



Singapore Northeast Line:

will soon be the largest, fully automatic metro system in the world

ALSTOM

Transport
Project Story

- [Systems integration
- [Rolling stock
- [Control and information
- [Testing prior to commissioning

Singapore seeks its ideal transport system

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The island of Singapore is densely populated and highly urban, with some 4 million inhabitants. Much of its development has come within the last two decades, the result of an economic boom. Singapore's need to improve public transport infrastructure rapidly intensified, becoming a pressing issue. To meet the surge in demand while improving overall land transport infrastructure, the Singaporean government set up the Land Transport Authority (LTA) in September 1995. The LTA's mission is to provide the people of Singapore with a highly efficient, comfortable, safe and convenient transport system at an acceptable price.

In seeking its new metro system, the LTA would go far beyond the traditional. Singapore's new automatic metro was to represent the new Singapore: modern, innovative and sophisticated. Naturally, the new metro system had to have more than just good looks and fast cars: it had to move great numbers of people in comfort and be fully automatic, utterly safe and reliable. While taking advantage of the most advanced technology, the new "dream metro" also had to be cost-effective both in the initial investment and in long-term operations costs. And it had to be built, and up and running in the shortest time possible.



- Systems integration
- Rolling stock
- Control and information
- Testing prior to commissioning

A fully automatic metro

In response to its February 1997 international call for tenders, the LTA received proposals from many world-leading transport suppliers; it retained the most outstanding, ALSTOM's METROPOLIS fully automatic metro. The reasons were clear: the ALSTOM system fulfilled every aspect of the LTA's technical and aesthetic requirements, offered the most attractive price as well as rapid time-to-delivery and commissioning with guaranteed service-performance levels.

Beginning of a long-term relationship

In July 1997 and January 1998, 2 contracts for Singapore's Northeast Line were signed between the LTA and ALSTOM, marking the beginning of a long and successful relationship. With great pleasure, we assumed responsibility for the supply, delivery, testing and commissioning of 25 six-car METROPOLIS trainsets as well as associated services, signaling and automatic train control.

In February 1999, following contracts for signaling and rolling stock, we were awarded a contract for system integration. The contract assigns ALSTOM the

responsibility for defining the metro system's operating modes and principles as well as performing core-system integration tests, at our dedicated test center in Valenciennes, France.

Today, the new 20-kilometer underground Northeast Mass Rapid Transit Line has become reality. A showcase for the most modern metro technology, it is the world's first fully automatic heavy-rail metro and the highest-capacity automatic metro. In December 2002, the LTA handed over operation of the line to the operator, SBS Transit.

METROPOLIS Northeast Line, the ultra-modern metro

- Line length: 20 km, all in tunnel
- Number of stations: 16, with platform screen doors
- Number of trainsets: 25 of six cars
- Route: from Punggol (Northeast) to Harbor Front (South)
- Depot: trains operate in full automatic mode
- Maximum design speed: 100 km/h
- Capacity: 1,920 passengers per train (6 passengers/m²)
- Extra trains can be injected as required, with headway of only 90 seconds
- Highest safety and reliability guaranteed: high redundancy with proven components



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The Northeast Line

Construction of the Northeast Line began in January 1996 with the aim of starting commercial operation by 2003. Today, we are proud to see this goal achieved. The 20-kilometer line stretches from Punggol in the Northeast to the Harbor Front in the South. The fully underground route passes through the central business district, following the transport corridors of Serangoon Road and Upper Serangoon Road to the new towns of Hougang, Sengkang and Punggol. The line consists of 16 stations with platform screen doors. Trains operate in full automatic mode on both the line and in the depot.

A strong commitment

Our expertise in mass transit benefits many of the major networks of the world: Paris, London, Hong Kong, Mexico and Sao Paulo, to name but a few. One in four metro cars in operation worldwide was designed and built by ALSTOM. Few companies can match our experience and resources, built over a century.

