TRIALS & TESTING

TU DARMSTADT – RESEARCH, TRAINING & MORE BESIDES

IN THE FIELD OF RAILWAY OPERATIONS, TECHNISCHE UNIVERSITÄT DARMSTADT (TU DARMSTADT) AND ITS DEDICATED RESEARCH CENTRE EISENBAHNBETRIEBSFELD DARMSTADT (EBD) OFFER A RANGE OF KEY SERVICES. THESE INCLUDE A SIMULATION FACILITY FOR RESEARCH PURPOSES, TRAINING FOR STUDENTS, AND FURTHER EDUCATION FOR ENGINEERING FIRMS.

Eisenbahnbetriebsfeld Darmstadt is operated by a collaboration of DB Training, Learning & Consulting, the 'Railways' Academic Working Group (AKA Bahn), and the Department of Railway Systems and Railway Engineering at TU Darmstadt. The centre opened in 2006 at its current location near the city's main station (Darmstadt is situated in centre-west Germany). The signalling and interlocking teaching facilities at the university date back to 1914 when the first signal box was set up for teaching purposes. From 1935 to 1939, the initial laboratory, which consisted of several mechanical and electro-mechanical signal boxes, gradually expanded. Over the years, more modern technology, such as relay interlocking systems and electronic interlocking, have been added. Due to the increasing needs for space on the campus, the laboratory had to be dismantled in 2000; the signal boxes went into storage and the original room was used as a computer lab. As an interim measure, a pilot installation was built at the department, with three interlocking systems to test new systems, such as the indirect control of the elements of a roadway and courses. The indirect control utilises a control level between the interface of the interlocking and the model elements of a roadway, e.g. points and signals. In the autumn of 2004, reconstruction of the laboratory began thanks to joint cooperation.

At EBD today, almost 1,000 metres of track to a scale of 1:87 (size H0) are installed. To satisfy the need for greater track length, the track scale was set at 1:250. Overall, EBD provides 90km of main and branch lines. The model system consists of a double-track railway ring, a single-track line, and a dual link (see Fig. 1). The latter enables the entire system to be divided into two rings, which may be used in any combination depending on the number of seminar participants. In addition, there are two dead end routes.

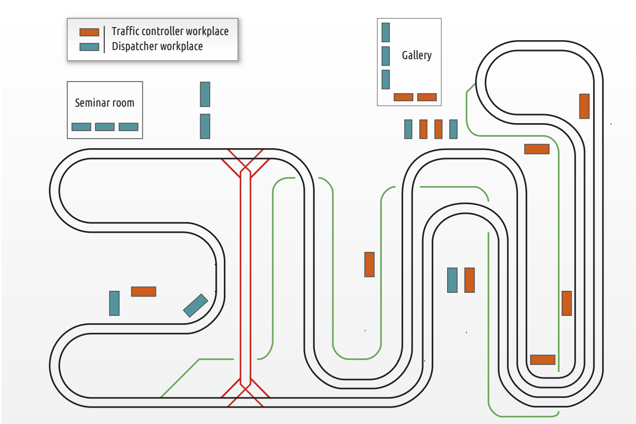

Fig. 1. Basic track layout

Source: AKA Bahn

The facility covers some 500 square metres and consists of 13 stations, 160 main tracks, and 380 points and derailers. Additionally, the focus on passenger transport has been extended to include goods and dispatching processes, as well. Therefore two large freight stations with an automated hump for the distribution of cars on the tracks, an international section, a ferry station, and a tram section can also be found. The bandwidth of the integrated interlocking technology ranges from mechanical to modern electronic. In addition to the original signal boxes from 1935 and the signal boxes added to the original laboratory up until its demolition in 2000, one electro-mechanical signal box, two relay interlocking systems, and a number of self-programmed replicas of electronic interlocking have been added.

INTERLOCKING TECHNOLOGIES REPRESENTED AT EBD

As already mentioned, there are four different general types of interlocking technologies represented at EBD:

- mechanical signal boxes
- electro-mechanical signal boxes
- relay interlocking systems
- electronic interlocking systems.

Numerous variations of mechanical signal boxes evolved from the first entry into service in 1867 up until the introduction of the 'Einheitsstellwerk' (standard interlocking) in the 1920s. All these types of boxes share similar modes of operation. Elements of the roadway are

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switched manually via levers and cables. Afterwards, these elements are locked mechanically and fixed electrically. The EBD has two mechanical signal boxes supplied by the company Juedel.

