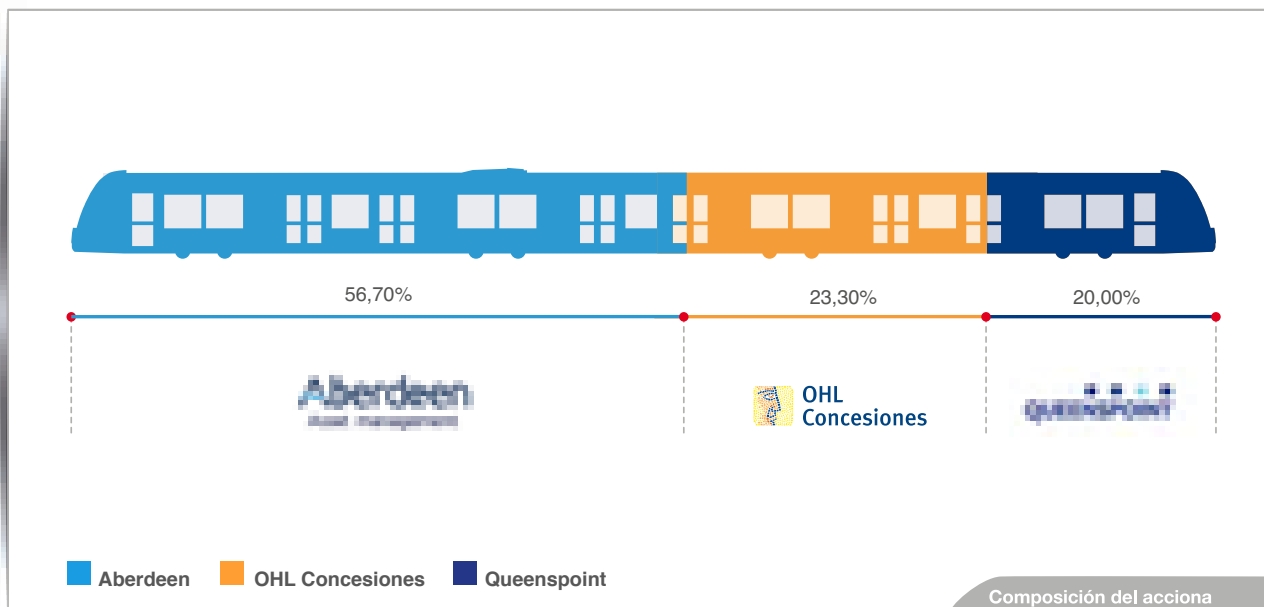
2.2 Shareholders

The shares of MLO are held by three companies, each prestigious in their respective business areas:



Aberdeen - 56,70%

- Aberdeen is a pure asset management company that only manage assets for third parties, allowing them to focus solely on their needs.
- Their clients access their investment expertise drawn from three main asset classes: equities, fixed income and property, as well as tailored solutions.
- Their investment teams are based in the markets or regions in which they invest.



OHL CONCESIONES - 23,30%

- OHL Concesiones is a business group in the forefront of the international market of public private partnerships in transportation infrastructures projects.
- Experts in the financing, development and operation of toll roads, ports, railways and airports.

QUEENSPPOINT - 20%

- Joint venture between **Allianz Capital Partners** and **Bastion Infrastructure Group**. Investment Managers in infrastructure and energy assets.



2.3. Chronology of major milestones

2004	<ul style="list-style-type: none"> • August: Construction MM 	
2005	<ul style="list-style-type: none"> • February: Construction OC 	
2006	<ul style="list-style-type: none"> • April 20: Publication of request for tenders • June 25: Submission of tender • July 18: Contract Award 	<ul style="list-style-type: none"> • August 30: Company created • September 15: Concession contract • December 12: Financing contract
2007	<ul style="list-style-type: none"> • May: Construction completed • July 27: Commercial service 	
2008	<ul style="list-style-type: none"> • April 19: 5 million users • September: ISO Certification: 9k. 14k. and OSHAS: 18k. 	<ul style="list-style-type: none"> • December 5: 10 million users
2009	<ul style="list-style-type: none"> • July 15: 15 million users • September: ISO Certification: 27k. 	
2010	<ul style="list-style-type: none"> • March 5: 20 million users • October: diMLO launched • October 28: 25 million users 	<ul style="list-style-type: none"> • October: Consortium with OHL in preventive management • November: UITP Award
2011	<ul style="list-style-type: none"> • May 28: 30 million users • June: MLO takes over preventive maintenance of fixed installations and rolling stock 	<ul style="list-style-type: none"> • July: ISO/OSHAS Recertification • October: OHL Award in ORP
2012	<ul style="list-style-type: none"> • January 27: 35 million users • March: Express Service Opens • May: Activation "Salida Oeste" 	<ul style="list-style-type: none"> • April: CRTM Award for Promotion of Public Transportation Sustainable Mobility • October: 40 million users
2013	<ul style="list-style-type: none"> • January: Passenger WiFi Service • June: 10 million km traveled 	<ul style="list-style-type: none"> • November: Award for Europe's Best Light Rail Line Operator of the year • Sustainability report 2007-2012
2014	<ul style="list-style-type: none"> • January: Award for CSR education project 2nd Public Transport and Sustainable Mobility Promotion Awards 	<ul style="list-style-type: none"> • November: 3rd place in International Tram Drivers Championship • Prize for three ground-breaking initiatives in the 1st edition of the Innova Awards
2015	<ul style="list-style-type: none"> • November: Award for Management Excellence in Maintenance 2015, in the Infrastructures category 	<ul style="list-style-type: none"> • December: Most innovating company in II edición Premios Innova
2016	<ul style="list-style-type: none"> • May: Launch of new MLO Website and App • June: 60 million users 	<ul style="list-style-type: none"> • October: Installation of USB charging ports in vehicles

Chronology of major milestones



03



The network of Metro Ligero Oeste





In 2007 the public transportation system of the Community of Madrid added 36 km of light rail, divided among four lines, to its transportation network

Close to 200,000 people who live or work in the municipalities of Madrid, Boadilla del Monte, Alcorcón, or Pozuelo de Alarcón have access to the light rail network managed by MLO.