Some 300 ALSTOM employees situated in seven industrial sites were dedicated to the Northeast Line project. By successfully fulfilling complex undertakings such as this one, ALSTOM continuously reinforces its reputation for excellence in project management.



Also in the works: the Circle Line

The Northeast Line is an important part of the development of mass transit in Singapore, but the LTA has also set in motion a project to build another, longer line based on the same ALSTOM rolling stock, signaling and control systems.

The Circle Line is set to become the longest fully automated metro line, 35 kilometers long, at completion. ALSTOM is carrying out overall project management, system engineering and integration, and is supplying rolling stock, signaling equipment, automatic train control and supervision, the power supply system and trackwork.

Circle Line facts

- Length: 35 kilometers
- Number of stations: 35
- Number of trainsets: 40 trainsets of 3 cars
- Train length: 70 m
- Train width: 3.2 m
- Passengers per train: 960



Singapore's metro network

- Systems integration
- Rolling stock
- Control and information
- Testing prior to commissioning

Systems integration

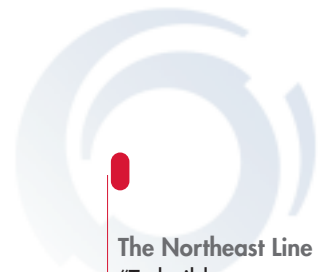
Only an exceptionally highly skilled team can manage the complexity of integrating a complete rail transport system. ALSTOM personnel are among the most experienced in the rail industry, with expertise in structuring, financing, designing, constructing, testing and commissioning integrated rail systems.

Our Systems team has orchestrated railway system projects all over the world, using our own products as well as coordinating with third-party suppliers.

AXONIS is our fully automatic metro solution, a combination of METROPOLIS rolling stock and URBALIS train control. Flexible and cost-effective, this solution takes into account rail owners' needs: ensuring adequate and smooth operation of all parts of a fully automatic metro system, delivering the best performances in terms of safety, reliability and quality and, of course, keeping both service-operation costs and life-cycle costs to a minimum.

The importance of testing

Singapore's Northeast Line is the world's first fully automatic heavy-rail system. While riders are bound to notice that the train doesn't require a driver, they travel in full confidence, and for good reason. We verify the safety, reliability and efficiency of individual trains and their integrated systems through an extensive series of tests.



The Northeast Line challenge

"To build a metro system that can operate under normal conditions is quite common. To build one that can cope with any event that may occur during the course of revenue service - and without manned intervention - that's the challenge. Fully automatic operation is strictly for top experts. All the components that make up the system must be able to react to any event, and in a coordinated manner."

K.K. Tan,
Managing Director, ALSTOM in Singapore



Project management and systems integration skills are key to turnkey projects

- ▮ Systems integration
- ▮ Rolling stock
- ▮ Control and information
- ▮ Testing prior to commissioning

Rolling stock

Many of the world's metro systems have benefited from our experience and expertise. In more than 40 cities, a full quarter of all metro cars in operation are ALSTOM vehicles, some 25,000 ALSTOM cars in all. Our engineers drew on this experience in the development of the modular metro train METROPOLIS, which was born of our own patented OPTIONIC DESIGN methodology.

Customer-tailored solution

OPTIONIC DESIGN allows our customers to "customize" the proven METROPOLIS metro-train design. They may specify any car dimension (height, width and length) within a broad range of parameters, and they may select technical modules and interior amenities from a rich portfolio. Service-proven technology and components assure the most competitive price, delivery times and performance. In this way,

municipalities looking to place smaller orders of rolling stock can obtain the world-class value that ALSTOM provides to the world's largest networks.

