Ansaldo STS

Ansaldo STS, is a leader in the field of railway and urban transport technologies. The company operates through two business units, Transportation Solutions and Signalling, in designing, producing and managing rail and signalling systems.

Ansaldo STS, listed on the Milan Stock Exchange, acts as both main contractor and systems integrator, providing turnkey solutions for major projects worldwide.
Copenhagen Metro

The Best Metro in the World 2008
The Best Metro in the World 2009

Winner Announcement:
March 23, 2010 Metrorail Conference
The Best Metro in the World 2010

Honour Roll

Best Metro
Winner: Copenhagen Metro

Best Driveless Metro
Winner: Copenhagen Metro

Best Metro Europe
Winner: London Underground

Best Metro Asia Pacific
Winner: SMRT

Best Metro Americas
Winner: São Paulo Metro

Most Innovative Use of Technology
Winner: SMRT

Most Energy Efficient Metro
Winner: SMRT

Most Improved Metro
Winner: Delhi Metro Rail Corporation

Special Merit Award for Commitment to the Environment
Winner: Montreal Transit Corporation (STM)
Copenhagen celebrated the opening of a new Metro on October 19, 2002. It was an entirely new way of traveling around Copenhagen, and the new system was both an immediate transportation solution and part of a strategic development plan for the Danish capital.

After years of increasing traffic problems and debates on different transportation systems, the contracts for a modern and innovative Metro were signed by The Ørestad Development Corporation and Ansaldo STS in 1996. Finally, the work of giving Copenhagen a Metro could begin.

Copenhagen not only received an efficient transportation system, but also a system where safety, modern design, and service are key.

The Copenhagen Metro is built to operate 24 hours a day with headways as low as 2 minutes, and gets from one station to the next within 1 or 2 minutes, reaching speeds of up to 80 km/h.

The entire Metro is fully automated. It is a well-known fact that a driverless system controlled by today’s advanced technologies is far safer and more precise in operation than manually systems can ever be. The technical systems take over the operation itself, which enables staff to concentrate on looking after the passengers and maintaining the system.

A big city Metro is all about getting from one place to another in the most convenient and quickest way possible. In Copenhagen, this means very frequent departures. It makes no sense to talk of time schedules when, during peak hours, there is another train approaching the station within 2 minutes (the system can handle an operational headway down to 90 seconds). It is easy for passengers to get on and off the train because of the broad doorways - room for wheelchairs, prams and bicycles - and with no stairs or gap from platform to train, stops become even shorter.

The longest possible trip on the Metro - between the two terminal stations, Copenhagen Airport, through the entire city to Værløse – is 14 km long and the trip takes 25 minutes. The average Metro passenger spends about 7 minutes in the system.

By 2005, the Copenhagen Metro has carried 36 mio passengers. This is expected to rise. Already in 2005 the Copenhagen Metro carried 36 mio. passengers. This is expected to rise in the years to come due to several urban development projects along the lines of the Metro.
After some scepticism concerning the driverless concept, Copenhageners have enthusiastically embraced their new Metro.

Already, after only the first few years of operation, the Metro has not only made public transportation more effective, but it has even changed some habits of the citizens.

The Danish Transport Research Institute (DTF), a research institute under the Danish Ministry of Transport and Energy, conducted several surveys of traffic in Copenhagen before the Metro was built and during the first couple of years after the opening of the first phases.

According to the DTF, a lot of traffic from other transportation modes has moved to the Metro. During the first 2 years of operation the Metro got up to 47% of the bus passengers and up to 20% of the local train passengers on certain parts of the Metro line. Up to 13% of the car drivers and 9% of the bicycle riders also chose to switch to the Metro in some areas during the same first 2 years, 2003 and 2004.

The DTF expects the tendency to switch to the Metro to grow in the coming years and to change even more radically after the completion of the Cityring line.

The availability of the Metro has also increased the overall amount of travel in general. It seems that the Copenhageners want to travel more, when they have the right transportation.

The Copenhagen Metro is an integrated part of a larger plan for the development of Copenhagen. Not only does it enhance the existing city traffic, it also contributes to the development of Copenhagen itself.

The Metro was the very first building project in an entirely new district near Copenhagen, called Ørestad. After just a few years, the area is now rapidly developing with construction to accommodate companies, private housing, shopping malls, and more.