Further developments led to the electro-mechanical signal boxes, which first entered service in 1894. The principles for protecting the roadway and the need for visual inspection of the roadway did not change. However, elements of the roadway are switched via electric motors. As a result, the area of control is expanded from a radius of one kilometre to about two kilometres, and larger stations can be controlled by one electro-mechanical signal box instead of multiple mechanical signal boxes. At EBD, there are 2 x type 'Siemens & Halske 1912' (E43) electro-mechanical signal boxes.

Signal boxes with relay interlocking technology feature a schematic illustration of the controlled stations' track layout. In addition to this, there is no need for visual inspection of the roadway during standard operations because of the introduction of track-occupancy detection. For safety reasons, every operation requires two pressed buttons. In Germany, relay interlocking technology first entered service in 1948. The controllable area has a radius of about 6.5 kilometres, and, additionally, it is possible to telecontrol multiple signal boxes. At EBD, three signal boxes with (simulated) relay technology can be found. Two of them are 'DrS2' types, and the third is an 'SpDrS60.' The latter introduces a part-autonomous setting of the roadway. The operator selects start and destination; the signal boxes identify and switch the necessary elements of the roadway by themselves.

The most modern type at EBD is the electronic interlocking. It was first introduced to Germany in 1986. The principles are based on relay interlocking technology, but the relays are replaced by computer components. As a result, less space is needed. Modern types of electronic interlocking feature an automatic selection of the roadway based on the reported number of the train. At EBD, no commercial electronic interlocking can be found. A re-engineered software version based on the fundamental functional principles is used.

A possible expansion of the installation would feature two relay interlocking technology signal boxes from former Eastern Germany (former GDR), a 'GS II DR' and an 'EZMG'. The latter is of Soviet origin. Through this expansion, EBD would be the only facility featuring all mainly used interlocking technologies of the reunited Germany.

APPLICATIONS

With such a wide range of technical elements, EBD is used for highly versatile training and research purposes. Its miniature reality permits practical, initial, and advanced training in railway operations, control and scheduling. It is used by DB Training primarily for the education and training of personnel from Deutsche Bahn AG (e.g. dispatchers from DB Regio and DB Fernverkehr), by AKA Bahn for private simulation training sessions, and by TU Darmstadt for courses. The courses are supported by AKA Bahn.

In one of their bachelor grade courses, students at TU Darmstadt discover all the possibilities offered at EBD. They get to know the process of 'driving a train' by utilising the different interlocking techniques, and gain an insight into the complexity of the process.

Source: DB AG/Ralf Braun

Fig. 2. Theoretical and practical training

All kinds of mechanical, electromechanical, and relay interlockings to the modern electronic interlocking are available

The aim of this session is to build an early interest among students for the rail system, and for the master grade courses at the chair of railway engineering. The latter offers, by way of example, a 'railroad safety systems' course that includes training at EBD and covers the following topics:

- basic requirements for security systems
- the fundamentals of safety engineering
- the principles of signal boxes
- future development of interlocking systems.

During the second part of this course, students learn about deviations from normal operating procedures including:

- irregularities and disruptions in railway operations
- 'Zugleitbetrieb,' or operations during construction phases.

The wide range of possible applications at EBD demands various technical equipment and solutions:

- realistic simulation of railway operations
- presentation of interlocking techniques
- a variable number of participants (5 to 15) for seminars in the field of railway operation fundamentals
- 'personal saving' configuration of the signal boxes used
- provision of dispatcher workstations
- simulation of interferences in the exercise sequences.

To simulate faults or deviations from normal operation, many options are available, of which:

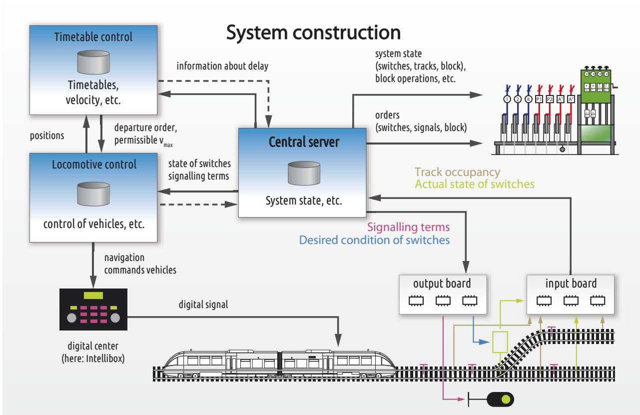
- speed restrictions may be simulated at any location across the whole installation
- delay data, schedules, and other special timetable data, such as holding time extensions or the failure of maintenance to track closures or interlocking problems, can be imported into the currently running schedule.