Consequently, the LTA was able to specify precisely what form they wanted their Singapore METROPOLIS to take in terms of width, length, axle load, ventilation or air conditioning, and traction system as well as the interior and exterior design. *(for more details, go to page 10)*



METROPOLIS for Singapore NEL, before commissioning



- METROPOLIS,**
a success around the world
- ▮ More than 1,300 cars sold
 - ▮ Singapore Northeast Line**
 - ▮ Singapore Circle Line
 - ▮ Warsaw Line 1*
 - ▮ Shanghai Line 3*
 - ▮ Shanghai Xin Min Line
 - ▮ Nanjing Line 1
 - ▮ Buenos Aires Line A*
 - ▮ Sao Paulo Line 5
 - ▮ Santiago Line 4
 - ▮ Barcelona Line 9

*already in revenue service
**handed over to operator

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Traction designed and built for reliability

Reliability is a key factor when choosing a traction system for a fully automatic metro. The fully automatic metro for the Northeast Line is equipped with our ONIX system. ONIX is a compact drive system that integrates the technology of the AC motor, advanced control electronics and an IGBT (Insulated Gate Bipolar Transistor) inverter. ONIX is lightweight, reliable and also very easy to maintain. Since the traction system is discretely located and operates at low noise levels, passenger comfort is respected. With its standard modular design, the service-proven ONIX system ensures cost effectiveness while maintaining safety, reliability, high availability and flexibility.

Northeast Line rolling stock features

For passenger comfort:

- Air-conditioning
- Passenger information system
- Closed circuit television (video-surveillance)
- Public address system

For guaranteed safety:

- Under-frame fire barrier (one-hour endurance)
- Wide gangway access throughout trainset
- Front-end detrainment door
- Good acoustic ergonomics
- Fully equipped driver desk for manual operation at full speed
- Fire and smoke detection system
- All-train status information
- Data managed by control center
- Every major component doubled to ensure seamless passenger operations in automatic operation



A modern, spacious interior



ONIX traction system prior to installation



Future passengers contribute to their metro's interior design

In July 1999, a one-to-one scale model of the Northeast Line was delivered for interior-design approval. LTA presented it to the general public and invited prospective riders to give their opinion. The results were taken into account and the LTA modified the seat color and floor carpeting as well as the design and layout of the passenger poles, finally settling on tri-poles.

- Systems integration
- Rolling stock
- Control and information
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Control and information

URBALIS 300

The Northeast Line's fully automatic operation requires the highest level of safety, reliability and availability. To meet the stringent safety and efficiency requirements, ALSTOM's URBALIS 300 fully Automatic Train Control system was selected.

The state-of-the-art Moving-Block Automatic Train Control (ATC) of URBALIS 300 optimizes headway (the separation of trains on the line). URBALIS 300 also enables extra trains to be injected automatically into the system at rush hour to increase passenger capacity and reduce congestion. In the depot, trains are also operated in full automatic mode.

Communication between the train and the fixed signaling equipment has been dramatically improved by the high-performance continuous and secured transmission (IAGO). Microwave slots, part of IAGO system, are placed along the track. Station-based automatic train supervision ensures a greater degree of availability. Built-in test equipment has also been included, and Eurobalise standards have been adopted for spot transmission.

Finally, URBALIS 300, provides a very high level of flexibility that allows to deal with any events during the automatic operation.
(for more details, go to page 11)



MASTRIA, ATC on-board equipment

- Systems integration
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Testing prior to commissioning

Fact file: Valenciennes test center

- The performance test circuit is a linear track 2.75 kilometers long, on which one test train may run at a maximum speed of 100 km/h.
- The endurance test circuit is a loop 1.83 kilometers long, on which one test train runs at a maximum speed of 70 km/h.
- The fully automatic test circuit is a loop 1.8 kilometers long on which two test trains run at a speed of 65 km/h.

Power supply for the three test tracks varies:

- DC (600, 750, 1200, 1500, 3000V)
- AC (25 kV 50 Hz, 25 kV 60 Hz, 15 kV 16 2/3 Hz)

Fully tested before delivery

Testing is a critical element in reducing risk for the operator. The METROPOLIS trains and the URBALIS train-control system for the Northeast Line were put through an extensive battery of tests to ensure their quality, safety and reliability. Thanks to this comprehensive series of tests, we were able to deliver fully qualified rolling stock and systems, ready for operation.