Along another section of the line, the Metro has contributed to the redevelopment of another area: A part of the island Amager, which after the introduction of the Metro has become a much more integrated part of the city.

As well, the rest of the world has been interested in the construction and the operation of this new Metro. Thousands of delegations, visitors, and interested professionals have visited Copenhagen from all over the world. It is obvious to everybody that this is the kind of system for the future – and Copenhagen is the place to see it.

The next phase of the Copenhagen Metro is already decided and plans are ongoing. On January 7, 2011, Ansaldo STS was awarded a contract for the Design, Build, Operation and Maintenance of the new Metro.

Phase 4, also called The Cityring, will have exchange stations with the existing Metro line and will surround the city center as follows:
- 16 km of double track mostly underground
- 17 stations + 1 service station
- 90,000 m² Depot (CMC)
- 2 Control Center (Main and Emergency)
- Fleet of 28 trains
- 24/7 service
- 100 s peak hours headway
- 98% Service Availability.
A safe place

The Copenhagen Metro takes safety very seriously. A driverless system is the ultimate way to eliminate the element of human error, which is a proven method to increase safety. At the same time, all the critical parts of the Metro system are designed to be redundant, so it is possible to maintain operation even if parts of the system close down or get damaged. This goes for everything from the traction motors on the trains, to every single part of the automated system, to the entire control room: There is a spare that will take over in case of malfunction.

The physical design and the choice of different sub-systems themselves are also determined by the effort to build a safe Metro for Copenhagen. Trains and stations have video surveillance and the ability for direct radio contact from the passenger to the control room. All stations and trains are bright and friendly, there are visible Metro employees to assist passengers all around the system, and all underground stations have walls of glass between platforms and track areas with doors that open only when there is a train at the station. The tunnels are lit and cell phone communication is possible from anywhere in the Metro.

The Copenhagen Metro reflects the fact that safety has been the keyword throughout the design, the construction, and for the operation. What is not immediately visible is the fact that this Metro is the first system in the world that is tested and approved according to the new and very demanding European CENELEC safety standards. Ansaldo Trasporti Sistemi Ferroviari has been the pioneer of breaking new ground that will be followed by future railways and their suppliers around Europe and elsewhere.

Environmental solutions

The Copenhagen Metro not only lives up to the demanding Danish rules on environment, but has visions of its own. During the design phase, special solutions were identified for noise reduction as well as for reducing vibration. Under the sensitive areas of the city, the track, is placed on bi-block concrete sleepers with special vibration absorbers. Furthermore, the wheels of the vehicles consist of two concentric and independent parts interfaced by special vibration absorbers.

For the operation, that means a considerable noise reduction through meticulous maintenance of wheels and rails. For instance, the Metro has its own lathe machine for reprofiling the wheels, which makes a significant difference for noise reduction.

Energy consumption has been reduced by placing underground stations higher than the lines between them and letting the line drop several meters between stations. This also enhances acceleration and braking, and in addition, the regenerativ braking energy is recycled by the power supply system.

The very consistent and leading edge train interior design makes it possible to keep the trains cleaner, which is not only a question of general comfort and aesthetics, but also crucial to the part of the population with allergies.

All the materials for the Metro were chosen according to demanding fire safety and environmental parameters.

The Metro is also an environmentally-friendly transportation choice for the city:

- For every person that uses the Metro instead of the bus, the CO2 outlet is reduced by 75%. For every person on the Metro instead of alone in a car, the CO2 outlet drops by no less than 83%.

Ansaldo STS is using an environmental management system in accordance with ISO 14000 specifically developed for the Metro system. This guarantees an internationally high level of environmental performance.
The Metro lines cover 21 km – 10 km in tunnels and 11 km on elevated tracks and at grade.
22 stations – 9 underground and 13 above ground.
34 trains in all. Each train is 39 m long and 2.65 m wide.
Each train carries 300 passengers – and has room for wheelchairs, prams and bicycles.
Top speed: 80 km/h. Average speed including stops: 40 km/h.
The trip between two stations takes between 1 and 2 minutes.
The trip between the 2 terminal stations, Copenhagen Airport and Vanløse, takes 25 minutes.
Headway down to 2 minutes in rush-hours. 15 minutes during nights.
Driverless.
Two ways to get extra help and service at any time:
Ask a Metrosteward or press a button and get direct contact with control room.
Video survey of stations and inside trains.
The system

New, but proven

Ansaldo STS was chosen as contractor for the Copenhagen Metro. The Ørestad Development Corporation asked for a driverless system that could be operated and maintained around the clock and could comply with very high demands on design, safety, service availability, passenger service, and reduced environmental impact.