3.1 MLO zone map

In 2007 the public transportation system of the Community of Madrid added 36 km of light rail, divided among four lines, to its transportation network.

Since July of that same year MLO has been managing two of the lines, connecting the municipalities of Boadilla del Monte, Alcorcón and Pozuelo de Alarcón to the Metro, Commuter train and Urban and Intercity bus networks that are managed by the Regional Transportation Consortium of Madrid.

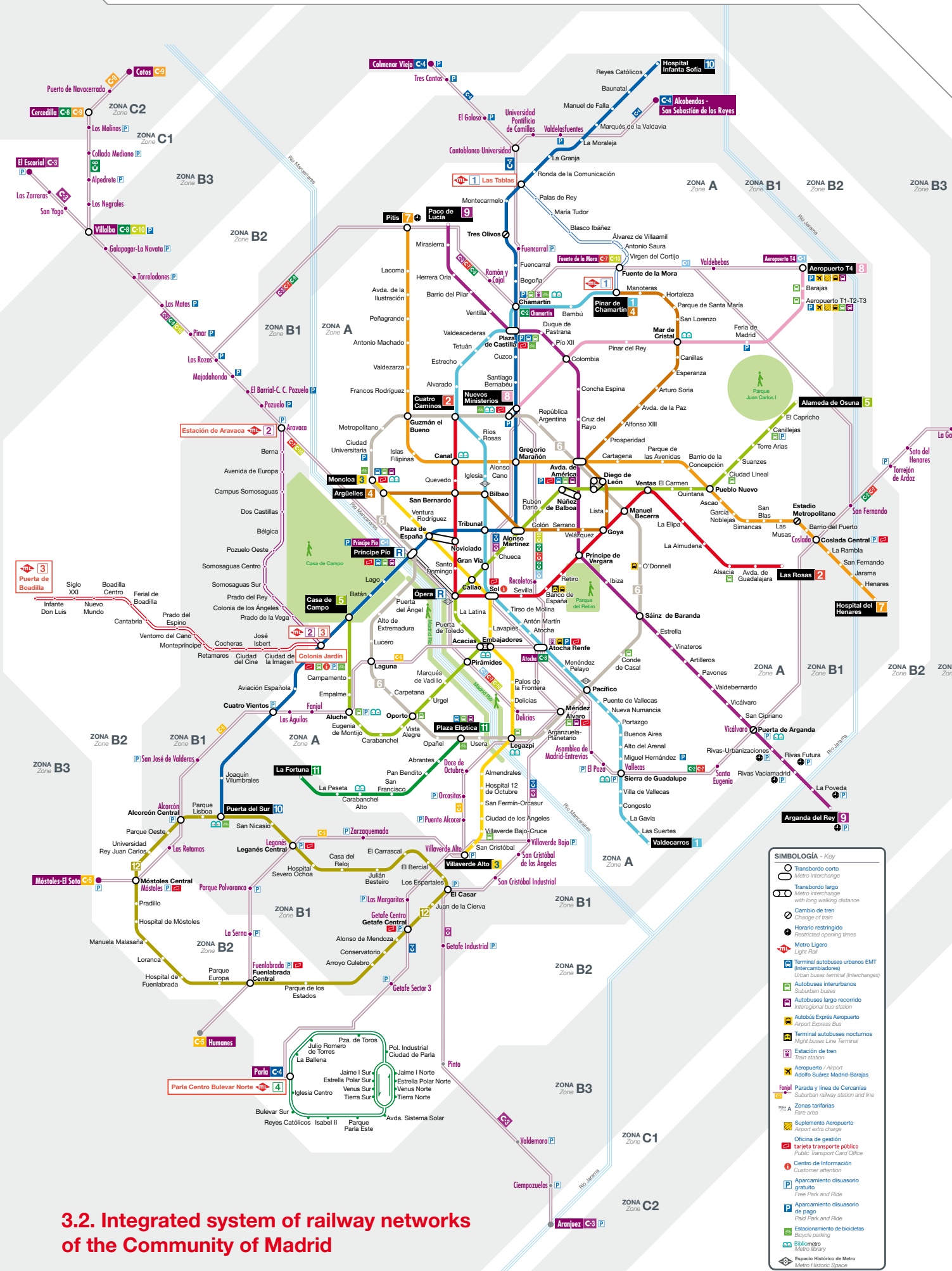
Areas served - ML2

- 1 Colonia Jardín
- 2 Quirón Hospital
- 3 RTVE
- 4 La Finca Business Park
- 5 Zoco de Pozuelo Shopping Center
- 6 Somosaguas University Campus
- 7 Aravaca Renfe-Cercanías Station

Areas served - ML3

- 1 Colonia Jardín
- 8 Ciudad de la Imagen / Carrefour
- 9 Kinépolis Entertainment Center
- 10 San Pablo CEU University
- 11 Ventorro del Cano and Prado del Espino Industrial parks
- 12 Grupo Santander Financial City
- 13 Boadilla del Monte Town Center