The train-testing center, adjacent to our metro-building factory in Valenciennes, France, enables us to perform tests without the inconvenience of monopolizing a customer's track.

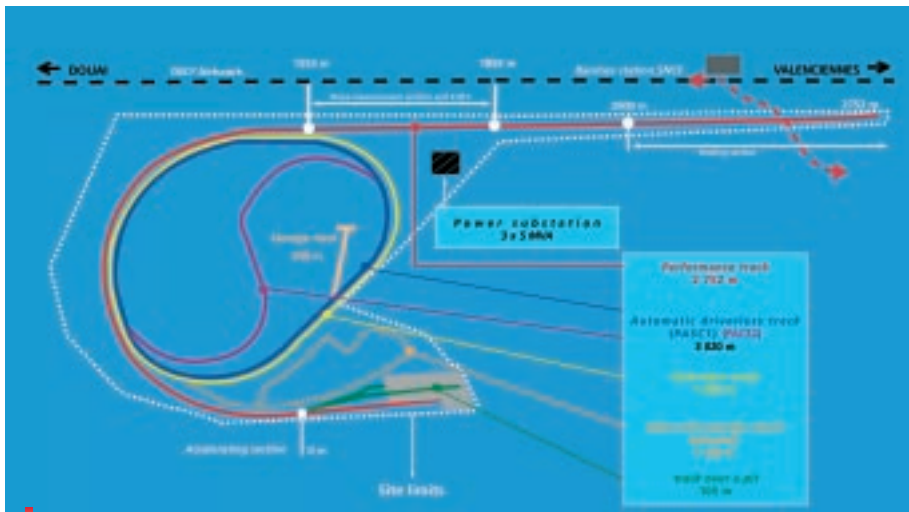
Systems integration tests were carried out at the Valenciennes test center over a period of 18 months, from October 2000 to February 2002. For three months, from November 2001 to January 2002, rolling stock endurance tests were performed.



The test center at Valenciennes, France

Thus the integration and validation of the trains, the signaling, the communications and the control system were processed at the earliest stages, before Singapore commissioning.

The tests included running the trains for 12-hour days over two months at a stretch, running them at top speed and without a driver. The tests covered 1,500 scenarios involving 30,000 test steps and ranged from the failure of a simple component to a major breakdown.



Technical diagram of the capabilities of the test center

- Systems integration
- Rolling stock
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For experts: rolling stock

Passenger safety

The METROPOLIS trains for the Northeast Line are made of fire-resistant materials and have many anti-fire safety features. The car floors themselves serve as a fire barrier, proven capable of withstanding temperatures of 1,000 degrees Celsius for one hour without collapse. This one-hour safety margin is largely sufficient; trains can reach the next station or be evacuated within minutes.

With the push of a button found at both ends of the train, ramps with handrails descend and passengers can evacuate.



Front-end emergency exit

Technical features

Type of operation	Fully automatic
6 cars per train	Tc + M + M + M + M + Tc
Power supply	1,500 V catenary
Car-body material	Welded aluminum
Train length	138.5 m (23,65 m)
Train width	3.2 m
Gangway	1.4 m wide
Floor height	1,110 mm
Electric doors per side of car	4
Door width	1,400 mm
Type of door	External sliding
Number of seats/train	296 + 2 wheel chair spaces
Total capacity/train	1,920 persons (6 pass/m ²)
Train weight	337 t (6 pass/m ²)
Bogies	16 t per axle
Motor bogie wheel diameter	850 mm
Installed power	16 x 150 kW
Maximum design speed	100 km/h
Acceleration	1.1 m/s ²
Deceleration rate	1.4 m/s ² in emergency braking mode
Stopping accuracy	±300 mm

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For experts: control and information

The Northeast Line's fully automatic system, URBALIS 300, includes:

- MASTRIA Automatic Train Control system
- SMARTLOCK interlocking system
- ICONIS Data Management System
- IAGO waveguide communications



IAGO waveguide

MASTRIA

The Northeast Automatic Train Control (ATC) Line is based on our MASTRIA system, using Moving-Block technology with redundancy. The MASTRIA system uses two-way digital transmission by IAGO waveguide with an Automatic Train Protection system (ATP) that eliminates the risks of collisions and derailments, an Automatic Train Operation system (ATO) that drives the metro, and a train Data Management System (DMS) that concentrates and dispatches rolling stock information with fixed equipment.