The railway system including all sub-systems that were chosen for the Copenhagen Metro show a fine balance of two main requirements:

- It is a technologically advanced and well-integrated system in order to meet the demands of being driverless, safe, future-proof, and available for operation around the clock.
- Nevertheless, most of the chosen solutions are based on well-known technology and on experience from all over the world in order to ensure performance stability.

The system designed by Ansaldo Trasporti Sistemi Ferroviari is formed from a synthesis of the two requirements, which was possible due to the vast experience and many diverse products represented by the Ansaldo group companies involved (see the company profiles at p. 30).

Sub-systems

Ansaldo STS is supplying the following sub-systems for the Copenhagen Metro:

- Rolling stock
- Control and Maintenance Center with service vehicles and equipment
- Automatic Train Control (ATC)
- SCADA (Supervision, Control, and Data Acquisition)
- Radio, Communication, PSIS (Passenger Safety and Information System)
- Power supply and Traction power
- Permanent Way
- Platform Screen Doors
- Obstacle Detection System

The services provided by Ansaldo STS besides the system itself are:

- System design
- System and sub-system integration
- System level testing
- Safety assessment
- Operation and Maintenance for 8 years

In the following pages, each sub-system and the process of implementation is briefly described. For further technical specifications, also see the listings on the last pages.
Design process of vehicles

Even before The Ørestad Development Corporation and Ansaldo STS signed the contract for the Metro, both parties had high ambitions for the design of the vehicles themselves. The requirements from The Ørestad Development Corporation were precise and thoroughly researched and Ansaldo STS entered into the tender hand in hand with one of the most famous industrial designers in the world: The Giugiaro Design company. The Ørestad Development Corporation and their Danish design consultant companies, KHRAS and Carl Bro, worked closely with Ansaldo STS and Giugiaro Design to find the optimal solutions. The length of the vehicles were already determined by the layout of the stations, and the dimensions of the doors, flex areas and seats were found via extensive testing in the design laboratory with simulated passengers.

The outcome of the joint effort was a very coherent design concept, resulting in some radical and rather unusual design choices. For instance, it was decided not to have any technical equipment inside the vehicle at all. Instead this is all gathered in modules and placed underneath the vehicle to be easily exchanged with spare modules in case of maintenance requirements. Inside the vehicles are the bare essentials in a modern design in order to optimize passenger convenience, cleanliness, functionality, accessibility for disabled, and maintenance work.

The whole process was visualized and tested thoroughly in different model constructions, starting with basic features for testing optimal accessibility for all sorts of passengers and scenarios. The next step was an actual 1:5 model of the vehicle front, and finally a full scale 1:1 mock-up. Engineers and architects from all three parties contributed and found solutions to satisfy the very high ambitions on functionality, technology, and the aesthetic impression in order to create a truly original and tailor-made vehicle for the Copenhagen Metro.

Rolling stock

The Metro trains are designed by the famous Italian designer Giorgetto Giugiaro – known worldwide for industrial design and the design of sports cars for Alfa Romeo and Volkswagen. The vehicles for the Copenhagen Metro all consist of 3 carriages with articulation assemblies, so the train inside appears as one big open room. The design is stylistically consistent and there is plenty of space for bicycles, wheelchairs and prams. Large panoramic windows all the way around ensure a good view for the passengers. Each train is 39 m long, 2.65 m wide and made of aluminium. Each train has 4 bogies – of which 3 have motors. The maximum speed is 80 km/h and the average speed including stops at stations is 40 km/h.
Ansaldo STS built the “home of the Metro,” the Control and Maintenance Center, which is located in Ørestad. Physically, the center consists of 11,000 m² of buildings, which includes a control room, emergency control room, all facilities for maintaining the trains, automated washing hall, hall for interior cleaning, hall for removal of graffiti, power supply units and administration. Apart from the buildings, there are 5 km of track within the premises for parking and shunting trains and an 800 m long permanent test track for testing trains after maintenance and repair. The area is fenced and secured against intrusion for safety reasons (live tracks) – and to prevent vandalism.
SCADA

