German Centre for
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Report 13 (2021)

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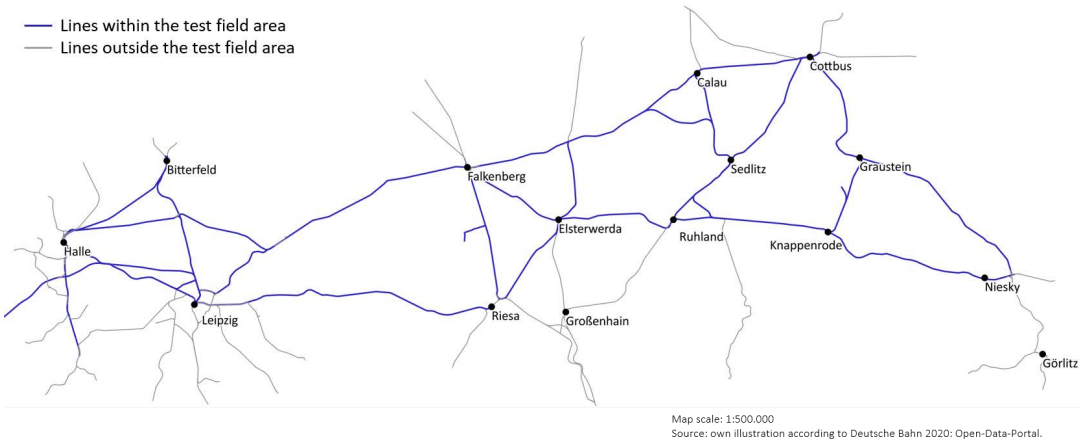

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Investigation of possibilities and requirements for an open digital test field for railway traffic

Summary

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Abstract

By setting up an open digital test field, the German Centre for Rail Traffic Research (DZSF) will offer new research opportunities that will close existing gaps in the range of railway test facilities. Among those long-established test facilities with test loops or test tracks, in particular the commercial interests of significant train manufacturing companies are pursued. Existing test facilities are therefore not used for non-commercial research purposes, or only to a very limited extent.

The open digital test field will be unique in Europe. It will enable multiple tests of new technologies and innovations on an existing railway network under real-life conditions. Located between Halle (Saale), Cottbus and Niesky in the federal German states Brandenburg, Saxony and Saxony-Anhalt, the test field will use approximately 350 km of existing main lines of the DB Netz AG, serving both regional and long-distance passenger transport as well as freight transport. In addition, a supplementary railway network of approximately 500 km length is available. The infrastructure covers almost the entire range of operational and infrastructural real-life conditions. The test field will especially address research activities in the fields of autonomous driving, signaling and communication respectively digitalisation. An essential part is also noise reduction research in a noise laboratory (LärmLab).

First experiments and tests can immediately be executed, e.g., in the field of environmental and climate protection, monitoring of operational procedures, traffic procedures and maintenance procedures, optimization of digital innovations or projects that involve passengers. However, several tests still require some infrastructural and project-specific upgrades. Within the study, test requirements and upgrades needed are identified separately for individual testing projects. Moreover, time spans for implementation are estimated. In the case of project-specific investments, cost sharing with external project partners is conceivable. For investments in basic equipment (especially office rooms, vehicle and laboratory halls and track infrastructure as well as rail test vehicles), an annual budget of approximately 10 million Euros is valued over a period of 10 years.

A stakeholder survey within the rail sector confirms the concept that is elaborated in this study. The concept contains research fields, testing requirements and necessary infrastructure investments. The survey also revealed that stakeholders desire short lead times and time slots for testing as long and uninterrupted as possible. The neutrality of a test field operator is also of great relevance for the respondents.

Legal evaluations of the organizational model and the testing modes planned in the open digital test field reveal several upcoming restrictions. Restrictions concern the provision of track capacities as well as railway safety rules that need to be observed. A corresponding amendment to the railway regulatory law (ERegG) in regard to general testing purposes and test rides is therefore desirable.

