



The High Speed Rail System in Korea

ALSTOM

Transport
Project Story



A SPECIFIC NEED

- Improving travel for millions of Koreans
- Korea chooses ALSTOM as project manager

Improving travel for millions of Koreans

South Korea's new High Speed Rail system is relieving the economically-important Seoul-Busan corridor of road congestion, offering citizens a comfortable, efficient means of travel.

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Seventy percent of South Korea's population lives along the Seoul-Busan corridor. The Seoul region alone is home to 19 million people. With their taste for travel, it is not surprising that this is one of the country's busiest thoroughfares - and the most in need of improvement to ease road, rail and air congestion. Today, the High Speed Rail system is providing this relief, offering South Koreans a comfortable and highly efficient means of travel.

The Seoul-Busan corridor

The Seoul-Busan corridor is strategically important for the country: 75% of its Gross National Product is made here. The corridor connects important cities Incheon and Busan, as well as ports and airports, and represents 65% of passenger traffic and 70% of freight. Keeping traffic fluid along it is a top priority for the government. Officials turned to rail for their solution, convinced by the proven technology of High Speed.

Travel time reduced to 2 hours 40

The new High Speed line covers 412 km, much of it mountainous, and includes 190 km of tunnels and 120 km of viaducts. It is estimated that 120 million passengers will use the line annually, making it the busiest route in the world. Travel time between Busan and Seoul has been cut down to a mere 2 hours 40 minutes from 4 hours 10 minutes.

When the Seoul-Busan High Speed Line is fully completed in 2008, travel time will be reduced to 1 hour 56 minutes - twice as fast as traditional train and three times quicker than car. It will serve six cities in all: Seoul, Cheonan, Daejeon, Daegu, Gyeongju and Busan.



The Korea Train eXpress fleet circulates on High Speed and traditional lines

Improving travel for millions of Koreans

Korea chooses ALSTOM as project manager

Korea chooses ALSTOM as project manager

ALSTOM's wide experience and high safety and reliability standards made it the clear choice for managing Korea's High Speed Rail project.

Key milestones

- 1994 Contract signature
- 1996 Partial disruption of civil works due to technical difficulties
- 1997 Roll out of the first KTX train in France; Asian financial crisis
- 1998 Re-definition of the project, contract negotiations and a new start
- 1999 First run of a KTX on the test track in Korea
- 2000 12 French trains delivered in Korea; 300 kph achieved on the test track
- 2001 Commissioning of the test track; Work begins on first Korean trains
- 2002 Site Testing of the 12 first trains; Implementation of Fixed Equipment
- 2003 Integration testing; Commissioning of Seoul – Daejeon section
- 2004 Revenue service begins: Seoul-Daegu / Busan & Seoul-Daejeon / Mokpo
- 2006 Warranty and Maintenance; Contract completed
- 2008 Final section Seoul – Busan added, completing the New High Speed Line

The Korean High Speed Rail Construction Authority (KHRC) chose TGV* technology to modernise its railways, signing a contract with an ALSTOM and Eukorail-led consortium for the supply of a high-speed train network connecting Seoul to Busan. The order includes 46 Korea Train eXpress (KTX) trains, traffic control systems, catenary and maintenance services. As project co-leaders, ALSTOM and Eukorail were responsible for the core system's design, engineering, manufacturing, installation, integration and commissioning. Eukorail is a Korean-based subsidiary of ALSTOM, established in 1994 to manage Franco-Korean Consortiums for rail projects.

Who's who in the KTX project?

Customer:

- during the construction phase: KHRC - now called KRNA
- for the revenue service phase, since January 2004: KNR - also called KORAIL

KTGV Consortium members:

- ALSTOM,
- Eukorail,
- CSEE Transport,
- Daewoo,
- Hanjin,
- Hyundai,
- Iljin Electric,
- LG Cable,
- LG Industrial Systems,
- Rotem,
- Samsung Electronics,
- Samsung SDS.

*TGV IS A TRADEMARK OF THE SNCF



The first KTX train leaving France for Korea in 1998

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Systems integration with TGV technology

ALSTOM adapted France's highly successful TGV technology to create an integral High Speed Rail system in Korea and delivered it on time, thanks to rigorous systems integration management.