(Supervisory Control And Data Acquisition), or SCADA, is a system that makes it possible to monitor all equipment on stations, in trains, along the tracks, and in the Control and Maintenance Center from the control room. By a comprehensive system of sensors and devices, the Control Room operator can check that the circuit breakers, isolators, escalators, lifts, fire fighting equipment, ventilation, elevators, and every piece of equipment in the entire Metro is working properly. Furthermore, several commands can be executed by the operator to change the status of the above mentioned components: circuit breakers and isolators can remotely be opened and closed, ventilation fans can be switched on, elevators can be stopped and escalators be reversed when required.

ATC

(Automatic Train Control) – the key to automation. The driverless Metro is operated by technical systems, all kept under surveillance by the operators in the control room in the Control and Maintenance Center in Ørestad. The technology ensures that the trains stop at the right place at the stations, open and close the doors, leave the stations, keep the correct speed and keep a secure distance between the trains. All this happens by means of systems integrated in the trains, on the tracks, on the stations and in the control room:

• **ATC** consists of 3 systems, each having its own purpose.

• **ATP** (Automatic Train Protection) ensures that the correct distance is maintained between trains and that switches are set correctly. The system constantly surveys the position and the speed of the train and will automatically intervene, if it becomes necessary to adjust the speed or to stop the train for safety reasons.

• **ATO** (Automatic Train Operation) is an autopilot system that ensures that the trains stop at the right position at the platform, open and close the doors and adjust the speed within the limits imposed by the ATP. An ATO system is, contrary to a train driver, capable of surveying the entire operation and monitoring the status of each vehicle.

• **ATS** (Automatic Train Supervision) is the superior traffic and survey system. It controls and coordinates all traffic and maintains a schematic review of the entire Metro for the operators in the control room. It controls the arrival and departure of trains from all stations and includes automatic vehicle dispatching, automatic routing, schedule control, and zone speed restriction.

Communication

Outside the stations, on the platforms, and inside the trains, there is information for the passengers on screens and signs and via loudspeakers – and the Metro Stewards around the system can answer questions at any time. Through this, the Metro provides clarity and ease of travelling. Furthermore, passengers can get relevant information about the Metro from the Customer Service Center as well as following the operation in real-time and browsing all sorts of Metro information on www.m.dk.

In all trains, in every station, and along the line between stations and rescue shafts, call-points have been installed, from which passengers can get in direct contact with a Metro operator in the control room by pressing a button. There is also a button for emergency calls, which always will be given first priority by the system.

In short, these systems consist of all the connections that it takes to control the rest of the systems, inform the passengers and supervise their safety in stations and in trains. The system provides:

• **Radio link**
  - between control room and service personnel
  - between the passenger vehicles and the control room
  - between the service vehicles and the control room
• **Telephones**
• **Passenger Information Display (PID) in trains and on platforms**
• **Loudspeaker system with both programmed and real-time announcements**
• **Call-points with contact to control room from both trains, platforms and line**
• **Video survey of trains, stations and the Control and Maintenance Center**
• **Recording, both visual and auditory**

The system can be programmed for the most suitable type of survey for the occasion. For instance, monitors will always automatically show a passenger using one of the call-points, so that the control room operator can immediately get an impression of the situation from where the call has been made.

The passengers can hear and read relevant information both inside the train and in the stations. There is automated information about the service – for instance about when the next train will arrive and immediate information if any irregularity occurs or other things of interest for the passengers.
Power and Traction

Three independent 10.5 kV rings supply the Copenhagen Metro. In total, eight different electrical utility feeds supply the connected rings. If there is a failure in one point of the ring, the system can be reconfigured to ensure the power supply to the stations of the ring is maintained.

Every station is equipped with two redundant 10.5/0.4 kV transformers to provide a power supply to all of the subsystems installed in the station (e.g. ATC, SCADA, PSIS, Radio, Ventilation, etc.) A sub-set of these sub-systems is fed via an Uninterruptible Power Supply (UPS) system to ensure the availability of the sub-system even when the power supply is completely missing in the 10.5 kV ring.

