



CCL - THE LONGEST AUTOMATIC METRO LINE IN THE WORLD

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SUMMARY

From an ambition to permanently improve the public transport system in Singapore to the implementation of what consists the longest automatic metro line in the world, a new interesting and challenging industrial story is being written.

Are presented in the following the different aspect of this adventure.

- The key factor taken into account to prepare the future
- The basis of the industrial arrangement with ALSTOM
- The scope of the contract allocated and its inheritance from previous contract such as North East Line
- Alstom an integrator able to delivered turnkey integrated solutions
- Track installation : the challenge
- A CBTC solution
- High tech and custom tailored train

1 SINGAPORE DECIDES TO CONNECT DISPARATE RAIL LINES

The Rail Transit System which first started in the 80's has not stopped expanding since. The latest addition of the Circle Line with its interconnecting stations will allow travelers to switch lines without having to go to the city center, cutting down on travel times.

Singapore, an independent island of less than 700 sq. km on the tip of the Malaysian peninsula, is one of the world's most important ports and a key financial trading center for Southeast Asia.



Figure 1 : Merlion - Singapore

With a prosperous economy based on exporting manufactured goods and services, Singapore's population of 4.3 million enjoys a high standard of living. Local taste in this mostly urban nation runs to the modern and sophisticated, and this is reflected in the Land Transport Authority's choice of a fully automatic transport system for its latest rail project, the Circle Line.

Singapore sought to create the Circle Line primarily to improve travel efficiency in its public transit system. Six interchange stations will allow people to travel much more directly to their destinations rather than having to go into the city center to change lines, and thus cut significant amounts of time from their rail trips. For example, right now, it would take a commuter 26 minutes to travel from his home in Bishan along the North-South Line to his job at Paya Lebar on the East-West Line. After the Circle Line enters commercial service, the person will be able to change at the connecting station and cut his or her travel time in half to the same destination – a mere 13 minutes.



Figure 2 : Orchard Road - Singapore

As well as improving its passengers' comfort and safety, the prestigious Circle Line will also give a boost to Singapore's international image, as the owners of the world's longest fully automatic metro.

Rail facts and figures

Today, the older East-West and North-South lines, completed respectively in 1987 and 1996, and the new fully automatic North-East Line, which began transporting passengers in 2003, transport a total of 1.3 million passengers daily, an average of 180,000 per hour and per direction. LTA estimates passenger usage for 2015 at 500,000 people per day on the Circle Line, some 15,000 people per hour and per direction.

2 NOTATION

- ATS : Automatic Train Supervision
- AXONIS™ : System Engineering Methodology developed to integrate all Alstom's product from Design to Test and Commissioning.
- CCL : Circle Line
- IAGO™ : Informatisation et Automatisation par Guide d'Onde
- ICONIS™ : Alstom range of ATS products.
- KCD : Kim Chuan Depot (Singapore)
- METROPOLIS™ : Alstom Range of Train addressing Mass Transit Market.
- NEL : North East Line.
- OPTIONIC™ : Alstom methodology enabling a customisation of train from a catalog of standard elements. Dimensions and End profile are adapted to customer requests.
- SCADA : Supervision Control And Data Acquisition
- URBALIS™ : Alstom Range of Signalling System addressing Mass Transit Market.

3 CIRCLE LINE AND ALSTOM STORY

3.1 Choosing ALSTOM: A Systems Solution From A Proven Partner

A strong, long-term relationship with ALSTOM and the success of a preceding project together—the fully automatic North East Line—made LTA confident in its choice of ALSTOM once again for

its Circle Line project, a fully integrated systems solution.

The history goes like this: in December 2000, Singapore's Land Transport Authority (LTA) awarded ALSTOM, in consortium with Singapore Technologies Electronics (STE), an order for the turnkey supply of the first stage of the Circle Line. An order for the second stage followed in June 2001. Two years later, in February 2002, LTA again chose the ALSTOM –STE consortium for the remaining stages of the project. The five stages represent a total of 34 km, 29 stations, 40 new trains and an investment of 774 million euros.

Mr Wee-Meng Sim, LTA project director for Circle Line E&M, recalls how the project—and ALSTOM's participation—came about: "By 2000, when LTA was readying to announce the Marina Line, as the Circle Line was initially called, we decided to treat it as a system work package under a single contract because it was then just one stage of the line, which connects the National Stadium to the City. This was awarded to ALSTOM. That project eventually grew to five stages but we were confident that ALSTOM could handle it as an integrated system, seeing as how they were managing the NEL*. They have the right resources and the experience to handle the additional work load."

ALSTOM's dedicated Customer director for the Circle Line (and NEL before it), Mr. KK Tan, reveals the supplier's view: "Our advantage came from the NEL* project already underway. Everyday we were proving we could deliver on our contractual promises. The customer felt the risk was lower having worked with ALSTOM even though the NEL was not yet open. Experience on NEL has helped us with the Circle Line in that we understand the customer: their high expectations and how project management should be handled and what manufacturing facilities they will need."



Figure 3 : Singapore MAP (NEL & CCL)

* The North East Line, awarded in 1997, opened for commercial service in June 2003.