With Eukorail, ALSTOM led 13 French and Korean companies known collectively as "KTGVC," the Korea TGV Consortium. A team dedicated to Systems engineering and commissioning was established at the project's inception. It followed the project through to full systems commissioning: ensuring compatibility between consortium and non-consortium sub-systems; defining the Project Safety Policy and managing Consortium safety activities up to the delivery of the Consortium Safety Case; and defining and managing a consistent Testing & Commissioning Program from factory tests up to Full System site integration tests, ensuring their completeness to provide the customer with a fully operational system.

Managing a multi-cultural staff over geographical, linguistic and cultural barriers was a major challenge for ALSTOM and Eukorail. Close collaboration between supplier and customer was the key to the project's success. The new TGV line – one of the most complex in the world – meets the highest safety and reliability standards for major railway transport systems.

Full integration, testing and commissioning

Among the complex tasks required and successfully fulfilled were: specification of 74 interfaces either between supplier sub-systems or between customer sub-systems; management of a Technical baseline of more than 1 500 technical documents from the customer to ensure a unique technical reference for the design of

each individual sub-system; management and follow-up of the overall System configuration up to the Full System Commissioning. Also, management and approval of 600 engineering changes; analysis of tests related to interfaces, with 27 Systems integration tests carried out to ensure conformity with contractual performances (such as headway, trip time, energy consumption). The team also was responsible for delivery of all safety documentation necessary, including the overall Consortium Safety Case.



ALSTOM experts explaining KHRC engineers the principles of high speed

Happy ending

There were very few technical interface problems raised during the integration stage.

The fully operational system, compliant with contract requirements, was delivered on-time.

Success in a multi-cultural environment

From the start, the Korean High Speed Rail project community had clear goals: to establish true team spirit in a motivating atmosphere, and to merge the large variety of activities into a single project team. Working together, ALSTOM and its Korean subsidiary devised their strategy for an efficient organization capable of functioning smoothly in the complex, bi-geographical context. A solid organization, rather than a transient, single project approach, was created, along with the establishment of rapid and immediate lines of communication and records between Europe and Korea. Records of all communications were required, which led to the installation of a specialized electronic system for record storage and retrieval. Language and cultural gaps were overcome thanks to international flexibility, close support and co-operation of Korean staff.

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Technology transfer: the first TGV exported as a "system solution"

In 2002, following ALSTOM's technology transfer, Korean manufacturers delivered their first locally built KTX train.

The scope of the technology transfer that ALSTOM provided to South Korea, now complete, covered rolling stock, catenary and traffic control system manufacturing, including the transfer of documents, technical training and support of Korean engineers. In France, training covered detail drawing, process designing, alignment of manufacturing facilities, key parts manufacturing and testing, and quality control. The technology transfer also included technical support from French engineers to Korean companies (plant planning, production facility establishment, welding, manufacturing, assembly and tests).

Of a total 46 trains, 34 were manufactured locally with technical assistance and training, beginning in October 1998. All trainsets underwent testing, under ALSTOM and Eukorail responsibility, on the test section of the Korean high-speed line and have been officially accepted by KHRC.

Transferring knowledge and practices

The operation's complexity was mainly due to the high-technology content of the products transferred. The technology transfer began with transferring and updating approximately 350,000 high

speed train documents: drawings, specifications, manufacturing documents, procedures, purchasing documents, and training documents. Then came the training of Korean engineers: more than 1200 Koreans were trained in ALSTOM offices and factories in Europe. Even more were assisted in local production in Korea by over 1000 French engineers. In all, the process took place in 12 European factories and 13 Korean sites.



Technology transfer, Korean and European engineers working together on-site

Quality in Korea: Eukorail certified ISO 9001:2000

On December 19, 2003, Lloyd's Register Quality Assurance Korea delivered ISO 9001:2000 Certification to Eukorail for its Quality Management System. The scope of audit was "Provision of Consortium Leadership for Railways Projects Management". This achievement is the result of experience accumulated with this major project and will surely be an asset toward further rail business in Korea.

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Rolling stock: a proven track record

In choosing TGV technology, Korea joins eight European countries where over 500 ALSTOM-built TGV trains operate daily.

