



Alta Velocidad Española, a TGV for Spain

ALSTOM

Transport

Project Story (Oct. 05)

Customer challenge

Alstom's solution

Spain speeds its EU integration with high speed rail

Spain's bright new future became truly apparent by the 1980s. With the 1992 Olympic Games and Universal Exposition before it, the country was out to modernize its infrastructure and image, and take its place within the European Union. The introduction of high speed rail in Spain would play a large part in advancing its integration.

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The 471-km Madrid – Seville route, which includes 17 tunnels, runs over much mountainous terrain. The AVE also runs on the Madrid – Barcelona corridor up to Lérida. It should reach Barcelona in 2007 and the French border near Perpignan in 2009. The AVE network is expected to serve an estimated 5.6 million passengers annually.

The prospect of hosting the 1992 Olympic Games and Universal Exposition gave the Spanish government the catalyst it needed to improve its rail network. In 1988, it opted for a high speed rail transport network as part of a much larger modernization program. Improving the mobility of both citizens and goods throughout the country and providing fast, direct access to its European neighbors would provide an excellent means of promoting Spain's integration in the European Union. It would also bring relief to the congested rail lines between the Madrid area and Andalusia, in the south. In another priority, the government used the rail project to strengthen Spain's own industry, stipulating that the supplier use a high level

of local content in its proven solution and provide a technology transfer, thus insuring new expertise and employment for Spain.

AVE takes shape

The infrastructure modernization program included redefining the existing network, creating new lines and new adapted rolling-stock. In parallel, Spanish Railways (RENFE) restructured and repositioned its railway activities. The Spanish government has allocated 41 billion euros for the construction of new rail infrastructure before 2007. The goal: for all provincial cities to be less than four hours travelling time from Madrid, and 6.5 hours from Barcelona. The solution: AVE, *Alta Velocidad Española*, the Spanish TGV*.

Customer challenge

Alstom's solution

Alstom and the Big Picture

A rail project with a nation-building scope and fixed deadline requires a supplier that has the big picture clearly in view. Not only must the company understand every aspect of the project, it must be able to provide the best solutions to make it a reality: proven technology, experienced teams, expert project management and optimized costs. For Spain, the choice was clear: Alstom.

Key milestones

- 1986: Spain decides to build a new line to Andalusia.
- 1988: RENFE launches international call-to-tender for 24 high speed trainsets.
- 1988: Offers are submitted.
- 1988: Spain decides to adopt UIC standard track gauge.
- 1988: Alstom (GEC ALSTHOM) wins tender.
- 1989: Alstom and RENFE sign the rolling stock contract.
- 1991: First AVE trainset is presented to RENFE President at Alstom factory in Belfort, France.
- 1992: Revenue service begins on the Madrid-Seville line.
- 1992: Alstom is awarded 10-year maintenance contract for AVE fleet.
- 2000: Track operator GIF selects Alstom for power supply on the high speed line between Madrid and Barcelona.
- 2002: RENFE renews maintenance with Alstom under new 14 year contract.
- 2002: Alstom is chosen to supply onboard signaling equipment for new ERTMS level 2 standards.
- 2004: Alstom awarded a contract for installing ERTMS Level 2 equipment in Lanzaderas (TAV S-104) cabs.
- 2002: GIF selects Alstom for the Madrid-Alicante high speed line: laying double track, catenary and power supply.

Thanks to its flexible and complementary product range, Alstom can meet any customer need. For Spain, a global solution was in order. Alstom was able to provide specially adapted, proven solutions for Spain's rolling stock, maintenance, infrastructure and signalization. Alstom began by winning a contract for the supply of 24 high speed trains: the first AVE would be a TGV* specifically designed for Spain and would involve a major technology transfer. The rolling stock contract was quickly followed by a 10-year contract for train maintenance. This contract, renewed for a further 14 years in 2002, covers not only all the rolling stock supplied by Alstom, but all brands of high speed trains under Spain's AVE name. With the Alstom-RENFE relationship working out nicely, Spain was confident in choosing Alstom for related AVE contracts in information solutions and infrastructure.

What is an AVE (Alta Velocidad Española)?

AVE is a brand name given to trains that cover both high speed and regional networks. As our high speed trains are based on TGV* technology, some suburban-regional EMU with maximum speed of 250 km/h are able to run on every kind of track.



