

HITACHI
Inspire the Next[™]

The European Railway Traffic Management System ERTMS





The Globally leading ERTMS

ERTMS, European Railway Traffic Management System, is the new European, interoperable railway signalling system.

The ERTMS concept has been developed in 3 different levels of system architecture. Level 1 and level 2 of ERTMS are already implemented and in revenue service in most European countries and beyond, with Hitachi Rail STS being the first provider to introduce this technology in Europe (UK, Spain, Sweden and France) and in the highly competitive markets of China and India.

Interoperability enables a train equipped with ERTMS to travel without signal system boundaries within the ERTMS fitted infrastructure network, regardless of the country the train is travelling in, the legal nature of the infrastructure manager or the supplier providing the ERTMS system.

Hitachi Rail STS can offer the performance guarantee of a global leader in ERTMS components and systems for Conventional, Freight and High Speed lines worldwide. Our experience builds upon our pioneering achievements in the most important worldwide networks, including China, Czech Republic, France, Germany, Italy, Libya, Spain, Turkey, U.A.E. and UK.

Hitachi Rail STS has also been responsible for the first lines in revenue service running solely on ERTMS level 2 without a fallback system: Rome-Naples, since 2006 and Turin-Novara, Milan- Bologna since 2008.



Hitachi Rail STS is pioneering the implementation of ERTMS (or ERTMS-based) Satellite Solutions, developing products and systems to be deployed in numerous projects in different Countries (e.g. Italy, Russia, Australia, etc.); moreover, Hitachi Rail STS has been one of the most active UNISIG members in defining the architecture and system specification to introduce satellite-based location technology (GPS, Galileo, GLONASS, etc.) within the ERTMS/ETCS core, as it has been standardized in the latest decade.

ERTMS Level 1

ERTMS Level 1 is a Train Control System based on intermittent track-to-train communication using Eurobalise® and optional advanced data Infill.



Components and functions of the Wayside equipment:

Eurobalise®

- Energized by power from train antenna
- Fixed type: Stores infrastructure data as pre-formatted 'telegrams' (position reference, speed limits, line gradient, works on the line, etc.)
- Switchable type: sends to train movement authorities and trackside the telegrams received by LEU
- Class A reduced and standard sizes.

Lineside Electronic Unit (LEU)

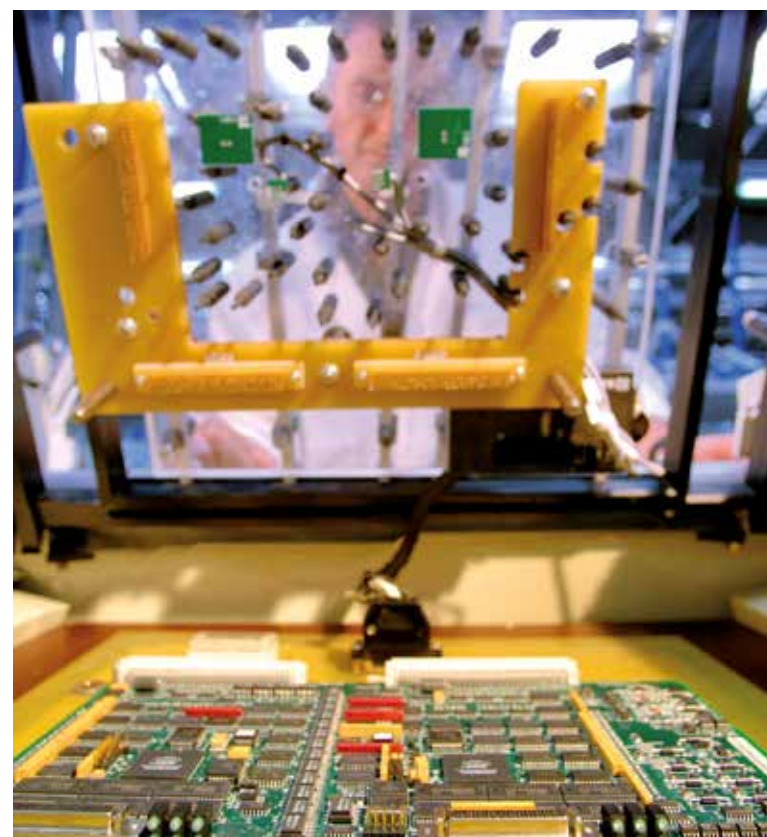
- Captures movement authority information from interlocking or signal aspect
- Selects and sends telegrams to Eurobalise® that contain movement authorities and trackside data.

