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THE EUROPEAN TRAIN CONTROL SYSTEM IN THALES SIGNALLING SOLUTIONS

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Abstract: *Rail signalling solutions designed by Thales integrate conventional signalling technology with advanced systems based on the European Train Control System (ETCS) standard. The degree of integration is classified according to the different levels defined in this standard. Level 1 is still based on light signals, but Eurobalises increasingly replace national intermittent train protection systems. Thales has provided equipment for several national level 1 projects. In level 2 a continuous train supervision is achieved. The Radio Block Centre (RBC) developed by Thales is responsible for the centralised protection of train movements for lines that are operated with level 2 equipment. It receives a train's position from its onboard unit and the trackside signalling information from the interlocking system. With this information and with the properties of the underlying track map it generates the movement authority for the train. In various European projects the interoperability of the Thales RBC with signalling equipment of other manufacturers has been proven.*

Key words**:** *ETCS, Radio Block Centre, ERTMS, Interoperability*

1. INTRODUCTION

With the directive 96/48 the European Commission has laid down the legal basis for the implementation of the European Train Control System. Two main objectives of this standard are

- to establish interoperability across system- and country borders
- to cope with the predicted increase of railway traffic in upcoming years by improving the operational throughput of railway lines.

Thales Rail Signalling Solutions have positioned themselves a leading supplier of signalling equipment in conventional railway technology as well as in ETCS based solutions. Apart from Thales Eurobalise beacons, train detection, interlocking and central traffic control systems the Thales Radio Block Centre (RBC) plays a central role in ETCS level 2 infrastructure solutions.

This article gives an overview of Thales' ETCS activities with focus on the RBC's position in the ETCS system and its functioning. Furthermore the degree of interoperability with other systems is demonstrated by references to European signalling projects.

2. ETCS LEVELS

Traditional signalling systems differ considerably from country to country. Therefore ETCS faces the challenge to facilitate a stepwise evolution towards a standardised technology. For this different levels are defined within ETCS.

Level 0 – this means an ETCS vehicle is used in a non-ETCS environment. The train driver follows the national trackside signals. National balise systems are used for cab signalling. The

ETCS onboard equipment provides a maximum speed supervision. Eurobalises are used only to announce/command level transitions.

Level STM (Specific Transmission Module) – the national train system guides the train but Eurobalises are used to announce/command level transitions. The existing onboard unit (OBU) interacts with the ETCS-OBU. Access to ETCS onboard functions is supported.

Level 1 – combines existing national signalling systems with ETCS technology. Eurobalises pick up signal aspects from the still existing trackside signals via Lineside Electronics Units (LEU) and transmit them to the vehicle as a movement authority together with route data at fixed points. With this information the onboard unit calculates the maximum speed and the braking curve. While guidance over Eurobalises relies on spot transmission to the vehicle an extension of level 1 is achieved by Euroloop. This consists in a continuous transmission of signalling information using trackside cables that emit electrical radiation.. Where Euroloop is installed conventional light signals can be omitted, but train detection and train integrity supervision are performed by the trackside equipment of the underlying signalling system.

Level 2 - in this level the train guidance is fully based on continuous digital radio signalling. Trackside light signals are no more needed. The Eurbalises are used as “milestones” to determine the exact train’s position and to synchronize the continuous onboard position calculation. Furthermore they serve to limit ETCS areas from conventionally equipped tracks and mark the RBC boarders. The train is in permanent communication with the Radio Block Centre. The route is still secured by the interlocking and hence national signalling rules apply for this. However only the RBC grants the movement authority to the vehicle. Upon track and train specific data the OBU calculates the braking curves and monitors the maximum permitted speed.

It is possible to equip lines both with level 1 and level 2 in order to allow trains of different equipment to run. A level 2 equipped train is able to operate in a level 1 environment (downward compatibility).

Level 3 – encompasses a fully radio based train spacing with the absence of fixed track sections. This way of operation comes close to the principle of driving with absolute braking distance spacing. However the concept crucially depends on a reliable train integrity supervision and is still in early development.

3. THE THALES RADIO BLOCK CENTRE

3.1 POSITION OF THE THALES-RBC WITHIN ETCS

Figure 1 Overview of the ETCS system shows the architecture of the level 2 ETCS system and the position of the Thales RBC in it.

The Thales RBC maintains a central static route map and receives the variable states of the track elements from the interlocking as well as the current positions from the trains. The Thales RBC transmits the movement authority and a track description of the secured route including e.g. the admitted line speed profile to the vehicle. The OBU receives the movement authority and the track description and calculates from it the actual speed profile up to the destination by using static and dynamical train data.