Disruption or interference scenarios are used at both fundamental and dispatching seminars. Here, an increasing number of interferences will occur during the progress of the seminars, so the difficulty and stress applied can be specifically adjusted during each training sequence. As shown in Figure 1 (p.152), dispatchers can work side by side with signal box controllers.

SIMULATION OF RAILWAY OPERATIONS

A basic prerequisite for the simulation of railway operations is the representation of the interlocking technology in relation to the system model. At EBD, all kinds of mechanical, electromechanical, and relay interlockings to the modern electronic interlocking are available. Based on the old technology of mechanical interlocking, a better understanding of the security logic is gained. Similarly, the interaction of individual components, such as using the mechanical lock box on the switchboard for example, can be demonstrated. Like the pilot installation, the control orders of the interlocking are not directly passed on to the model system, but to the EBD central server. The latter issues the orders to the components of the model system. At the same time, the system reports the track layout and the actual position of the switches to the central server.

For a realistic simulation, many other technical systems are required in addition to the existing signal boxes. All systems



Source: AKA Bahn

Fig. 3. Technical concept

are supplied by the EBD central server, which stores the system states. The interaction between the systems is shown in Figure 3. Through defined interfaces and the use of free software, the EBD system achieves high flexibility.

The 'Fahrplansteuerung' provides automatic control of scheduled trains. At the central database, depending on the chosen seminar, different timetables with different densities of trains are stored. The Fahrplansteuerung also ensures that a train does not leave before its departure time or, in case of a delay, compliance with the minimum holding time. In addition to the schedules for the various events, the decomposition and conversion schedules are stored in the database. This ensures that the vehicles can be driven automatically in the underground parking station after the seminar.

The 'Loksteuerung' ensures that all vehicles move with realistic (based on the distance scale) velocities as a function of the signal terms and authorised line speed. The Loksteuerung also simulates the intermittent cab signalling system, the 'PZB' train protection system, and slow rides over switches or due to interference. In addition, it stores vehicle locations, which in turn can be passed to the central server. This information can be used by other programmes such as the route overview (BLeiDis).

The 'EBD Kontrollzentrum' is a programme for the easy and central definition of simulation parameters, e.g. simulation time, which is set according to the seminar schedule and can be stopped at any time during operation. This is used, among other things, to centrally analyse conflict situations that have occurred with all participants at the scene. Furthermore, it is possible to switch between operation with old technology, mixed operation with old

Source: DB AG/Ralf Braun

Fig. 4. Central operations centre

The work of the dispatchers in the control centres and TPs has a direct impact on the timeliness and quality of the services provided. Especially during disruptions, swift and competent decisions are needed

technology and electronic interlocking, and sole operation with electronic interlocking. For most stations at EBD, it is possible to select which interlocking technology is used to control the model system. It is also possible to completely deactivate individual stations. As such, the number of workstations can be customised according to the number of participants of the seminar. As an alternative to full or partial operating with old technology, the complete system can be operated from a central operations centre at EBD with two regulators (see Fig. 4). Additionally, as in actual operation, a train control to support the regulators is available. The system can be operated flexibly with two (during dispatching seminars) or up to 14 people (during seminars focusing on train operation).

The electronic interlocking, the above-mentioned necessary programmes for railway operations, and the existing hardware (control and monitoring boards) used at EBD have been and are developed by AKA Bahn. In part, initial experience of developing these programmes has already been obtained from the pilot installation. Due to the dedication of AKA Bahn regarding the maintenance of the technical systems, EBD can be operated independently from interlocking technology manufacturers.

SOFTWARE TOOLS TO SUPPORT THE DISPATCHING PROCESS – DISPOSIM

Due to the separation of the infrastructure manager (EIU) and the owners/operators of the rolling stock (EVU) in Germany, the EVU organises the dispatching process. This includes securing passenger transition in case of delays, organising replacement traffic, replacing defective rolling stock, and other tasks.