Radio Infill Unit (RIU)

- Radio Infill is a function that can be optionally added to ERTMS Level 1 in order to increase the performance of the line. The purpose of the Radio Infill Unit is to transmit the message corresponding to a Eurobalise® in advance to the train. In this way, a train approaching the application zone of a more restrictive condition can revoke braking as soon as the 'signal clears' without waiting to reach the balise itself. The Infill message is transmitted via radio using GSM-R and Euroradio safety protocols, as used in ERTMS Level 2. The use of radio allows continuous Infill coverage for data radio equipped trains on fitted sections between balises.

Main functions of on-board equipment

- Receipt and analysis of the information about trackside status and characteristics of the movement authority sent by Eurobalise® or by the Radio Infill Unit
- Calculation of the dynamic speed profile in relation to the train characteristics which are already stored on-board
- Selection of the most restrictive speed value to be observed at the locations ahead
- Comparison between the train actual speed with the permitted speed and, if necessary, automatic brake application
- Display of indications and provision of alerts/warnings to the driver.



ERTMS Level 2

ERTMS Level 2 is a Train Control System based on continuous communication of variable data between the Radio Block Center (RBC) and the trains, via a radio system. Some additional information is received on board via fixed balises.

The radio system chosen for European Railways is GSM-R in the 900 MHz frequency band. The radio coverage may be continuous or even selective depending on the rail traffic density to be supported.

The Radio Block Center (RBC) supports open channel communication with up to 60 trains concurrently. The RBC knows from trains their positions; it receives train detection and route status information from the Interlocking and Automatic Block System as applicable, and makes information available to each train in the form of movement authorities.

Components and functions of Central and Wayside equipment

Radio Block Center (RBC)

- Interface with local Interlockings to obtain signalling related information, like e.g. signal aspects, track occupations and route status, and (where supported) to provide instructions to the interlocking such as releasing approach-locking controls
- Management of movement authorities for all trains within the controlled area
- Storage, management and transmission of selected trackside data
- Encryption/decryption of messages exchanged with the trains
- Communication with any adjacent RBC, with ERTMS Control Center, etc.

LEU

- The LEU is not mandatory in an ERTMS level 2 environment, as variable data Eurobalise® are generally not used

Eurobalise®

- Energized by power from train antenna
- Stores infrastructure data as pre-formatted 'telegrams' (position reference, speed limits, line gradient, etc.)
- When energized, it sends to train telegrams containing its fixed information (there is no LEU connection), as variable data Eurobalise® are generally not used.

Main functions of on-board equipment

- Reception on-board from the RBC of data including movement authorities, information about the status and characteristics of the track ahead and the distance to the next balise. The train sends its position with respect to Eurobalise® back to the RBC
- Calculation of the dynamic speed profile, in relation to the train characteristics which are known on-board
- Selection of the most restrictive speed value to be observed at the locations ahead
- Comparison between the train's actual speed and the permitted speed with, if necessary, mandatory brake application
- Display of indications and provision of alerts/warnings to the driver
- Provision of 'planning' information to the driver about the route ahead enabling efficient driving.



