7 Functional test of EULYNX Components in RailSiTe® Laboratory

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7.1 Introduction

EULYNX (European Initiative Linking Interlocking Subsystems) is a European initiative founded in 2014 to harmonize and standardize interfaces in rail infrastructure. First members of the initiative were railway operators DB Netz (Germany), Prorail (Netherlands), Infrabel (Belgium), SNCF (France), CFL (Luxembourg) and Network Rail (Great Britain). Operators from other countries have joined by 2020, so that currently the initiative includes 14 countries.

Based on the challenge that maintenance and further development of existing field components through the various interfaces and manufacturers is both - cost and time-consuming, the focus was on the development of uniform industrial standards for modular signal box technology. With this purpose, standardized architecture and interfaces were developed, for example for communication (SCI, Standard Communication Interface), for maintenance (SMI, Standard Maintenance Interface), for diagnosis (SDI, Standard Diagnostics Interface) and for the transfer of safety-critical information (SSI, Standard Security Interface). The IP-based communication between system components uses RaSTA (Rail Safe Transport Application) protocol, which is specially tailored to the requirements of railway signal technology [1].

From technical point of view, EULYNX relies on formal description languages as SysML and RailTopoModel for modeling stretching topologies. Development milestones in so called Baselines are tracked within the standardized EULYNX reference architecture in which functions and components of the system are described. The latest, published version is Baseline 3 [2], which will be used in Germany in several projects by Pintsch, Hitachi, Alstom and Thales. The earliest start of operating digital interlocking technology with Baseline 3 will be September 2023 in the city of Zwiesel in eastern Bavaria.

Especially in safety-critical environments like the railway sector testing of the used components and their communication is mandatory. Therefore, this paper describes the integration of the rather new EULYNX specifications into an existing testing environment for railway applications. First, the general motivation of laboratory tests is presented leading to additional requirements for testing against the EULYNX specification. After that follows the main part where the integration into the testing laboratory RailSiTe® (Railway Simulation and Testing) regarding the overall concept and software as well as hardware components is explained. Finally, we present current testing opportunities for suppliers and an outlook on further developments.

7.2 Motivation of laboratory tests

The Institute of Transportation Systems at the German Aerospace Center in Braunschweig, Germany is developing new test methods and concepts for railway management and signaling technology since its foundation in 2001. The institute's own developed test laboratory RailSiTe® has been accredited for testing ETCS components since 2012 according to DIN EN ISO / IEC 17025 [3]. Within 2023 accreditation will be extended to include testing for infrastructure components according to EULYNX specifications. The motivation is to transfer the increasing number of tests from the field to a controlled laboratory environment. Simulation environments, such as RailSiTe®, offer the advantage that they enable on the one hand cheaper and faster tests and on the other hand test constraints are precisely reproducible. In addition, testing of in particular newly developed components in the field is much more complex and cannot cover all scenarios to be tested (such as failures or defects) but were needed to approve them. Faster and more efficient tests are also possible in test laboratories since test cases are formalized and can be carried out automatically. To achieve compatibility and conformity an object controller is pre-switched before each infrastructure element. The interfaces of these object controllers are standardized. In order to demonstrate conformity of EULYNX requirements and the compatibility between individual components, extensive tests are also necessary here. In the RailSiTe® laboratory, these tests can be carried out independently - from manufacturer and operator - and efficiently.

7.3 EULYNX testing requirements

Driven by the need to standardize interfaces EULYNX working group is building up specifications for conformity tests. These specifications are the common base in case of requirements for testing all infrastructure elements such as signals, level crossings, points, and so on. The aim of EULYNX organization is that all specifications are complete, correct, approved and free of charge available. After building up all needed requirements they intend to convert to standardization body for EULYNX to set up a European standard, which includes the handling of bug fixes, error corrections and support national implementations.