All trains were delivered on time



The government used the rail project to strengthen its own industry

Fulfilling contractual commitments

The rolling stock contract called for a technology transfer and a high degree of local content. The latter led Alstom to make a series of acquisitions in local manufacturing sites, in Valencia and Barcelona, and to modernize them to be able to handle high speed technology and production criteria. The result: all but four AVE were built in Spain.

- Rolling stock
- Technology transfer
- Maintenance
- Information solutions
- Infrastructure

AVE, like a bird in flight, at one with the environment

The speed and agility of the AVE is reflected in its logo and name, “bird” in Spanish. Alstom supplied the 24 trainsets of Spain’s top-range fleet by developing a new high speed train based on its proven TGV* Atlantique for SNCF.

Alstom supplied 24 trainsets for high speed use in Spain: 18 AVE and six Euromed. While the TGV* for Spain is based on Alstom’s TGV* Atlantique generation of products, it benefits from certain technical and aesthetic improvements that allow it to adapt specifically to the RENFE network and meet Spanish passenger expectations.

Many of the modifications stem from Spain’s hotter climate and more

mountainous landscape. For example, with 17 tunnels on the main route, the AVE needed protection from pressure waves on entering tunnels. Breaking performance on slopes of 30‰ were improved. Other adaptations include compatibility with Spain’s line voltage of 25 kV / 50 Hz and 3 kVdc, the most advanced onboard ERTMS control equipment, and more powerful auxiliaries.



Enhancing Spanish Railways' image: AVE aesthetics and symbols have been deliberately designed to entertain a certain ambiguity between train and plane

Among the improvements for passenger comfort were:

- A new interior design
- More space between seats for improved passenger comfort
- An at-seat audio-video system for each passenger
- An air-conditioning system equal to the Spanish climate
- Improvements for mobility-impaired passengers

Despite the tight schedule, all trains were delivered on time. The first AVE was presented in 24 months in its French factory, having already undergone 6-month trials. The remainder of the order was built and delivered in Spain at a rate of two trains per month.

- Rolling stock
- Technology transfer
- Maintenance
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- Infrastructure

Sharing technology with customers

Among the key conditions for obtaining this order were a substantial technology transfer and the acquisition of Spanish firms which led to the production of a large number of AVE trainsets in Spain. Alstom's past experience in complex contracts and commitment to fulfilling the Spanish conditions were behind the AVE success.

The complexity of this technology transfer operation was mainly due to the high technology content of the products transferred, the number of participants (five plants in Spain and six in France) and the adapted legal relationships. Of course, there was also the large number of trainsets to be produced in Spain. Only four AVE trainsets were produced in France, and these included Spanish source components. All the others were made in Spain, with the rate of integration of local components growing steadily, and reaching approximately 90% in the last AVE train.

France, Alstom Units:

- Aytré: design and manufacture of intermediate AVE trailer cars.
- Belfort: design, manufacture and integration of power cars.
- Tarbes: design and manufacture of electrical equipment.
- Le Creusot: design and manufacture of bogies.
- Saint-Ouen: design and manufacture of main transformers
- Ormans: design and manufacture of traction motors.

De Dietrich, located in Reichshoffen, designed and manufactured the end trailers.



Most of the trainsets were produced in Spain

Industrial cooperation: who did what on the AVE?

Technology transfer contracts were signed between Alstom and each of the Spanish companies.

Spain, Alstom newly acquired units:

- Barcelona, formerly MTM, manufactured traction motors, large electric equipment blocks, bogies, power cars, and was also responsible for integration of power cars into trainsets and subsequent testing.
- Madrid, formerly Ateinsa, carried out assembly, cabling and finishing work of second-class trailer cars.
- Valencia, formerly Meinfesa, manufactured the AVE electric equipment blocks.

CAF, the well-known Spanish coach, locomotive and metro manufacturer, built the AVE trailer cars.

SEPSA, an independent Spanish company, built the AVE converters.



AVE is the result of international cooperation between five production units in Spain and six in France

- [Rolling stock
- [Technology transfer
- [Maintenance
- [Information solutions
- [Infrastructure

Peak performance and shiny good looks: a question of maintenance

Since Alstom's initial maintenance contract for the Spanish AVE fleet, in 1992, our company has been reselected over competition for 3 consecutive contract renewals. The AVE maintenance programme has proven so efficient that we have used it as the basis of our Service offer for customers worldwide.