The Korean KTX high-speed train is the newest member in a growing family of very high speed trains, all linked by their common TGV technology heritage, developed with the SNCF, French national railways. Its closest "cousin" is the Eurostar, which links Paris and London in little more than three hours. Eurostar, which is equipped with systems for three different voltage and signalling standards, is the market leader for Paris – London travel with a 65% share, as well as a 49 % share of the Brussels-London market in 2003. The four-

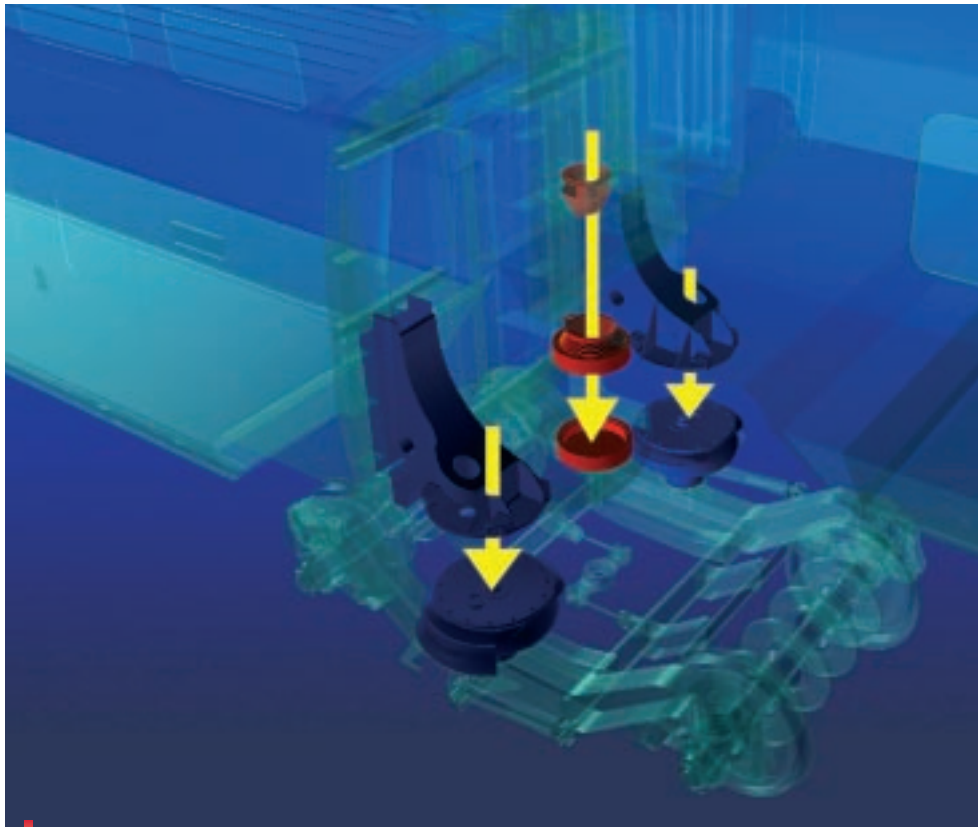
voltage Thalys TGV fleet leads Paris-Brussels travel, with 55% of the market. Transport experts expect the KTX to absorb 40% of road traffic and 60% of plane traffic between the Seoul and Busan.

Speed, safety and comfort

The TGV has an unparalleled track record in terms of longevity and safety. All TGV trains are based on an articulated design, allowing a broad and diversified range of models with the same degree of comfort and safety.

Flexibility in terms of passenger capacity and interior layout, as well as in traction and signalling equipment allows their adaptation to the individual needs of international networks. ALSTOM's offer includes single or multiple unit trains that can vary in capacity from 200 to more than 1,100 passengers.

After 22 years of operation, TGV trains have travelled over 1.5 billion kilometres and transported over 1 billion passengers.



Articulated architecture: the key to safety and comfort at high speed

In a traditional trainset, each car rests on two bogies. The cars of a TGV are articulated, or joined, by "median" bogies, positioned between two cars in the train. The resulting reduction in the number of bogies optimizes the use of power and saves energy as well as diminishes the overall weight of the train and aerodynamic drag. Since passengers are not seated above the bogies, their comfort is enhanced by a reduction in vibration and noise. Stability is another major benefit of articulation, both in regular high-speed operation and in emergency situations. In the unlikely event of a collision, the train cars stay together and upright, thus ensuring a protected environment for passengers.

