Alstom—Future Trends in Railway Transportation

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Introduction

There is no doubt that railway transportation has a great future—it perfectly matches the needs of our modern society and economy, which is characterized by increasing mobility of goods and persons, high value of time saving, and demand for more safety while ensuring sustainable development. The public is coming to appreciate more-and-more the advantages of railways over other transport modes—higher energy efficiency, lower land occupation, lower emission (CO_2, pollutants), etc.

However, although rail's future looks brighter than it has for years, the world is changing fast with more competition between transport modes. For example, low-cost airlines are now competing directly with railway operators over some sectors. To make rail's bright future a reality, railway engineering companies must prepare and anticipate by investing in new technologies.

The new transportation systems (high-speed rail, tilting trains, digital signalling, driverless metros) developed in the last 20 years are now mature worldwide standards. In addition to 'historical' operators extending their networks, newcomers are emerging and both groups are demanding more. And their customers—railway operating companies—are changing too! They are less technical, meaning less 'directive' in their technical specifications, but are becoming more commercial and more business oriented in order to attract passengers and increase revenues.

In this rapidly changing world, Alstom wants to be the leader in offering new products matching customers' needs as demonstrated by its 'Customer First' corporate slogan.

Mature Railway Systems

High-speed rail transport

Alstom has been the major player in the evolution towards high-speed services with over 500 very-high-speed trains already delivered in Europe and throughout the world, and over 400 high-speed (more than 220 km/h) tilting trains. Alstom technology set the world railway speed record (515.3 km/h) in 1990, demonstrating the quality of its concepts and proving that there are still some margins left for even higher operations speeds.

After building three generations of TGV very-high-speed trains, Alstom is now developing the fourth generation Automotrice Grande Vitesse (AGV) with prototype delivery due in late 2007. The AGV will offer more modularity, more operation flexibility (ability to couple three trains), and will be more energy efficient due to massive weight reduction. The AGV will meet the various needs of all train operators worldwide.

Together with Alstom's redesigned duplex (double-deck) TGV, the company's AGV cutting-edge traction technology will complete the product line of very-high-speed trains from the AGV's seating capacity of 250 to 500 seats on the duplex TGV and up to more than 1200 seats on the 'jumbo' duplex TGV.

The debate over distributed traction versus centralized loco traction is finished because Alstom has mastered both and leaves the choice to the customer's specific needs—distributed traction for single-deck medium-capacity services, and centralized power for double-deck large-capacity services.

New AGV rolling stock (Alstom)

Digital signalling

The new European Rail Traffic Management System (ERTMS) represents a huge change in European train signalling systems. It is the first system adopted by all European networks after many decades of each country using dedicated national systems. It is the first digital system using a 'non-specific railway' media transmission called GSM-R between infrastructure and rolling stock. The system is flexible and can manage the movement of any train operating on any network, offering migration of train intelligence from the trackside onto the train. This is a real signalling revolution. Now the time for implementation has come after years of development (and millions of euros in costs); Alstom is playing a key role in implementation by taking the lead in two major European projects—conventional lines in

Switzerland, and a new high-speed line between Rome and Naples in Italy, as well as other Europe-wide projects. One challenge is keeping with the 'base' product guaranteeing Europe-wide interoperability, while taking as much account as possible of the specific needs of customers who are not ready to adapt their operational rules to the new ERTMS. It is imperative for Alstom to make ETRMS an operational reality, because it is of paramount importance in development of European cross-border operations!

Driverless metros

After the great success of our first fully driverless Singapore subway, operated by Singapore MRT Ltd. (see *JRTR* 18, pp. 26–30), the first system in the world designed and implemented by a single company, our goal is to create a unique generic product that we are calling *Urbalis Evolution* to meet the needs of every customer worldwide. It will support both the moving-block signalling system for driver operation as well as driverless operations, providing an easy migration path when the time is ripe. Support for platform doors, or any other system offering a very high level of safety for controlling passenger access to trains, is another example of the system's flexibility.