In addition to the simulation of the above-described line-side operations, simulation of the dispatching process is also carried out at EBD. Special programmes have been re-engineered from software used in real operations, and are collectively referred to as DispoSim.

The dispatchers in the control centres ('Leitstelle') are responsible for providing rolling stock, while the dispatchers in the traffic control centres ('TP') monitor the train movements. They do not operate signal boxes, but are responsible for providing connection information to all the players involved in the dispatching process during diversions or re-allocations. Thus the work of the dispatchers in the control centres and TPs has a direct impact on the timeliness and quality of the services provided. Especially during disruptions, swift and competent decisions are needed, and these are usually taken under high stress and time pressure. The dispatchers tackle the problem based on their experience. Nevertheless, additional education and training is required. In order to train dispatchers for this task, DB Regio has developed a qualification programme. Part of this involves training stress and disturbance management. More recently, 'quality-conscious dispatching' has been added to the portfolio. Both courses rely on DispoSim and place additional heavy demands on the infrastructure and software programmes at EBD.

To support the training, various applications used by the dispatchers in real life are simulated at EBD. These include an information system and different personnel and vehicle resource planning software tools, each with additional systems used by the instructor for data manipulation (see Fig. 5).

Information system

This simulates different forms of customer information, whereby the user is able to display and edit disruption data. Furthermore, it is possible to create and edit forecasts for train arrivals and the remaining route of selected trains. Detours and partial train cancellations can be dispatched, too.

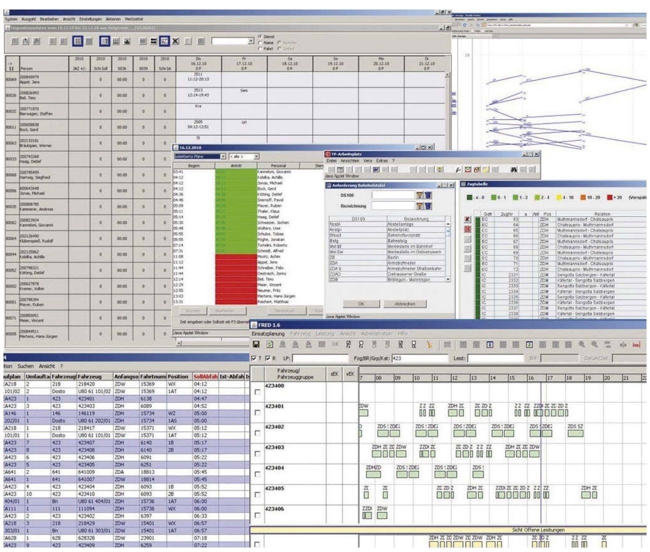
Vehicle resource planning

This tool is used for ad hoc vehicle management. It can display all services that are assigned to a vehicle, while the dispatcher can create, edit, and break services. There is also a display of the overall movement of selected trains.

Personnel resource planning

The system is used for the dispatching process concerning personnel. It is used to monitor staff and to trigger dispatching processes. The current manning of trains can be displayed and modified. Staff on current and upcoming shifts can be informed about changes in their schedule and general disturbances in the railway network.

In addition, there is another system that combines both personnel and vehicle resource planning. It can be used in parallel or as an alternative for the two systems mentioned above, depending on which software tools the trainee uses in his or her real job. The implemented functions are similar in all personnel and vehicle management systems.



Source: TU Darmstadt

Fig. 5. Software tools for dispatching

DispoSim

Based on the replication of existing systems that are used productively in Germany, DispoSim primarily serves training purposes. Therefore, only the functions needed for specific training are implemented in the different software tools, which in turn can help simplify the implementation by abstraction and by using a different software architecture. Given that integration of productive systems is too costly and in many places not feasible, yet interaction with the systems is necessary for high-quality training, the chosen solution offers an optimal path between full integration and the absence of interactive computing systems.

All DispoSim applications use a central database. This simplifies maintenance of the database, which only has to be carried out in one place, plus the different processes can be carried out in parallel. Changes of data made in one system are directly accessible to other systems.