With the planned open digital test field, new possibilities for innovation, employment and economic development are opened in the rail sector in general and in the former mining regions of Saxony and Brandenburg in particular. The project has the potential to combine several objectives. In the upcoming investment decisions, the leverage effect of the monetary resources used, which is considered to be significant, should be taken into account.

1 Introduction

The purpose of this study on behalf of the DZSF is the investigation of possibilities and requirements for an open digital test field for railway traffic. Establishing such a test field facilitates technological innovations and thereby serves the purpose of implementing the Federal Research program of Rail Transport.

2 Requirements and Goals of the Open Digital Test Field

The analysis of established testing facilities shows that those with test loops or test tracks as well as laboratories and test benches are usually used commercially and owned by big railway manufacturers and can therefore not/rarely be used for research purposes. Testing facilities with test loops are needed for the industrial licensing process. Therefore, capacities for research activities are given on a small scale and go in hand with long lead times. In addition, there is a lack of test facilities that allow tests under real-life conditions, which is essential for the introduction of new procedures and technologies. The long lead times and limited access to existing European test facilities thus represent a major barrier to important innovation projects.

The establishment of the test field creates a new range of research opportunities and thereby closes a gap in the existing research landscape. Compared to existing test facilities, the open digital test field is unique in size and orientation. To promote applied research, the test field will operate as a neutral platform for cooperation between research and industry and will be able to offer test capacities that are flexibly available and at short notice. In addition to the established companies on the market, small rail technology companies or companies from other sectors and non-commercial research institutions will also find the necessary conditions for testing their technologies and ideas. The DZSF provides organizational support for carrying out the investigations by acting as “one-stop-shop” for the sector. The basic equipment for investigations of new technologies is provided. The test field is suitable for numerous test issues with a focus on topics related to automation and digitalization. The test field will include both separated own lines as well as lines of DB Netz AG that are in regular operation, so that tests can be carried out in interaction with regular traffic. By including trackside areas and the surroundings, studies on climate, environmental and noise protection (LärmLab) will be feasible. Figure 1 shows the total of eleven research fields, which are all subordinate to the thematic fields of the Federal Rail Research Program.

