Systemtechnik Activity Report 2020/2021

Content

Cover photo: DB Systemtechnik;
inside photos: Georg Trüb, Kai-Uwe Nielsen

Progressive technology for the railway sector

At the moment, politicians and the public alike are focussing on the railway more than ever before; sustainable mobility is more important than ever before; and more money is flowing into the rail sector than ever before. It's true that this is a great opportunity, but it also comes with a duty for the industry to target the funds now at its disposal to the right places, in a way that befits the modern age.

DB Systemtechnik supports the entire sector as Europe's only cross-system service provider in the areas of rolling stock, infrastructure and all cross-disciplinary topics. We have divided our services into eight product groups in order to create a clear range of services for our customers.

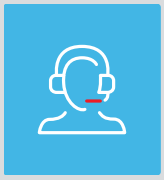
It is not only about handling current customer projects to optimise ongoing operations, but also about future topics such as the ETCS upgrade of existing fleets, IT and OT security, the future of diesel technology or the optimisation of approval processes.

This year's activity report once again gives you an overview of the wide range of activities performed by DB Systemtechnik and an insight into some of the projects on which our experts are successfully working for our customers worldwide.

Your Hans Peter Lang
Managing director
CTO Deutsche Bahn AG

Our product groups

We offer rail technology solutions for the entire rail system. Our product groups at a glance:



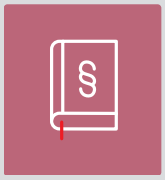
Rail technology, operations and maintenance

We advise you on all topics relating to the entire railway system. We analyse your technical pro-blems and design solutions just for you, covering rolling stock, components and infrastructure. What is more, we always consider your bottom line.

Design

Our engineers, technicians and technical draughtsmen are at your side with engineering and production services for rail vehicles: for everything from minor technical modifications to extensive redesigns of local and long-distance trainsets.

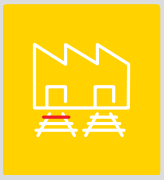
We repair accident and corrosion damage and support maintenance providers with production technologies. We reduce maintenance costs and maximise the availability of rolling stock by examining its operating behaviour.



ECM and maintenance rules

We can help you create and improve your maintenance rules. We ensure clear processes and legal certainty for amending maintenance specifications in line with European regulations and directives.

This naturally includes the safe introduction of new maintenance methods and technologies, such as condition-based or predictive maintenance.



Workshop systems, machinery and equipment

We provide you with key expertise for rail vehicle preparation and maintenance. Our services range from designing, planning and improving workshop and logistics systems to specifications, acceptances and improvements for plant, machinery and equipment.

We take care of new builds, conversions, extensions and improvements. Our rail-specific experience from a host of workshop projects ensures optimal integration into your operating processes.

Tests, trials and simulations

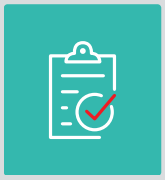
We inspect every part of the rail system for you. Through tests, trials and simulations in our test facilities or on the track, we can draw conclusions about your rolling stock, infrastructure and components and examine how different subsystems interact.

The findings offer you greater planning certainty or provide the basis for approvals, series production or commissioning in the context of verifying compliance.

Measurement, testing and diagnostic systems

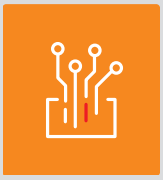
Our measurement, testing and diagnostic systems help you monitor your rolling stock and infrastructure along with their components. These high-precision, safe, robust and reliable instruments are available from us individually or as part of projects to optimise approvals, maintenance or operations.

Benefit from our many years of expertise, for example in wear behaviour and damage analysis.



Regulatory approval and safety

We offer appraisals, inspections and expert opinions for rolling stock, infrastructure and components. With our experts and recognised assessors, we provide you with all the required assessments and technical certificates, tailored to your needs (e.g. as an assessment body).



Digital products

We skilfully combine our decades of experience in railway technology with the use of digital technologies and system solutions. We advise and manage implementation projects in the areas of IoT & automation, data & analytics and condition-based rules.

By using the latest IT infrastructures and algorithms, we enable you to generate tangible added value from data and continuously enhance your business processes. We support you with innovations to reduce costs and increase availability.

DB Systemtechnik: Our contribution to Strong Rail

Photo: Jens Jeske

The Strong Rail Group strategy has set the direction of Deutsche Bahn's core business since 2019. It focuses on the intent to shift more traffic to rail. We at DB Systemtechnik are directing our resources toward supporting this objective.