Based on the specification the EULYNX working group provides formalized test cases, which consist of multiple test steps for testing the compliance against the specification and refer to one or more requirements. Foremost advantage of formalized test cases is that they are unequivocal and, thus, can be executed automatically. Another simplification for laboratory testing is the standardized catalog of requirements for laboratories. Therefore, the automation of test processes can be executed in real time [4].

The following image gives an overview of the architecture used in EULYNX. It shows which standardized interfaces are fixed for the individual infrastructure elements in the railway sector to communicate with each other and exchange data.

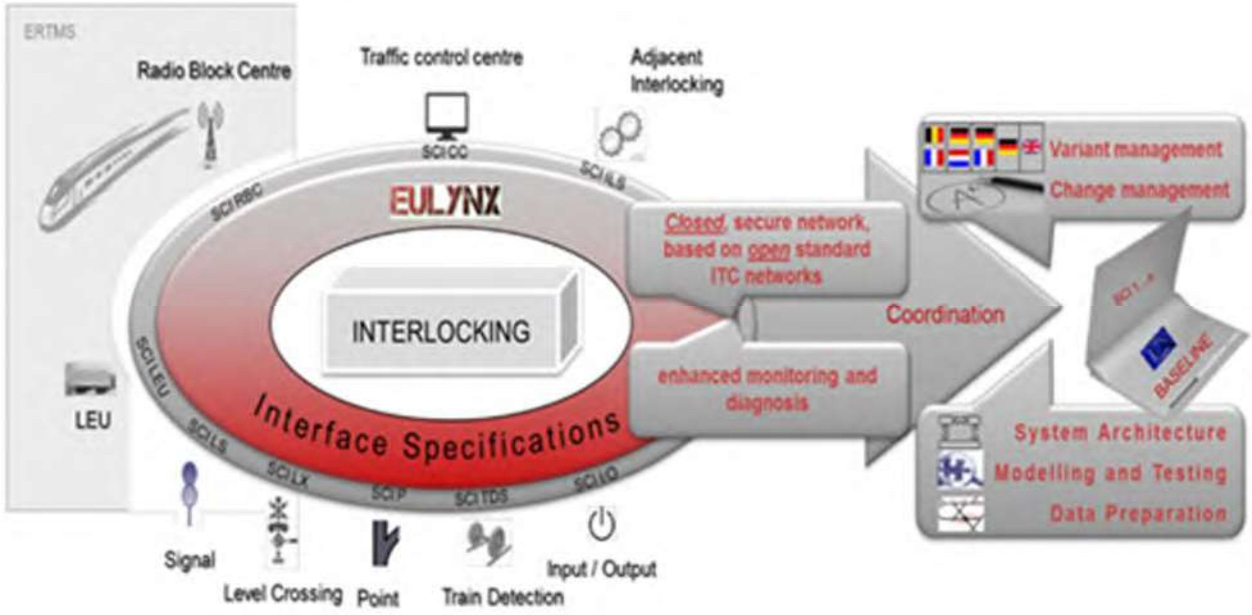

Figure 7-1: EULYNX architecture [5]

The architecture contents 10 different interface specifications summarizing different groups of infrastructure elements. The acronyms follow the rule: first SCI for "Standard Communication Interface" followed be the abbreviation for the particular infrastructure element such as LS (light signals), LX (level crossings), P (points), TDS (train detection system), I/O (input / output device) and TSS (trackside safety system). On top of theses groups there are common defined interfaces for radio block center (SCI RBC), traffic management system (SCI CC), adjacent interlocking (SCI ILS) and lineside electronic unit (SCI LEU) [10]. In the next part the interfaces currently implemented in the RailSiTe® laboratory will be described.

7.4 EULYNX Implementation

The RailSiTe® laboratory at the Institute of Transportation Systems is able to test railway infrastructure elements against conformity to the EULYNX specifications. For this purpose, it provides software to connect the standardized interface (SCI) to the laboratory environment, in which all other components can be simulated. The behavior of the interface of the DUT (Device under test; the Object Controller of the respective infrastructure element) is compared in individual test steps with the requirements of the EULYNX specifications. The result of this test is a report including the evaluation "specification is met" (passed) or "specification is not met" (failed) for each individual test step. This test report is provided to the customer for approval.