The TGV's articulated trainset principle

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Rolling stock: adapted architecture and technology

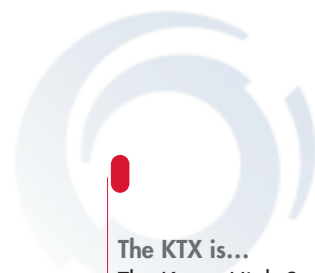
While their TGV technology was inspired by France's "TGV reseau" fleet, the KTX trains for the Korean High Speed Line differ from their French relations in many more aspects than just their long "nose".

Each train is 388 metres long, equalling the Eurostar as the longest TGV trains in use. Each train can carry 935 passengers (equalling the capacity of two Boeing 747s) and weighs 700t. Unlike several European fleets, the KTX only requires a mono-voltage system, allowing it to have less roof-fitted equipment, such as pantographs.

Key points of adaptation

The 20-vehicle KTX train has advanced safety features including triple friction, regenerative and rheostatic braking, and

an integral fire detection system for best resistance to fire and clearance of smoke. Passenger benefits include swivel seats in first class, and a 4-channel audio system. Passenger information is transmitted via onboard video system: first class is equipped with four 16-inch, colour, ceiling-mounted video monitors, with two in second class. With no bar or restaurant car, more space is available for passenger seats. The trains have been designed to reinforce air sealing to limit passenger discomfort from rapid air pressure variations when trains enter or exit tunnels at high speed.



The KTX is...

The Korea High Speed train is comprised of two power cars, one at each end, with 18 articulated trailers per trainset, and two motorized trailer coaches. Each trainset is mounted on 17 trailer bogies and 6 motor bogies.

System characteristics

- Configuration: PC + MT + 16 IT + MT + PC
- Maximum commercial speed: 300 km/h
- Track gauge / Rail: 1435 mm / UIC 60
- Power supply: 25 kV 60 Hz
- Capacity: 935 seats (127 first class seats, 808 2nd class seats + 30 folding seats in vestibules)



Swivel seats add to passenger comfort

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Train control system

Signaling is a key element of a railway system with respect to safety and traffic performance. ALSTOM has proven its ability to provide this crucial element, in coordination with French (CSEE) and Korean (LGIS, Samsung) Consortium members.

The Centralized Traffic Center (CTC) system supplied by ALSTOM with its Korean partners enables the overall management and supervision of traffic on the High Speed Line sections in manual or automatic mode. The CTC is associated with an interlocking system provided by ALSTOM to ensure a safe control and monitoring of routes, point machines and signals all along the High Speed Line; as well as an Automatic Train Control system (ATC) supplied by our French and Korean partners, designed to transmit to the driver's cab the maximum authorized speed with respect to safety, and monitor in safety the train's speed and position at all times. Together, these three sub-systems create a High Speed Train Control System capable of ensuring the highest levels of safety.

Smoothing an awkward situation

ALSTOM had to manage diplomatically as two groups in the Consortium are usually led by companies in competition with each other. Thanks to a very structured Consortium management, the inevitable obstacles and difficulties that occurred during the course of the project were resolved in a timely manner and benefiting all parties, the client foremost.

The signalling system was commissioned and operated with KTX three years prior to the start of Revenue Service on the 60-km section of High Speed Test Track in Korea, demonstrating very good availability.



Centralized Traffic Control (CTC) and Interlocking

The CTC and Interlocking systems supplied by ALSTOM and Korean partners supervise train operations along the line and in intermediate stations. They organize the route by monitoring the points machines and signalling system in stations and in terminals, for the interlocking (IXL).

The CTC allows the automatic management of train timetables. It ensures connection to peripheral sub-systems such as : clock system, passenger information and power management.



Centralized Traffic Control Centre

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Overhead power lines

ALSTOM's infrastructure expertise played a specific role in creating Korea's High Speed Rail system as project pilot for the overhead catenary.