Ten of the 22 stations are also equipped with rectifier transformers and inverter transformers to supply the conductor rail (also called the third rail) at 750V DC and to return the braking power produced by the trains on the line.

This third rail system supplies the required power to the passenger vehicle via collector shoes installed on each motorized bogie of the train (six in total, three per side).

Obstacle Detection System

While the platform screen doors provide protection for passengers on the underground stations, there is another safety system for the above ground stations. At all above ground stations, either a system of closely spaced infrared rays or a laser beam scanner ensures that the system reacts immediately if someone or something falls down on the tracks. If this occurs the approaching train will be stopped before entering the station.

Platform Screen Doors

All underground stations are equipped with platform screen doors that completely separate the platforms from the tunnel area. This increases the comfort for passengers in the station, as they are spared the inevitable wind from the tunnel. Additionally, the platform screen doors optimize safety as they can entirely prevent any access from platforms to the tunnel and subsequently to the track areas. Any unscheduled opening of the doors will cause the immediate stop of all trains running in that specific tunnel section. The transparent sliding doors, made of glass, are controlled by the ATC system and open simultaneously with the doors of the train when the train stops at the station.

Permanent way

The permanent way is made of UIC54 track with a standard gauge of 1435 mm. On elevated parts of the line and on embankments the tracks are ballasted. In the tunnel a slab track with blocks and rubber boots are used. Switches are the “swing nose” type – also called movable frogs – which are new to Denmark.
The process of construction

System design

Ansaldo STS is a turnkey system supplier and specializes in managing the entire implementation process. One of the major advantages of having a single main contractor for the system is that the integration of the sub-systems is a part of the original design. Many different technical systems have to communicate with each other. The better the integration, the better – and more safe – the operation. When the subsystems are fully integrated from the start, it is easier to configure the system according to the user’s specific needs and the operation will be more efficient.

Since the preliminary design phase, special attention has been allocated to the interfaces between different subsystems to ensure that all the requirements needed for the operation of each sub-system were clearly specified by all the others.

Ansaldo STS and the sub-contractors tested functionality and system integration for the Copenhagen Metro from 1999 and until the opening of the first phase in 2002.

This commenced first on the test track inside the Control and Maintenance Center area, and in May 2000, moved onto the Metro tracks, gradually taking over single parts of the line from the civil works contractor.

The more than 3 years of testing were necessary to ensure optimal functionality and integration and to live up to the comprehensive demands on safety documentation. This final test called forth the final approval in the form of an Operator Certificate.

Integration

Ansaldo STS STS is a turnkey system supplier and specializes in managing the entire implementation process. One of the major advantages of having a single main contractor for the system is that the integration of the sub-systems is a part of the original design. Many different technical systems have to communicate with each other. The better the integration, the better – and more safe – the operation. When the subsystems are fully integrated from the start, it is easier to configure the system according to the user’s specific needs and the operation will be more efficient.

Since the preliminary design phase, special attention has been allocated to the interfaces between different subsystems to ensure that all the requirements needed for the operation of each sub-system were clearly specified by all the others.

Ansaldo STS and the sub-contractors tested functionality and system integration for the Copenhagen Metro from 1999 and until the opening of the first phase in 2002.

This commenced first on the test track inside the Control and Maintenance Center area, and in May 2000, moved onto the Metro tracks, gradually taking over single parts of the line from the civil works contractor.

The more than 3 years of testing were necessary to ensure optimal functionality and integration and to live up to the comprehensive demands on safety documentation. This final test called forth the final approval in the form of an Operator Certificate.

System level testing

The test strategy was defined by the idea that follows these three main steps:

- Each sub-system is tested in each location (station and/or shaft) and is considered a unique entity.
- A final step of the testing activity proves the integration among the sub-systems.
- As a last step the overall functionality is tested through system level testing.

The testing was performed according to a strict plan and was closely surveyed by the independent safety assessor TÜV Intertraffic, and culminating with 3 months of trial running, which means following the requirements of running in revenue service but without passengers. During this time the operator had to test all procedures for actual operation and demonstrate his capability to operate and maintain the system in normal, degraded, and emergency modes.

This final test called forth the final approval in the form of an Operator Certificate.