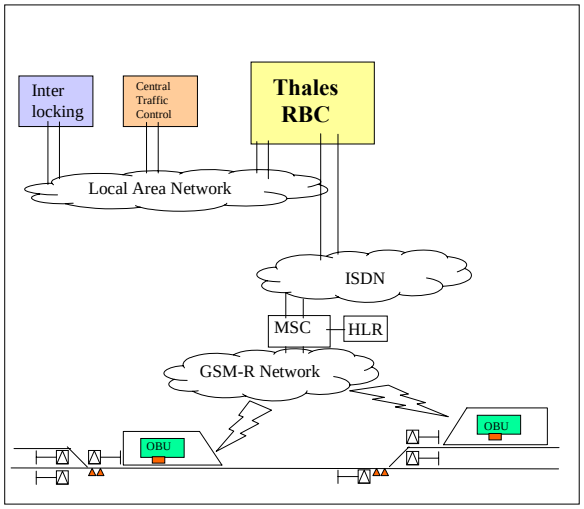

Figure 1 Overview of the ETCS system

Through a local area network the Thales RBC is connected with the interlocking and the central traffic control systems that may serve for the operation of the line. The communication with the OBU of the vehicle takes place via the Global System of Mobile Communication – Railway (GSM-R), using the Mobile Services Switching Centre (MCS) as access point with correlated Home Location Register (HLR). The connection

between Thales RBC and MSC is based on the Integrated Services Digital Network (ISDN).

3.2 INTERNAL ARCHITECTURE

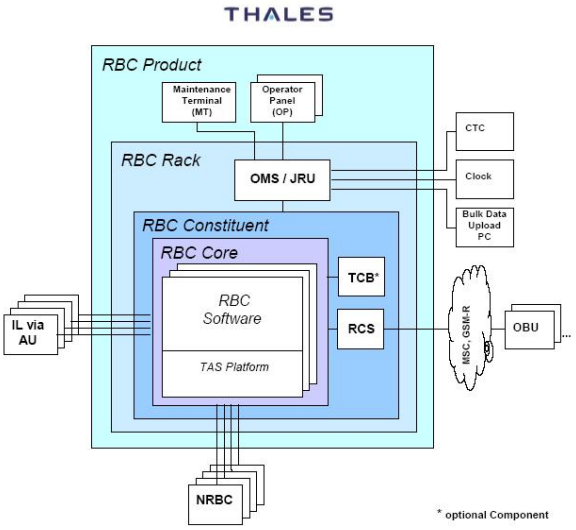

Figure 2 Architecture of the Thales RBC

The Thales RBC (see in Figure 2 Architecture of the Thales RBC) is based on a 2oo3 architecture, the "TAS platform", which is used in various safety related Thales products such as the LockTrac 6131 *ELEKTRA* interlocking, the LockTrac 6151 *ESTW L90 5* interlocking and the 6315 FieldTrac axle counter. Applications running on this platform are subject to a voting mechanism that compares the results of all three instances and only allows an output if at least two computing nodes come to the same result.

The RBC core contains the train guidance functions according to the ETCS specifications and is developed according to the safety integrity level 4. It also manages handovers to neighbour RBC. Its software is implemented on the "TAS platform".

The Protocol Conversion Unit (PCU) hosts the adaptation and communication software for the interworking with the interlocking. It is also based on the TAS platform in a 2oo3 configuration. As the RBC-interlocking interface is not standardized the supplier-specific adaptations are realised on this module. Interfaces to interlockings of various suppliers are already available, see chapter 4.

The Radio Communication System is responsible for the data communication towards the GSM-R infrastructure, thus to the OBU. It is based on a redundant industry PC architecture with ISDN routers and an uninterrupted power supply. This interface is supplier-independent.

The Operation and Maintenance Server (OMS) serves as interface adaptation towards operator control systems and diagnosis facilities. It is based on a redundant industry PC architecture. This concept facilitates the adaptation to country-specific Central Traffic Control systems (CTC). The Thales RBC product itself is operated from the Operator Panel (OP). Diagnosis messages are displayed either on a maintenance terminal or on the OP depending on the context.

The components of the Thales RBC internally communicate via the generic protocol RACOON (Railway Application Communication On Open Networks) which is designed for safety related applications on distinct computers over open or closed networks. This protocol is compliant with EN 50159-2 ("Requirements for Safety-related Communication on Open Transmission Systems").

All modules of Thales RBC product except the OP and the maintenance terminal are contained in the RBC rack that consists of two 19" cabinets.

3.3 EXTERNAL INTERFACES

Interlocking - The interface towards the interlocking is based on protocol stacks like SAHARA (SAfe, Highly Available and RedundAnt protocol) or other proprietary stacks. The lowest protocol layer is UDP or TCP. Redundant communication paths are used. The interlocking secures routes for the train movements and reports the states of points and signals to the Thales RBC. Optionally this information is enhanced by route type, permitted speed and signal stop reason.

Neighbour RBC – the interface to neighbour RBC of the same ETCS area is compliant with the Subset-098 v1.0.0 protocol via a closed network. A permanent communication is maintained that enables the handover or takeover of a train to or from the neighbour RBC area at any time.

Onboard Unit – the communication to the OBU takes places via the GSM-R network. For this the Thales RBC communicates via redundant S2M ISDN connections with the MSC of the GSM-R infrastructure. This interface is consistent with the UNISIG specifications. Thus compliant OBU of any supplier are supported.