7.5 Test concept

The laboratory offers conformity and interoperability testing of individual infrastructure elements such as level crossings, switches, traffic signals, etc. Each DUT has a preceding object controller which communicates with the simulated elements in the RailSiTe® testing software via the corresponding interface. The associated object controllers are connected via LAN to the laboratory software and are integrated into the simulation environment. On the software side, our test program is used for this purpose. The object controller exchanges - either with the interlocking or with other infrastructure elements - formalized messages (e.g. a connection request in RaSTA or a SCI command or message). This is followed by a check whether the object controller reacts according to the test case. The result is output as a target / actual comparison in the form of a test report.

7.5.1 Test execution

In the first step, customer's hardware (object controller) is connected to the laboratory via ethernet. Then the individual customer-specific parameters are adjusted in the configuration file. After successful integration, the test sequences (multiple test cases that are executed after another) are started and run completely automated. If differences between the expected messages and received messages are detected, the test steps are marked as failed and the sequence can continue or stop, depending on the settings. All formalized steps are automatically evaluated and marked in the test report as passed or failed.

7.5.2 Evaluation of the test results

The automated comparison and evaluation of the requirements from the EULYNX specifications (in the formalized test cases) and the actual state of the DUT already takes place during the test run. This evaluation output is displayed in a report where the test results are unambiguous (passed / failed) and are completely traceable due to the formalization of the test cases. The test report is generated automatically and serves the manufacturer as proof of the conformity of his component.

7.5.3 RailSiTe® - Test Bench Implementation

Hardware

The mobile EULYNX test bench (Figure 7-2) is a highly mobile and compact "test lab on wheels", which can be set up at any manufacturer and can also be controlled remotely, if needed.

KVM-Switch: The work place is equipped with a Full-HD display and a keyboard with touchpad (like a laptop). It is possible to connect and switch between 7 video inputs.

Ethernet-Switch: Ethernet-Hub can be used to test multiple devices at once and offers the possibility to work in a virtual private network (VPN). It enables remote testing and better support through DLR in case of problems.

Raspberry Pi: It works as an object controller simulator (Light Signal in this case). Multiple LEDs can be controlled via WAGO-Box for testing and implementation purposes.

WAGO Modbus Module: The Modbus-Protocol is a communication protocol based on a Master/Slave-Architecture. The protocol’s goal is to establish a quick, reliable and fast communication between the automation system and field elements. The WAGO-Modbus provides digital I/O's that are used in simulation of error signals (e.g. faulty Light Signal) for object controllers.

PC: The operating system is Ubuntu 22.04 LTS. The PC has multiple Ethernet Ports, a wireless network interface controller, a 256 GB SSD Card containing the OS with two extra 2 TB RAID hard drives. As a consequence, this redundant setup can ensure continuous workflow even in case the SSD or one of the hard drives' crashes.

Figure 7-2: The mobile EULYNX Test Bench (Photos: DLR)

Power Supply: The power supply has two channels (Master/Slave) with voltages of +/- 0-30 V (or +/- 0-60 V) and can generate a current of 0-10 A. This covers the needs of typical railway applications (48 V) and different train components can be supplied with voltage and therefore be automatically tested.

Software

The architecture of the RailSiTe® testing software is shown in Figure 7-3 and each module will be explained in this chapter.