Safety assessment

Since the start of the conceptual design phase and all through the detailed design, installation and testing phases, the concern for providing the best possible safety for passengers has required a parallel process to manage safety issues. This process conforms to the German BOSstrab standard and the newly developed European standards EN 50126, EN 50128, and EN 50129, which aims to reduce the risk of any type of accident to the lowest possible level.

This process, technically called “Safety Assessment” or “Safety Certification,” has gone through the definition of a safety plan, the formulation of safety requirements, at both qualitative and quantitative level, the design and construction against these requirements, and, finally, the demonstration and documentation that these requirements are fulfilled (the “Safety Case”).

Each system and each piece of equipment has been reviewed, inspected and tested for internal safety and safe interface with the other parts of the Metro at both local and integrated levels. In this way, it has been proven that the risk of accidents and casualties for this advanced driverless system was within the specified requirements.

On completion of this process, the Metro was certified for passenger operation by the Danish Railway Inspectorate (today: The National Rail Authority) via the Ørestad Development Corporation and their independent safety assessor TÜV Intertraffic.

Operation and Maintenance

This year, Ansaldo “STS was awarded a contract for additional 5 (+3 optional) years of Operation & Maintenance.

By accepting this, Ansaldo demonstrated a commitment to developing a system capable of achieving full passenger satisfaction.

Today the Metro is operated up to 24 hours a day with headways down to 2 minutes. It has a stable operation with a service availability close to 99% and a high level of customer service and maintenance of the system.
Rolling stock
• Total fleet: 34 vehicles
• Bidirectional three-bogie
• Length: 39 m
• Width: 2.85 m
• Weight: 52 tons
• Body: Aluminium
• Doors: 6 double doors on each side
• Capacity: 300 persons
• Maximum speed: 80 km/h
• Acceleration in operation: 1.3 m/s
• Braking in operation: 1.3 m/s
• IGBT converters on vehicles supplied by contact shoes (three on each side of the vehicle).

Control and Maintenance Center
11,000 m² of buildings including:
• Control room
• Extra/emergency control room
• Workshops for:
  - Maintenance
  - Automatic exterior cleaning
  - Automatic operation for manual interior clearing
  - Griotti removal facility
• Administration block
• Power station
  - Rectifier rated power: 1,500 kW
  - Auxiliary power supply (transformer): 16 kVA
• Service vehicles
  - 1 general service locomotive for removal of failed revenue vehicle
  - 1 light diesel rail service vehicle for maintenance
  - 1 heavy diesel rail service vehicle for maintenance
  - 1 commercial road truck
  - 1 tunnel washing road/rail machine.

5 km of tracks including:
• 600 m of permanent test track mounted with all equipment to be found on the Metro line
• Tracks for the storing and storage of trains.

Automatic Train Control (ATC)
• Driverless operation through ATC consisting of:
  - Automatic train protection (ATP)
  - Automatic train operation (ATO)
  - Automatic train supervision (ATS)
• Equipment for line (stations and wayside):
  - Interlocking Microlok II
  - Track Microlok II
  - AF902 track circuit controller
  - Non-vital logic emulator (NVLE)
  - TWC transmitter/receiver
  - TWC loops
  - AFOIC units
  - Coupling units
  - Transcoders (TX)
  - Receivers (Rx)
• Functions for line (stations and wayside), for example:
  - Train detection
  - Speed command transmission
  - Interlocking control
  - Speed restriction
  - Berthing
  - Automatic coupling
  - Direction control
  - Train separation
  - Emergency stop
  - Train-to-wayside communication
  - Platform screen door interface.

• Equipment for vehicles:
  - Vehicle Microlok II
  - TWC antennas
  - Pick-up coils (PLC)
• Functions for vehicles, for example:
  - Speed limit reception/decoding
  - Speed monitoring
  - Vehicle overspeed protection
  - Brake assurance
  - Propulsion/braking interface
  - Door control
  - ATO failover
  - Automatic coupling
  - Vehicle direction control
  - Automatic track operation
  - Control and monitoring functions
  - Emergency stop requests.

SCADA (Supervisory Control And Data Acquisition)
Architecture mainly based on PLC units located in each station and shaft for the control and monitoring etc.
• Equipment in each station (elevators, escalators, fire fighting tools, drainage pumps, etc.)
• Equipment in vehicles (doors, fire/smoke sensors, etc.)
• Tunnel emergency ventilation system.
Each PLC is monitored through the communication network by two hot-stand-by system servers placed in the Control and Maintenance Center.

