Feature

Hitachi's Entry into the European Railway Market

Sir Stephen Gomersall

Introduction

On 1 June 2005, Hitachi concluded its first major contract with the British Strategic Rail Authority (SRA) for the supply of high-speed trains to the UK network for services beginning in 2009. I am grateful for this opportunity to describe to *JRTR* readers some of the background and details of this contract, and what it may mean for the future of relations between Japan and Europe in the railway industry.

Fortunately, Hitachi was named preferred supplier for this important new business exactly when I joined the company as the person responsible for the Group's European strategy. The success helped re-awaken interest in Europe as a growth area for Hitachi's global business. The reasons behind it were threefold: first, a determined effort by the team involved, under the leadership of then Vice President Mr Yoshiro Kuwata, to enter the British market. Preparation took 5 years and success came only at the third attempt; second, the enormous effort taken to prove Hitachi's systems on the UK network by running a demonstration train—this helped not only convince the policymakers that Hitachi was serious, but also built relationships with future partners; third, the quality of the offer combined with the dissatisfaction of the British government with the performance of new trains ordered from other manufacturers.

Britain has a long history of association with Japan in the railway field. British engineers and banks helped to build Japan's first railways, and many early locomotives were supplied from the UK. When the latest privatizations took place in Japan and the UK, Japan retained a vertically integrated regional company structure, while the British government separated the ownership of track and trains, and allowed competing operators to use the same lines. For the first 10 years of British privatization, this complex structure of targets and financial penalties, which was supposed to raise performance, combined with the generally poor state of both infrastructure and rolling stock, led to poor morale in the industry and a general feeling that Japan had done everything right while Britain had done everything wrong. While I was British Ambassador to Japan, British operators were reluctant even to visit Japan because the levels of performance were thought to be so advanced as to be inapplicable in a British context. Nonetheless, in 2000, we re-established a regular government-to-government railway dialogue with private-sector participation, resulting in open and valuable debate both on policy and on technologies.

Things are now changing. The railways in Britain have shown the fastest growth in Europe, with passenger miles travelled increasing by 39% over the last decade, and freight by 48%. Timekeeping has significantly improved. Lessons have been learned from problems with the early operating franchises, and there is a sense of greater stability and confidence in the industry. For the first time, the government has started talking about studies of a high-speed rail network (although many doubt that it will finance a new shinkansen-type system). Therefore, we hope that the introduction of Hitachi's trains on the Channel Tunnel Rail Link (CTRL) in 2009 will be another positive step in re-building railways in Britain to the highest international standards.

From steam to shinkansen

Hitachi has been manufacturing railway systems since it first manufactured steam locomotives in 1920. The company now supplies total rail systems including electric multiple units (EMUs), shinkansen train sets, monorails, signalling and electrical power and supply systems. Since the 1950s, Hitachi has been working on the world-famous shinkansen system that entered operations in 1964. Hitachi's scope of supply includes rolling stock, propulsion equipment, signalling systems, substations and seat reservation systems. One of the first Series 0 is now in the British National Railway Museum in York. Since then, Hitachi has produced more than 1500 shinkansen carriages, and

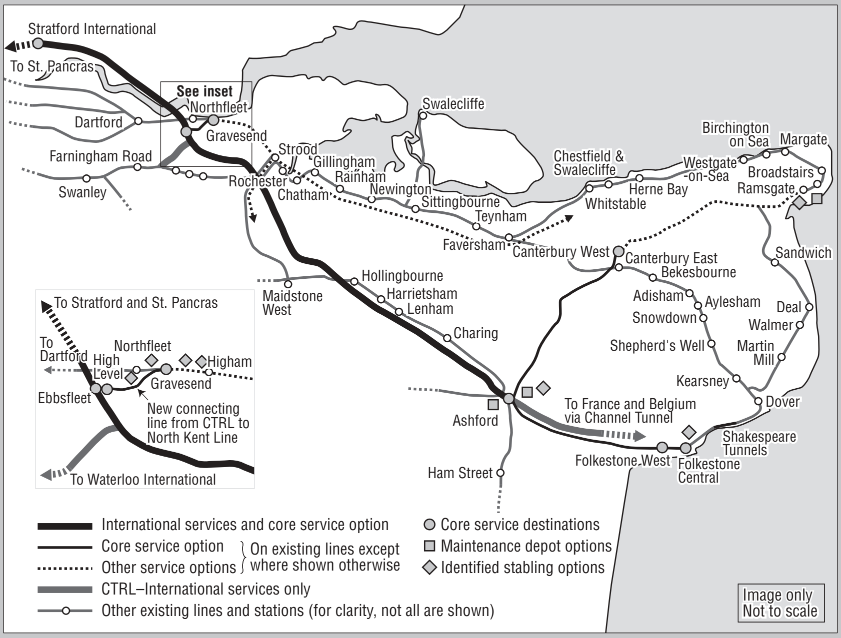
Hitachi Kasado Works in Yamaguchi Prefecture (Hitachi Europe) is currently supplying its most up-to-date 'bullet trains' to Taiwan. Trials of a future generation of shinkansen designed to run at 360 km/h are now underway in cooperation with JR East.

