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CCS TSI Compliant On-board ETCS Development

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OVERVIEW: A Standardised Signalling System has been introduced for the further improvement of railway operation and capacity enhancement. ETCS is a common signalling system which has been developed in Europe to enable train services to cross boundaries between different countries without the need to change signalling systems or locomotives. ETCS is part of the ERTMS and many systems have already been implemented around the world. In November 2013, Hitachi On-board ETCS was formally endorsed through a rigorous European assessment process demonstrating compliance with the relevant TSIs and European Norms at the highest Safety Integrity Level (SIL4). Hitachi's IEP Class 800/801 will be fitted with Hitachi on-board ETCS.

INTRODUCTION

In the UK, Hitachi has successfully delivered the Class 395 fleets for High Speed 1 (HS1) and completed traction replacement for the Class 465 fleets. Thanks to the on time, on budget delivery of these projects and remarkable reliability figures, the biggest rolling stock contract in UK railway history has been awarded to Hitachi; known as the Intercity Express Programme (IEP), including rolling stock delivery as well as maintenance (see Fig. 1). These achievements drive Hitachi's growth in transportation systems on a global scale.

Fig. 1—IEP rolling stock
This is a computer graphic of Hitachi's IEP rolling stock for the UK

Hitachi has commenced the development of an European Train Control System (ETCS) solution, which is a single and harmonised signalling system, with the ambition of becoming a global market supplier. This has been a joint development with Network Rail (NR) who is the Infrastructure Manager of the UK rail network and responsible for the implementation of ETCS in accordance with applicable EU directives. Hitachi, working in collaboration with NR, successfully delivered a proof of concept for the on-board Hitachi ETCS. This was fitted to a Class 97 locomotive as part of the Verification Train 3 project. This tested interoperability with a different supplier's trackside system that is currently in use on the Cambrian Line.

GENERAL DESCRIPTION OF ETCS

Deployment

ETCS is a common signalling system which has been developed throughout Europe, led by the European Union to enable an interoperable train service. It is now being embraced by a growing number of other countries worldwide, especially in non-EU countries such as China and India. More than 9,000 trains and 68,000 km of track have now been fitted with ETCS.

System Architecture Description

Fig. 2 shows the generic ETCS system architecture. Eurobalises are installed between running rails to provide geographical location information to ETCS fitted trains. For the most basic implementation (known as Level 1) trackside Lineside Electronic Units (LEUs) generate Movement Authorities (MAs) based on signal aspects. These are then transmitted to the trainborne controller via Eurobalises. For the next step 'Level 2' implementation (to be introduced in the UK) an Radio Block Centre (RBC) is responsible for generating the MA and sending it to the train via the Global System for Mobile Communication - Railway (GSM-R) network, giving a continuous communication train control system. For both cases, train detection is managed by a trackside subsystem such as track circuits.

The main on-board unit is called an European Vital Computer (EVC) which supervises the train, generating a braking curve based on information such as the MA, train speed and current position. This braking curve is calculated to protect the train from overspeeding and exceeding the limit of the given movement authority. The EVC has a major responsibility for safety critical functions. Information

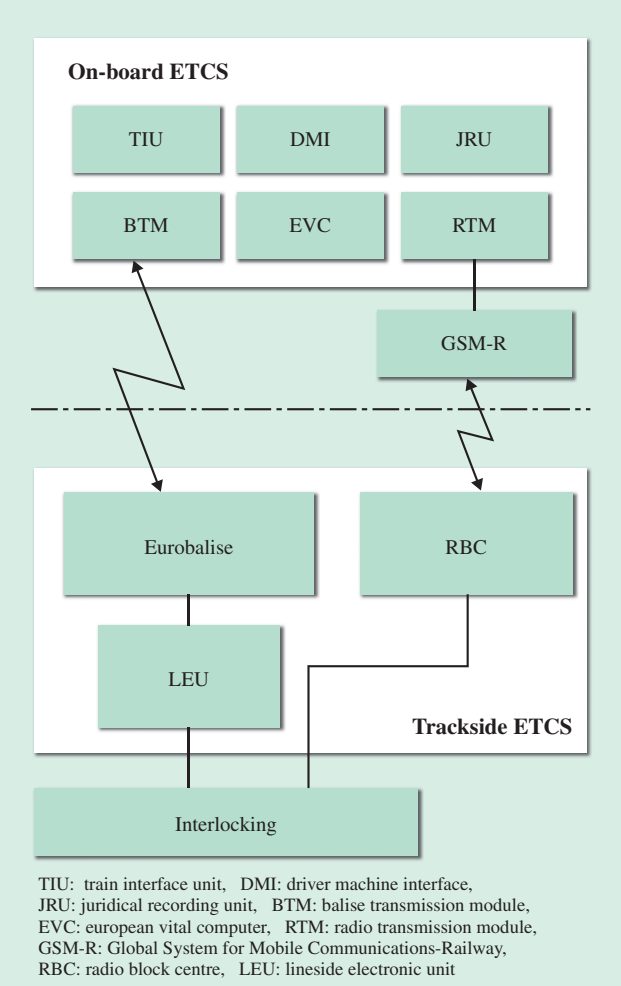

Fig. 2—ETCS and Its Interface
This shows an overall ETCS architecture and its interface defined in EU directives.

including the current speed, distance to end of MA and the track condition is displayed on the Driver Machine Interface (DMI). The DMI is also used for entering driver identification and train running number. Train information and behaviour is stored in a train recorder known as the Juridical Recording Unit (JRU). This is mandatory by law for the detailed investigation of root causes of incidents, therefore, the JRU has been designed for water resistance, fire resistance and crashworthiness.