We will achieve this by systematically pursuing our Y strategy over the long term. In addition to the services we provide for DB customers, thanks to the projects we carry out for third parties, such as manufacturers, operators, maintenance providers, transport authorities and so on, we are able to incorporate our expertise from the non-DB market into solutions for DB in order to further the Strong Rail strategy. To this end, we're not only looking at the bigger picture when it comes to our partnership networks; we're also looking at the bigger geographical picture.

Dr. Bernd Zirkler, Head of Business Development

Borrowing from the Group strategy, we have aligned our company strategy with four building blocks. In concrete terms, this means that we are pooling our forces:

For the climate.
We are getting the rail system ready for the decarbonisation of transport, driving the development of resource-saving, environmentally friendly technologies and using these innovations in our own operations.

For rail.
DB Systemtechnik is all about safe technology that works well, improving the availability and reliability of infrastructure for the mobility of the future.

For people.
We offer new solutions that make the rail system efficient and competitive.

For Europe.
We operate on an international level, with a particular focus on strengthening rail transport in Germany and Europe, expanding our expertise on a daily basis.

Photo: DB Systemtechnik, DB Fahrzeuginstandhaltung

Alternative drive technology for the climate.

Stefan Heibl
Mechanical Traction Equipment
and Internal Combustion Engine
Location: Munich

Stefan Heibl, tell us about yourself and what you do at DB Systemtechnik.

I have worked in the Mechanical Traction Equipment and Internal Combustion Engine department at DB Systemtechnik since 2007. My main focus has always been on diesel engines and all of the necessary peripherals as well as turbo and automatic gearboxes and technical support throughout their entire product life cycle. I also work on simulations of drive trains and the associated dynamics of rail vehicles.

Through studies and simulations and by collaborating on development projects, I have also been able to study how to reduce the fuel consumption of diesel drives, for example by hybridisation of the drive drain.

How do alternative drive systems contribute to the "For the climate" building block and the Strong Rail strategy

Alternative drive systems are drive designs that replace traditional diesel drive technology but do not require electric overhead line equipment, or rely on it only to some extent. For rail vehicles, we're focusing on hybridised diesel, bi-mode, fuel cell and battery electric drive systems.

These drive systems can significantly reduce the carbon footprint of vehicles, and when they run on renewable electricity or hydrogen, the carbon footprint is almost nothing at all.

Since we can't retrofit the existing fleet of diesel locomotives and diesel multiple units with alternative drive technology overnight, alternative fuels, such as hydrotreated vegetable oils (HVOs) or even e-fuels in the future, are also a good way to reduce the carbon emissions of these traction units that contribute to the overall footprint. Diesel engines have been tested with alternative fuels, and the DB Group is also focusing heavily on alternative fuels.

Could you give us some specific examples?

The use of HVO biodiesel is currently being tested with diesel engines for DB Cargo and DB Fernverkehr AG in test rigs at the DB Fahrzeuginstandhaltung maintenance depot in Bremen with support from DB Systemtechnik. The tests are measuring whether switching to HVO affects exhaust emissions.

Since using alternative fuels in diesel engines does not eliminate soot particle emissions, solutions for retrofitting vehicles with diesel particulate filters to reduce soot particle emissions are also being installed and tested in certain diesel multiple units, including in the DB Regio VT 612 and the VT 605 advanced TrainLab. DB Systemtechnik is also helping with these tests.

Digitalisation for rail.

Rupert Lange-Brandenburg
Head of the Digital Products & Services Business Line and CDO
Location: Frankfurt

Rupert Lange-Brandenburg, tell us about yourself and what you do at DB Systemtechnik.

After my time at Lufthansa and more than 13 years in IT at DB Netz AG and DB Systel, I became the Head of the new Digital Products & Services Business Line (BL) and CDO at DB Systemtechnik in 2020.

The new BL focuses on developing new digital products and services and enhancing existing ones at DB Systemtechnik by pursuing a strategy of digitalisation and by developing appropriate new business models. It advises and leads implementation projects in IoT and automation; data and analytics; and processes, standards and regulations.

By using modern IT infrastructures and algorithms, it can generate tangible added value from data and continuously enhance business processes. We've come up with a vision based on all this (see graphic below).

Could you give us some specific examples?

