



A high-speed solution for the UK's West Coast Main Line

ALSTOM

Transport
Project Story

Customer challenge

Alstom's solution

Revolutionary ambitions for rail in the UK

Sir Richard Branson's vision of world-class rail in the UK focused on a high-speed solution, to be delivered by his company, Virgin Trains: a fleet of state-of-the-art tilting trains that would provide faster, more comfortable intercity service the length of the West Coast Main Line, the UK's most important rail line, upgraded to new European standards.

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With the UK's rail privatization in 1994, Sir Richard Branson's ambitions in the rail industry began in earnest. His stated objectives were in keeping with his well-known larger-than-life image as record company mogul, airline founder/president and hot-air balloon champion. He was out to "revolutionize" British rail travel. His focus included the West Coast Main Line.

The West Coast Main Line

The backbone of the UK's rail network carrying 15 million passengers annually, the West Coast Main Line is Europe's busiest main line. It links England, North Wales and Scotland in a web of intercity services operating between London Euston, Glasgow, Manchester, Liverpool, Holyhead, Birmingham and West Midlands stations.

With the West Coast franchise, Sir Richard set out to spearhead a transformation of UK rail by offering a world-class travel experience, and thus win back passengers from airlines, buses and private vehicles. Brand new tilting trains, reduced travel times, increased train services and greater passenger numbers were all part of this vision. This would be a difficult endeavor for several reasons. Suggesting tilting trains would pose a particular challenge in the UK, as UK rail industry players remember a different tilt technology from the late 1970s, when the Advanced Passenger Train was under development and later abandoned. In addition, the West Coast Main Line would



Europe's most heavily used mainline railway

require Railtrack (now Network Rail) to provide upgrades of track, signaling and power supply to bring it to modern standards – a multi-billion euro investment, the biggest rail project in Europe.

HISTORY OF THE PROJECT

■ Customer challenge

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The professionals

In 1997, Sir Richard's rail operating company, Virgin Trains, was awarded the franchise for the West Coast Main Line (WCML) for an initial 12-year period. Having promised a new fleet of high-speed trains offering radically improved services on an upgraded system by 2003, Sir Richard and his company were in need of the best rail experts. Not only did they need proven technical solutions, they needed expert financing and project management to guide them through this complex situation within a short time frame. Virgin Trains turned to Alstom and its then partner Fiat Ferroviaria (now incorporated within Alstom) to help it make good on promises to the British people.



Sir Richard Branson's ambitious objective: revolutionize UK rail transport

Key dates

- 1994: Privatization of British Railways
- 1996: Virgin wins West Coast franchise following discussion with Alstom/Fiat and based on replacement of all rolling stock with new tilting trains
- 1997: Virgin starts running franchise and planning train procurement
- 1999: Virgin signs contracts with Alstom/Fiat for 53 Pendolino tilting trains and maintenance for 13 years
- February 2001: First pre-series Pendolino delivered to Alstom Midlands Test Center
- July 2001: Pendolino launched before press at Alstom Midlands Test Center at 200 km/h with full tilt
- June 2002: First Pendolino accepted by Virgin Trains
- July 2002: Driver training begins and special passenger service between Birmingham and Manchester for Commonwealth Games
- January 2003: First passenger service between London and Manchester; record times
- September 2003: Drivers started training for tilt
- December 2003: First run at 200 km/h on a section of the WCML
- September 2004: Train delivery completed
- September 2004: 36 Pendolinos in service at 200 km/h with tilt WCML Phase I upgrade completed; Record run from London – Manchester in 1h 54min. Regular services at 2h 15min
- June 2005: Full Pendolino timetable requiring 46 trains 363 days a year

Customer challenge

Alstom's solution

Alstom leads the project to success

Virgin Trains chose Alstom to supply and maintain its new fleet of trains because it needed a company that had both a deep understanding of the UK railway system and the expertise to champion this challenging and complex project.

In 1999, Alstom and Fiat Ferroviaria were chosen to design, supply and maintain 53 nine-car Pendolino tilting trains. Under the financing framework, the trains were ordered by Angel Leasing Company, a wholly-owned subsidiary of The Royal Bank of Scotland that is now leasing the fleet to Virgin Trains for the duration of their 12-year franchise. Highly experienced in working with complex financial structures, Alstom was able to provide a solution that served all the parties involved to their satisfaction.