Setting future standards

Tough competition and environmental standards have forced operators in Japan and elsewhere to look not only at speed, but at cost, weight, and environmental concerns. Hitachi's solutions include its A-train rolling stock with a recyclable modular structure and a new production system; signalling systems using advanced information technology; and an environment-friendly train fitted with a hybrid power system.

Image of A-train (Hitachi Europe)

Figure 1 Route of CTRL Domestic Service



A-train and Characteristics of UK Rolling Stock

The A-train, Hitachi's latest aluminium railcar system, was initially placed in service on commuter and suburban lines, and has now been developed and deployed on high-speed routes. It features: (1) a precision, high-quality aluminium double-skin body constructed by friction-stir welding (FSW); (2) fully self-supporting interior modules; and (3) an integral hollow extruded mounting rail to which the modules are fastened. In addition to providing a quieter ride, better rigidity, and improved safety, the use of FSW technology results in sleek aluminium double-skin rail carriages with virtually no distortion. Adoption of a modular approach for the interior has reduced the production lead time, simplified the work involved in refurbishing carriages, and yielded other cost efficiencies. Finally, the fastenings were designed with recycling in mind to facilitate dismantling of decommissioned cars and sorting of materials.

Domestic trains on the CTRL will link London St. Pancras Station and east London with the Kent coast, sharing the new tracks also used by the *Eurostar* services to France and Belgium (Fig. 1). The contract provides for Hitachi to build and maintain 28 new high-speed A-trains, which will be owned by HSBC Rail as the rolling stock leasing company (ROSCO) and leased to the operator of the Integrated Kent Franchise.

From the *Eurostar* lines, the trains will divert onto local lines to destinations in Kent. Units will operate in 12-car formations during peak hours with coupling and uncoupling at Ashford. This will slash journey times into London. In addition, following the announcement that London is to host the 2012 Olympic Games, the service will be an integral part of the system transporting spectators to the games via Stratford in east London.

Hitachi's long experience of designing and manufacturing shinkansen trains, which operate in a heavily tunnelled environment and in some cases on existing lines, has been a perfect basis for developing the high-speed A-train design.

Train configuration

The 225.3 km/h Hitachi A-trains will be configured as six-car units with 354 'premium' standard seats fully compliant with the RVAR and Disability Act, including space for two wheelchairs and one standard and one disabled toilet. Train configuration has been optimized for standardization to maximize reliability consisting of two basic car designs per six-car unit as follows:

- 2 x Driving Pantograph Trailer Standard
  One car with disabled toilet module
  One car with standard toilet module
- 4 x Motor Standard

British interior design experts are now working with Hitachi to create a highly attractive interior, using experience gained from recent commissions to build new rolling stock in the UK. The designers will build-in measures to combat vandalism and maximize reliability. Although key changes to the standard Japanese designs are necessary to meet UK standards and regulations in some areas, the Japanese approach to reliability and availability has not been compromised in the high-speed A-train design.

