ETCS Level 1 now goes from tests to implementation

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Abstract

The first operational system tests of the new European Train Control System (ETCS) level 1 as the control/command part of the ERTMS (European Rail Traffic Management System) have been successfully performed in October/November 1999 on the Vienna-Budapest line, and the first implementation of the system is being prepared for installation on a 250 km part of the Sofia-Burgas line (Bulgaria). The first project was co-ordinated and the second project is being performed by Alcatel Transport Automation Systems Austria. The major problems and preliminary results of both projects will be summarised in the paper with an emphasis on track-side data preparation.

1 Introduction

1.1 ETCS and its application levels

Facing a growing demand for environmental friendly transport services, the European railways are hindered in efficient use of their infrastructure due to historically grown and incompatible ATP systems. Currently 14 different ATP systems are in operation throughout Europe and their replacement is not a matter of years but a matter of decades. Therefore a major European initiative in ERTMS/ETCS is aiming at the implementation of an efficient European wide ATP system. Since the transition to this new system will not be easily achieved, the following basic requirements were defined:

- upcoming European standard,
- flexible application on the different railway demands
  (via modularity and different application levels),
- interoperability with the existing ATP systems.
Interoperability will be ensured via development and inclusion of STMs (Specific Transmission Modules) for the various national systems. The functional requirements to the ERTMS/ETCS have been defined in [1].

The system modularity is reached through definition of 3 main application levels (see [2]):

**ETCS level 1**

The lowest ETCS level is defined as addition to existing national signal systems and is aimed at an increase of safety. Existing signal information and all necessary track data at the existing signal locations are punctually transmitted via electromagnetic transponders (Eurobalises) to the train. The balises are powered by the passing train with a 27MHz electromagnetic field and respond via sending track to train information at 4.3 MHz with a data rate of approx. 564kbit/s. The train's on-board unit (OBU) continuously monitors the allowed train speed and warns the train driver in the case of speeding. If the warning is not recognised and the speed not reduced accordingly within a certain time period, the brakes are applied by the OBU or even a train trip is triggered. An additional transmission of so called infill information in front of the signals via radio, leaky cable or additional balises can reduce the disadvantage of punctual information transmission and provide operational improvements of the line capacity.

**ETCS level 2**

A continuous data transmission to and from the train is performed via digital radio GSM-R, which is allows to replace the existing way-side signalling. With this application level the way-side signals can be replaced by cab signalling, but the train movement is still limited by the fixed blocks of the conventional signalling system with its track-side occupation detection systems.

**ETCS level 3**

As in level 2, a continuous data transmission to and from the train is performed via digital radio GSM-R, which can replace the conventional signalling. Furthermore, the train movement is no longer limited by the fixed blocks of the conventional signalling system. Instead a moving block operation is feasible where the train integrity is monitored on board and axle counters or track circuits are no longer required.

**1.2 Alcatel approach to ERTMS/ETCS**

Alcatel Transport Automation Systems as a developer and supplier of train control and protection systems is involved in the development of ERTMS/ETCS by participation in major European projects on this field since the beginning. Since the specification phase of ERTMS/ETCS is now coming to an end, pilot tests and commercial projects are now forming the main focus for suppliers
including Alcatel as well as for users. Within world-wide acting Alcatel TAS, Alcatel TAS Austria is the competence centre for ETCS level 1.

After the successful first real operational ETCS level 1 tests on the Vienna - Budapest line, Alcatel TAS Austria is currently preparing the first commercial ETCS level 1 implementation on the Sofia - Burgas line in Bulgaria.

In both projects, the Alcatel TAS Austria system approach is a decentralised ETCS level 1 system [3]. In this structure, the realisation of ETCS level 1 systems involves the application of track-side equipment without any need for connection to the interlocking system and with virtually no influence on the existing signalling system after equipment installation (see Figure 1).

Figure 1: Decentralised ETCS level 1 track layout

Decentralised LEUs (Line-side Electronic Units) are transmitting track to train information by detecting the signal status and transmitting the respective ETCS compliant telegrams to the train.

Two balises are used for the detection of the train movement direction, where the first balise only contains fixed information, such as gradient profile and static speed profile, and the second balise transmits signal dependant information such as movement authority and route dependant linking information.

2 The ETCS-VB pilot project

In the 4th Framework Program of the EC (in the transport research and development part) the Vienna-Budapest project was aimed at the demonstration of real life performance of the new ETCS level 1 system. Together with a consortium consisting of the railways MÁV and ÖBB, the independent Austrian
Research and Test Centre Arsenal and 4 other railway industry partners, Alcatel TAS Austria was responsible for the project management and for the track-side equipment of the Austrian part of the Vienna-Budapest test line. The tests were successfully completed in November 1999 on the 45 km long equipped test line on both sides of the border between Austria and Hungary [4]. Especially the dramatically enhanced information for the train driver together with the achieved safety standard have impressed the international audience at the life demonstration of the system (a video documentation of some of the test runs is available [5]). In the following sections some details of the necessary data preparation are being presented and discussed.

2.1 Preconditions for ETCS level 1 data preparation

The following steps were necessary in preparing the LEU and Eurobalise telegrams for the Austrian track side:

- Track data collection,
- Signal aspect data and route information,
- On site measurement and verification,
- Packet definition (according to SRS Class P [6], since the full definition of ETCS Class 1 was not available at the time of the project),
- Telegram content definition,
- User bit generation,
- encoding of the telegrams according to FFFS Eurobalise coding strategy [7],
- Programming of the LEUs with the coded data,
- Programming of the balises with coded data (fixed telegrams or default telegrams, respectively).