ON-BOARD ETCS DEVELOPMENT

Key technical challenges

The following are the key technical challenges for on-board ETCS development:

- Development of a robust platform applicable for the variety of ETCS functions
- Compliance with mandatory European Standards

TABLE 1. E-OPE module technical data

No.	Items	Technical Data
1	CPU	GEMINI
2	Frequency	64MHz
3	Brake output	ATC-LSI
4	Serial communication	12
5	Input / Output	Input: 96 Output: 48

CPU: central processing unit, ATC: automatic train control, LSI: large-scale integration

• Demonstration of interoperability

Robust Platform

Due to the integration of highly advanced technological systems, the ETCS platform requires the capability to handle a great deal of data compared to existing signalling systems. A dedicated fail safe Computer Processing Unit (CPU) based on a modular system called 'E-OPE', has been developed to meet these various requirements. Table 1 shows the technical data of the E-OPE module.

This module has the following features:

- Speed supervise function; 10 times as fast as existing technology given by enhanced operating frequency, increased built-in RAM and the reduction of data traffic between Printed Circuited Boards (PCBs)
- Enables connection with peripheral sub-systems
- Further safety improvements with the integration of a newly developed device incorporating proven fail-safe CPUs

Compliance with European Norms

Technical Specifications for Interoperability (TSIs) are the specifications issued by the European Rail Agency and adopted in a Decision by the European Commission to ensure interoperability for the European Rail network. TSIs consist of several categories such as Rolling Stock, Energy and Infrastructure. Signalling is covered in the Control Command and Signalling (CCS)TSI. For placing into the market and taking into service, compliance must be checked and endorsed by an independent Notified Body (NoBo), initially as a generic product. The standards that must be complied to include:

- Electrical and mechanical specification standards
- ETCS requirement specifications and associated Subsets
- RAMS standards (Reliability, Availability, Maintainability, Safety)

In addition to the conformance checks above, a rigorous safety justification is also required against European Norms. The key challenge for this development was the collaboration between Hitachi's own safety design philosophy cultivated on the Japanese Railway environment and European design procedures.

This safety procedure has been formally approved by an ISA (Independent Safety Assessor) as Safety Integrity Level 4 (SIL 4) and the generic product has been fully certified by a NoBo against 2012/88/EU, 2012/696/EU and relevant EN norms.

Demonstration of Interoperability

ETCS is designed for interoperability and therefore must pass a full set of mandatory test sequences carried out in an accredited laboratory. The Hitachi on-board ETCS solution has successfully concluded its EVC testing as a generic product, passing all ETCS functional tests. For this project and future ETCS projects, Hitachi has selected Multitel ABSL laboratories to test its ETCS solutions.

This interoperability testing was conducted against Subset 076 version 2.3.3 which consists of 93 train operational scenarios, approximately 1,800 test cases and more than 35 thousand steps. ETCS onsite testing is a very detailed and time-consuming process with a large number of processes to be validated. Multitel, the first ISO 17025 accredited laboratory for ETCS functional testing, completed a full set of tests within 2 months (See Fig. 3).

Following the completion of TSI compliant testing, the Hitachi on-board ETCS solution has successfully connected to the Network Rail Cambrian Line signalling system and achieved ETCS Level 2 operation. This achievement came as part of Hitachi Rail Europe's 'Verification-Train 3' project to

Fig. 3—Functional Lab Testing
This shows the interoperability testing environment at Multitel (European Reference Laboratory).

Fig. 4—Class 97 Locomotive This shows the Class 97301 diesel locomotive at Porthmadog.

trial ETCS on-board equipment in the UK. During this project, a Class 97 locomotive (97301) was successfully retro-fitted with Hitachi's on-board system to prove interoperability with other systems currently in use. As part of this recent success, the Hitachi system was correctly identified by the Network Rail Signalling System and Control Centre in Wales (Machynlleth) without any system failures. The locomotive was driven under its own power using ETCS Level 2 and communicating via the GSM-R radio network in various operational modes. The trial was completed in September 2013, running more than 1,200 km without any major failures (See Fig. 4).

SPECIFIC APPLICATIONS

The ETCS Level 2 in-cab radio based signalling system will also be implemented on the IEP Class 800/801 rolling stock project, to be delivered onto the Great Western and East Coast Main Lines.

Hitachi has also separately signed a contract with NR for the implementation of ETCS on two Class 37 locomotives. This work will include the design, vehicle modifications, installation, testing and commissioning on the Cambrian Line in the UK, scheduled for completion in August 2015.

CONCLUSIONS

Hitachi On-board ETCS has been formally endorsed through a rigorous assessment process demonstrating compliance with the relevant TSIs and European Norms at the highest Safety Integrity Level 4 (SIL4). Hitachi's IEP Class 800/801 will be fitted with Hitachi on-board ETCS. Hitachi is now seeking to supply ETCS solutions to the global market place.

ACKNOWLEDGEMENTS

We want to take this opportunity to express our thanks to Multitel staff for their hard work and tireless effort to complete the interoperability testing on Hitachi's on-board ETCS solution.

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