3.2. Integrated system of railway networks of the Community of Madrid

Oficina de gestión tarjeta transporte público
Administration offices
Ver relación y horarios en www.crtm.es
See at www.crtm.es

- RENFE-CERCANÍAS LÍNEAS DE FERROCARRIL - SUBURBAN RAILWAY LINES**
- C-1 Príncipe Pío - Atocha - Recoletos - Chamartín - Valdebebas - Aeropuerto T4
 - C-2 Guadalajara - Atocha - Recoletos - Chamartín
 - C-3 Aranjuez - Atocha - Sol - Chamartín - El Escorial
 - C-4 Parla - Atocha - Sol - Chamartín - Alcobendas - San Sebastián de los Reyes / Colmenar Viejo
 - C-5 Móstoles-El Soto - Atocha - Fuenlabrada - Humanes
 - C-7 Alcalá de Henares - Atocha - Recoletos - Chamartín - Príncipe Pío - Atocha - Chamartín - Fuente de la Mora
 - C-8 Atocha - Recoletos - Chamartín - Villalba - Cercedilla
 - C-9 Cercedilla - Cotos
 - C-10 Villalba - Príncipe Pío - Atocha - Recoletos - Chamartín / Fuente de la Mora

- LÍNEA METRO - METRO LINES**
- 1 Pinar de Chamartín - Valdecarros
 - 2 Las Rosas - Cuatro Caminos
 - 3 Villaverde Alto - Moncloa
 - 4 Argüelles - Pinar de Chamartín
 - 5 Alameda de Osuna - Casa de Campo
 - 6 Circular
 - 7 Hospital del Henares - Pitis
 - 8 Nuevos Ministerios - Aeropuerto
 - 9 Paco de Lucía - Arganda del Rey
 - 10 Hospital Infanta Sofía - Puerta del Sur
 - 11 Plaza Elíptica - La Fortuna
 - 12 Metrosur
 - 13 Opera - Príncipe Pío
- LÍNEA METRO LIGERO - LIGHT RAIL LINES**
- 1 Pinar de Chamartín - Las Tablas
 - 2 Colonia Jardín - Estación de Aravaca
 - 3 Colonia Jardín - Puerta de Boadilla
 - 4 Tranvía de Parla: líneas circular

ZONA C1 ZONA C2 ZONA E1



3.3 Main characteristics of the MLO network

The MLO network is made up of two lines: ML2, which connects Line 10 of the Metro to Pozuelo de Alarcón, has 13 stops from Colonia Jardín to Estación de Aravaca and a length of 8.7 kilometers; and ML3, which runs between Colonia Jardín and Boadilla del Monte, with 16 stations and a total length of 13,53 kilometers.



All of our stations are accessible for people with limited mobility.

		
Commencement of works	February 2005	
Commissioning	July 2007	
Length	8.63 km	13.53 km
Stations or stops	13 (3 underground)	16 (2 underground)
Interchange stations	2	2
Average distance between stops	720m	900m
Total route time	22,5 minutes	32 minutes
Maximum operating speed	50km/h (urban), 70km/h (suburban), 20km/h (pedestrian)	
Average commercial speed	23,01km/h	25,36km/h
Vehicle availability at rush hour	10	13
Frecuency at rush hour	6 minutes	
Track gauge	1,435m	
Standard platform width	7.80m	
Average platform length	45m	
Electrical service connections	3	
Structures	2 bridges and 8 tunnels	4 bridges and 5 tunnels
Traction substations	4 underground/ 1 surface	4 underground/ 3 surface
Longest tunnel length	1,150m	880m
Road crossings	13	49

04

Operating System

of Metro Ligerio Oeste



The operation system includes the areas of operations, rolling stock, fixed installations and systems

In terms of corporate structure, MLO is divided into five operating areas that are directly aimed at production, and two support areas, which play a vital role in the development of the company.

General Management is supported on the Integrated Management System, which allows it to monitor the results of the activity from different perspectives, thereby allowing the correct strategic decisions to be made.

MLO is responsible for the management of all of the operation and maintenance: works, installations, rolling stock. MLO has currently a workforce of 230 people.

Mission

To offer a safe, punctual, accessible and sustainable mobility service.