2.2 Generation of the ETCS level 1 telegrams for Vienna-Budapest

Since nearly all equipment parts and software components were in prototype stadium for the tests in this project, the telegram contents were also prepared mainly "manually" based on pre-programmed MS-Excel sheets using makros. An example for a single balise telegram is illustrated in Figure 2. Approximately 18000 lines of XLS-based Class P code were produced and verified for the 18 km Austrian part of the test site.

Especially location-sensitive linking information between the balise groups was very difficult to review and extremely work intensive when balise group reallocation was required. All this prototyping problems led to an early specification and start of development for an advanced ETCS level 1 planning tool for professional use in the commercial Bulgarian project.
3 Installation of a ETCS level 1 system in Bulgaria

3.1 Project overview

The contract with Bulgarian State Railways (BDZ) includes the delivery of ETCS level 1 track-side equipment for about 250 km of line between Sofia and Burgas consisting of Eurobalises and LEUs and ETCS level 1 on-board systems for about 80 locomotives. Furthermore, the new ATP must be compatible with the existing ATP system JZG703, which is based on 12bit Ericsson balises. This means, the ETCS equipped locomotives must be able to run on JZG equipped lines without performance reduction in comparison with this system, and also an upgrade of the JZG on-board system for operation on ETCS line sections was requested for about 90 locomotives. The deliveries also include the data preparation for the line and acceptance tests.
3.2 Generation of ETCS level 1 telegrams for Bulgaria

The main functionality of the developed data preparation tool involves the following tasks:

- The tool collects all track data and signal data from railway’s files into a database,
- it calculates the telegram user bits for each data point and each valid signal aspect in a partly interactive and customer-specific way, and
- it performs the safety encoding for each telegram according to the ETCS Eurobalise subsystem specification.

A separate tool, the data verification tool, performs the decoding of the telegrams independent from the encoding tool and hence allows verification of the telegrams by comparison with the original railway data. By using this tool, the final telegram data will be re-translated into readable files and given to BDZ for checking and release.

Both tools work off-line (on a PC or laptop). The encoded telegrams can be stored on one floppy disk, and from there be loaded into the LEU using a laptop via its serial interface. A transmission error check is performed for this transmission using an additional CRC, separately for the scrambled and transformed user bits and for the safety codes, which are stored into the two independent channels of the LEU. The scheme of track-side data preparation and verification is illustrated in Figure 3.

Figure 3: Data preparation tool functionality
3.3 Main data entry level of the tool

The main level of the data preparation tool handles all track-related information for the further planning process such as:

- Defined projects
- Defined main tracks of a project and sub-sections
- Static speed profiles
- Gradient profiles
- Fallback profiles to national systems
- Temporary speed restrictions
- Train type definition
- Signal data and LEU-type definitions
- Balise placement rules and predefined telegram contents

As an data entry opportunity for track data a schematic track editor is provided which collects all track locations in a graphical way as front end to the underlying database (Figure 4).

3.4 Schematic track layout editor

The schematic track layout editor (Figure 5) allows free definition of track layouts as a basis for the following telegram content definition. With easy to use symbols and the related km definition of the influence point on the track, a complete characterisation of the line as a basis for the following telegram calculation is being made.
3.5 Route information handling

Special care had to be taken on route information handling, since no direct route information is available from the interlocking. Mainly via predefinition of signal aspect to route relations in combination with intelligent repositioning provision, the route uncertainty without interlocking information can be handled. An example is illustrated in Figure 6.

Based on the defined track layout, the location of signals and switches, signal aspect and route information (where required), speed signs, static speed and gradient profiles, the tool is able to calculate the ETCS telegrams and to provide safety encoding as well as telegram data verification by decoding and printing of different types of reports. In the Bulgaria project of Alcatel TAS Austria, the telegrams are defined and calculated based on the ERTMS SRS Class 1, version 1.2.0 [8], due to the fact that the latest version 2.0.0 was still not available. However, the tool will be upgraded for the new specification for further applications.
The addition of temporary speed restrictions to the telegrams is foreseen, and safety as well as security aspects have been taken into account during specification and design of the tool.

Figure 6: Route definition example in schematic track editor

4 Conclusions

The new European train control system ERTMS/ETCS is now being tested in pilot installations and also the first commercial installations and applications are being prepared by different suppliers for different customers. Alcatel Austria AG takes part in this process and prepares after the successful participation in the Vienna – Budapest tests of an ETCS level 1 system the delivery of the system for installation on parts of the Sofia – Burgas line in Bulgaria.

One important part of a larger installation project is the data preparation. This task requires a tool to accurately collect all required data, to calculate the huge amount of necessary track-to-train telegrams for different locations and signal aspects, to provide means for safety encoding and telegram verification, and to prevent unauthorised change of data and telegrams. A related track-side data preparation and verification tool has been specified and developed to meet these requirements.
References

[1] ETCS Functional Requirements Specification (FRS); Version 4.0, Ref. UIC/A200/FRS.02-935614-4.00-960827

[2] Interoperability and ERTMS/ETCS levels definition, version 6. EEIG ERTMS Users Group, 31/7/98, Ref. 96e013


[5] Vienna – Budapest ERTMS Test Demonstration Video. 24 minutes, English language. SL Video, Vienna – Munich 1999. To be ordered from the UIC or the ETCSVB project co-ordinator


[8] ERTMS/ETCS Class 1, UNISIG System Requirements Specification (SRS), Version 1.2.0, Ref.: SUBSET-026-x, 30.7.1999