Renewed trust

In providing advanced maintenance services for customers, our main objectives are to achieve maximum safety, high reliability and passenger comfort while minimising maintenance costs. Alstom has been maintaining RENFE's fleet of 18 AVE for the Madrid-Seville line, six Euromed trains for the Barcelona-Valencia-Alicante line and 21 Siemens locomotives for both lines since 1992. Some 250 Alstom

employees, working out of three operator-owned maintenance facilities, are responsible for assuring the maintenance plan. One of the keys of our maintenance success is that the contract is tied to strict reliability and availability commitments, based on a price per kilometer. AVE is now our maintenance model for high speed trains. The renewed trust of RENFE, for three consecutive periods, is the proof of a successful collaboration with our customer.

Basis of our service offer worldwide

Thanks to our experienced teams and advanced maintenance engineering, "continuous improvement" has become our maintenance approach. The maintenance of AVE trains, which has been continuously optimised over the last years, is a perfect example of maintenance engineering expertise in improving total availability and reliability for the customer.

Each maintenance plan is derived after carefully assessing individual life cycle histories and adjusting their known operating condition to their functional environment. This approach largely eliminates unscheduled equipment repairs and downtime, a great economic benefit. Overhaul and repairs of train components are integrated within maintenance and facilities, further increasing economic benefit and in-depth knowledge. All trainset, vehicle system and component histories and cost are tracked on a continuous basis, which allows exact planning and cost accounting, and provides a functional tool to adjust the maintenance activities and material stock levels.



Workshop areas are based on specific studies

Key results

- Contractual performance: 100% contractual availability.
- Contractual reliability: based on 10 minute delays in departure or arrival times..
- Kilometers between breakdowns: 1 000 000 km
- July 1995: ISO 9002 quality certificate for AVE.
- March 1998: ISO 9002 quality certificate for Euromed.



AVE maintenance workshop

- [Rolling stock
- [Technology transfer
- [Maintenance
- [Information solutions
- [Infrastructure

Alstom train control systems: assuring the safety of Spain's trains

As a leader in interoperability with 20 projects in 10 countries, it is not surprising that Alstom was chosen by RENFE to supply ATLAS™, its ERTMS-compliant cab signaling system, for Spain's regional high speed fleets.

ERTMS and Alstom

ERTMS comes from the European Union initiative to create a unique control command system for railways to enable interoperability throughout European rail network. ERTMS is a single Automatic Train Control (ATC) and management system standardized at European-level and based on a single set of functional and interface specifications.

ATLAS is Alstom's ERTMS-based solution

ATLAS controls train movement, ensuring train safety and direct train operations. It allows smaller headway resulting in reduced journey times and better optimization on the network. With minimum or no line-side equipment, the customer benefits from low installation and maintenance costs. Alstom has already achieved great success in interoperability: we are currently providing the ATLAS solution in 10 European countries – 20 projects in all.

Benefits of ATLAS ERTMS system:

- interoperability
- highest levels of safety
- speeds up to 500 km/h
- radio communications GSM-R
- low life cycle costs
- high reliability, availability and maintainability

Alstom received two orders from RENFE for ERTMS on-board equipment to upgrade the signaling systems of its regional high speed fleets. ATLAS 200, Alstom's ERTMS-based solution, will allow the trains to operate safely under the new pan-European standard for interoperability.

EuroAVE (TAV S-100)

In March 2002, Alstom received a contract to upgrade the cab signaling system of its EuroAVE (TAV S-100) fleet to ERTMS Levels 1 and 2. This fleet of 18 Alstom-built trains has been in commercial service at speeds of up to 300 km/h between Madrid – Sevilla since 1992 and on Madrid – Zaragoza – Lérida high speed lines since October 2003. The latter is a section of the future Madrid – Zaragoza – Lérida – Barcelona – French border high speed line. Nine trains have been equipped with ERTMS Level 1 and 2, allowing them to run on the Madrid-Lérida line with the new standard as soon as the ERTMS trackside infrastructure is ready in late 2005.

The GSM-R voice radio has been operative since the start of Madrid-Lérida commercial service. Installation of the new equipment was carried out during the fleet's normal maintenance activities.

Lanzaderas (TAV S-104)

In 2004, Alstom received an order for fitting Lanzaderas (TAV S-104) train cabs with its ERTMS-Level 2 solution. The Lanzaderas TAV S-104 is a new suburban-regional EMU with maximum speed of 250 km/h adapted to meet the needs of RENFE.