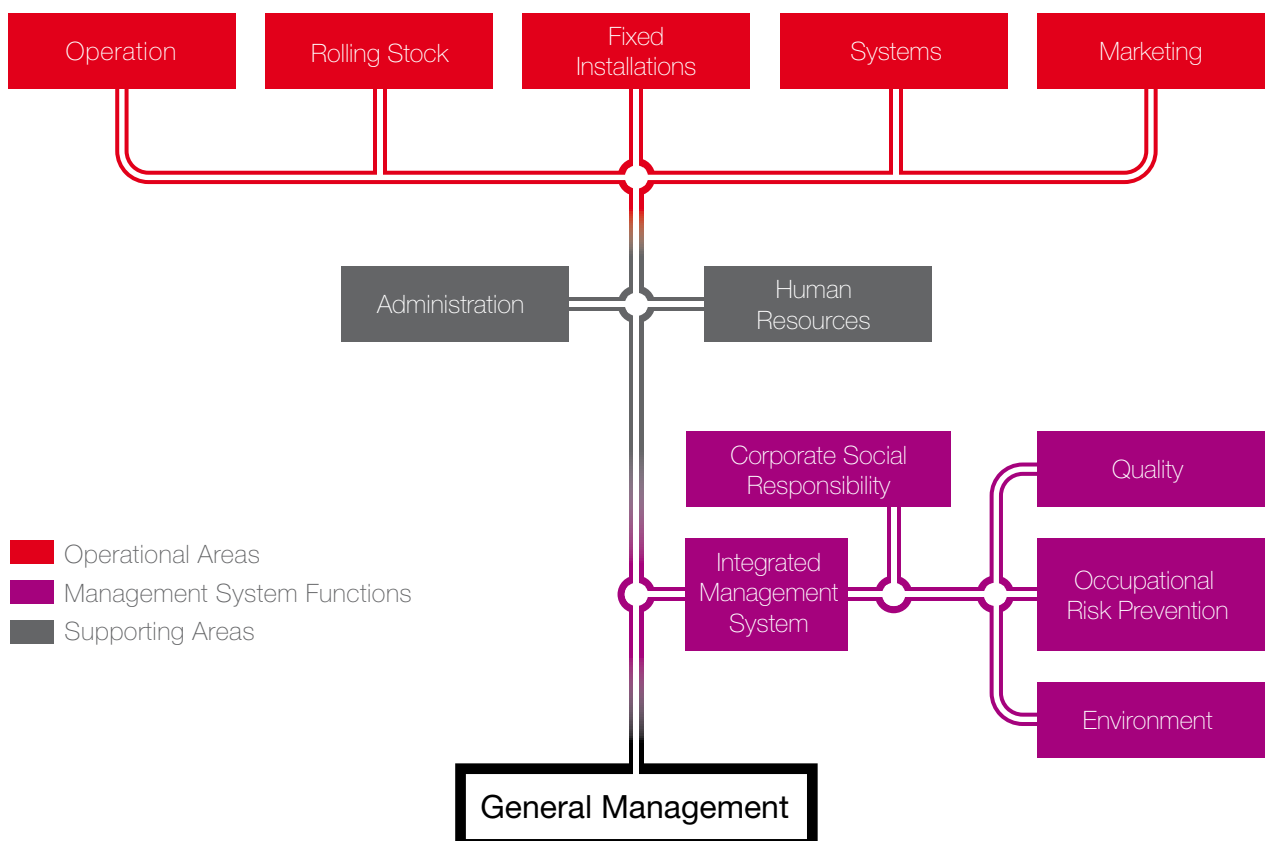
Vision

To be a leading national transportation company, one that stands out from the rest based on our firm commitment to all of our stakeholders.

Values

Committed, rigorous and responsible team seeking excellence and guaranteeing the satisfaction of our customers.

Organizational structure





4.1 Operation

The operations area has about 122 employees (drivers, inspectors, CCP operators, customer-service staff).

This area manages the following:

LINE

Production of the transportation service

- Service planning.
- Driving and provision of the public transportation service.
- Inspection and fraud control.
- Training and continuous professional development for the corresponding operating positions.

SAFETY

- Implementation of a Safety Management System (SMS) for traffic, which makes it possible to control the normal risk factors, to prevent or mitigate them, and guarantee a safe, reliable service.
- Definition and tracking of a Self-protection Plan that is used to manage potential emergency situations, coordinating internal teams as well as external support teams (firefighters, police, etc.).

MONITORING

Control of the provision of the surveillance service

- Preventive surveillance of the installations and their access points.
- Surveillance of users and support for operations personnel.
- Management of CCTV circuits.
- Collection and transportation of fare money.

CCP

Control of operations and users information

- Management of traffic and real-time users information.
- Remote control and surveillance of operation system
- Coordination of maintenance activities.
- Management and coordination of incidents to restore service.





TOOLS

The Central Control Post (CCP) includes the following tools to carry out its functions:

SCADA Supervisory Control and Data Acquisition System: supervision and control of the energy system.

SAE or AVLS Automatic Vehicle Location System: location of vehicles and management of frequencies.

CTC Light Rail signalling management system.

Communication (radio-telephony, intercom, public address system and telephony).

SDCTU control of traffic lights.

CCTV video surveillance system.

TCE Station Remote Control, which includes:

- Elevators
- Escalators
- Fire detection

- Pump wells and tunnel ventilation
- Tunnel ventilation
- Ticketing

PERFORMANCE INDICATORS

- Availability (% of kilometers travelled/planned):
 - Greater than 99,27%
- Punctuality (trips with no delays longer than 1 minute):
 - More than 91% (average of the last 12 months)
- Accident rate (collisions)*
 - Average since 2008: 3,48 accidents per 10⁶km
 - Last 12 months: 4,58 accidents per 10⁶km

* This indicator refers to collisions with third parties, in which it is important to note that no serious injuries occurred in any of the cases and none were the result of errors or transgressions by MLO drivers.



Workshops and depots



Storage



Wash tunnel



Parking building





Maintenance workshop



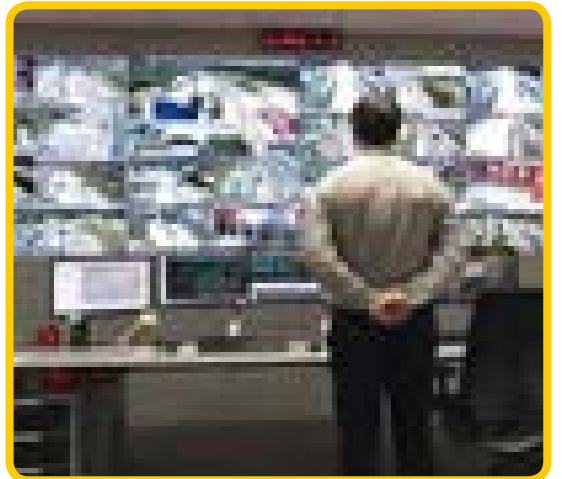
Service building



Office



CCP - Central Control Post



4.2. Rolling Stock

MLO has a group about 23 professionals who manage the comprehensive maintenance of the fleet of 27 vehicles and the workshop equipment located in the depots.