Communication
• Closed circuit TV surveillance of stations and trains
• Tetra radio communication between the control room, vehicle, station and line.
• Public address system in stations and trains
• Information displays in stations and trains
• Call point with direct control room contact in stations, wayside and trains.

Power supply and Traction power
• External sources 10 kV, 50 Hz
• High voltage circuit breakers
• Two transformers – one for redundancy
• UPS 380 V, 50 Hz
• No. of substations: 10 mainline plus depot consisting of mono group with rectifiers (750 V DC) and mono group inverters for regenerative braking and power reversal to 10 kV line
• Third rail isolators
• Insulation covered bottom contact third rail system formed from an aluminium conductor with a stainless steel contact surface.

Permanent way
• UIC54 profile running rail
• Gauge 1435 mm
• Ballasted track on above ground sections
• Concrete slab with steel plates in tunnel sections
• Movable frogs of the swing nose type.

Platform screen doors
• Installed in each of the nine underground stations
• Six sliding doors and additional twelve hinged emergency doors on each side of the platforms.
• The system is operated under the control of the ATC system.

Obstacle detection system
The system is based on two different technologies. Both are operated under the control of the ATC system.

Infrared beam array equipment (installed in phase 1):
• Installed in the five stations of the above ground section
• There are approx. 48 bars installed in each station depending on the exact length of the platform
• Each bar contains 8 transmitter/receiver pairs giving a total of 16 beams.

Laser beam scanner (installed in phase 2B and phase 3 stations):
• Installed in the three stations of the above ground section (phase 2B) and four stations of the above ground section (phase 3)
• Each platform has multiple sensor heads continuously scanning the track area.
• Objects are detected by the laser beam striking an obstacle within the monitored field.
Sub-suppliers. The main sub-suppliers of Ansaldo STS for the Copenhagen Metro have been (arranged alphabetically):

<table>
<thead>
<tr>
<th>Company</th>
<th>Scope of work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcatel Italia S.p.A.</td>
<td>Radio, Communication, and Passenger safety and information systems</td>
</tr>
<tr>
<td>AnsaldoBreda S.p.A.</td>
<td>Rolling stock</td>
</tr>
<tr>
<td>AtosOrigin S.p.A.</td>
<td>SCADA system</td>
</tr>
<tr>
<td>BN Skilte A/S</td>
<td>Static signs</td>
</tr>
<tr>
<td>Brecknell Willis &amp; Co.</td>
<td>Third rail</td>
</tr>
<tr>
<td>D’Appolonia S.p.A.</td>
<td>Safety Assessment</td>
</tr>
<tr>
<td>Carlo Gavazzi Impianti S.p.A.</td>
<td>Installation (of power supply, traction power, and ATC equipment)</td>
</tr>
<tr>
<td>Kinnarps A/S</td>
<td>Furniture (for Control and Maintenance Center)</td>
</tr>
<tr>
<td>Metro Service A/S</td>
<td>Operation and maintenance</td>
</tr>
<tr>
<td>Metropolitana Milanese S.p.A.</td>
<td>Work facilities and service vehicles at CMC</td>
</tr>
<tr>
<td>Rockwell Automation S.r.l. / HITEC Engineering</td>
<td>Obstacle detection system (Phase 2 and 3)</td>
</tr>
<tr>
<td>Skanska Jensen A/S</td>
<td>Control and Maintenance Center</td>
</tr>
<tr>
<td>Swedish Railway System AB</td>
<td>Permanent way</td>
</tr>
<tr>
<td>T2M Automation / Matra Systems Munters A/S</td>
<td>Obstacle detection system (phase 1)</td>
</tr>
<tr>
<td>Ultra Electronics, PMES</td>
<td>Design and supply of electrical power equipment</td>
</tr>
<tr>
<td>Union Switch &amp; Signal International Co.</td>
<td>ATC (Automatic train control)</td>
</tr>
<tr>
<td>(a Ansaldo STS company)</td>
<td></td>
</tr>
<tr>
<td>Westinghouse Brakes Ltd.</td>
<td>Platform screen doors</td>
</tr>
</tbody>
</table>