The train has significant levels of redundancy in all major systems with the ability to keep on timetable even with a 25% loss in traction performance. Japanese-style sliding doors have been retained from the shinkansen design to deliver high reliability and meet the strict requirement for dwell times of 1 minute on the new CTRL lines. Coupling and uncoupling will be a key feature of the service, as units will be configured to operate in 12-car formations for peak services. Coupling and uncoupling will be achieved in just 1 minute, which is a common feature in Japanese rail operations. Indeed, a number of systems that were previously unique to Japan will be introduced to the UK on the new A-trains to cope with service demands.

Carriage body design

The carriage body will be manufactured from lightweight, easy-to-recycle aluminium. Double-skinned aluminium extrusions are assembled to form a frameless body shell, giving excellent sound insulation and the ability to insert a fully modular interior. In order to manufacture to high tolerances and minimize weight, Hitachi has pioneered use of FSW to minimize distortion during manufacturing. Rather than melting, this method uses plastic flow to join aluminium thereby making the joints stronger than the parent metal itself. This results in a smoother surface finish and a stronger car body at lower weight. In addition, to cope with high-speed operation on heavily tunnelled routes, the cars will be airtight to minimize passenger discomfort from air pressure changes. Hitachi has many years of experience in design for tunnel operations and has a unique air chamber testing facility at its Kasado Works in southern Japan.

Bogie design

The combination of high-speed running on new infrastructure and low-speed running over tight curves gives a number of challenges to the A-train bogie design. Hitachi has designed and produced a bogie specifically for the UK market in collaboration with established UK experts utilizing measured UK track data. This bogie design will be optimized during the train design programme and extensive work has already begun with Network Rail to optimize this design and harmonize the interface with the infrastructure.

Manufacturing and testing

Although a number of key components will be sourced from leading European suppliers to meet UK standards and regulations, the trains will be manufactured in Japan and shipped complete to the UK. Hitachi's main works at Kasado will use its own dock so that completed carriages can move straight from the test track to ships for transportation to the UK.

As part of the comprehensive on-site testing facilities, Hitachi has a Real Time Simulator, which is used to verify the hardware and software of logic units and traction inverter control algorithms. It simulates electrical systems such as voltage sources, filters, inverters, motors, and also mechanical systems, such as models of bogies, car bodies, and adhesion characteristics. It is connected with the actual logic unit and verifies the logic unit's hardware and software. A dynamometer test bed will be used during verification of electrical equipment and combined testing of electrical equipment, such as transformers, inverters, and motors. An equivalent condition to actual running conditions is achieved by using flywheels as load. The dynamometer test bed is also used for testing mechanical equipment, such as bogies and brakes. Soak tests will be carried out to establish running temperatures for electrical and mechanical equipment.

However, Hitachi recognizes the fact that absolute testing can only be done in the

Artist's image of CTRL domestic train (Hitachi Europe)

UK on the UK network. The company faces a key challenge to complete comprehensive testing and gain approvals for both the DC networks in Kent and the new CTRL AC lines.

Understanding key differences between UK and Japanese railway standards and operations has been essential in Hitachi's preparations to enter the UK rolling-stock market. Over the last 4 years, Hitachi has invested heavily in demonstrating the compatibility and reliability of its traction and electrical systems through its verification train project. This test train has successfully completed testing on the AC and DC networks and the CTRL line. The results of these tests, as well as the measurement of track quality, will be fed into the design process for the high-speed A-train. Ensuring success in these critical areas has been a key element in our preparation. Hitachi is looking forward to forming a strong team with the new operator of Integrated Kent Franchise and Network Rail to meet these challenges.