Future Products and Systems

Customers first and technology platforms

The days when customers (especially in Europe) were involved (at least partly) in rolling stock design and fed their expertise in operations and maintenance into new-product development have passed. European rolling-stock companies now perform development using their own resources, requiring increases in their expertise in new fields, such as operations and maintenance engineering. Based on its world-leading maintenance expertise acquired through various contracts (high-speed trains (AVEs) for RENFE in Spain, metros like the London Underground, locomotives as for the Burlington Northern Santa Fe (BNSF) Railway in the USA, etc. in Europe (especially in the UK and Spain) and the USA, Alstom has launched its new 'Design for Operability and Serviceability' programme, to give the company all the tools and methodology required to master all aspects of a new product in order to meet customers' needs for products that are ready to operate and easy to maintain with the lowest life-cycle cost. By mastering every aspect of the train, it becomes possible to pre-fit a train for modern maintenance technologies, such as conditional and predictive maintenance.

Mastering system

Many of our customers have been defining and designing whole systems such as high-speed systems for main lines and urban metros themselves.

On the other hand, some (mostly newcomers to the rail business) prefer to focus on their operator role and require delivery of a complete turnkey system that is ready to operate. Two good examples of the latter are Alstom's delivery of major components for the high-speed Korean Train Express (KTX) of Korea Railroad (Korail) (see *JRTR* 40, pp. 8–13), and the fully driverless Singapore subway.

To execute these two large contracts, Alstom developed a comprehensive engineering database including specific knowledge about all components of such systems, as well as mastery of all logistics interfaces needed to make the projects a success. The successful day-to-day operations of these two systems demonstrates Alstom's capacity to design, build, manage, and deliver high-quality transportation systems that integrate the specificities and operational practices of pre-existing networks for customers anywhere in the world.

As another example, although Alstom is

New CTRL2 high-speed line in UK (Alstom)

well known for its rolling stock and signalling products, few non-engineers know that the company is also in charge of design and delivery of the various elements (power supply, catenary, slab track) for the new Channel Tunnel Rail Link Section 2 (CTRL2) high-speed line linking the Channel Tunnel and London St. Pancras due to open for *Eurostar* services in 2007.

Clearly, any railway integrator like Alstom must now be able to master large transportation systems based on comprehensive knowledge of each and every component.

Standardized or Specific Products

The majority of European operators have a long history of defining products (rolling stock, power supply, signalling, catenaries) they need. Consequently, during product development, they were closely involved in design review, prototype testing at their own facilities, and integrating maintenance and operations requirements.

Under these circumstances, they were prepared to pay for development costs and could accept a development schedule that included a debugging period early in the new product life cycle. However, this is no longer true for any customer. Now products must be delivered on a very tight schedule, fully ready for operation with operating and maintenance rules integrated. And the development cost must be borne by the supplier. However, at the same time (and too frequently), the same customer still wants a product closely fitting specific needs, and with a specific design (aesthetics and interior) offering flagship recognition.

Managing this contradiction

The rest of this article explains how Alstom developed the *Citadis* platform to solve these contradictory needs for light rail vehicles (LRVs).

Alstom has been developing standardized platforms (traction equipment, bogies, digital signalling, etc.) for some years, but the company can also offer flexible architectures for various configurations matching specific customer needs.

The key has been to develop prevalidated components or sub-systems that can be shared by products. For example, although Alstom's new *Pendolino* (250 km/h, tilting high-speed train) and the AGV (350 km/h, distributed power) seem to be quite different products, they share a significant number of components.

Sustainable Development

Although railway transportation is by far the best solution for sustainable development compared to other modes, railway companies must still demonstrate to customers and public bodies that they are pursuing improvements.

For example, energy efficiency can be improved further by implementing regenerative braking on almost any train, even high-speed trains where it is less useful than for urban trains and which must have rheostatic braking for safety. Consequently, even the two very high-speed Duplex TGV and AGV both have rheostatic and regenerative braking.

