Chapter 5
Verification and Validation of Interoperability

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ABSTRACT
The chapter shows an approach to use existing test methods to prove technical as well as operational interoperability. The first kinds of tests are test sequences to validate conformity of a single constituent – here, an on-board on-board unit (OBU) of the European Train Control System (ETCS) in the European Rail Traffic Management System (ERTMS). The second kind of tests is the integration test for assemblies – here, the complete on-board equipment. The third kinds of tests are the tests for the validation of operational serviceability. An approach for the stepwise integration of the different kinds of tests is shown. As a conclusion the perspective for the use of these test sequences in an independent test lab is given.

INTRODUCTION
Trains need long distances for braking. A regular train needs approx. 1 km for braking to standstill from 160 km/h. So they cannot be driven on sight as road vehicles. Therefore train control systems are in use since many years. Those systems supervise the driving speed of the trains and trigger an automatic braking if the driver does not react properly. These train control systems have been subject of national regulation for many years. Since the year 1989 the European Commission supports the specification and implementation of a harmonized European System in order to substitute the more than 20 proprietary national signaling systems by one harmonized system. This shall improve trans-border railway operation and open the markets of railway operation as well as train control systems.

The European Rail Traffic Management System (ERTMS) consists out of the safe communication System GSM-Railway (GSM-R) and the
European Train Control System (ETCS). ERTMS/ETCS should implement technical as well as operational interoperability on the trans-European railway network. This means that a train, which is equipped with ETCS, can run on every line, which is equipped with ETCS.

Technically seen the ETCS on-board unit (OBU) consists of a central vital computer system, a spot transmission system from trackside transponders called EuroBalises, the wireless communication system EuroRadio, one or two Driver-Machine-Interfaces (DMI), a Juridical Recording Unit (JRU) and a train interface unit (TIU). In the ETCS application level 1, EuroBalises or short Balises are used to transmit the permission to run, given by a conventional wayside signal, to the train. In the ETCS application levels 2 and 3, movement authorities are sent by the so-called radio block center (RBC) to the train and shown on-board by the DMI to the driver.

Six different companies commit themselves to implement ETCS and to provide products to the railways in Europe. This leads to the need to prove that all the products fulfill the following high-level requirements:

1. They have been implemented according to the European system requirement specification – the so-called conformity,
2. They interact technically in the correct way – the so-called technical interoperability,
3. They fulfill together the operational functionality – the so-called operational interoperability,
4. They are doing what the railway needs to perform the operational tasks – the so-called serviceability
5. They are doing all this under all conditions in a safe way.

So those components for safe railway applications need to be tested comprehensively before taken into operation. These tests have to

**BACKGROUND**

Currently ETCS is getting more and more into operation in Europe (Stanley2011).

Some European countries are already operating ETCS (see Figure 1), for example, Switzerland uses ETCS Level 2 on the routes Mattstetten - Rothrist and Lütschberg - Base tunnel Spain successfully installed ETCS Level 1 and Level 2 on the route Madrid - Barcelona, and the Deutsche Bahn AG (Germany Railways) is preparing several routes (French boarder - Saarbrücken - Ludwigshafen (POS north), Nürnberg - Ingolstadt - Munich (NIM) satisfying the requirements of the current legal ETCS system requirement specification (SRS v2.3.0d).

In order to validate the interoperability of ETCS components they could be tested on a real track but the costs and efforts are very expensive (e.g., a train has to be moved to the track, the trips have to be arranged with daily traffic, etc.). To save costs it is necessary as a first step to check the conformity and interoperability of new ETCS components in a laboratory as well as to check if they are in line with the requirements of the ETCS.

Figure 2 illustrates the proposed stepwise methodology and approach for testing technical, line-specific and operational requirements and the interaction and collaboration of the different components.

**TECHNICAL INTEROPERABILITY**

The ETCS onboard units (OBU) will be tested on component level using the conformity and interoperability Test Standard for ETCS onboard units (Subset-076 (UNISIG, 2008)) and Reference Test Architecture (Subset-094 (UNISIG, 2009)) released by the European Railway Agency with the Test Sequence Debugger (TSD) in order to approve the compliancy and conformity against the SRS. The technical interoperability of train- and trackside components, i.e. OBU and Radio Block
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