Delivery, operation and maintenance

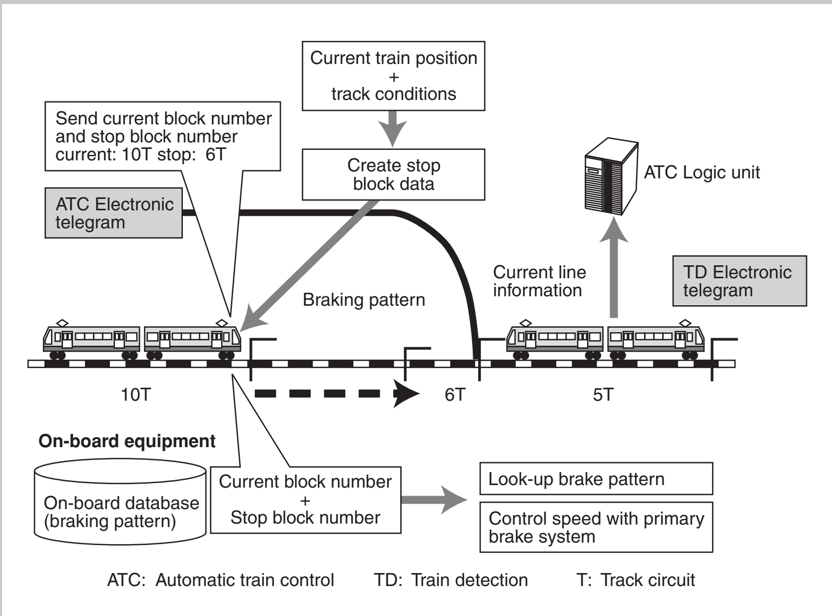
The first four units will be delivered during the summer of 2007. Depot construction is being managed by the Department for Transport and it will be handed over to Hitachi as a fully fitted and functional depot prior to the first delivery.

These first four units will be used extensively for the testing programme. The rest of the fleet will be delivered progressively throughout 2009 and the service will be introduced in full by the end of that year.

Hitachi has worked with leading experts in the UK to develop a maintenance solution that integrates the Japanese maintenance approach into the UK. Maintenance will be conducted by fully trained UK technicians. The Japanese approach sees Hitachi working with stringent targets relating to reliability, maintainability, testability, and availability. These drive low life-cycle costs and enable Hitachi to confidently guarantee high levels of reliability. The company's maintenance philosophy focusses on preventive maintenance leading to predictive maintenance over a period of time.

To ensure rapid reliability growth, initially a defensive approach will be taken. Relatively frequent inspections and cautious criteria for changing wearing parts will be used until the build-up of

Figure 2 Digital ATC System



evidence and data permits construction of algorithms to accurately predict parts life, taking into account all aspects of the duty cycle.

Using modern proven technology, maintenance is becoming increasingly automated. This enhances the level of data/records, reduces manpower levels, increases the quality of data and results in the continuing development of predictive-based maintenance, hence further optimizing cost.

In the following sections, I would like to introduce Hitachi's recent technical achievements in Japan.

Advanced On-board Radio-based Signalling System

Hitachi has developed signalling systems to increase transportation capacity and ease rush-hour traffic on busy lines, using digital information processing and telecommunication technologies. The Digital Automatic Train Control (Digital ATC) on-board signalling system (Fig. 2) developed by Hitachi has been operating in the Greater Tokyo area since 2003 and on the Tohoku Shinkansen since 2004. Lines with on-board signalling installed as standard are expanding. The main features of Digital ATC are:

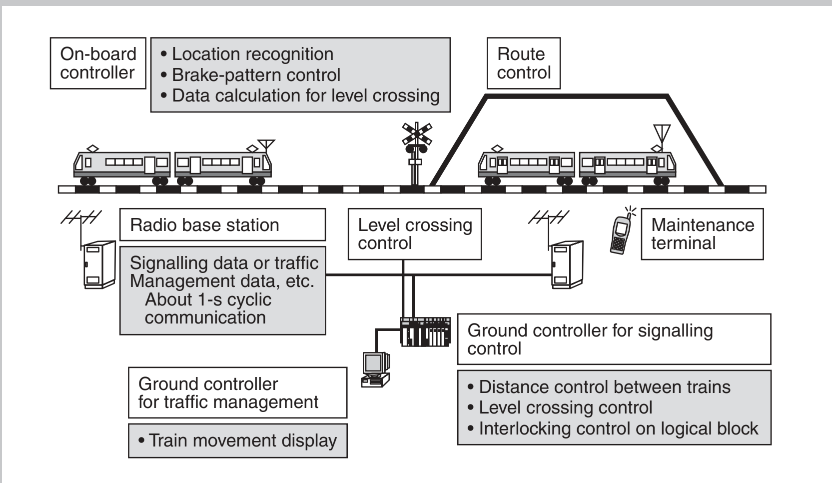
- Conventional automatic train protection (ATP) systems control the train speed in accordance with the permitted speed for each block section, but multiple braking is necessary before the trains stop. Therefore, trains start decelerating far before the theoretical minimum braking distance, resulting in headway losses and increased journey times. Digital ATC transmits stopping point information to an on-board device by a digital telegram via the rail. The on-board device selects the optimum restricted speed profile from the on-board database according to the telegram. Then, the on-board system applies steady continuous braking to improve ride comfort and actually shorten journey time by decreasing braking amounts.
- The train brake control system can be upgraded to improve operating performance without changing the ground equipment by merely updating the on-board equipment database.
- The system provides both excellent reliability and cost performance by using general-purpose IT equipment and by switching over to total equipment fault diagnosis via an automated system.