Another and complementary way to save energy is to reduce train weight. This is a permanent ongoing project for Alstom engineers based on intelligent design (optimizing structure) and use of new materials (high-tensile steel, alloys and composites). For example, at 200-m long and a weight of just 380 tonnes when fully loaded with 450 passengers, the AGV sets a new lightweight record in the TGV family, which is itself already lighter than many competitors thanks to the reduced number of bogies.

Ecological design

Building environment-friendly products is a must for engineers. In train design, typical eco goals are:

- Only air- or water-cooled traction
- No liquid emissions on track (for example, storage toilets and non-chemical water additives)
- Reduced noise and vibration levels (for example, more than 10 dB (A) reduction between first and third generation TGVs at maximum speed)
- Complete material lifetime inventory management (selection of easily recycled materials and use of less materials)

Citadis—Standardization and Customization

The new *Citadis* LRV product range is an example of the genuine synthesis Alstom is achieving in developing new products and typifies what the company aims to offer customers—a customized product with a standard technical platform; a beautiful and unique train; and high environmental friendliness.

The unique *Citadis* concept is based on modularity, standardization and customization:

- Modularity enables the capacity to meet the client's evolving needs (for example, by increasing length). *Citadis* meets the widest possible range of size needs—body width can vary from 2.3 to 2.65 m while lengths can vary from 20 to 50 m. In Montpellier (France), *Citadis* trams were so popular that after 2 years the operator had to increase carrying capacity and ordered thirty 10-m extensions for the existing vehicles. All vehicles were extended to 40 m in summer 2002 with no interruption to commercial services (Fig. 1).
- Standardization permits reduced acquisition costs with decreased delivery times and assured high quality. The *Citadis* modularized range of service-proven traction systems and bogies permits customers to tailor each vehicle to their needs and constraints. To offer world-class products in small

Figure 1 Modular *Citadis* Tram

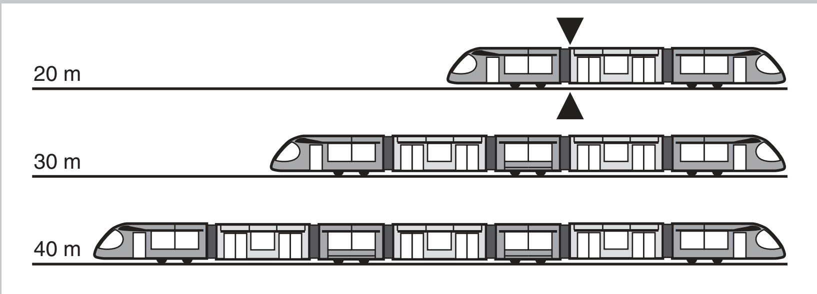


Figure 2 One City, One Image

lots, Alstom developed Optionic Design, its generic train design methodology. This was conceived to answer evolving customer needs by proposing technically-proven solutions scaled to specific requirements like new specifications, tighter budgets, and shortened manufacturing lead times. Customers benefit from upstream cost reductions while Optionic Design offers Alstom unique flexibility in meeting evolving needs worldwide.