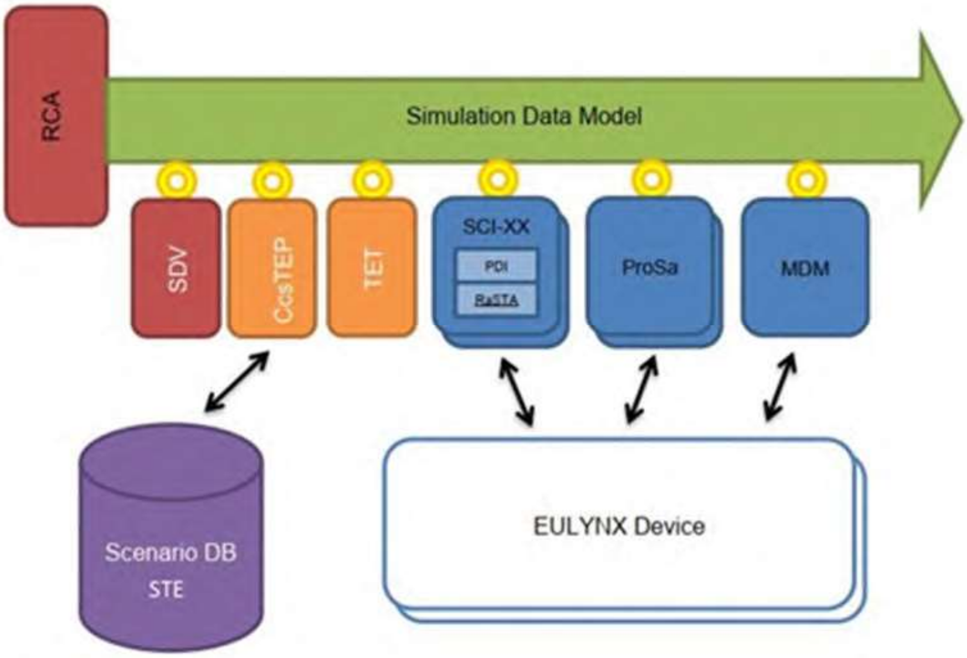

Figure 7-3: Architecture of the RailSiTe® Test Software

The EULYNX test sequences and cases are stored in the Scenario Database (DB) and can be easily imported to or exported from the DB in its original Excel format. The Test Editor (STE) manages the Scenario DB and allows to edit existing test sequences as well as generating new ones (Figure 7-4).