SMARTLOCK

The Computer-Based Interlocking (CBI) system for the Northeast Line is from our SMARTLOCK product line. The CBI implements the interlocking functions for the main line and depot, and features the ability to call routes and control switches. It interfaces with the Automatic Train Control system, the platform screen doors and the DMS.

ICONIS

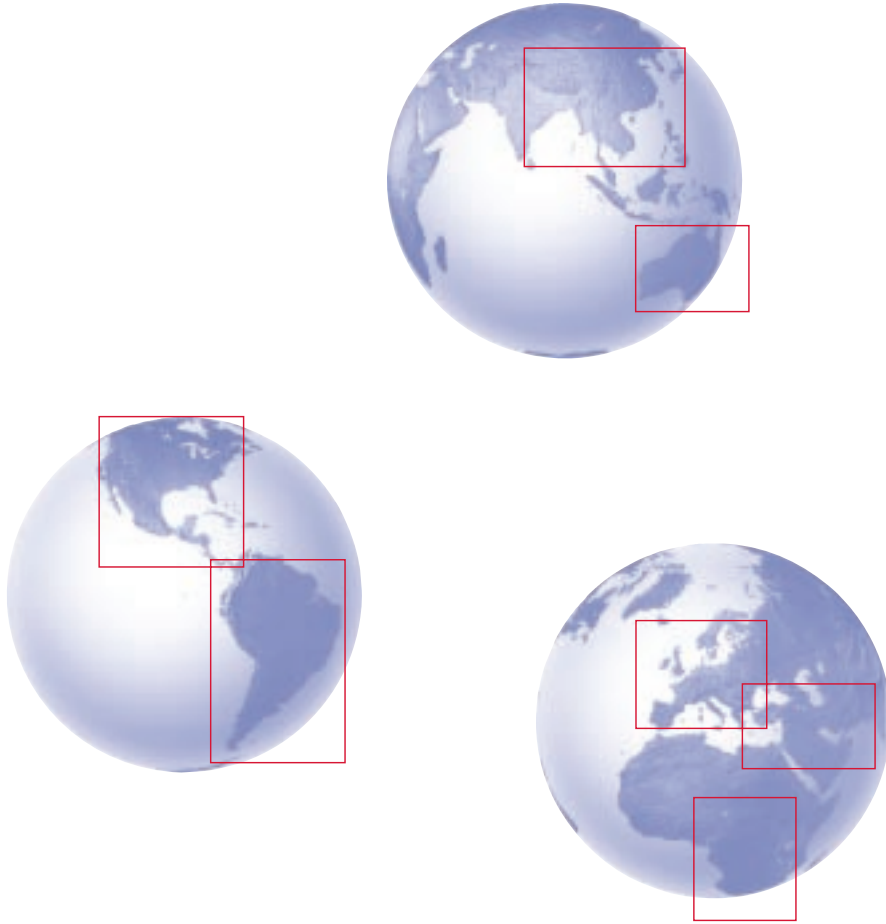
The Data Management System uses processor-based equipment for station-based automatic train supervision. It monitors and controls signaling equipment, platform screen doors and trains.



SMARTLOCK interlocking system

IAGO

For the Northeast Line, the two-way continuous transmission system uses a waveguide information network for fail safe operation of ATC, maintenance dispatching and diffusion of passenger information. Its wide bandwidth provides the capability to transmit video. Direct-sequence spread-spectrum technology protects communications against interference. The transmission medium is a rugged, leaky waveguide laid along the track. Active base stations are designed to be located within the signaling equipment room. The system requires very little maintenance.



To find the ALSTOM Transport contact in your country, consult:
www.transport.alstom.com/worldcontact

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