In addition to DispoSim, there are other EBD functionalities used for training purposes. The simulation time can be halted, if necessary, to give direct feedback to participants and discuss decisions made and their impact on the current situation. Furthermore, the central server provides real-time data to the DispoSim database, and the information is presented to trainees in their respective tools. This requires locating every single train in every block section or track of a station. In addition, timestamps are assigned to

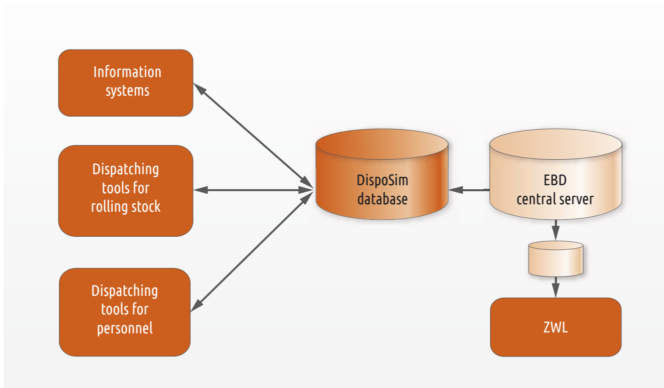


Fig. 6. General structure of DispoSim

Source: TU Darmstadt

the location data. This enables the simulation of real-life dispatching. The seminar leader can choose from a wide range of situations in order to modify the current scenario during the training. Also, communication devices such as VoIP telephony, train describer, and BLeiDis are also used in the training courses.

The recently developed representation of a time-way line (ZWL) provides instructors and participants with a quick overview of the operational situation in a format they are familiar with from their regular jobs. The ZWL relies on the EBD's central server to collect the relevant plan and real-time data read-outs (see Fig. 6). These are then processed in a separate database and can be displayed at any workstation using the ZWL representation.

The simulation application DispoSim, in conjunction with EBD, forms a strong foundation for conducting realistic training aimed at transport dispatchers. The current seminars are proving to be a great success and the participant feedback is always very positive.

FUTURE DEVELOPMENTS

The existing systems of EBD have been developed and expanded continuously since its opening. The centre provides excellent conditions for teaching, training, and research. And in the future, it will continue to adjust its current set of tools to suit new seminar topics. Thus the simulation installation is always growing and evolving due to the requirements and specifications derived from training needs.

One further aim is to address and involve other target groups in new seminars, e.g. dispatchers from infrastructure managers or the passenger information services. Furthermore, the involvement of the centre and its simulation capabilities in research projects will continue ■

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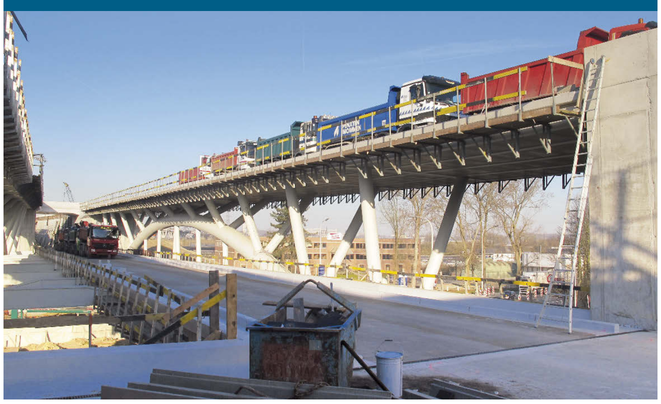
DEVELOPMENTS CONTINUE IN THE EUROPEAN RAIL SECTOR

BELGORAIL HAS RECEIVED OFFICIAL RECOGNITION IN FRANCE



The French Public Railway Safety Authority (EPSF) has recently approved BELGORAIL as a qualified body to assess the design and production of new or substantially modified rail systems and subsystems.

BELGORAIL, a rail certification body whose purpose is to certify the compliance of railway vehicles, installations and rail services in relation to European and national technical norms and standards, has just obtained additional recognition.

After having obtained the status of competent body in Luxembourg in 2011 and having been the first accredited European body in 2012 for the certification of Entities in Charge of Maintenance (ECM), the company is continuing to expand its area of activity.

The company can now also act in France in the field of rail system certification on the basis of the French national regulations in force.

Since its creation in June 2004, the company BELGORAIL has enjoyed rapid growth. It has been awarded the status of notified body within the framework of the interoperability directive (2008/57/EC) and is active in several European countries as well

as on an international level for inspections, audits, safety studies (including risk management methods), product certification, ECM Certification and services in the rail transport sector ■

MORE INFORMATION

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