The Pendolino fleet for Virgin's West Coast Main Line featured their latest design of electric tilting trains founded on long experience and constant evolution. The new fleet is the center piece of Virgin's plans for delivering a radically improved service on the West Coast, offering enormous improvements in performance, comfort, noise levels, facilities and general customer ambiance. The trains have been tested for operations at 225 km/h, at present they operate at 200 km/h due to infrastructure limitations.

Service Level Agreement

Alstom is providing full train services to Virgin including: safety case management; maintenance of all operating licenses; comprehensive train maintenance; end of day train cleaning and on-board in-service train cleaning. This work is undertaken at the four main WCML depots Alstom took over from Virgin and which have seen significant investment.



The Birmingham team on the factory floor during production

International collaboration for a high-tech solution

With tilting technology in Italy and train assembly facilities in the UK, the answer was to deploy expert project management to bring the two together. Alstom orchestrated the UK Pendolino project in this way, also drawing from its sites in Switzerland and France to assure product quality and delivery.

The Pendolino is a truly European train, with its bodyshells built in Italy and bogies and tilt system coming from Switzerland. Traction for the trains relies on the proven Alstom

Onix second-generation electric drive. All these components came together at Alstom's plant in Birmingham, where Virgin's new train was designed.

To manage risks on this ambitious project, Alstom adopted a new approach to production, building two pre-series trains for acceptance and validation testing at its UK test center and on the WCML rail network. Meanwhile on the production line, four trains were rolled out per month, allowing all 53 trains to be available for service at 200 km/h during 2004.

Customer challenge

Alstom's solution

On-board the Pendolino

The nine-car train has 439 seats and complies fully with the requirements of the UK's Disability Discrimination Act. On-board facilities include a self-service shop, a serving galley, at-seat audio equipment and electronic on-board information and reservation systems.

The Alstom Midlands Test Center
 With Virgin wanting to take delivery of fully tested trains and testing on the main line limited to night hours or weekends and subject to delay, Alstom determined that to ensure the delivery of the project it would have to build a dedicated test center in the UK. Alstom invested €30 million to build the Alstom Midlands Test Center at Old Dalby in Leicestershire which included replacing the old British Rail track and upgrading it for 200 km/h running. With its unique 21 km testing capability on electrified track it has been fully operational since 2001, testing Pendolino trains up to 200 km/h in total safety. The Center also includes an on-site building for the Train Control System (TCS) signaling and control center and a 6.6 km loop of track built in partnership with Railtrack to allow for the further development of TCS signaling systems and testing of interfaces with European Rail Traffic Management System (ERTMS) Levels 1 & 2 for future deployment in the UK.



Pendolino interior features are specially designed for a high level of comfort



Test runs at the Midlands Test Center

- Rolling stock

- Maintenance

- Signaling

A powerful, high-tech train designed for reliability

The secret of the Pendolino's reliability is the levels of redundancy built into its design concept.



Virgin Pendolinos were manufactured in Alstom's Birmingham, UK site

Behind the tilt

Today's tilting train has rectified a problem that doomed the APT, an earlier UK tilting train abandoned in the early 1980s because of passenger discomfort during tilting due to tilt fully compensating for the lateral acceleration experienced by the passenger. The Pendolino compensates only partially for tilt so that the passenger still feels a slight movement in curves at high-speed, thus avoiding the discomfort felt by the disorientation of the senses.

By tilting the carriage body up to 8 degrees, it is possible for the train to achieve a 24% increase in speed around curves. The tilt system was developed from earlier Pendolino designs which had the equipment mounted inside the coaches; today it is under the car body, bolted to a "bogie bolster" – a large plate on top of the bogie. The bolster tilts from side-to-side on rollers

driven by an electric actuator in the center of the bogie, under the bolster. In the UK, the Pendolino's tilting system uses an electric actuator, rather than hydraulic, for a faster response and lower maintenance.

Designed for availability and reliability

The Pendolino has been designed with distributed traction equipment and degraded modes of operation. Thus as long as it receives overhead power it can rescue itself from failure in most situations.

The UK Pendolino is effectively two multiple units coupled together. Each half-train has its own pantograph, traction package and air-conditioning and can operate independently while cross feeding the other with braking and hotel-power (heating, ventilation and air-conditioning). Each unit can also accept 25 kV AC power from the other's pantograph.