Hitachi Rail STS Wayside Equipment



Lineside Encoder Unit (LEU)

The purpose of the LEU is to interface Eurobalise® with lineside devices like Interlockings, Automatic Block logic and/or Signals, in order to acquire movement authority information and to convert this into conditioning messages to be sent to the appropriate balise group for retransmission to and subsequent processing by the on-board equipment. Hitachi Rail STS can supply both “Group LEUs” or “Signal LEUs”.

Each “Group LEU” can drive up to 4 balises. Up to 8 such Group LEU can be housed in Eurorack cabinets close to the equipment with which they interface (e.g. Interlockings) to obtain relevant signalling information. The maximum distance between balise and LEU is 5 km.

“Signal LEUs” are intended to offer a cheaper and more flexible solution that can derive power supply from lamp signals (less than 6w are needed for the base configuration) to which they are directly interfaced.



Each “Signal LEU” – according to the different type of chosen configuration – can drive up to 8 outputs (Balises or LOOMOs) and manage up to 30 inputs (AC or DC, Voltage or Current); according to the desired IP level, it can be housed in different types of small cabinets (resin or metallic).

As regards the “Group LEUs”, direct connection is made to Hitachi Rail STS’s interlockings. Connection to modern third party interlocking systems is made with serial data links using either a safety protocol stack based on “Profibus” or an HDLC proprietary interface. Connection to relay interlockings is made through voltage free relay contacts. LEUs support remote diagnostic maintenance network connections.

“Signal LEUs” – since they are interfaced directly to signal lamps – do not need additional devices to obtain the needed signalling information.

Eurobalise®

Eurobalise®, developed by Hitachi Rail STS, is a certified Class A balise suitable for SIL 4 applications. The purpose of the Eurobalise® is to transmit data to the train on-board equipment. Within ERTMS Level 1 infrastructure, the data sent provides the complete information needed from the wayside for train movement to be safely supervised. The data to be sent is selected by the connected LEU so that the on-board system can calculate a safe speed profile and advise this and the relevant movement authority to the driver.

Within ERTMS Level 2 infrastructure the Eurobalise® normally provides fixed information about the local infrastructure and acts as a position reference, as the variable information is provided by the GSM-R Euroradio data connection to the RBC. Balise data transmission takes place only when it is energized by the train passing over it. Energy transmission (telepowering) relies on magnetic coupling between the on-board antenna and a tuned loop within the balise. Both short and long telegrams are supported.

As well as application within ERTMS infrastructure, Eurobalise® may be deployed within existing compatible national intermittent ATP systems: SCMT, RSDD, KVB, EBICAB. It also has applications in Radio Signalling and Mass Transit.

Hitachi Rail STS product range includes the Reduced Size Eurobalise® as well, which brings within a smaller shell (whose size and weight are about a half) the same core benefits and characteristics of the above described Standard Size Eurobalise® (in compliance with the relevant European specifications), namely:

- Suitable for SIL 4 applications
- 1023- and 341-bit telegrams
- Suitable for fixed- and variable-data transmission (through LEUs)
- Suitable for both Railways and Metro applications
- Compatible with the majority supports used in ERTMS and KER applications.

Moreover, Hitachi Rail STS Reduced Size Eurobalise® features Air-gap programming (in addition to the standard “Interface C” Programming), thus allowing quicker telegrams downloading.



Radio Block Center (RBC)

The RBC is the wayside system designed to control railway traffic in ERTMS Level 2 equipped territory. It acquires signalling-related information (E.G. block occupancy, route set information etc.) from associated interlocking equipment and provides movement authorities to trains within its controlled area.

The RBC consists of the following parts:

1) A redundant Vital safety management subsystem, based on proprietary 2-out-of-3 architecture and SIL 4 certified, supporting:

- Message encryption and decryption, according to EURORADIO specifications
- Movement Authority Management
- Human Machine Interface.