The main target of radio-based signalling is to eliminate safety control based on track circuits. Its basic function is to determine train location at the on-board controller, transmit this information to a field controller by radio communications, track all trains with this data at the field controller and transmit the limit of movement authority from the field controller to the train.

It is an on-board controller-driven system with following functions: (1) to determine the location of trains as in Digital ATC; (2) to communicate with field controllers; (3) to generate brake patterns according to continuously changing line movement authority; and (4) to cope with problems in communication or position recognition. The field receivers must have train-tracking functions to pinpoint the location of trains by using train location recognition data instead of track circuits. The system enables moving-block control because train location data is point data and does not occupy track circuits. Field controllers must track trains by controlling the hand-over between radio equipment, such as a cellular phone, because one piece of ground-side radio equipment cannot cover a long distance. This method enables ground-side equipment to track and communicate with trains over the whole line. This radio-based signalling makes field controllers and trains cooperate through duplex radio.

Hitachi is playing an important role in development of the radio-based signalling system called the Advanced Train Administration and Communications System (ATACS) led by JR East and installed on JR East's Senseki Line since 1997 (Fig. 3). The basic functions have been verified through extensive tests. Between October 2003 and February 2005, tests on ATACS

Figure 3 ATACS System



equipment installed on all 18 EMUs running on the Senseki Line confirmed long-term safety and reliability plus many additional functions.

Environment-friendly Diesel Trains from Hitachi

Railways contributing to global warming countermeasures

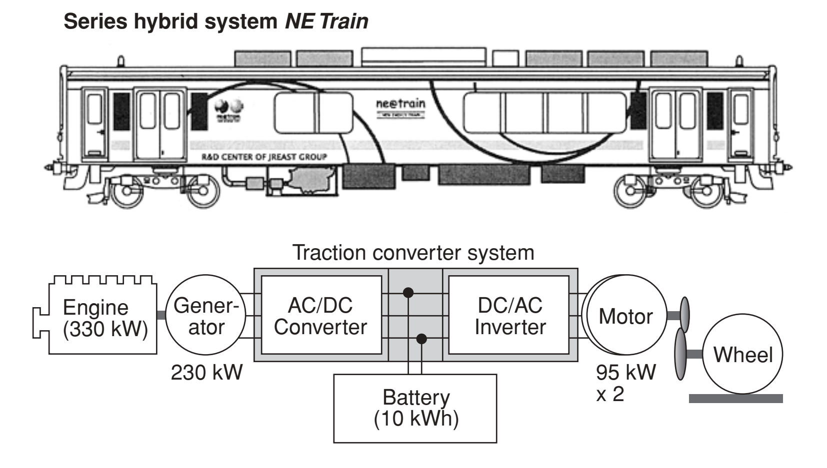
The entire 20th century has been characterized by a pursuit of greater comfort and convenience in human lifestyles. Technology has evolved exponentially over this period. However, at the same time, there have been growing concerns regarding destruction of the natural environment—particularly the effects of global warming caused by CO_2 and other greenhouse gases. Measures to combat these trends have become an increasingly urgent issue.

Many developed nations have adopted the Kyoto Protocol, stipulating that overall emissions of greenhouse gases shall be reduced by at least 5% below 1990 levels. To achieve these goals, global-warming prevention measures must be undertaken by both the private and public sector; in other words, we must work to reduce CO_2 exhaust volumes.