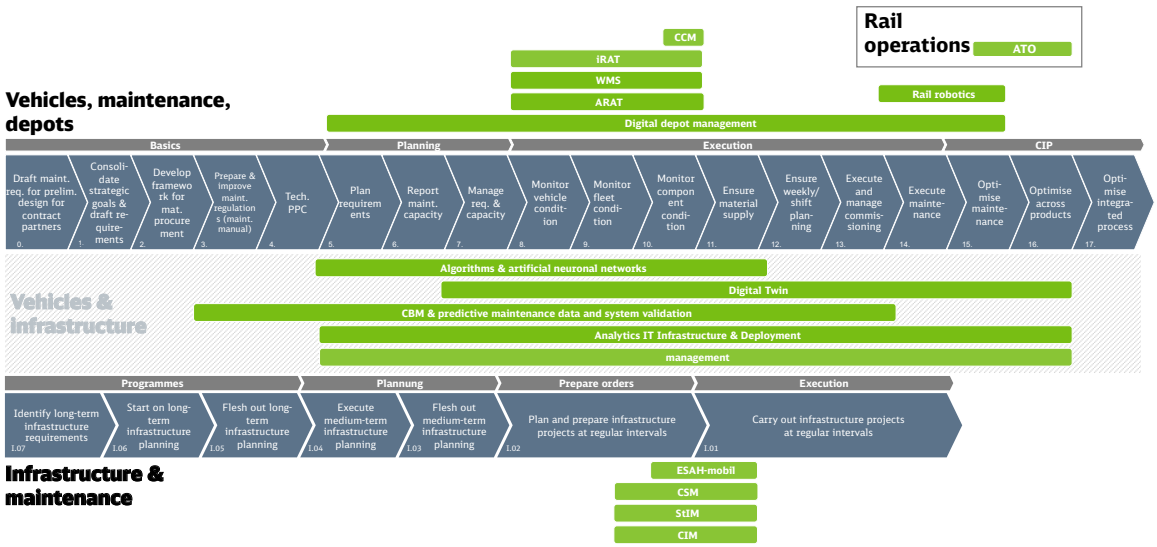
One new product we are currently developing and will continue to build on is the use of robotics to tackle vehicle maintenance challenges. We believe that robotics is a powerful way to leverage efficiency that will increase growth and throughput even if the infrastructure stays constant. Robotics will also help employees to focus on their core tasks and over the long term will become an integral component of the rail system, as we have seen happen in the automotive industry. Before it makes financial sense to use robotics, you need to know what automation can do and have expertise in vehicle maintenance processes.

We are acquiring and strengthening this knowledge and expertise. Specifically, we're already working on two robotics projects through the DB Group's DIFa programme on digital asset maintenance: automated maintenance shed cleaning and automated graffiti removal. We're systematically recording manual processes and using them to determine technical requirements and develop relevant business cases and approaches to solutions.

Robotics will open up a wide range of opportunities for the future of rail. In some areas robotics will be essential if we are to increase capacity. In addition to cleaning processes, it can also provide support for important areas, in particular logistics, transport and inspection. It will also play a role in infrastructure maintenance, for example by automating vegetation management and welding processes. All in all, we are optimistic that we will make a major contribution toward improving the rail system by offering this product and serving as a link between rail and industry.

How does robotics as a specific product contribute to the "For rail" building block and the Strong Rail strategy?

We are creating major advantages down the line for the DB Group's business units by expanding how we use robotics. We will be able to leverage significant efficiency in the contractually required availability and maintenance of vehicles, for example. If we can make smart use of robotics at depots, we can automate workflows and processes, making them faster and more efficient.



VISION FOR 2021:

The digital products and services of DBST. Positioning our products in our customers' E2E business processes.

Photos: DB Systemtechnik, Pixabay, DB AG, Max Lautenschläger

Redesign projects for people.

Daniel Brunkert
Head of Rolling Stock Competence Centre
Location: Leipzig

Daniel Brunkert, tell us about yourself and what you do at DB Systemtechnik.

I joined the DB Group in 2017 and lead the Rolling Stock Competence Centre at DB Systemtechnik. With some 200 employees at nine locations, our competence centre provides a wide range of engineering services for the existing vehicles of the DB Group and other private railways, primarily in German-speaking countries.

How do engineering services contribute to the "For people" building block and the Strong Rail strategy?

One of the services we offer is development and design for retrofit projects. These projects involve modernising existing vehicles used for long distance, regional and local rail passenger transport to meet the current requirements of client bodies, operators and passengers. These types of redesigns primarily involve both the interior – new seats, floor coverings, sanitary and catering areas, innovative vehicle-interior designs and lighting concepts – as well as vehicle IT, which provides guests with information about rail operations and allows them to connect to the internet via WiFi, among other things. In this respect, this engineering service has a considerable impact on passenger comfort and therefore the "For people" building block of the Strong Rail strategy – a good reason for us to complete redesign projects on time, cost effectively and with a high level of quality.

Could you give us some specific examples?