Tilting: an option for any high-speed train on classic track

While new to the UK, Pendolino trains have been operating in nine other European countries for two decades: Italy (1985), Germany (1990), France (1996), Spain (1996), Portugal (1996), Finland (1992), Czech Republic (1995), Switzerland (1993), and Slovenia (1998). Tilting trains require few if any changes to the infrastructure, which makes them an attractive alternative to very high-speed trains that require costly dedicated high-speed track. Tilting is a proven, technical solution that can be applied to any single-deck, high-speed train running on classic tracks. In leaning into curves rather than having to slow down for them, trains can reduce their route run times significantly. Both hydraulic and electromechanical systems are available for tilting, and both have been especially designed so that passengers remain in total comfort and safety while tilting at up to 8°.



The Pendolino offers excellent performance in terms of acceleration, braking and ride quality

- └ Rolling stock
- └ Maintenance
- └ Signaling

Lifetime Service Provision

Maintenance is critical to the success of the new fleet. In undertaking the maintenance-for-life of the Pendolino fleet, Alstom is committed to assuring its constant excellent performance. We have made long-term investments in the UK in terms of facilities, human resources and methods to ensure that trains run at peak performance throughout the course of their life.

In signing a contract for new trains and service provision in 1999, Alstom had a long-term vision of its role, accepting responsibility for the fleet's daily performance for life. From the very beginning of the trains' conception, our engineers have kept maintenance in mind.

Investing in Traincare in the UK

In a major undertaking to fulfil this long-term commitment, Alstom has taken over the former Virgin West Coast depots in a long-term leasing agreement and transformed them into Traincare depots. The Pendolino fleet is serviced at these depots, the main ones being located in Glasgow, Manchester, Wolverhampton and London.

The WCML Traincare depots are equipped with the machinery, the components and the necessary expert staff to keep the Pendolino fleet running in peak condition, as well as other rolling stock maintained for customers other than Virgin West Coast.

Creating state-of-the-art Traincare depots: a €34-million investment

Following their take-over, Alstom invested over €34 million in modernizing former Virgin sites, transforming them into Traincare depots. New equipment at the depots includes: train-washing plants, simultaneous train lifting systems, wheel/bogie/equipment drop tables, controlled emission toilet facilities, and overhead air-conditioning lifting equipment. In addition, improvements were also made to track and overhead lines. The greatest changes were at Manchester, which hasn't seen this degree of modernization since the switch from steam to diesel in the 1950's. The simultaneous train lift can raise an entire nine-car Pendolino, facilitating access to the underside, notably for overhaul work.



3000 experts dedicated to maintenance performance in the UK

Maintenance-for-life calls for a specialized and dedicated team of experts. These teams must be familiar with a specific train's components and systems and then be able to provide the precise maintenance they need to function continuously at their best for the train's overall performance. To this end, Alstom has recruited many of its test department engineers into its Traincare depots to ensure it has the right level of expertise to maintain the Pendolinos.



Train washing at one of the Virgin Pendolino depots

- ┌ Rolling stock
- ┌ Maintenance
- ┌ Signaling

Raising UK train control to new European standards

Alstom's involvement in the West Coast upgrade also included designing, developing and delivering an innovative Tilt Authorisation and Speed Supervision system utilizing components from the European Railway Traffic Management System.



The Pendolino train includes an ergonomic driver cab and easy-to-use driver machine interface for operating the TASS tilt technology

As the spacing of tracks and the gauge for surrounding structures in the UK are smaller than for Continental European railways, Pendolinos in the UK cannot be allowed to tilt at will, for risk of coming into contact with other vehicles or infrastructure such as tunnel walls.

To satisfy the particular needs of Virgin Trains, our local Alstom team in the UK took the lead in defining the functionality and operating principles of the Tilt Authorization and Speed Supervision system (TASS).

The TASS system controls the train's ability to tilt according to its location, the train being tilt-locked by default unless otherwise signaled. TASS is fully compatible with ERTMS. The TASS system was developed and tested at our Midlands Test Center.

Since 2004, TASS has been in full-scale commercial service every day on almost all the passenger trains on the West Coast Main Line.

The new TASS system supervises the train using data from trackside eurobalises, spaced roughly two to five km apart, which pass data to the train. The data authorizes the train to tilt, turning the tilt system on and off at the appropriate places and defines the permitted speeds through curves. TASS is a fail-safe, SIL4 system; if a balise fails or is missed, the train will not tilt until the next valid working balise is reached and new instructions are provided.