CIRCLE LINE - KEY PROJECT MILESTONES

- Signature of the turnkey contract: 28 Dec 2000
- Notification of the first stage: 28 Dec 2000
- Notification of the second stage: 31 May 2001

Notification of stages 3 to 5 :31 Jan 2002
Start of infrastructure work: 1 sept 2004
Delivery of first METROPOLIS metro: 31 Oct 2005
Delivery of last METROPOLIS metro: 28 Feb 2007
Start of the tests running (Stages 2) 1 sept 2007
Delivery of turnkey project to operator (Stage 2): 31 Jan 2008
Start of commercial service (stages 2 and 3): Mid 2008
Start of commercial service all line: Early 2010
Warranty period: 1 year after completion of each stage

3.2 ALSTOM As Systems Integrator And Project Manager

ALSTOM is supplying the Circle Line as a fully integrated system, a turnkey solution. This proven solution can be used anywhere in the world...



Figure 4 : A North East Line Station

ALSTOM (70%) is responsible for the overall project management, the system engineering and integration, the supply of rolling stock, signaling equipment, automatic train control and supervision, power supply system and trackwork. ALSTOM's **AXONIS**TM fully automated metro system comprises 40 three-car **METROPOLIS**TM trainsets and an **URBALIS**TM CBTC system. A similar system is already in operation on Singapore's North East Line. STE (30%) is handling installation of signaling equipment, control center, communication, platform screen doors, station information system and access management system. The civil works are being managed by the customer.

NEL And The Circle Line: Similar Products, Different Project Treatment

The fully automatic North East Line, precursor of the Circle Line, and also largely supplied by ALSTOM, was quickly adopted by the public for its extreme comfort, precision and safety. NEL has been drawing interest from transit authorities worldwide: Asia, Australia and European countries. The 34-km Circle Line will use the same basic system as the highly successful NEL: METROPOLIS rolling stock and an URBALIS 300 CBTC signaling system—all supplied by ALSTOM. The big difference between the two projects is not so much the components involved but how the projects have been treated. NEL began life as separate parts engineered to function together

while the Circle Line has been designed from day 1 as a single, fully integrated system: designed, produced, installed and commissioned by ALSTOM.

A total of approximately 1,500 people are involved in the Circle Line project; 200-250 ALSTOM employees are on-site primarily for overall management, installation, testing and commissioning. Thanks to ALSTOM's international presence, design and manufacturing is being carried out in several countries in the worldwide: Rolling Stock: Valenciennes for testing, some components from China, final assembly France; Signaling: France, Italy and Canada (Bangalore, India for application engineering); Infrastructure: rails from Japan, transformers from Turkey and Germany.

On-time delivery: a question of good interfacing and lots of flexibility!

"ALSTOM is managing schedule coordination with civil works contractors: interfacing and planning so we are ready to work as soon as we receive access to sites. There has been a major delay in infrastructure due to a civil works problem—a tunnel collapse. It has been a challenge for us in that we have to be very flexible for the customer. The original station site was abandoned and moved to a new location. We held a workshop with LTA to minimize the effect; the new schedule has been confirmed. We are keeping to the original schedule for train delivery, however, to show the client what we are capable of! We've come up with a means of storing the trains in Singapore, adding more tracks to the depot to store them until the line is ready. Thanks to a good working partnership with the customer, we are on-time, even ahead!" Philippe Prevot, ASLTOM Project Director Circle Line.

Key figures

Line length: 34 kilometers
Number of stations: 29
Number of trains: 40 three-car trains
Capacity per train: 931 (148 seated)
Maximum frequency: every 90 seconds
Maximum speed: 90 km/h

3.3 Integrating Infrastructure

Supplying a metro's physical hardware and equipment is just the beginning. With our expertise in systems management, we also assure it all works together smoothly. While very few companies have the full range of skills needed to deliver, anywhere in the world, the solution most appropriate to the specific requirements of a unique project, with projects like the Circle Line, ALSTOM consistently shows its ability to provide complete solutions and manage system projects wherever they take place and whatever the size.

In a turnkey project, such as the Circle Line, we supply infrastructure and ensure complete system

integration and interface management from design to installation and testing & commissioning.

Alternatively, we can also supply separate subsystems that form part of a complete electrical and mechanical solution.

3.4 Challenging Track Installation: 30 Meters Down And Limited Access

ALSTOM is drawing on its pool of infrastructure experts to coordinate a very unusual situation for trackworks and related logistics: a work site deep underground whose only access is via shafts.

The Circle Line is a highly unusual project in terms of track installation. Despite decades of experience in track installation on every type of rail project worldwide, this will be the first time that ALSTOM is carrying out all the underground work with access uniquely via shafts — descending 20-30 meters in this case.



Figure 5 : Rail welding on KCD Staging Area

There are five main shafts along the line and in the maintenance depot for moving heavy construction equipment such as work trains, plant and materials in and out.