VEHICLES

MLO's vehicles are from Alstom's Citadis line, model TGA 302.

They are 32m long with 100% low floor and a capacity for more than 200 passengers, with specific areas for people with limited mobility. They are equipped with 4 double doors and 2 single doors on each side.

The vehicles have a top speed of 70km/h, accelerating at 1.20m/s^2 , and braking with a deceleration of 3m/s^2 in the case of emergency braking.

All of the vehicles are equipped with connections for mobile devices to the internet thanks to their WiFi networks and free USB charging ports.

DEPOTS

MLO's depots have all of the equipment needed to provide comprehensive maintenance of the vehicle fleet over its entire lifetime, including large-scale overhauls.



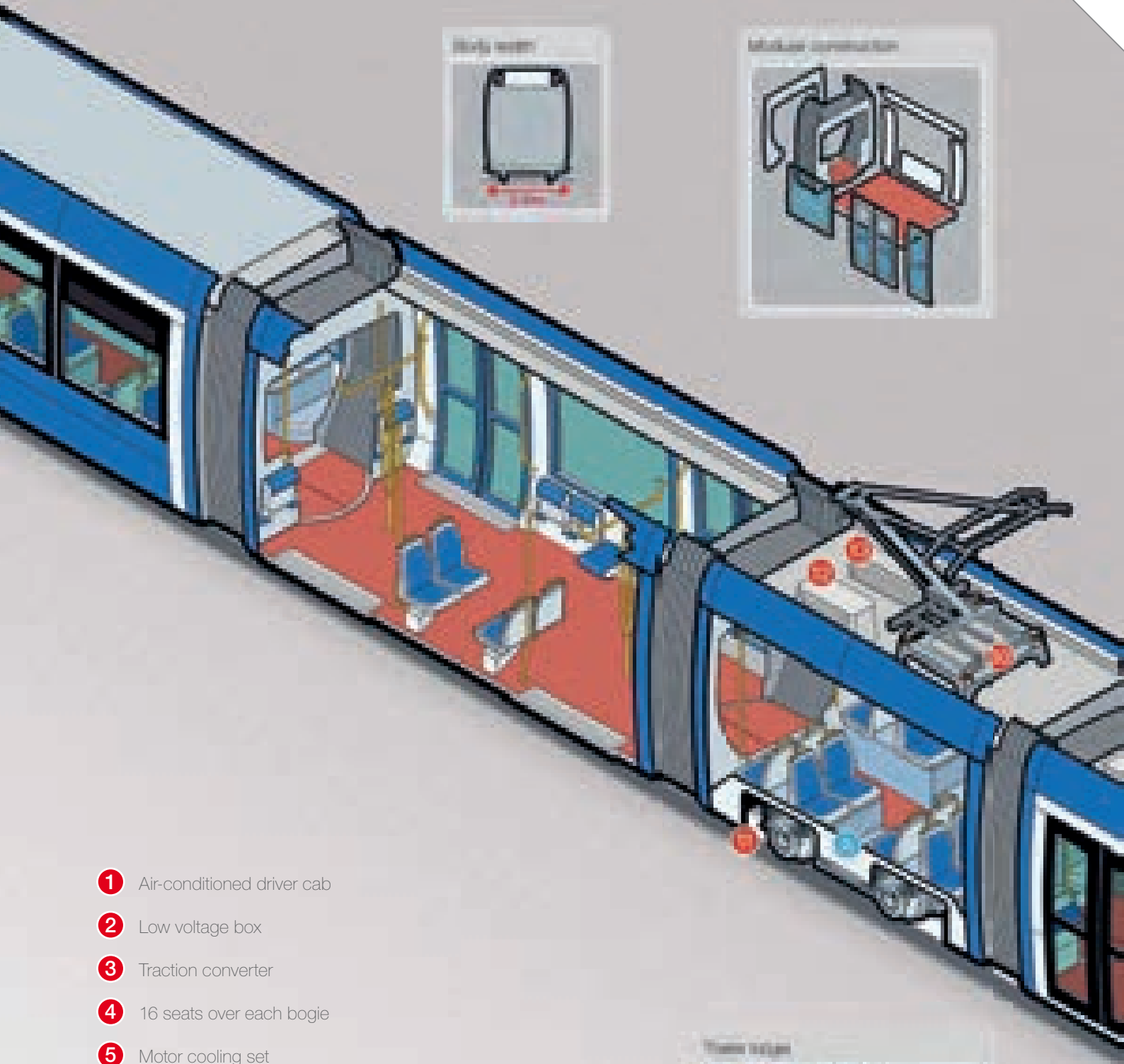
The principal equipment includes:

- Wash tunnel
- Sand storage silo with a capacity of 30mt
- Under-floor wheel lathe
- Lift jacks
- Overhead cranes
- Access platforms to vehicle roofs
- Undercarriage wash zone