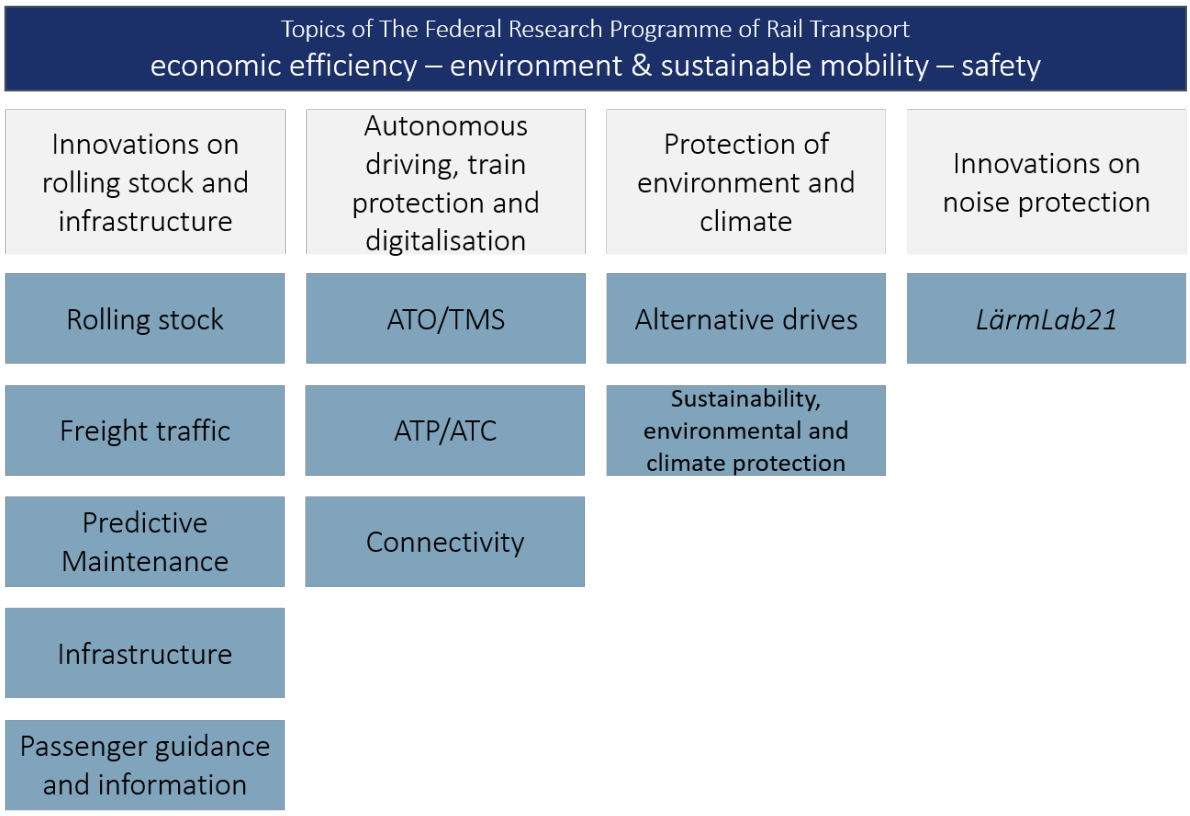

Figure 1: Research fields of the open digital test field

The test field will be located between Halle (Saale), Cottbus and Niesky in the federal German states of Brandenburg, Saxony and Saxony-Anhalt. The test field includes regularly used tracks (cf. Figure 2) with different characteristics, abandoned tracks with the option for reactivation as well as the railway infrastructure of the lignite mining areas for perspective subsequent use.

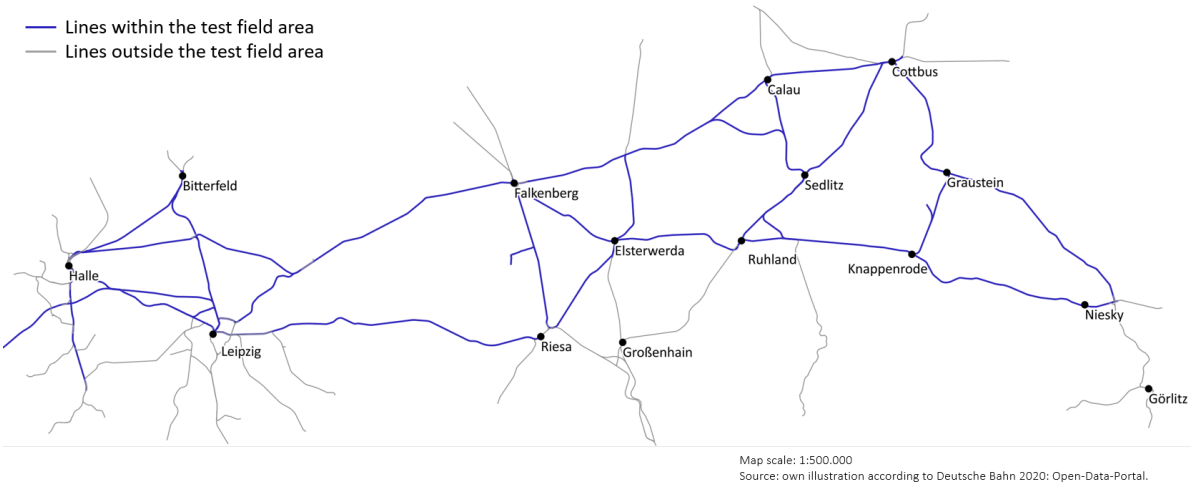

Figure 2: Overview of existing lines of DB Netz AG within the test field area

The existing track network comprises approximated 350 km of main lines. In addition, there is a supplementary network of approximated 500 km in length. Most of the lines are both double-tracked and