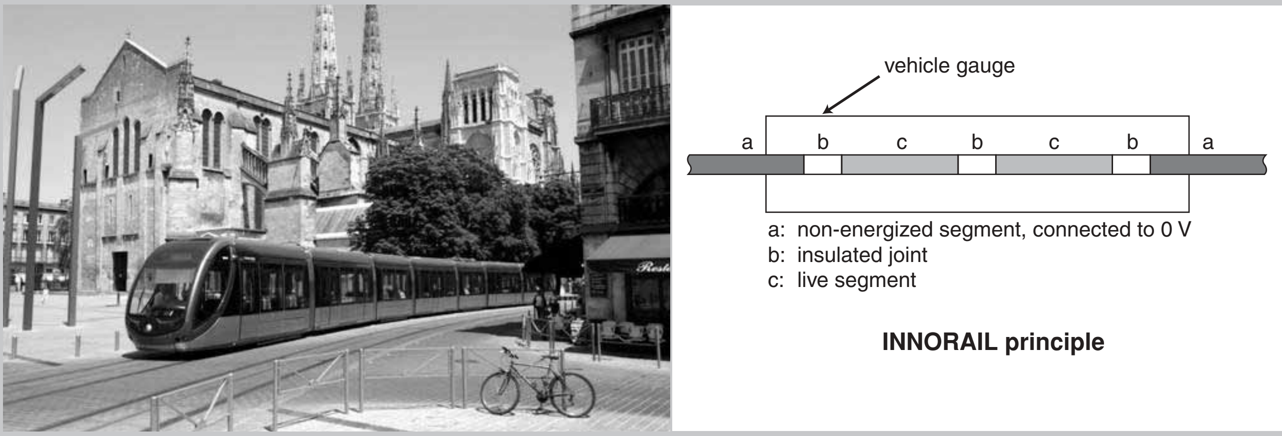
• Customization offers customers key visible elements to achieve a flagship image. *Citadis* technical standardization doesn't automatically mean a fixed-design interior and exterior. The Optionic Design system allows Alstom to offer service-proven solutions scaled to unique local dimensions and configured to specific city requirements. These are integrated at the very beginning of the design process to produce an offer incorporating standardization and customization. In addition, customers can define certain characteristics, such as head design, car interior, seat arrangement, passenger amenities, and driver's cab and control panel, downstream. This means that although *Citadis* trams are technically similar, no two have exactly the same interior or exterior design. In this way, each *Citadis* tram can be a flagship for the municipal spirit.
Customization is shown in Figure 2, illustrating the various head designs of the single *Citadis* family. From left to right and top to bottom they are: Barcelona, Bordeaux Dublin, Orléans, Rotterdam, Melbourne, proposed design, Lyons, Montepellier, Paris, Strasbourg, Valenciennes.

Catenary-free Solutions

Environment-friendly design is not just about noise, pollution and sustainable development. It also means full visual harmony with the city backdrop. Some cities with historic architecture require different solutions such as catenary-free trams either in just the city centre or across the whole system. And to save energy, Alstom offers technologies to recover braking energy while remaining zero-emission vehicles. Depending on the

Artist's impression of *Citadis* crossing Place Masséna (Mission Tramway Nice) (Alstom)

Figure 3 *Citadis* Tram in Front of Bordeaux Cathedral



length of the catenary-free section, different technologies can be used, as explained below.

Battery for short sections

For catenary-free sections of limited length, such as crossing an historic square in a city centre, high-speed performance is irrelevant. For example, Nice in south-east France has two historic squares at the Place Masséna and Place Garibaldi that required catenary-free operation for a distance of about 500 m each. To meet this need and degraded mode requirements, the city choose *Citadis* trams. These 20 vehicles, to be delivered in 2007, will carry NiMH batteries, which offer a good compromise between performance, weight, volume and life-cycle cost, allowing the trams to cross the two catenary-free squares at lower speeds.

INNORAIL for longer sections

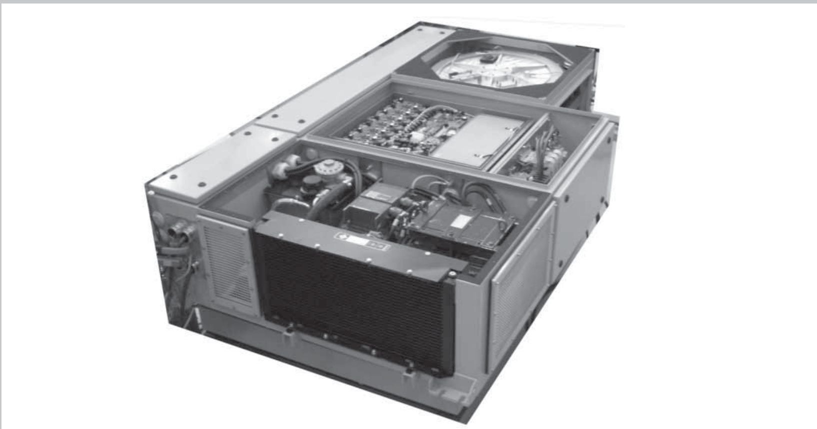
The Bordeaux Urban Community in south-west France is developing a new three-line tramway network that will total 43 km in 2007. One 10.5-km section is catenary-free. The delivered solution combines normal overhead power collection by pantograph from a catenary plus the INNORAIL power supply system developed by Alstom. This novel system integrates a conducting rail into the track infrastructure; the rail is divided into sections separated by insulated joints and either one or two sections are energized at any one time. The energized section is always just under the vehicle between the front and back axles to power the vehicle along the track.