Railways are said to be environmentally friendly compared with automobiles, but there is still more progress to be made on environmental issues in the industry. Hitachi, jointly with JR East, has developed a hybrid traction system that contributes to reduction of CO_2 on a global scale to protect the Earth by improving fuel consumption of diesel trains.

JR East's Class *Kiya* E991 hybrid train (Hitachi Europe)

Figure 4 Hybrid Traction System



Hybrid traction system

As a step towards providing environmental-friendly propulsion systems, Hitachi has developed a hybrid traction system, combining an engine generator with storage batteries (Fig. 4). This system provides regenerative braking that was not previously possible on conventional diesel-powered trains, making it possible to increase energy savings via regenerated power. The system uses a series-hybrid configuration designed to allow immediate system conversion (by replacing the engine generator with a fuel-cell unit) in the future when fuel-cell technology becomes more widely established.

This hybrid traction system was installed in a JR East Class *Kiya* E991 experimental vehicle for performance trials. The *Kiya* E991 has a 330-kW engine, 230-kW generator (rated) and two 95-kW (rated)

traction motors. In normal operation, the train starts using battery power only. At 30 kph, when the battery reaches its maximum discharge level, the diesel engine regenerates most of the power required for continued acceleration up to maximum speed. Charging of the battery begins after the train has started to coast and decelerate. This is then supplemented during regenerative braking.
The hybrid experimental train has run for more than 25,000 km on JR East's lines since May 2003, achieving the following results:
- 20% reduction in fuel
- 50% reduction in emissions
- Noise reduction near stations
- Reduction in maintenance costs

The environment-friendly hybrid trains have attracted interest from across the globe. The hybrid traction system has the following advantages:
- Creation of environment-friendly systems
  The series-hybrid system allows engine speed to be set irrespective of vehicle speed, permitting high-efficiency power generation as a result of operating predominantly in the low-fuel-consumption engine speed range, which also reduces exhaust gases. The use of electric train inverter control technology allows regenerative braking. Using regenerated energy temporarily stored in batteries as auxiliary power for acceleration is expected to give fuel savings of approximately 20% and to reduce emissions by approximately 50% compared with conventional diesel trains. An engine cut-out control is also used to reduce noise when stopped at stations.
- Reduced maintenance
  The series-hybrid system eliminates the need for equipment such as hydraulic transmissions, which entail high maintenance costs on conventional diesel trains. Similarly, commonality of equipment with electric trains saves on maintenance labour costs and allows more efficient utilization of existing inspection equipment.

Following successful trials of the Class *Kiya* E991, JR East has desided to start commercial operations with newly-built three-car hybrid DMUs on the Koumi Line in 2007.

Stepping Forward

For the time being, Hitachi's efforts in the European railway sector are very much focused on delivering the UK CTRL project to time and with 100% reliability. Excellent performance will be one of the keys to acceptance of Japanese technology within the European market, where other opportunities are now likely to arise. Using some of the technologies referred to above, Hitachi will be a bidder for other UK projects, and will be looking in due course at how it could meet the requirements of other European markets for rail vehicles, power components and control systems. Future work is bound to involve both greater European content on the one hand, and a willingness to work with other Japanese companies and international consortia on major projects. Hitachi firmly believes that the key to success will mean being appreciated as a company that contributes to local industry, and to understand and meet precisely the needs of each customer in the most competitive and dependable manner. ■

Stephen J. Gomersall

Sir Stephen Gomersall is Chief Executive for Europe at Hitachi, Ltd. He joined Hitachi following his retirement in 2004 as British Ambassador to Japan, a role he held since 1999. His roles as a UK diplomat for 34 years include Director of International Security at the Foreign and Commonwealth Office, Ambassador and Deputy Permanent Representative of the UK Mission to the UN, and Head of Security Policy Department.

Further Reading

S. Aoyagi, Development of ATACS and the Second Phase Test Run Result, WCRR2001, 2001.
Y. Baba, et al., Radio Train Control System (ATACS), *JR East Technical Review*, No. 3, 2004.
Y. Kon, Development in Japan: Latest State of the ATACS System, UIC2002, 2002.
Y. Kon, The New Train Control System ATACS by Using ADS Technologies, IWADS2002, 2002.