Cryptographic Keys - For protecting the transmission path between the RBC and the OBU cryptographic procedures are used. The cryptographic keys are loaded to the RBC product and stored on a separate hardware, the Trusted Computing Base (TCB). For security and confidentiality this process is independent from the loading of the crypto-software.

3.4 TRAIN GUIDANCE BY THALES-RBC

Guidance of trains in the ETCS context encompasses the following procedures:

Accepting a vehicle - Once a vehicle's OBU has initiated the radio communication to the RBC the compatibility of the system versions of both systems is checked in the OBU and the train control is started.

Granting a movement authority – According to the current position reported from the vehicle the RBC sends a movement authority in accordance with the signal and point states given by the interlocking. This movement authority is extended if the vehicle requires so and if the interlocking clears the next signal in the travel path of the train. The movement authority includes track information such as speed restrictions, slopes, and the end of authority – the position where the vehicle has to stop. An advantage of the Thales solution is that movement authorities are calculated dynamically without the need of projected routes.

Emergency stop – the RBC can cancel or shorten a movement authority with an emergency stop telegram.

Releasing a vehicle – when the vehicle is leaving the RBC towards a neighbour RBC area a handover procedure is initiated, otherwise – if it is leaving the level 2 area completely - an exit authority is sent. The RBC closes the radio communication to the vehicle.

Shunting and driving on sight – ETCS allows to grant movement authorities for shunting mode or driving on sight.

The Thales RBC supports various ETCS level transitions such as trains entering a level 2 area from level 0, level STM or level 1 and vice versa. Also manual transitions initiated by the train driver (train at rest) are implemented. However country-specific operating rules have to be considered for these procedures.

4. THALES-RBC IN THE EUROPEAN CONTEXT

Thales has equipped a considerable number of lines with ETCS level 1 technology across Europe and overseas. The first line ever installed with ETCS was Sofia-Plovdiv in Bulgaria which is in operation since 2001.

Further Bulgarian projects have followed and are under implementation: the Plovdiv-Svilengrad line which includes level 1 equipment and the Thales LockTrac 6131 *ELEKTRA* interlocking. The Sofia-Karlovo line still runs with conventional signalling but will receive a central traffic control based on the *ELEKTRA* platform from Thales. The bid process for ETCS on this line is expected.

As to level 2 Thales has realised various international projects that include the Thales RBC:

- Lötschberg-Basistunnel - this 34,6 km tunnel line in Switzerland is fully equipped with ETCS level 2, omitting light signals in the tunnel. Thales RBC interfaces with 4 Thales LockTrac 6131 *ELEKTRA* interlockings. The line is in commercial operation since the end of 2007.
- High Speed Line Zuid – this Dutch line allows high speed traffic of up to 300 km/h between Amsterdam and the Belgian border. Thales realises the RBC-RBC handover with Alstom equipment at the end of this line. The interfacing interlocking is Siemens *SIMIS-W*.
- High speed lines in Spain – mixed operation level 1 and level 2 has been provided by Thales on the lines Lleida-Roda, Roda-Barcelona and Madrid-Valladolid. Here, speeds of up to 300 km/h and 350 km/h are allowed under level 1 and 2 respectively. Currently 11 Thales RBC are installed in Spain.. A further project for Cercanías Madrid (commuter lines) is under development.
- Berlin-Halle/Leipzig – this first ETCS level 2 line with Thales equipment in Germany is in commercial operation since June 2006. The Thales RBC interworks with Thales LockTrack 6111 *ESTW L90* and Siemens *SIMIS-C* interlockings.

The Thales RBC has proven interoperability with OBU of various manufacturers such as Alstom, Ansaldo and Siemens.

In the future progress of ETCS solutions in and outside Europe Thales will reinforce their position as a pacemaker in this technology.

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ЕВРОПЕЙСКАТА СИСТЕМА ЗА КОНТРОЛ НА ВЛАКОВЕТЕ В РЕШЕНИЯТА ЗА ОСИГУРИТЕЛНИТЕ УСТРОЙСТВА НА THALES

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Резюме: *Решенията за железопътнаосигурителна техника, проектирани от интегрираната конвенционална осигурителна технология на Thales с модерни системи, се базират на стандарта на Европейската система за контрол на влаковете (ETCS). Степента на интеграция се класифицира според различните равнища, определени в този стандарт. Равнище 1 все още се базира на светлинните сигнали, но Eurobalises все повече замества националните защитни влакови системи. Thales е осигурила съоръжения за няколко национални проекти за равнище 1. При равнище 2 е постигнато продължително наблюдение на влаковете. Радио блок центърът (RBC), разработен от Thales, е отговорен за централизираната защита на влаковото движение по линиите, които се експлоатират при съоръжения от равнище 2. Те получават информация за положението на влака от кабината на машиниста и информацията от осигурителната техника по релсовия път. С тази информация и с възможностите на картата на пътя този блок генерира ръководство за движението на влака. В различни европейски проекти е доказана оперативната съвместимост на Thales RBC с осигурителните съоръжения на други производители..*

***Ключови думи*:** *ETCS, Радио блок център, ERTMS, оперативна съвместимост.*