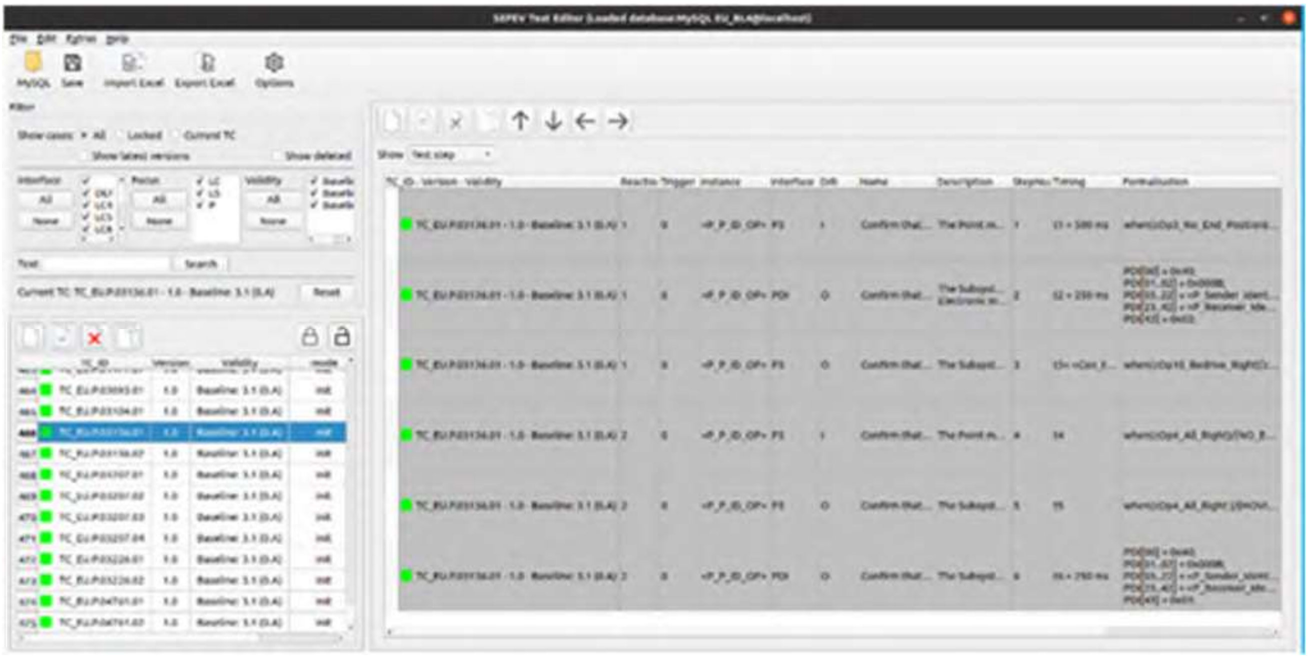

Figure 7-4: Scenario DB - An EULYNX Database with published test cases and self-build scenarios / sequences with multiple (sub) test cases (Screenshot: DLR)

The RailSiTe® Control Authority (RCA) starts and configures each component and coordinates the construction of the simulation data model which makes it the central application for running tests. All configuration parameters and further settings (e.g. RaSTA, ports, IPs) that are needed are stored in an individual file that is unique for each test sequence. Based on the configuration file the RCA starts all necessary simulation components and establishes a network connection to them. During the simulation, the RCA monitors and controls the components and synchronizes the distributed simulation data model.

The Simulation Data Viewer (SDV) offers a real-time view of the contents of the simulation data model.

The laboratory modules CCS Test Event Player (CcsTEP) and Test Event Tracker (TET) control the processing and logging of test scenarios. The TET logs scenario events, technical messages and models transitions to an SQLite or MySQL database. The CcsTEP first creates an event list by reading from the scenario database. During the simulation, these events are sent to the specified interfaces in the defined order indicated in the event list.

The laboratory modules Standard Communication Interface (SCI), Maintenance and Data Management (MDM) and Probe and Saboteur (ProSa) connect the DUT to the laboratory software.

The Maintenance and Diagnostic Module (MDM) is the interface between all connected test devices and the simulation environment for performing maintenance and diagnostic tasks. Currently, it is limited to receiving and logging SNMP (Simple Network Management Protocol) messages within the TET.

The ProSa-module connects the DUT to the simulation environment. By using this module, it is possible to receive test steps representing a sabotage event from CcsTEP and send them to the DUT or to receive probes from the DUT (Figure 7-5). Alternatively, both events can be invoked manually. The connection between a module in the simulation environment and the DUT is realized by WAGO modules.

7.6 Conclusion and Perspective

The implementation of the initial set of EULYNX tests into the laboratory has been completed. It was possible to integrate the elements under test into the simulation environment of the lab so that according to specifications the interfaces can be tested. At the present time, only a few specifications for some infrastructure elements are published. Therefore, in the coming months, continuous integration of new specifications has to be done as suppliers will have the need for testing their newly developed infrastructure elements for conformity.

Since tests are running in the RailSiTe® laboratory, next step is to bring the lab to the system to be tested. During the conception of EULYNX test laboratory the possibility of transporting the lab to the system to be tested has already been considered. The housing is fitted with rolls and has handles on both sides so that it can be brought to the customer's lab or anywhere in the field. Environmental conditions such as temperature and weather protection must be maintained. For executing these remote tests, the laboratory can be accessed via VPN (virtual private network) by an employee of the DLR in the institute of transportation systems.

In conclusion, EULYNX tests are brought to the lab and are successfully implemented for part of the published specifications. Suppliers can get a test report including the statement whether the interfaces conform to specifications.

In the next step it is planned to widen the tests to more supplier and other infrastructure elements.

7.7 References

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