Figure 6 : Concrete pouring on KCD Staging Area

While a difficult and unusual situation for the industry, as one manager explains, “there was no other alternative offered, so we had to adapt our methods and organization to accommodate this constraint.” At the same time, the most stringent safety practices are deployed and complied with in order to provide all working parties with a safe workplace at staging area around shaft access and in the tunnels.

3.5 URBALIS™ 300: A CBTC Solution

ALSTOM is active in promoting international signaling standards, such as Communication Based Train Control technology for metros. The Singapore NEL was the first heavy driverless metro system with steel wheels to enter revenue service worldwide. Both NEL and Circle Line train control systems are fully automatic. ALSTOM's

added value is our full system integration for complex projects.

CBTC definition

CBTC = Communications Based Train Control

The primary characteristics of a Communications-Based Train Control (CBTC) system include:

- High resolution train location determination, independent of track circuits
- Continuous, high capacity, bi-directional train-to-wayside data communications
- Trainborne and wayside processors performing vital functions.

3.5.1 Fully automatic train control for risk-free operations

Human error is by far the greatest contributing factor in rail accidents. In entrusting the train's regular operations to highly specialized, proven technology, operators of fully automatic metros go far in ensuring their passengers' safety.



Figure 7 : Operating Control Center - NEL

The Circle Line is equipped with the URBALIS 300 CBTC train control solution. It benefits from identical subsystems to NEL:

MASTRIA™ on-board computer system using moving-block technology with redundancy; SMARTLOCK™ interlocking; ICONIS™ data management system and IAGO™ waveguide.

Among the subsystems within the URBALIS 300 CBTC solution, the Circle Line will rely on ALSTOM's Automatic Train System or “ATS”. This controls the train timetable, headway and time in station, among other things. This is the first time that ALSTOM has developed ATS for a driverless system, and represents a major technological feat for our company. Participating Centers of excellence include ALSTOM's Integrated Control Center in Meudon (France) for software and our Montreal (Canada) unit.

3.5.2 High-technology & innovative solution

Applications in transit systems have a need of high communication level between their components. For URBALIS 300 CBTC, a continuous bi-directional redundant radio communication link is used between the trains and the trackside based on Waveguide.

As for the North East Line, the two-way continuous transmission system uses a Radio Waveguide Information Network for fail safe ATC operation, maintenance dispatching and passenger information. Its wide bandwidth provides the capability to transmit video. Direct Sequence Spread Spectrum technology originating from military transmission, protects communications against interference.

3.5.3 In case of emergency...

URBALIS 300 CBTC functions for Circle Line are similar to that of NEL. However, LTA decided to go with 3rd rail for the Circle Line instead of catenary as is used on the NEL. As the 3rd rail is at track level, ALSTOM engineers have had to design a special program to cut off the power supply to the track in case of an emergency that would require the evacuation of passengers, who would need to be able to walk on the line in total safety. After highly complex studies, the passenger evacuation system was customized to meet LTA's specific needs for the Circle Line.

3.5.4 Integrated testing

ALSTOM has long years of experience in manufacturing fully automatic trains. Each subsystem is tested in the factory before system integration. We verify individual trains' and integrated system's soundness through extensive testing for safety, reliability and efficiency. As system integrator, we conduct integration tests at the Valenciennes Test Center on our own rolling stock and signaling and also for co-contractors for the telecommunication system, Integrated Supervisory Control System (SCADA and ATS) and platform screen doors.

3.6 Rolling Stock

A fully automatic metro offering high capacity and speed is the most efficient means of transport for the world's leading cities, as Singapore will soon prove with the Circle Line.

ALSTOM Metros

Many of the world's metro systems have benefited from our experience and expertise.

One of every four metro cars in operation is an ALSTOM vehicle, some 25,000 ALSTOM cars in more than 40 cities.

Our engineers drew on this experience in the development of the modular metro train METROPOLIS, which was born of our own OPTIONIC DESIGN methodology.



Figure 8 : North East Line Train

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.

4 CONCLUSION

Circle Line is still at its beginning, but with the design phase well over, the initial choice made by LTA have been fruitful.

Overall E&M integration of the Trains, Signalling, Scada, and Communication under the leadership of Alstom and prior to the delivery in Singapore have shown a rapid increase of the system stability.

The use of not only proven technology but proven solution has enable to fully benefit from stabilised software and process, leading to a smooth integration and validation phase.

This positive results enable now to look toward the future and the coming commissioning phases to be carried out on site with a great level of confidence.

Technical Features:

Car lengths	Mc car = 23,65m T car = 22,80m
Train width	3,21m
Total capacity/train	931 (148 seats)
Train height	3,68m
Gangway	1,5 m wide
Floor hight	1,110 m
Electric doors per side of car	4
Door width	1,4 m
Nb of seats / train	148
Train weight	122,49 t
Bogies (axle load)	16 t per axle
Motorbogie wheel diameter	850 mm

Type of operation	Fully automatic
3 cars per train	Mc-T-Mc
Power supply	750V 3th rail
Car-body material	Welded aluminum
Installed power	1392 kW
Max speed	90 km/h
Acceleration	1,1 m/s ²
Deceleration	1,30 m/ s ² in emergency braking mode
Stopping accuracy	+_ 300 mm