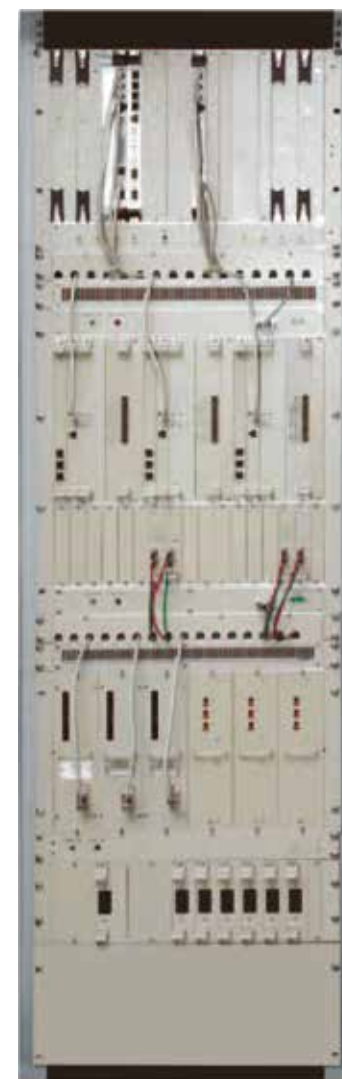
The RBC may be interfaced through the use of safety related protocols with both adjacent RBCs and Interlockings, with flexibility on the total number of interfaces.

The RBC can also be directly interfaced with traditional relay-based Interlockings. The RBC can even be interfaced directly with the field objects, and so it can perform some of the functionalities traditionally assigned to Interlockings.

The RBC is compliant to the most up-to-date UNISIG specification currently enforced by European laws (the so-called “Baseline 2.3.0 d”) and it is currently under upgrade towards the future Baseline 3.

2) A redundant Non Vital management subsystem based on commercial hardware architecture, including:

- Events recording and diagnostics, connected to the Maintenance Management System
- Remote supervision and/or CTC interface.



Hitachi Rail STS on-board equipment

The on-board equipment is designed in a modular architecture and supports a redundant PROFIBUS interface to the train systems. A 'two out of two' architecture is used for vital applications and modules can be duplicated for availability. The software of each module is developed in two levels with separate core software and application software.

The application software for each module is developed using formal methods that conform to applicable standards while supporting a high level of configurability. This means that adaptation to specific user and vehicle needs can be achieved with low investment in application-specific validation procedures.

The on-board system typically includes the following:

- **EVC** – The European Vital Computer, which is the core of the system. Its task is to safely manage the vital functions of the on-board subsystem and to provide support for diagnostic maintenance of the on-board subsystem.

Its modular software provides the following functions:

- Automatic Train Protection (ATP) and optional links to Automatic Train Operation (ATO)
- Train Management to support the Train Interface Unit (TIU), the interface with the vehicle's main and ancillary functions (odometry, etc....)
- The Driver Machine Interface function, capable of managing the driver's display(s), alerts/warnings and associated input devices
- Implement the Eurobalise® interface function, through the balise transmission module (BTM). The BTM controls the supply of energy for telepowering the balises. It receives and decodes the telegrams coming from the balises. It supports both Amplitude and Frequency Shift Keyed (ASK/FSK) messaging to provide backward compatibility with selected national ATP systems
- Radio Interface software can manage 3 GSM-R data radio units (two in normal service to support RBC transitions and one for redundancy).
- **DMI** – The ERTMS Driver / Machine interface typically comprises an LCD Screen panel for the control and indication functions, a voice synthesizer and configurable audible alert to inform the driver of changes to operating conditions and touch or soft-keys to accept data input.



- **TIU** – The Train Interface Unit typically comprises interface relays and circuitry that are custom to each train class.
- **Odometry** - Typically providing redundant tachometry and radar based sensing of distance, speed and acceleration. Tachometry is normally fitted to axle end, while the radar has forward / downward facing views to track. Alternate arrangements can match specific vehicle design.
- **Balise Antenna** –mounted under the vehicle with a clear view downwards to the track.
- **GSM-R** - data radio - a minimum of two and normally three radio sets are used per EVC with antenna typically roof mounted near to vehicle ends to support best reception in tunnels.
- **JRU** - The Juridical Recorder Unit providing 'black box' functions.