electrified and are almost completely equipped with German train control system PZB. The lines between Leipzig and Riesa and also between Leipzig, Halle and Bitterfeld are equipped with German linear train control system LZB. Enabled by LZB, the maximum speed of those tracks is 200 km/h, while the maximum speed for the rest of the network is mostly 100 or 120 km/h. The Erfurt-Halle line, which is part of the German Reunification Rail Transport Project No. 8.2 (VDE 8.2), and the Berlin-Dresden line (between Zossen and Rückersdorf) are both equipped with ETCS Level 2 what permits speeds up to and over 200 km/h. Both long- and short-distance passenger traffic and freight traffic is operated on those lines. Many lines in the area are part of the Trans-European Network (TEN). The Falkenberg-Horka section is also part of freight corridor No. 8.

Initial investigations can already be carried out or started in the short term on the existing track network of DB Netz AG that is used for regular operations. For example, in the field of environmental and climate protection, measuring stations can be installed or in the field of predictive maintenance, the establishment of a local radio network is possible. Another example is the field of alternative motors, where mobile refuelling of rail vehicles with alternative energy sources would be used. Several other tests to be carried out on the test field require an infrastructure that is separate from regular operations or extra technical equipment. An overall evaluation of the retrofit requirements depending on individual test projects shows that a high-performance radio data coverage with high bandwidth and low latency is required across all research fields. The 5G data radio standard should therefore be implemented as soon as possible. The same applies to (partial) equipment with ETCS Level 2 and Hybrid Level 3.

3 Required Equipment

The establishment of the test field requires as well basic organizational and infrastructural equipment. This includes personnel, an operating site with vehicle and laboratory halls, office workstations and IT-infrastructure. In addition to this initial expansion stage (stage 0), three further expansion stages (stages 1 to 3) are differentiated:

Step 0: Establishment of an organisational structure with basic infrastructural equipment
Step 1: Execution of short-term test possibilities during regular operation on existing infrastructure
Step 2: Use/reactivation and equipment of lines without regular service
Step 3: Realization of retrofits for the investigation of specific issues

At this early stage of the overall project “open digital test field”, all cost estimates can only be made roughly since various decisions with a significant influence on the overall costs have not been made yet. In addition, it must be considered that price information is often not yet available, especially for future technologies that may be implemented for the first time. Relevant questions in this context include the following:

- What is the organizational structure or form of operation (including allocation of running costs)?
- Will there be a cooperation using existing infrastructures or will own offices, halls, railway sidings etc. be built?
- Will there be a cooperation or will own personnel (administrators, assemblers, shunters, train drivers etc.) be employed?
- Is rolling stock shared, rented, or purchased within the framework of cooperations?
- How many lines/line kilometres are to be equipped with what kind of technology?
- Can cooperation models be entered into with the industry that result in lower equipment costs?

- What equipment should be provided promptly and what project-specific equipment should be decided on individually?
- How much is the share of costs to be borne by external project partners?

With progressing planning and realization of the open digital test field, the cost estimates must be continuously adjusted and specified accordingly. Table 1 shows the estimated investments in the basic equipment on the test field.

TABLE 1: ESTIMATED INVESTMENTS IN THE BASIC EQUIPMENT [MILLION EURO], (11.03.2021)

Basic equipment	**Step 0**	**Step 1**	**Step 2**	**Step 3**	**Sum**
Establishment of company grounds	25,0	-	-	-	**25,0**
Purchase of rolling stock	-	5,0	-	-	**5,0**
Purchase of track infrastructure	-	-	75,0	-	**75,0**
Sum					**105,0**

The total investments in the basic equipment are estimated to 105 million Euros. The investments break down into 25 million Euros for the establishment of company grounds (step 0), 5 million Euros for the acquisition of the company's own rolling stock (step 1) and 75 million Euros for the purchase and commissioning of the company's own track infrastructure (step 2).