They are currently being manufactured in Alstom's Santa Perpetua factory, near Barcelona. The shuttles will run at 250 km/h on the Madrid – Toledo and Madrid – Guadalajara sections of the Spanish high speed network. Some 20 shuttles are being equipped with the same equipment as are now on the S-100, Alstom's ADVANTI™ on-board computer, which acts as the "brain" of the train with onboard ERTMS levels 1 and 2, and GSM-R for voice and data communications. The trains will enter commercial service with ERTMS in 2005. As systems architecture and functionalities were similar for both contracts, the same test program was used for the second project, optimising the overall return of experience for the customer.



AVE driver cab in one of the 17 tunnels

- [Rolling stock
- [Technology transfer
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Connecting Spain by high speed rail

Alstom is a leading supplier of rail infrastructure products and services, with over 30 years of experience and 8,000 km of line electrified.

Having supplied the AVE rolling stock for RENFE, Alstom possesses a total understanding of the Spanish infrastructure needs. Recognizing this, national infrastructure operator GIF (Gestor de Infraestructuras Ferroviarias) signed a contract with Alstom for the power supply for the AVE Madrid-Barcelona line in December 2000. The project's scope included:

- 11 substations 2x25 kV - 400 kV - 2 x 60 MVA
- 54 autotransformer post 2 x 15 MVA
- Local control of substations and posts

Installation was completed at the end of November 2001 (Peñalba substation) and complete testing with power was carried out in February 2002. Take over of the Peñalba, Zaragoza and Lérida areas was carried out between July and November 2002.

On the Madrid-Alicante Line

Alstom's Infrastructure division also supplied the catenary and the power supply for the Madrid-Alicante Line. The contract began in December 2003 and work was carried out over 10 months. The scope included the supply, building and commissioning of 51 km of double track line for operations at 220 km/h, with the possibility of adaptation in the future to 350 km/h line - 25 kVac. Specifically, Alstom supplied 26 km of double track (OHL 3 kVCC) and the Movil Substation (3 kVCC).



Over 200,000 km of track – the equivalent of five times around the world – by Alstom specialist teams



For Spanish infrastructure operator GIF, Alstom supplied power supply and catenary for AVE lines



Awarded in 2004

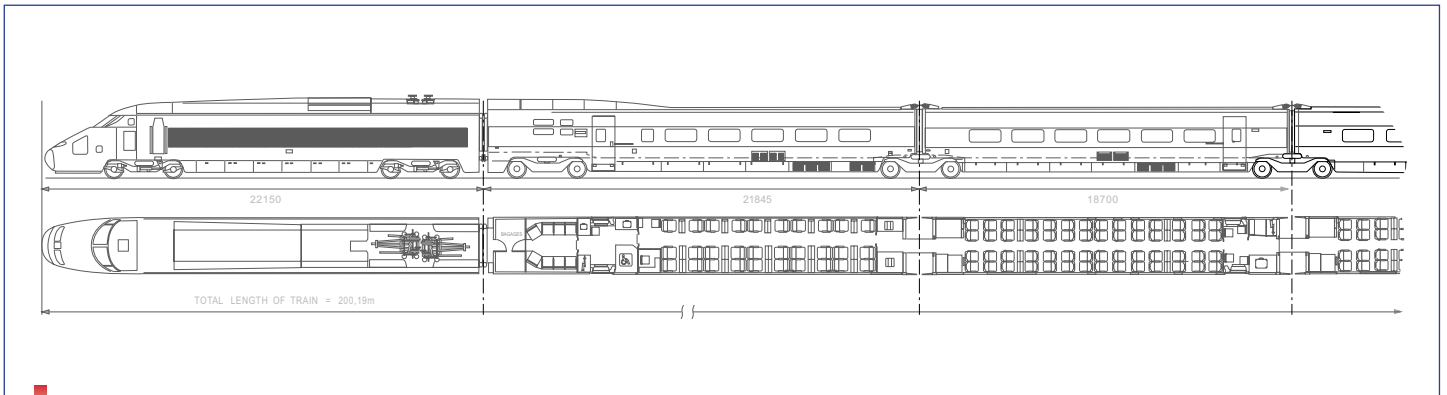
For the Cordoba – Malaga high speed line, Alstom has signed a contract for the design, build and maintain of :

- 2 power substations of 400 / 2 x 25 kV
- 1 power substation of 220 / 2 x 25 kV
- autotransformer centres

- ┌ For experts: Rolling stock
- ┌ For experts: Maintenance
- ┌ For experts: Information solutions



AVE, the newest single-deck TGV*



The “three-point principle”: in a TGV* articulated trainset, each trailer car has three bearing points. This architecture protects cars from the possibility of jackknifing or tipping over in the event of an accident

The AVE, first export success for the TGV*, allows passengers to travel by rail at 300 km per hour in comfort, style and safety. Based on the classic, single-deck TGV*, the AVE benefits from the TGV's

proven articulated trainset architecture while having all the technical adaptations to make it perfectly suited to the Spanish network. For example, the trainsets incorporate specific protection from

tunnel pressure waves to compensate for its many underground passages: the 417 km AVE line over mountainous terrain includes 17 tunnels.