ERTMS Benefits

- **Interoperability for international traffic:**
 - Stops at country borders for loco, crew and traction change can be minimized / nullified
 - Customers benefit from shorter and more reliable journey transit times.
- **Interoperability within individual countries:**
 - Legacy limited capability and mutually incompatible train control systems can be phased out
 - Wayside equipment can be reduced
 - Advantage can be taken from a more competitive supply market.
- **Communication-based train control provided by ERTMS** means that train movement decisions reflect the most current applicable conditions including track occupancy and train speed, and giving the benefits of:
 - Increase in railway capacity - more traffic, thus more efficiency and profitability
 - Increase in service performance (better adherence to schedule).
- **Cab signalling represents:**
 - A higher level of safety which is achieved, thus easing drivers' tasks and enforcing speed limits
 - Track layout design is no longer inhibited by viewing requirements for wayside optical signals—more efficient and flexible movement arrangements can be supported
 - Train service is less prone to disruption by weather conditions (fog etc).
- **System standardization offers the benefits of:**
 - Lower operating expenses
 - Better protection against premature obsolescence.

Thalys, the High Speed Train linking France, Belgium, the Netherlands and Germany is a clear example of how the European railway market has historically been built: each Thalys train is equipped with 7 mutually incompatible national ATP systems increasing costs, complexity and unavailability. ERTMS can replace all these systems with only one, single, interoperable, safe and efficient signalling solution.



European ERTMS strategy

In April 2004, the European Commission Directive 2004/50 amended two previous ERTMS Directives and established ERTMS as the system to be implemented on both High Speed and Conventional Lines, either new ones or upgraded.

In 2005, the European Commission initiated a project to study in detail the costs and benefits of early ERTMS provision on six key freight corridors:

| | |
|----------|--|
| A | Rotterdam-Genoa |
| B | Naples-Stockholm |
| C | Antwerp - Basel / Lyon |
| D | Valencia-Lyon-Turin-Ljubljana-Budapest |
| E | Dresden-Prague-Bucharest-Constanta |
| F | Aachen-Berlin-Warsaw-Terespol |

The outcome was a positive endorsement of ERTMS with European funding now available to help finance ERTMS application to over 10,000 km of track and thousands of rail vehicles all over Europe.



