Journal of large-scale research facilities

Journal of large-scale research facilities, 2, A88 (2016) http://dx.doi.org/10.17815/jlsrf-2-144

Published: 14.10.2016

RailSiTe® (Rail Simulation and Testing)

Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)
Institut für Verkehrssystemtechnik [*]

Instrument Scientists:
- Martin Johne, Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR); Institut für Verkehrssystemtechnik, Braunschweig, Germany, phone +49 531 295-3472, email: martin.johne@dlr.de
- Martin Busse, Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR); Institut für Verkehrssystemtechnik, Braunschweig, Germany, phone +49 531 295-3495, email: martin.busse@dlr.de

Abstract: RailSiTe® (**Rail Si**mulation and **Te**sting) is DLR's rail simulation and testing laboratory (see Figure 1). It is the implementation of a fully modular concept for the simulation of on-board and trackside control and safety technology. The RailSiTe® laboratory additionally comprises the RailSET (**Rail**way **Si**mulation **E**nvironment for **T**rain Drivers and Operators) human-factors laboratory, a realistic environment containing a realistic train mockup including 3D simulation.

Figure 1: RailSiTe® simulation and testing laboratory.

[*] **Cite article as:** Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR). (2016). RailSiTe® (Rail Simulation and Testing). *Journal of large-scale research facilities, 2,* A88. http://dx.doi.org/10.17815/jlsrf-2-144

1 Introduction

The RailSiTe® offers the capability to analyse, test and validate train control systems, subsystems and components. Both, the development and operation of the RailSiTe® laboratory have always been independent of operators, manufacturers and national authorities. In January 2012, RailSiTe® was accredited as an independent testing laboratory for on-board units of the new European Train Control System in accordance with DIN EN ISO/IEC 17025:2005. In co-simulations with the RailSET human-factors laboratory, new user interface concepts can be tested in a realistic environment, either as software simulations or as hardware prototypes.

2 Technical Description

2.1 RailSiTe®

The RailSiTe® laboratory allows the full simulation of the train- and trackside components of train control systems. These components are implemented in dedicated software modules. The modules exchange information over various interfaces. By removing a software module and integrating the hardware counterpart, the hardware can be run in the RailSiTe® simulation environment. This is called hardware in the loop. If necessary, interfaces can be added, to couple new external components.

2.2 RailSET

The RailSET (Railway Simulation Environment for Train Drivers and Operators) is a simulation environment containing a realistic train driver's cabin mockup with control panel and 3D simulation (see Figure 2).

Figure 2: RailSET (Railway Simulation Environment for Train Drivers and Operators).

An example of the visualization of the track simulation is given in Figure 3 shows an example of Braunschweig railway station. Other track infrastructures can be easily integrated by means of a railML-import interface (Railway Markup Language). The high resolution visualization is projected via a high resolution projector to a wall behind the mockup.
In the RailSET environment, rail human factor studies are conducted. Train drivers take part in the studies for investigating the human machine interaction. Their driving behavior, eye movements, and

Figure 3: Example of the visualized track simulation.

physiological parameters can be measured while driving. Figure 4 shows the workplace of the investigator outside of the RailSET with video transmission of the train driver, the track the driver sees in front of him or her, the control panel and the Driver Machine Interface DMI (e.g., for the European Train Control System ETCS). From this workplace, the investigator can also give instructions to the train driver.

Figure 4: Investigator's workplace associated to the RailSET.

3 Project Application Exampels

3.1 ETCS Conformity Testing

With its RailSiTe® railway laboratory, the Institute of Transportation Systems at DLR provides a cost-effective platform for interoperability and conformity testing that can even be integrated into development, particularly of ETCS on-board units (Asbach et al., 2013).
The Test Automation research group of the institute is continuously working to improve the quality of the individual testing phases from preparation to reporting. At the same time, it is developing processes and methods to reduce the time and cost of conformity testing. Once research findings are verified, they are applied directly in conformity testing.
A special feature: the test sequences are performed automatically, with a robot entering the information (see Figure 5) a train driver normally would. Tests can therefore be carried out all day, thus saving considerable time (Asbach & Ebrecht, 2010).
Test evaluation is also automated. A dedicated software application compares the test log with the target values and automatically indicates omissions or deviations in the messages and responses.
Thanks to these close links between research and test projects, RailSiTe® provides a particularly efficient laboratory environment for ETCS conformity testing.