Technical details

Number of trainsets	18 AVE and 6 EUROMED
Trainset configuration	M-8R-M
Carbody	Steel
Capacity	329
Length overall	200 m
Maximum width	2.9 m
Weight in working order	392 tonnes
Weight when laden	421 tonnes
Maximum speed in service	300 km/h
Axle load	17 tonnes
Power supply	25 kV 50 Hz and 3 kVdc
Continuous rating at 25 kV 50 Hz	8800 kW
Continuous rating at 3 kV (EUROMED)	7000 kW
Specific amenities	- Video and individual headphones for every 1 st & 2 nd class seats - Designed to be pressure tight in tunnel - Full air-conditioning

- For experts: Rolling stock
- For experts: Maintenance
- For experts: Information solutions

The art of train maintenance

Alstom's maintenance philosophy is based on a sound and detailed understanding of the trainset equipment, from whole integrated functioning unit to individual components, and the maintenance requirements to keep each unit at optimum performance.



Train washing at AVE maintenance depot

Maintenance engineering

The services performed by our teams are based on studies conducted by Alstom experts in "service engineering". Specifically, this entails studying the workshop areas, their arrangement and distribution in order to process the maintenance flow, and the types, quantities and specifications of:

- Parts and consumables required
- Maintenance plan synchronizing all equipment facilities with HR and logistics
- Maintenance documentation
- Training program and subsequent actions
- Additional services such as on-line emergency relief action, workshop train marshalling, train and personnel safety
- Procedures inside the shops
- Maintenance of facilities, equipment and tools

The maintenance scheme

- Preventive maintenance: scheduled visits, cleaning and revisions
- Conditional maintenance: dependant on a specific event
- Corrective operations: come into play after a breakdown
- Predictive work: dependent on the evolution of certain parameters

The AVE maintenance scope

The AVE maintenance integrates all requirements of high speed train maintenance from preventive to corrective visits supported with repair workshops for all auxiliary equipment.

- Comprehensive maintenance and cleaning of rolling stock
- Mid-life operations
- Parts repair and replacement, (bogies, brake system, electronic cards, springs)
- Maintenance of three depots



Our maintainers use the latest condition-based monitoring technologies. This allows them to take action before component condition could change and affect safety, availability and reliability

- For experts: Rolling stock
- For experts: Maintenance
- For experts: Information solutions

Information solutions: advanced technology and expert services

Alstom is a world leader in rail control systems with the most references, largest installed base in the industry and more than a century of experience. Our ERTMS Level 2 provides the advanced technology behind interoperability. Our ADVANTIK on-board computers (used aboard the AVE) allow interoperability at speeds of up to 500 km/h. Part of our ATLAS range of main line signaling products, this "train brain" monitors train speed, detects incorrect operation and warns the driver, applying the brakes if required.



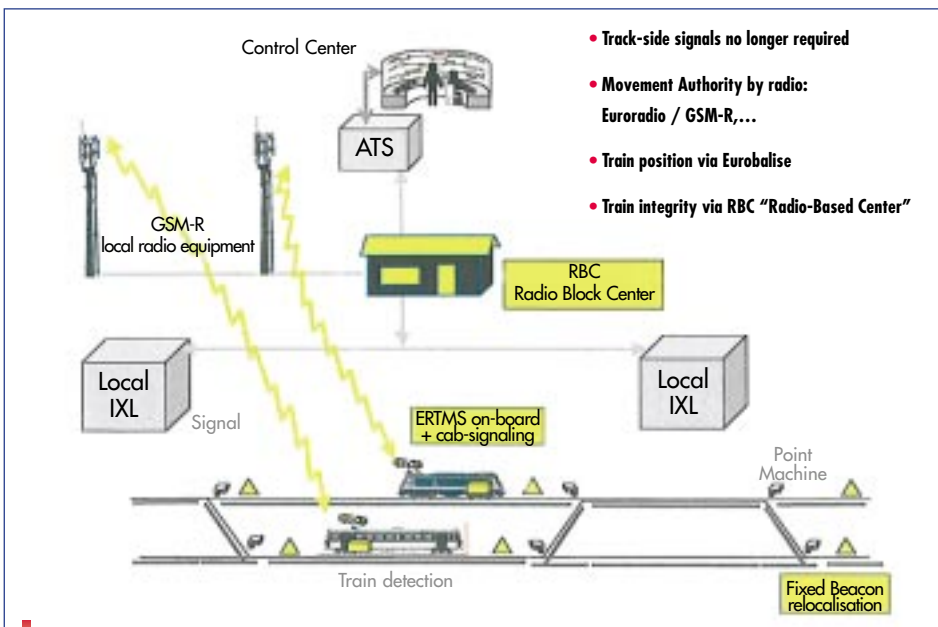
ADVANTIK allows interoperability at speeds of up to 500km/h