Specialized catenary on the dedicated High Speed line

The High Speed line's overhead catenary runs along 477 km of single track (133 km in open route, 163 km in tunnels and 181 km in viaducts). The contract awarded to the consortium includes the design, part of the supply (equipment, spare parts and specific tools) and supervision of installation, inspection, tests and commissioning of two 25 kV, 60 Hz overhead lines (by catenary designed for 350 kph). In addition, ALSTOM provided two lines of 40-metre removable catenary in the depot and developed and provided a specific de-icing system adapted to the demanding weather conditions in Korea.

It was an additional challenge for ALSTOM to transmit its know-how successfully. The company was able to fulfil its role as advisor and trainer, attributing its success to the good relations and mutual confidence existing it and the customer.

Transferring railway infrastructure technology

For the transfer of technology, client and client-subcontractors were trained for basic and detail design on the ALSTOM-specific Catenary Design Tool Software used on the project. Also provided was client and client-

subcontractor training for installation, with "on the job training" provided by supervisors to installers, elaboration of design, installation, inspection and tests procedures, and elaboration of operation and maintenance manuals.

ALSTOM's expertise in railway infrastructure covers every phase of electrification projects (DC, AC, HSL), from design and construction through testing, commissioning and maintenance. We also facilitate a transfer of technology between a French manufacturer and a local partner for contact wire manufacturing.

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Maintenance services

ALSTOM is supervising maintenance of the High Speed Rail line in Korea until 2006.

Within the associated services that it is providing, ALSTOM is responsible for supplying a maintenance plan, manuals, training and supervision. The maintenance plan describes in detail all functions and organisation necessary to properly maintain the work. The maintenance manuals - 622 in all - cover the operation and maintenance of each system and subsystem furnished (i.e. rolling stock, catenary and train control). Operation and maintenance training for rolling stock began in France after the contract was signed. For organising and conducting the first dynamic test on the first KTX train in Korea, four drivers and 3 catenary maintenance employees, all Korean, received special training in France for several weeks beginning in September 1999. This training was finalized in Korea.

The training of driving personnel includes a train simulator, developed and provided by ALSTOM especially for this project. From 1996 to 2003, ALSTOM trained 174 Koreans trainers and trainees during 660 weeks.

Expert supervision

ALSTOM began supervising maintenance upon delivery of the system to the customer and will continue for the next two years following the start of revenue service (2000 to 2006). The maintenance supervision services involve 130 men per year, providing many skills and expertise in various fields of activities. These are implemented in co-operation with SYSTRA/ SNCF. Their work also includes the definition and management of spare parts and specific maintenance tools.

A KTX driving simulator

ALSTOM provided a train operations simulator in 1999 to train Korean KTX drivers. The driving simulator puts the trainee in a real-life situation by recreating identically the driver compartment that he will be using in the Korean train. It reacts like a real train: the simulator has dynamic compartment movement with quadraphonic equipment reproducing the true sounds of a driver's cab, while computer graphics represent the Seoul/Busan line. An instructor manages the system. It enables him to teach a driver to deal with the different situations involved in driving a "TGV"-type train (routes, climate, breakdowns, works, junctions). Additionally, video screens positioned outside the simulator enable other trainees to follow their colleague's training while having access to information from the train and the instructor.