PERFORMANCE INDICATORS

- 99% fleet availability
- 98% fleet reliability



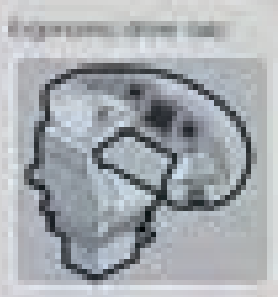
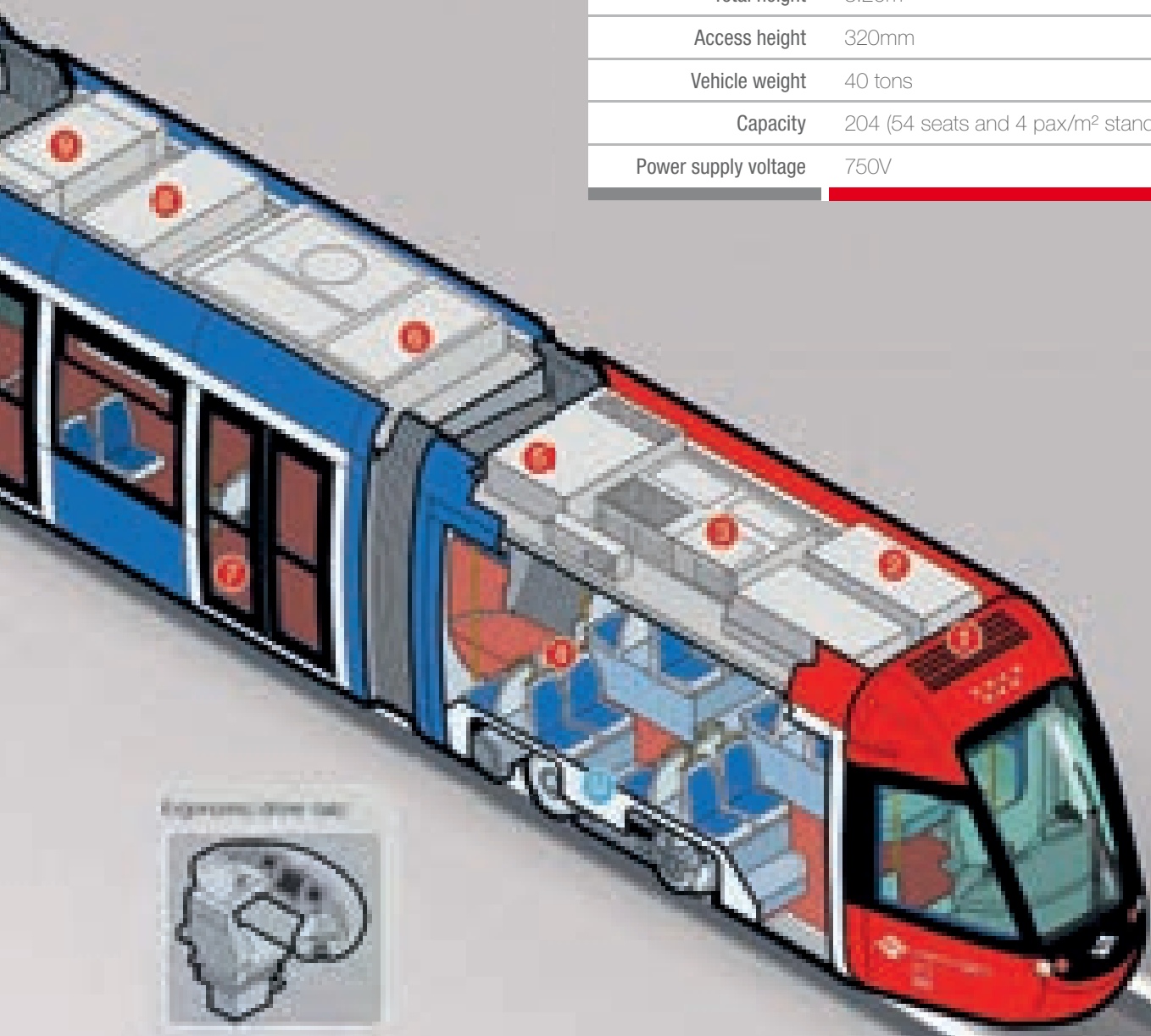


- ① Air-conditioned driver cab
- ② Low voltage box
- ③ Traction converter
- ④ 16 seats over each bogie
- ⑤ Motor cooling set
- ⑥ Heating and air-conditioning for passenger compartment
- ⑦ Double door, 1,300 mm of clear width
- ⑧ Braking resistor
- ⑨ Auxiliary converter and battery box
- ⑩ Pantograph
- ⑪ Accessibility for bogie maintenance
- ⑫ High speed circuit breaker
- ⑬ Lightning rod





Model	ALSTOM CITADIS TGA 302
Total planned fleet	27 units (23 commercial service, 2 in operation backup, and 2 maintenance backup)
Bogies	3 bogies (2 motors and 1 carrier NP)
Type	100% low-floor
Speed	20km/h on platform shared with pedestrians, 50km/h in urban areas, and up to 70km/h in suburban sections
Length	32.34m
Geometric parameters of the line	Capable of climbing slopes of up to 8%
Minimum radius of curvature	16m in workshop
Total width	2.40m
Total height	3.20m
Access height	320mm
Vehicle weight	40 tons
Capacity	204 (54 seats and 4 pax/m ² standing)
Power supply voltage	750V



4.3 Systems

The operation of modern transportation networks is based on a strong technological pillar in which computer and communications systems play a vital role.