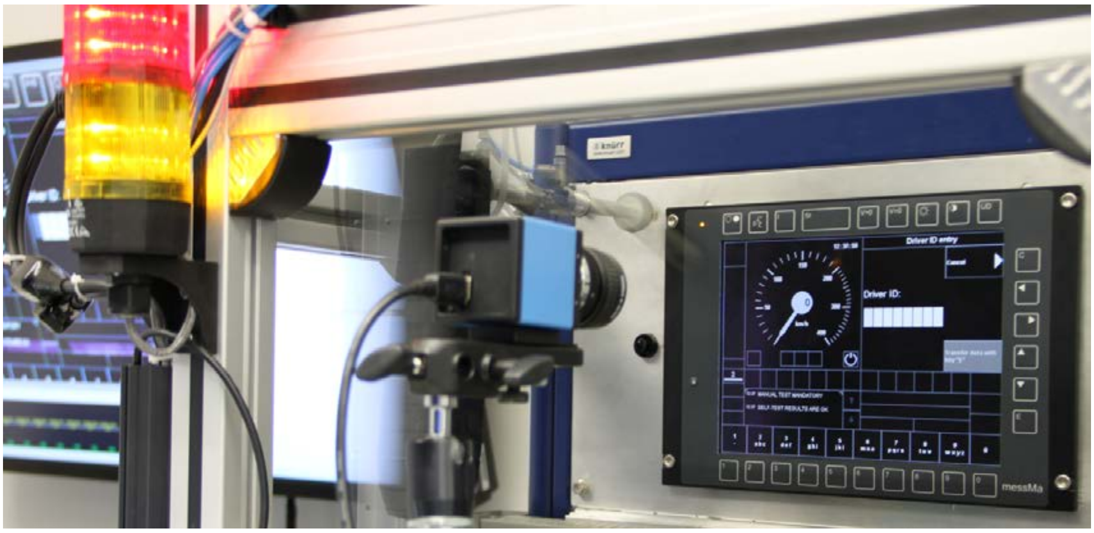

Figure 5: Automatic operation of DMI by robot.

3.2 Validation of Trackside Control and Safety Systems (CSS)

The RailSiTe® simulation and testing laboratory has a flexible, modular architecture. This permits the simulation and testing of individual rail system components in functional and operational scenarios. By including hardware-level interfaces, a wide range of trackside components of the control and safety systems can be integrated for technical or operational hardware-in-the-loop tests.

3.2.1 Validation of CSS Components

Thanks to its modular approach, RailSiTe® permits the integration of a wide range of different control and safety system components into different technical-operational simulations, thus allowing validation of the functionality of individual components or combinations of components.

3.2.2 New Concepts for Control Technology

New concepts and approaches, such as for operator workstations, can be developed quickly and efficiently and easily integrated into operational simulations.

3.2.3 GSM-R Radio Track

The transmission of digital message telegrams between train and track via GSM-R(ail), introduced as part of ETCS, is crucial for the interoperability of vehicles and track corridors throughout Europe. But it is particularly in this area that differences between the individual implementations cause disruptions. By linking radio block centres with ETCS on-board units from different manufacturers, RailSiTe® provides a platform for identifying and analysing potential problems.

3.3 Track Validation

Existing national rules of operations cannot always be fully modelled by the technical concepts of the new ETCS control and safety technology.
RailSiTe® helps overcome this hurdle: new or updated rules of operation can be checked and improved in RailSiTe®, in operational simulations using fictitious or real infrastructures. Moreover, such infrastructures can be simulated in the RailSET® driver's cab simulator for purposes such as training, including a visualisation of the track in a realistic environment (Busse et al., 2012).
New projects can be imported into RailSiTe® and operational requirements, even stress tests, thus verified. All this is possible from the early planning stages. Another option is the – partly automated – import of existing routes into the laboratory environment, which makes it possible to identify error sources quickly. Using data from juridical recording units, specific situations can be modelled accurately and reproduced as often as required. In these models, individual modules can be replaced by real hardware, permitting the identification of error sources.

3.4 RailSET: Human Factors Studies

With the RailSET environment, new user interface concepts can be tested regarding usability in a realistic environment, either as software simulations or as hardware prototypes (Naumann et al., 2013). For example, attention distribution between DMI and track can be measured via eye tracking in order to evaluate new DMI concepts (Figure 6;. Kohl et al. (2016)).

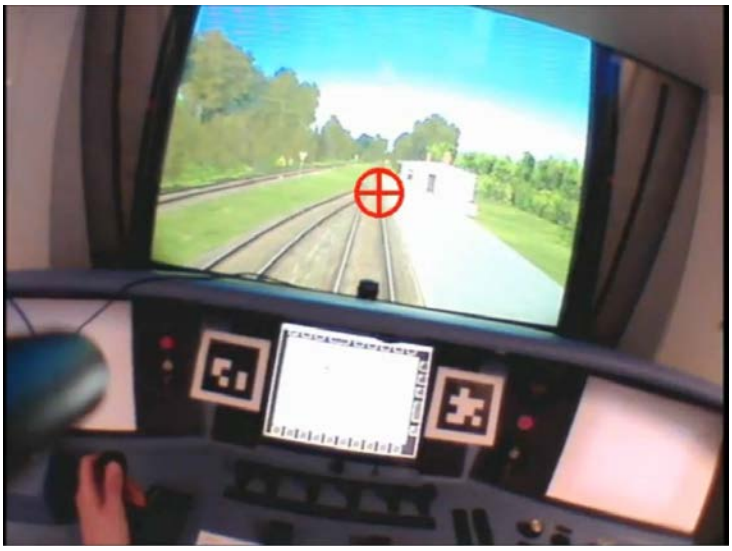

Figure 6: Eye movements of the train driver. The red cursor marks the attention focus.

Also, insights in the effects of, for example, fatigue and monotony of train drivers can be gained (Stein & Naumann, 2016).

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