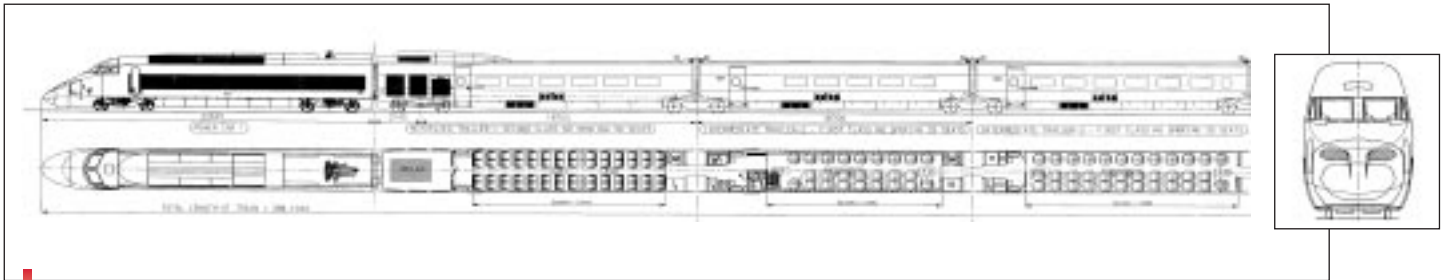


Maintenance of the KTX fleet, the Goyang depot



For experts: Rolling Stock

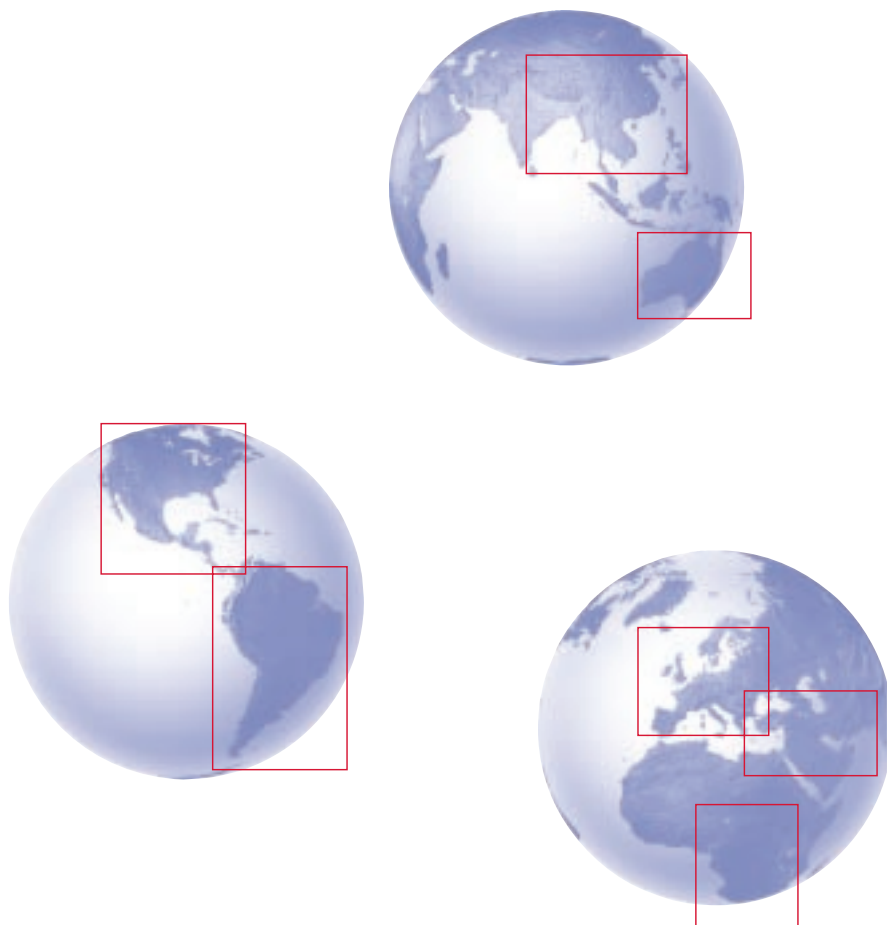
Rolling stock technical characteristics



Schematic diagram of the KTX

Technical features

Carbody	Carbody material	Steel
	Trainset modularity	46 trainsets (20-car trainset)
	Capacity per car	935 seats (127 in first class and 808 in second class)
	Dimensions	Length: 388 m
Bogie		Width: 2,904 m (maximum)
	Weight	701 t (empty) /771 t (fully loaded)
	Crashworthiness	Protection for tunnel pressure waves
	Axle load	17t
Traction	Suspension	secondary pneumatic suspension on the coaches
	Brakes	Electric regenerative rheostatic brakes
	Type	Electric traction equipment : 12 three-phase self commuting synchronous motors, powered by thyristor current inverters
	Dimensions	- frame size : 660 mm * 660 mm
		- frame length : 900 mm
		- weight : 1555 kg
	Cooling	force ventilated (1.25 m ³ /s)
	Maximum speed	300 km/k
	Catenary voltage	25 kV 60 Hz
	Motor	SM47 (standard: SMO ; voltage: 1500V, etc.)
Performances	Power	- traction power : 1130 kW
		- braking power : 663 kW
		- rated power : 1130 kW
	Headway	3mn
	Others	- max torque : 6900 Nm
		- maxRP : 4000 RPM
		- gear ratio : 2.189



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

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