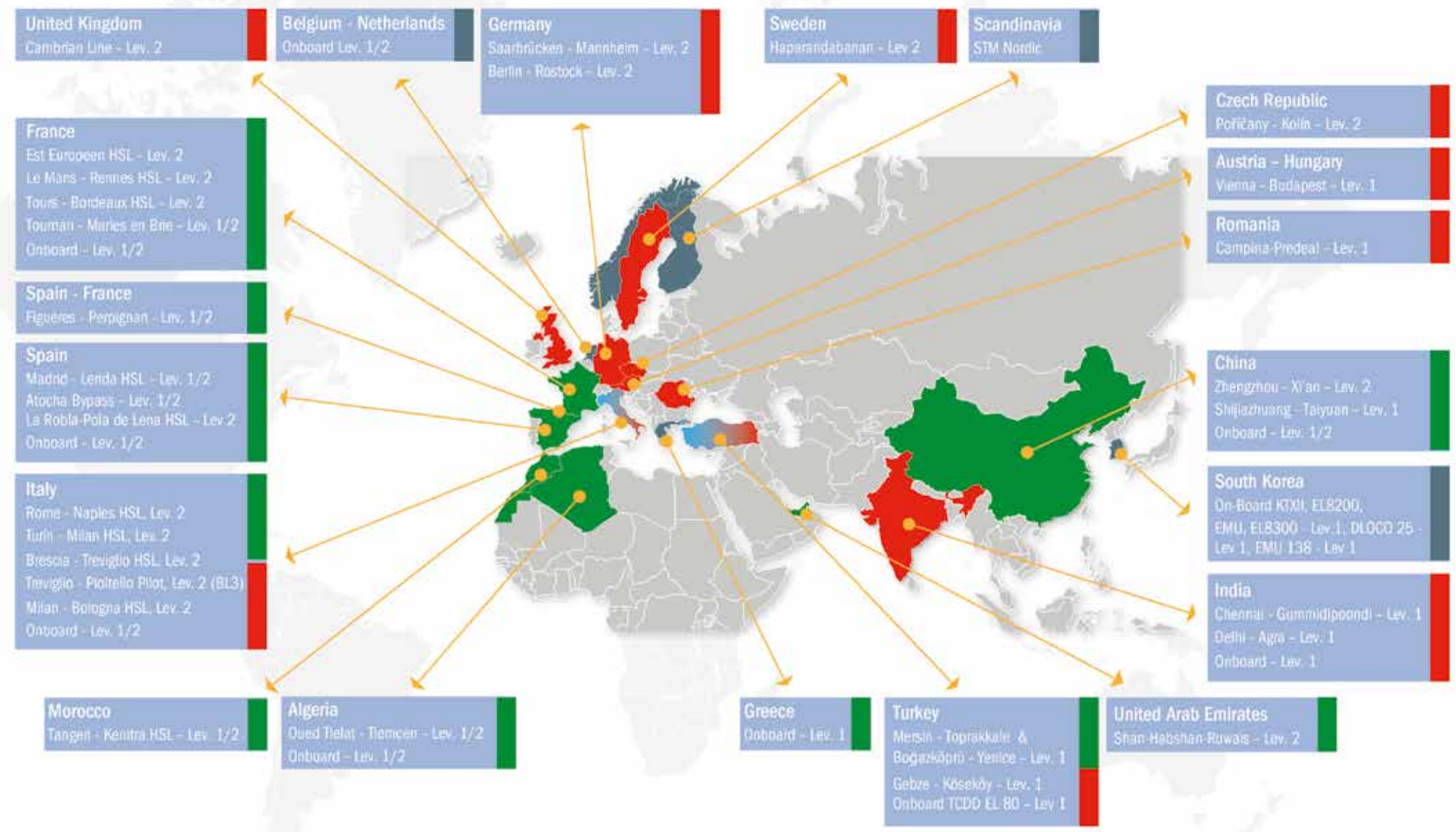
ERTMS/ETCS L1/L2 Main References

About Hitachi Rail STS

Pioneering some of the first High Speed Lines in commercial service running solely on an ERTMS Level 2 system (Rome - Naples in 2005 and Turin - Novara in 2006), Hitachi Rail STS has ever since been leader in ERTMS, the European interoperable railway signalling system.

Introducing its benefits all over Europe and beyond, with countries like China, India, South Korea and Turkey already embracing the most advanced signalling system, Hitachi Rail STS is also providing ERTMS for cross-border links between France and Spain (Perpignan-Figueres) and between France and Germany (Paris - Strasbourg - Frankfurt corridor, including Saarbrücken - Mannheim), linking some of the most important European High Speed networks with a reliable ERTMS Level 2 fully interoperable connection.

Hitachi Rail STS has thousands of kilometers of ERTMS lines in operation. It also has experience in superposing ERTMS levels 1 & 2 (i.e Madrid -Lleida High Speed Line). Many more kilometers are under construction and a substantial fleet of vehicles has been equipped with our ERTMS solutions. Only a leading company like Hitachi Rail STS can display such diverse references for implementing and adapting ERTMS to local requirements with satisfied clients all around the world.



■ Greenfield Projects
 ■ Brownfield Projects
 ■ OBU-only Projects

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