The TASS computer is vital to train operation – it is triple redundant with a two-out-of-three voting system to ensure safe operation in tilt.

TASS awarded

The TASS system was declared the overall winner of the 2005 Railway Innovations Award, at a ceremony in London. "The judges were unanimously impressed with the Alstom-led solution: the way that the ERTMS components have been applied has been particularly ingenious. The result is a practical and effective system to resolve a challenging technical problem. All those involved showed both innovation and team spirit to produce a solution that has been operationally successful."

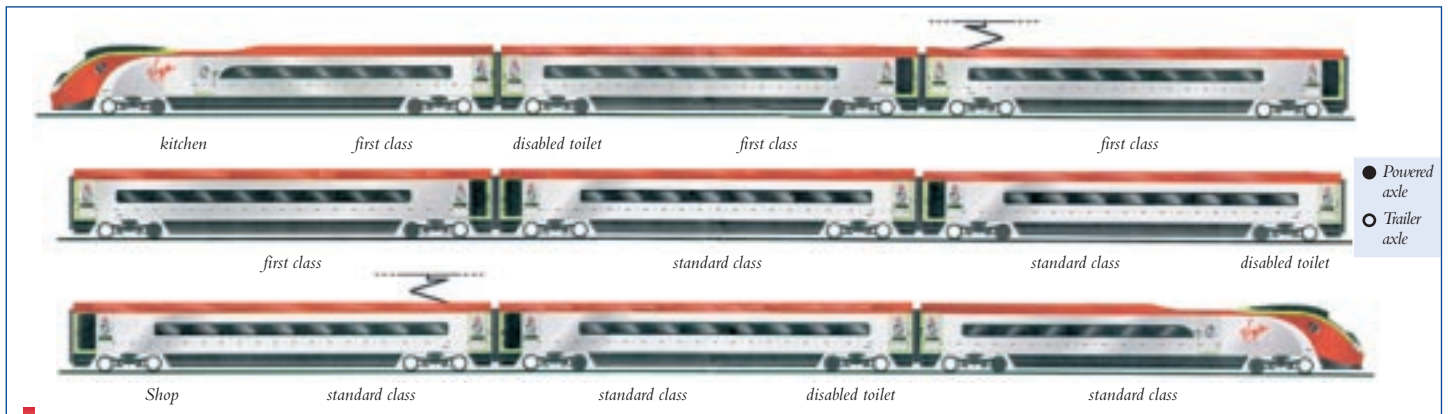
**UK industry magazine
Modern Railways, May 2005**



Engineers prepare for a test run with the TASS/Tilt test train at Alstom's Midlands Test Center

- ┌ For experts: Rolling stock
- ┌ For experts: Maintenance
- ┌ For experts: Signaling

Characteristics of this advanced-technology train



The Pendolino has 160 km of cabling and control wiring per train, 177 windows, 400 computers, 1,100 light bulbs, 11 air conditioning units, 188 brake pads and it carries 4695 litres of water

The Pendolino offers excellent performance in terms of acceleration, braking and ride quality. The train is powerful: at 5.1MW at the rail it has twice the traction power as its predecessor, the Class 87 locomotive and coaches trains operated by Virgin. Power is distributed through 12 traction motors to maximize adhesion

in acceleration/braking whilst keeping axle weights low.

The Pendolino accelerates from 0 to 100 km/h in under 60 seconds (900 meters) and reaches 200 km/h in just under 200 seconds. Braking is also a great improvement over the former Virgin fleet, with a 9% g brake delivered through three

braking systems including an energy-saving re-generative brake making its debut on intercity trains in the UK.

The tilt mechanism on the Pendolino allows it to corner 24% faster than non-tilt, for example, a train with tilt activated can take a bend at 200 kph but without tilt it must slow to 160 km/h.