Switching between the INNORAIL section and the catenary is controlled from the driver's cab. When the vehicle is stopped, the pantograph is lowered and the pickup shoes are lowered at the transition from the catenary section to the INNORAIL section and *vice versa*.

The inner bogie of each vehicle has two current pickups and antennas. The distance between the two pickups is longer than the length of the insulated joints, allowing continuity of power feeding as the vehicle moves from one section to the next. Each section is associated with a detection loop and the presence of each vehicle on a section is indicated by the on-board antennas.

The system uses 70 *Citadis* trams with the first units entering service on Line A in December 2003, followed by Line C in April 2004 and Line B in July 2004.

Figure 4 Flywheel on *Citadis* Roof



Flywheel in Rotterdam

The old-fashioned concept of flywheel storage offers a promising new way of storing energy on-board. It allows trams to operate over catenary-free sections and to recover braking energy, thus saving energy and permitting system optimization.

The advantages of flywheels are better cycle life and power density and rapid charge rate and storage efficiency. The energy stored in a flywheel is proportional to the square of the rotation speed and the square of the flywheel diameter but is only proportional to its mass. Modern flywheels made of composites with integrated electrical equipment and enclosed in a safe vacuum container are designed to rotate at speeds above 20,000 rpm, providing a net energy storage of 4 kWh and 325 kW of peak power.

The flywheel stores the energy generated during braking and makes it available when the vehicle accelerates to offer two advantages:

- On catenary-free sections, the vehicle can run at reasonable speed with good acceleration. Thanks to its rapid charge rate, the flywheel can be 'replenished' while the vehicle is standing at stops, allowing operation in a city free of overhead wires.
- On sections with a catenary, the flywheel provides load levelling to reduce investment in ground infrastructure.

Recent new technologies have led to huge reductions in flywheel size, permitting roof mounting. Working in conjunctions with the Center for Construction and Mechatronics (CCM) in the Netherlands, Alstom is carrying out a demonstration test using one of the 60 *Citadis* vehicles delivered to RET, the Rotterdom operator. After bench testing and runs on a test track in La Rochelle, the tram is now undergoing testing on Rotterdam's tramway network.

Citadis flywheel tests in Rotterdam (Alstom)

Conclusion

In the 1970s and 80s, many so-called 'transport experts' were predicting the demise of railway transportation in the face of other modern modes. But the rail resurgence this century leaves no doubt at all that rail is the best transport mode for modern advanced cities and that railways are here to stay.

But what about today's railway builders? The world is changing and to survive they must be more customer focussed; must increase and expand their skills; must be aware of growing environment concerns; and must undertake sustainable development. There are still good business opportunities, but they must be identified and taken on board. Railway builders have to remain more innovative, more focussed on customer needs, and deeply involved in the move towards sustainable development.

By doing so, we will all benefit and thrive. ■

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Mr Lacôte is Vice President for Technology of ALSTOM Transport. He graduated in engineering from Ecole Polytechnique and Ecole Nationale des Ponts et Chaussées and joined SNCF in 1974. He held various senior posts in rolling stock at SNCF and was in charge of development of the French TGV. He was Scientific and Technical Advisor to the SNCF Chairman before assuming his present post. The French government has conferred the chevalier de la Légion d'honneur on him.