In addition to the establishment of the operating site, the purchase of own track infrastructure has a significant share in the total costs. Even if some of the investigations can already be carried out on the existing network of DB Netz AG in the short term, the acquisition of own track infrastructure is necessary to complete the envisaged test portfolio. With the help of test field-owned lines that are separated from regular operations, it will be possible to carry out investigations that pose special safety requirements or would significantly impede regular operations.

According to a rough estimate, the retrofitting requirements of the open digital test field for specific issues (so-called project-specific investments) amount to approximately 122 million Euros. High investments are required in step 2 for the expansion of control and safety technology (58,2 million Euros), radio data transmission (15,0 million Euros) and the energy supply infrastructure (10,7 million Euros). However, these investments form the necessary infrastructural prerequisites for numerous project-specific test projects and should be carried out as quickly as possible despite the high costs.

Further 40 million Euros will be needed, among other things, to set up a monitoring system for environmental and climate protection projects, equipment for the LärmLab, specific sensor technology and infrastructures for Automatic Train Operation (ATO) trials. To stagger the costs, a realization period of 10 years is assumed. Despite of that initial trials and tests can be carried out right from the start.

The annual running costs for personnel, track access charges and maintenance are initially estimated at 1,5 million Euros. As the company's own infrastructure grows, annual running costs are expected to rise to 3,0 million Euros.

The high level of participation in a stakeholder survey conducted as part of the study testifies the relevance of and interest in the establishment of the open digital test field. The results of the survey show a

high level of approval for the basic orientation of the test field as well as for the fields of investigation and possible tests developed in detail. The sector considers test opportunities for autonomous driving and digitalization to be the most relevant. The preference towards longest possible uninterrupted time windows available for testing, underpins the need for test field-owned track infrastructure. In terms of organisational design, the respondents would like to see a neutral operator of the test field that provides support in the planning and execution of tests and makes its own rolling stock available. Lead times should be as short as possible and the test field itself should be easily accessible (by rail).

The legal evaluation must be divided into two parts. Firstly, the access to the test field and thereby the relevant questions under regulatory law will be scrutinized. Secondly, the implementation of the intended experiments in accordance with security law provisions will be legally assessed.

4 Legal Evaluation

In order to conduct the assessment of the different experiments **under regulatory law** provisions they have been sorted into three clusters:

1. Experiments including train rides on public railway lines
2. Experiments including train rides on private railway lines
3. Experiments excluding train rides

Having to be distinguished from the term “public” railway lines, “private railway lines” encompasses tracks that are property of private operators (such as private sector companies or registered associations etc.) and not in the property of the state or subsidiary companies held solely or with a majority interest by the DB group (for example the DB Netz AG). However, this distinction is not used to determine whether the railway line in question serves the public traffic as set forth in section 3 of the General Law on Railways (AEG: Allgemeines Eisenbahngesetz) and thus can be considered a public train (s. 3(2) AEG).

Firstly, the applicability of the Railway Regulation Law (ERegG: Eisenbahnregulierungsgesetz) for experimental train rides on “public railway lines” (1.) was assessed. As the testing field’s measuring tools and institutions are classified as service facilities, the right of access to these facilities and railway lines in question must be evaluated for each experiment on the grounds of the ERegG. The law relating to occasional traffic poses a feasible solution for lines that are not used to full capacity. However, in cases of traffic conflicts no priority access is granted under the current working timetable. A coordination unit managing the ordering and arrangement of access rights for service facilities and railway lines may be a good approach to solve this issue, however the implementation of such a model is hindered by the current legal framework.

Experiments with train rides on private tracks (2.) must also be assessed under the right of access set forth in s. 10 f. ERegG. Therefore, it is irrelevant whether the experiments are commenced on private or public lines as an access to service facilities must be provided anyways. Restricting the right of access under s. 15 ERegG for so-called Werksbahnen (company owned non-public railways) cannot be considered as the requirements set forth in the ERegG are not met.

The third cluster of experiments without train rides (3.) poses no issue under regulatory law.