The communications systems and networks that support MLO's lines are divided into:

- Communications systems which make it possible to establish data, voice and video communications between the central control terminal and the different elements distributed along the line and light rails.
- Control systems which integrate the supervision and control of all of the installations and vehicles on both lines.
- Ticketing systems integrated into the system of the Regional Transportation Consortium of Madrid.
- Office computing systems and management applications required for the operations of Metro Ligero Oeste.
- Safety and recovery systems aimed at maintaining the service, contingency plans and recovery of both data and systems in the event of incidents.



The Systems Maintenance area is responsible for providing technical support for all of these systems and for performing the following functions for them:

- Configuration and administration of operating systems, application servers, and databases, web servers, network architecture design and administration of communications devices.
- Securing of systems and communications.
- Analysis and development or installation of software solutions.
- Addressing queries and hardware and software issues.

The Systems Maintenance team is made up about 14 professionals to carry out all of these activities:

- Engineers and systems administrators, whose job is to administer and maintain the existing technical equipment, systems and communications.
- Programmer-analyst for software development, whose function is to develop and implement applications.
- Technicians and system operators, whose function is to maintain the existing technical equipment, systems and communications in the Data Centers of the central control post, technical rooms along the line and office and customer service workstations.



PERFORMANCE INDICATORS

The indicators that measure the effectiveness of the department are based on the availability of the critical systems, broken down as follows:

- Essential communications:
 - required limit 99,99%
 - availability achieved in 2016: 99,99%
- Control and communications equipment and Central Control Post systems:
 - required limit 99,00%
 - availability achieved in 2016: 99,51%
- Equipment for ticketing, sale, loading and reloading, validation and oversight:
 - required limit of 98,50% achieved in 2012
 - availability achieved in 2016: 99,54%



4.4. Fixed Installations

MLO has a team about 40 professionals from different areas such as track, electrification and signaling, who perform the maintenance of all of the infrastructure as well as the engineering for all modifications.

The MLO system includes:

- 22.4km of double track with grooved rails embedded in walkable concrete platform. Jacketed track system.
- 24 stops with 45-meter platforms with exclusive lighting and covered shelters.
- Three underground stations and one trench station, and two terminal stations that serve as interchange stations.
- Electrification 750 Vdc with tramway catenary integrated into the city centers through which it travels.
- 12 traction substations with an installed traction capacity of 12 MWQ and 18 transformer substations that form two interconnection rings, respectively.
- 62 road crossings to regulate car traffic with the light rail, along with pedestrian crossings, which give priority to the light rail trams over vehicle traffic.
- A railway signaling system that guarantees the safety of the light rail traffic through the use of audio-frequency track circuits and electrical-hydraulic tramway point machines.

- Fire protection systems in all MLO technical rooms, HVAC systems, forced ventilation in tunnels, pump wells and SOS systems, as well as generator sets and uninterruptible power supplies form part of the scope of action of the fixed installations department.
- The OAS (Operations Assistance System) provides the control terminal with the positions of the entire fleet, guaranteeing that the programmed frequency will be maintained, in addition to recalculating frequencies if any issues should occur.

INNOVATION

The department is working together with Alstom, the manufacturer of the signaling system, on the development of the SIDI software tool for remote maintenance and monitoring of the 6 interlocking rooms of the signaling system.

Joint engineering and development of the SCADA systems, integrating all the remote systems into the Siemens WIN CC Open Architecture SCADA, allows direct access to the equipment in all of the technical rooms, granting the ability to address a large number of issues without the need for *in situ* intervention while providing more intelligence than existing systems, such as the Smart Platform and Tunnel Activation Control (CEIPT)





and the Tunnel Ventilation Control System (SCVT), which permits management of air quality and temperature in stations and tunnels or configuring of ventilation in case of fire. The energy consumption of the entire network can be managed in real time, thereby allowing optimization of the network.

PERFORMANCE INDICATORS

In 2016 the issues attributed to Railway Infrastructure with an impact on operation, as a monthly average for all of the journeys, represented just 11 min. delay/month and 5,3 km/month lost.



4.5 Marketing

- Customer service
- Market analysis
- Communication and promotion
- Public relations
- Corporate Social Responsibility

PERFORMANCE INDICATORS

- 60% reduction in user complaints since the beginning of operation.
- Average response time of 3 days in 2016 for complaints and suggestions received from our users.

Technological innovation at the service of users

MLO bets on the **avant-garde technology** and **intelligent mobility** in the cities.



- Real time service information (App & Web)
- Contactless Public Transport Card
- Multi Card

MLO WEBSITE

www.metroligero-oeste.es



MLO APP

Real time service information



MLO Profiles



CORPORATE BLOG

www.blog.metroligero-oeste.es

REAL TIME INFORMATION SCREENS

Real time service information



4.6 Administration

- Financial
- Accounting
- Legal and Insurance
- General Services

The Administration and Control area is in charge of the following:

- Developing and executing all of the functions related to the budgetary, economic, administrative and accounting management of MLO, analyzing the results obtained every month and making the necessary budget adjustments so that the company has a healthy situation in regard to assets and monitoring activity to ensure that it is profitable for shareholders.
- Provide the support required by other departments in MLO, monitoring to ensure appropriate provisioning of assets, services and economic resources that are requested by those departments to adequately carry out their functions, always complying with the tax, mercantile, legal and accounting obligations that are in force.
- Track accidents and acts of vandalism that occur to installations or people.
- Provide the company with common services such as cafeteria, cleaning, messaging, etc.

4.7 Human Resources

- Personnel
- Occupational Risk Prevention
- Internal System

MLO's workforce is made up about 230 young, qualified professionals.