Technical details

| | |
|---|---|
| Track gauge | 1435/1432 mm (UK standards) |
| Line voltage | 25 kV 50Hz |
| Bodyshell | Aluminium |
| Configuration | 9-car configuration. Distributed power : 12 motored axles |
| Total length | 217 m |
| External maximum width of trailer car | 2730 mm |
| Weight (running order/normal load) | 466 tonnes |
| Passenger capacity | 145 first class, 294 standard class |
| Traction power | 5.1 MW |
| Starting acceleration (0-100km/h) (normal load, half-worn wheels) | 0.368 m/s ² |
| Maximum traction effort (half-worn wheels) | 204 kN |
| Maximum speed | 200 km/h (225 km/h design speed) |
| Signaling equipment | TASS tilt signaling system and equipment |
| Tilt mechanism | Electric actuation |
| Specific provisions | Train management system; Electronic seat reservation system; AGATE e-Media audio and visual passenger information systems; Wheelchair-compatible doorways; Toilets for disabled passengers; At-seat audio entertainment system, Shop facilities |

- For experts: Rolling stock
- For experts: Maintenance
- For experts: Signaling

Availability guaranteed

Alstom's maintenance philosophy is based on a sound and detailed understanding of train equipment, from individual components to whole, integrated, functioning units, and the requirements to maintain performance and availability.

Our specialists develop maintenance plans based on assessments made from the fault log data of individual trains, an approach which reduces train downtime significantly. Overhaul and repairs of train components are carried out in our facilities, to increase further the availability of trains to our customers.



Virgin Pendolinos in the Wembley Traincare depot



HVAC (Heating, Ventilation & Air Conditioning) module testing after repairs

Activities for safety and reliability are based on the analysis of historical data. Such data is provided by the train's centralized, on-board diagnostic system, and enables faults to be identified quickly. It can also be used remotely to retrieve data from in-service trains.

A computer-tracked maintenance plan

Maintenance activities are managed with the help of a computer system: train, vehicle system and component histories, as well as costs, are tracked on a continuous basis. This on-going process not only facilitates planning and cost accounting, but creates a functional tool to adjust the maintenance activities and spare parts' provision. Maintenance manuals and documentation are also fully integrated by our TrainTracer™ system. This interactive, electronic information management system allows shared access of the relevant maintenance documentation across all our depots. TrainTracer is accessible at each WCML depot: in all, some 163 users in five sites – over 100 users can access the system simultaneously.

Best practices

Alstom maintenance practices include the use of condition-based monitoring technologies to ensure that the systems weakened by loss of redundancy are repaired before failure. Maintenance techniques such as machine vision (Padview and Treadview), vibration, ultrasonic and thermography analysis are all applied to the Pendolino running gear.



A maintenance technician carries out vibration analysis on the train

- For experts: Rolling stock
- For experts: Maintenance
- For experts: Signaling

Proven technology for safe operations and high-tech amenities

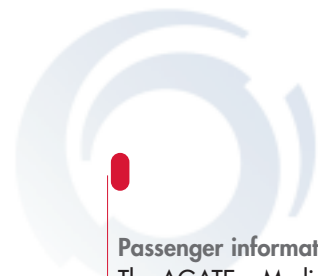
Alstom equipped the complete Virgin Pendolino fleet with its AGATE e-Media passenger information system.

Passenger amenities

Inside the train, as a passenger amenity, every seat has an electronic seat reservation display which can be updated when the train manager inputs the information onto the train's computer. This information is received from the central reservation system via Virgin's GSM network, and allows bookings up to half-an hour before departure. Electronic destination displays are provided on every exterior door and on every bulkhead. The displays are 'smart' indicators, with the train's

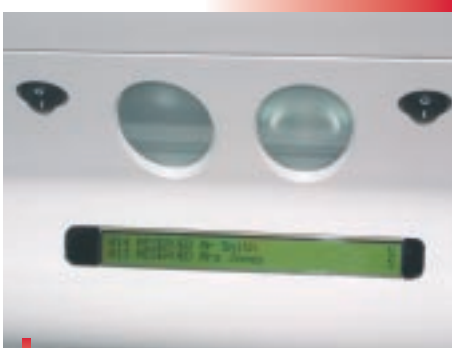
timetable in memory – they know the precise location of the train through the GPS tracking system – and display the next stop and calculate the expected arrival time.

The Pendolino is the first intercity train in the UK to have CCTV security cameras in every coach. These work continuously whenever the train is energized, with black box recordings to police standards. Each seat also features an airline-style audio system with 14 channels of live radio, news and recorded music.