Benefits of ERTMS Level 2:

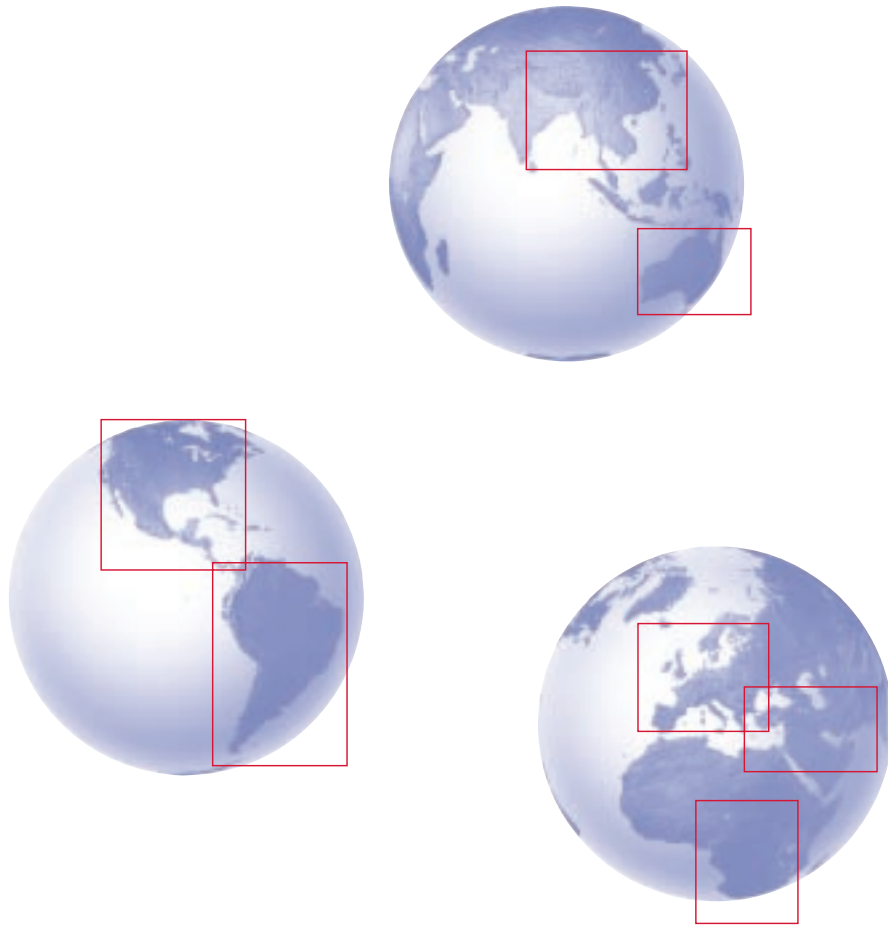
- Interoperability
- Speeds up to 500 km/h are possible
- ATP function
- Minimum or no track-side signals
- Reduced costs for installation and maintenance
- Lower life cycle costs
- Radio (including GSM-R) continuous transmission

ADVANTIK main on-board functions

- Calculation of dynamic speed profile; taking into account the train running characteristics which are known on-board
- Comparison of the actual train speed with the permitted speed and application of brakes if necessary
- Cab display to the driver
- Selection of the most restrictive value of the different speeds permitted at each location ahead
- The train reads Eurobalises and sends its position relative to the detected balises to RBC
- The train receives a movement authority and all track characteristics, static speed profiles and distances via radio



ERTMS Level 2 architecture



*"Alstom-built very high speed trains have carried over
1 billion passengers and travelled more than
1.5 billion kilometres since their introduction over 25 years ago.
More than 500 trains are in operation in Europe and Asia
at speeds of up to 320 km/h, an unparalleled achievement."*

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

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