Notable aspects:

- MLO's strong focus on training.
- The creation of an Internal Health Promotion Plan, guaranteeing the safety and health of employees and users.
- The Occupational Risk Prevention Management System that was put into practice in 2007/8 has adapted its actions to conform to the technical specifications of OHSAS 18001, receiving certification a year after the start of activity.

PERFORMANCE INDICATORS

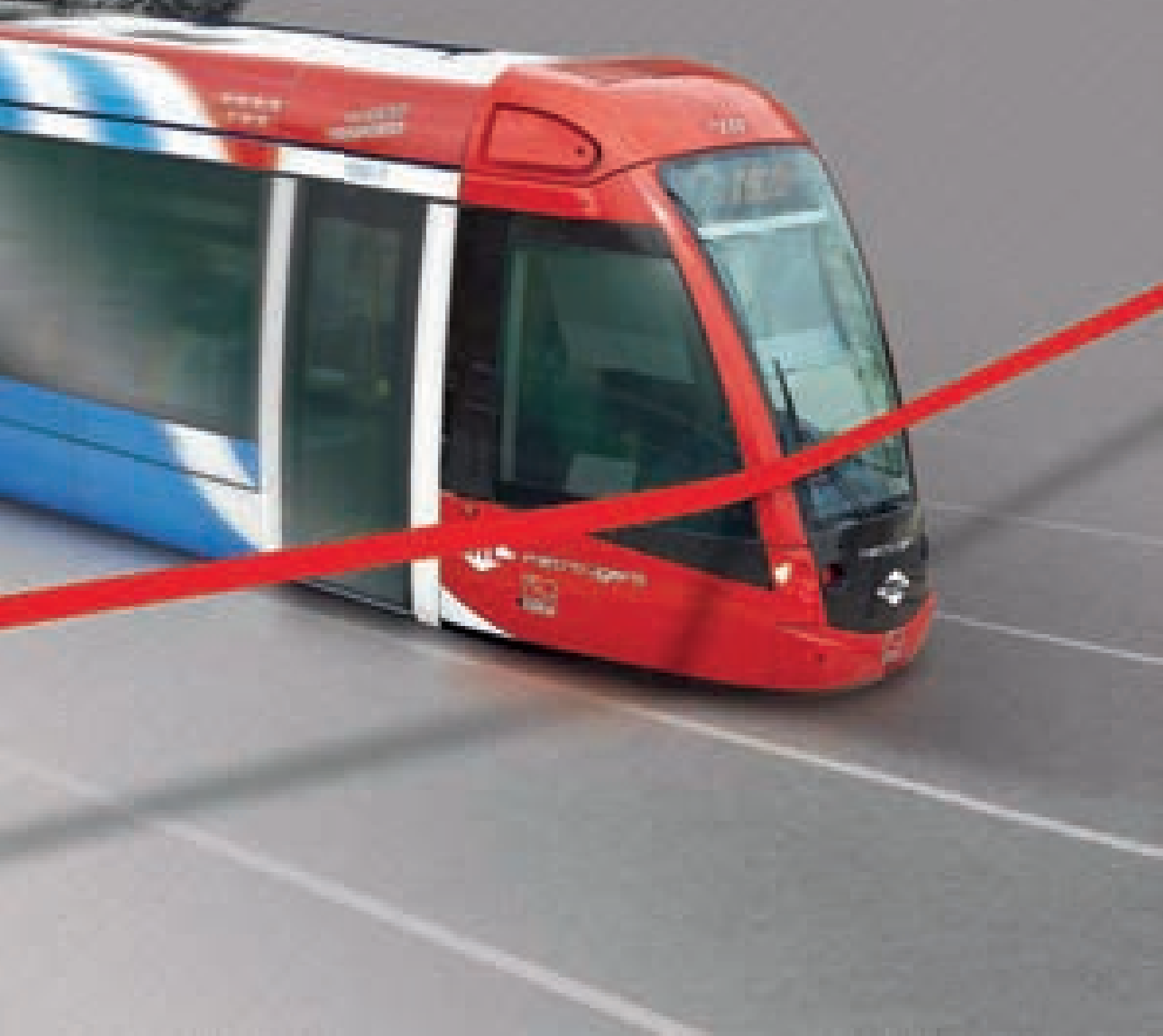
- 41,2 % reduction in the index of work-related accidents since the rollout of operations.




05

Certificates and Awards

of Metro Ligero Oeste





Challenge met: Triple certification (Quality, Environment, and Occupational Risk Prevention) in the first year of operation.

5.1 Recognition of best practice

Our commitment to important aspects such as customer satisfaction and environmental sustainability is backed by awards.

The best practices and effectiveness of the Integrated Management System (IMS) have received Triple Certification in accordance with the requirements in ISO-9001 (Quality), OHSAS-18001 (Occupational Safety and Health) and ISO-14001 (Environment).

Under the heading of awards, MLO has also received the following:

- Award for the Best Light Rail Initiative in the World (International Congress of Light Rail and Tramways - October 2010).
- Award for Public Transport and Sustainable Mobility Promotion in the Autonomous Community of Madrid 2012 (Regional Transport Consortium of Madrid (CRTM) for MLO's Marketing and Communication Team).
- Award for Europe's Best Light Rail Line Operator of the year. (Annual Rail Awards - November 2013).
- Young Railway Engineers Awards (Spanish Railways Foundation, April 2015).
- Award for Management Excellence in Maintenance, Infrastructures Category - PRISMA 3 (Sistepant - November 2015).



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