Passenger information

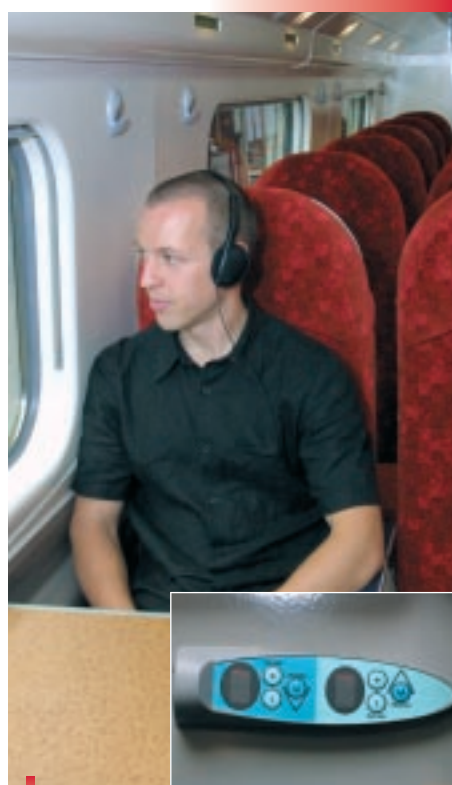
The AGATE e-Media range of solutions cover all trainborne or ground passenger information requirements. The 100T solution on-board the Virgin Pendolino includes: visual and audio station stop automated announcements, standard emergency messages that can be triggered by driver, passenger emergency intercom and background music.



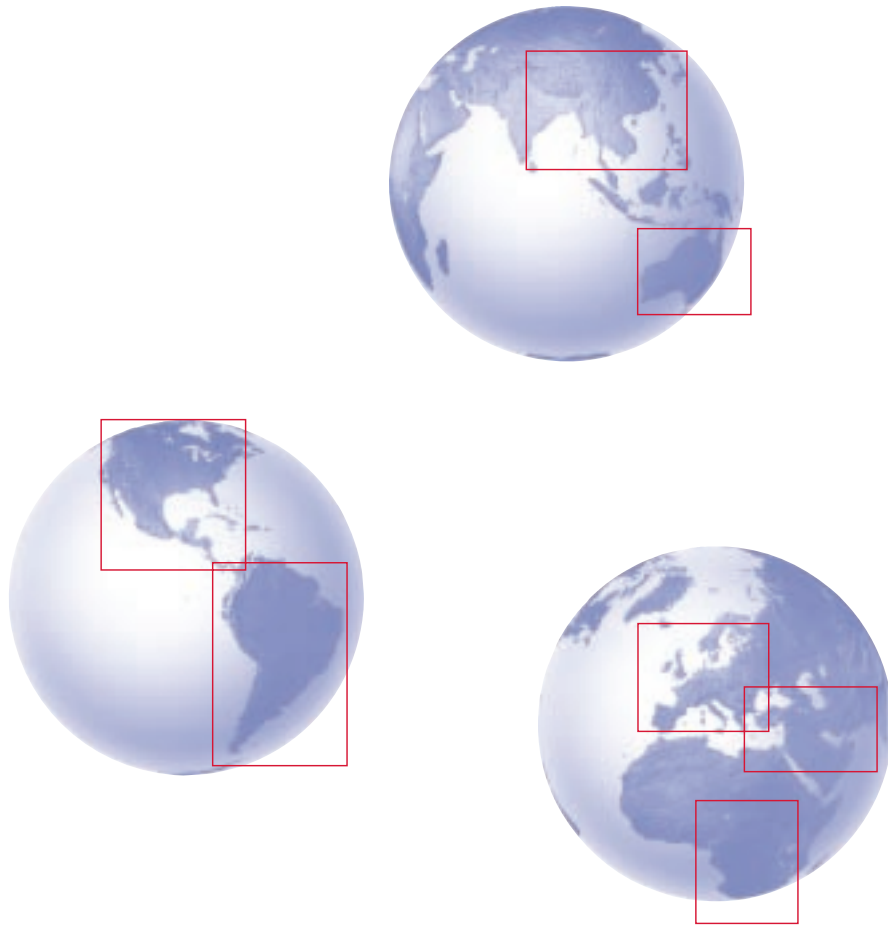
Electronic seat reservations displays are updated in real time by the train manager



Communicating in real-time with passengers is at the heart of customer-care for any modern transport system



Passengers benefit from a sophisticated at-seat audio system



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