However, as no test rides exist within the ERegG, its practical application is difficult where regulatory law is applicable. As a result, some regulations are unclear and lack sufficient legal certainty even after

interpretation. It is therefore necessary for the lawmaker to adapt or widen the existing ERegG to provide a better and legally more certain solution. The so-called temporary discontinuation of service (as used in Austria) or a mechanism sufficiently implementing test rides in capacity planning are recommended to achieve this goal.

To assess the implementation of the test field **under security law**, the planned experiments will be classified into four categories:

- Vehicle trials
- Infrastructure trials
- Operating tests
- Trials on environmental protection

Within these four categories more distinctions must be drawn between each trial, distinguishing for example trials only monitoring train rides without usage of modified vehicles or infrastructure from such using non-approved vehicles or infrastructure.

The trials can moreover differ as to the advancement of technology used in their testing means as well as to the possibility to apply the current legal framework.

All categories of vehicle and infrastructure trials, operating tests and trials on environmental protection must comply with the required operational safety. It is noteworthy that the effort needed to achieve operational safety for each category differs. In cases in which the existing legal framework is either inapplicable or insufficient, methodical approaches for risk management can be used instead. However, if the operational safety cannot be guaranteed, the trial in question cannot be conducted.

No standardized legal framework exists outside the application of the Statutory Order on the Authorization of Commissioning of Railways (EIGV: Eisenbahn-Inbetriebnahmegenehmigungsverordnung), and thus, outside the so-called “superior railroad network”, as well as for trial rides and other means of testing. Under s. 4 AEG arises a duty for non-public spatially separated railways and their infrastructure to ensure the safety of any railway traffic. To increase the certainty of the legal framework in regard to general testing purposes and test rides, an adjustment of the AEG and other statutes such as the Law on Railroad Construction and Operation (EBO: Eisenbahn-Bau- und Betriebsordnung), the EIGV and the Law on Railroad Construction and Operation for tracks connecting a factory to the railway system (BOA: the Bau- und Betriebsordnung für Anschlußbahnen) is strongly recommended. Additionally, it would be reasonable to also improve the clarity of the legal framework regarding the infrastructure of non-public independent railways.

Besides the clarification of legal issues, the start of operation of the open digital test field requires an operational organization under the management of the DZSF. Moreover, the preliminary cost estimates must be specified in more detail in the course of concrete planning steps and continuously adjusted according to the realization status of the test field. All here mentioned costs do not represent a final consideration but serve to identify essential investment requirements. In addition, some of the technologies considered to be forward-looking, such as FRMCS (Future Railway Mobile Communication System), ETCS Hybrid Level 3 and ATO, are still at a relatively early stage of development, so that test requirements are not yet fully foreseeable. The detailed explanations in the long version of the report are therefore to be understood as a basic set of questions that are reasonable to be investigated in an open digital test field.

5 Conclusion

It can be assumed that the open digital test field with the planned equipment in this project will be adequately positioned for future, respectively for research questions not yet foreseeable. A special opportunity for the further development of the rail transport system lies in the networking of different research areas on a large-scale infrastructure. In contrast to established test facilities which primarily serve the commercial interests of large rail vehicle manufacturers only offering a small amount of free capacity, the open digital test field offers a wide range of opportunities for short-term and flexible collaboration, including for small and medium-sized companies. Further advantages are the provision of test possibilities in real-operation environment and the neutrality of the test field for industry and science. These features coincide with the requirements expressed in the stakeholder survey.

With the establishment of the open digital test field, framework conditions are provided in order to push innovation processes in the field of rail transport significantly forward. The location of the test field in the federal German states of Brandenburg, Saxony and Saxony-Anhalt means that it is close to important research institutions and numerous rail-related companies. Thus, there are good conditions for a close interaction between science and industry. The establishment of the test field makes a significant contribution to securing and attracting highly qualified specialist and expanding the region's basis infrastructure (transportation, science, digital networks and public services). The test field also opens prospects for the surrounding lignite mining areas for the time after the lignite phase-out. Hence, the project offers the potential to link several objects. The leverage effect of the funds used, which is considered to be significant, can therefore be taken into account in the upcoming investment decisions.

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