Based on Strong Rail and the "More robust, more powerful, more pioneering" aspect, we have created a timetable with specific measures setting out how we want to improve our redesign projects and our entire range of services over the long term so that we can help to achieve the objectives of DB Systemtechnik and Strong Rail in the best way possible.

Here are a few examples of measures we have already implemented:

Design quality campaign (more robust)

We created uniform standards for design in the form of handbooks for mechanical and electrical design. The design quality specified in these standards is measured in all projects using MAPS feedback (monitoring system technology work packages and projects), and sources of errors are evaluated and processed so that we can take what we have learnt and apply it to the continuous development of standards.

Developing our range of services (more powerful)

Each of our services has a product team that works on a regular basis to improve the quality and economic aspects of the service and to supplement the service with additional components or brand new services. A special initiative called OFU has been in place for our redesign development service for over two years. As part of this initiative focusing on optimising retrofit projects, DB Regio, DB Fahrzeuginstandhaltung and DB Systemtechnik work together to develop the foundations for optimising redesign projects. Results, such as the product development process and different MAPS tools, have already had a considerable positive impact.

Virtual reality (more pioneering)

Virtual reality technology allows us to visualise redesigns in the very early stages of a project even if we don't yet have all of the design data. This helps us during concept meetings and marketing meetings with client bodies.

European Train Control System for Europe.

Oliver Hagemann
Head of High-Speed Train and EMU Competence Centre
Location: Krefeld/Cologne

Oliver Hagemann, tell us about yourself and what you do at DB Systemtechnik.

At DB Systemtechnik, my team and I at the High-Speed Train and EMU Competence Centre are responsible for engineering high-speed trains and electric multiple units at our two sites in Krefeld and Cologne.

A relatively recent addition to our team is the ETCS competence centre in Cologne. The European Train Control System (ETCS) aims to digitalise rail throughout Europe. In the coming years, standardised digital control-command and signalling systems will replace old signalling technology throughout Germany and the rest of Europe following a specific timetable. In later stages, lineside signals will disappear and trains will be able to travel more closely together, which will mean more trains with constant rail capacity.

For this system to work, not only does the infrastructure need to be equipped with ETCS technology; vehicles do as well. That means that DB has to buy new vehicles already equipped with ETCS technology or vehicles that are ETCS-ready. All operators still have vehicles that are not yet equipped to use ETCS lines. In many cases, these trains will still be in use for several more years or even decades. We need solutions and ideas for these vehicles in particular for how to integrate and test the train-side ETCS systems that are required, obtain approval and do all of this economically. This is where our Cologne team headed by Lutz Friedrich comes in. They are able to develop customer-specific solutions using the national and international ETCS expertise and knowledge about the different classes that they have established over the years. Together with other organisations at DB Systemtechnik, we're able to offer an all-in-one package including engineering, testing and approval.

Could you give us some specific examples of projects?

DB Systemtechnik, Siemens Mobility and Deutsche Bahn's Technology Division are working together on a project of partially integrated ETCS, which aims to develop an economical solution for Class 101 vehicles. The idea is to develop adaptable ETCS technology for retrofitting existing vehicles (old classes and the maintenance fleet) that can be integrated into vehicle control systems regardless of the manufacturer.

How does ETCS contribute to the "For Europe" building block and the Strong Rail strategy?

One of the Strong Rail building blocks is Digital Rail for Germany. Implementing digital infrastructure will make rail more robust. More people will be able to travel on the same infrastructure, and not just in Germany but throughout Europe. With the right vehicles for digital rail, we'll be able to make this happen. That's what we're working for.

DB Systemtechnik: The highlights 2020/2021

Photos: Mathias Kölling, Oliver Lang

10 years DB Systemtechnik GmbH

DB Systemtechnik made its debut as an independent companyon 1 September 2011. It is a real success story, with many highs and lots of exciting moments and developments. Over the last ten years, our headcount has risen from 600 to over 1,000 today and we have a presence not only throughout Germany, but also in France, Poland and China. Our UK subsidiary DB ESG, based in Derby, serves the UK market and more.

10 Jahre DB Systemtechnik GmbH

Welcome to our new test locomotive

A new Vectron Class 193 test locomotive with Baseline 3 ETCS equipment is the latest addition to our vehicle fleet and an important milestone when it comes to further developing and carrying out our projects. In the coming years, this locomotive will mainly be used on the DB lines of the Rhine–Alpine European Rail Freight Corridor (LINK), where it will perform ETCS acceptance runs with our test teams on behalf of DB Netz AG. The locomotive will also be essential for integrating ETCS equipment into lines as planned and for carrying out tests in a wide variety of disciplines.

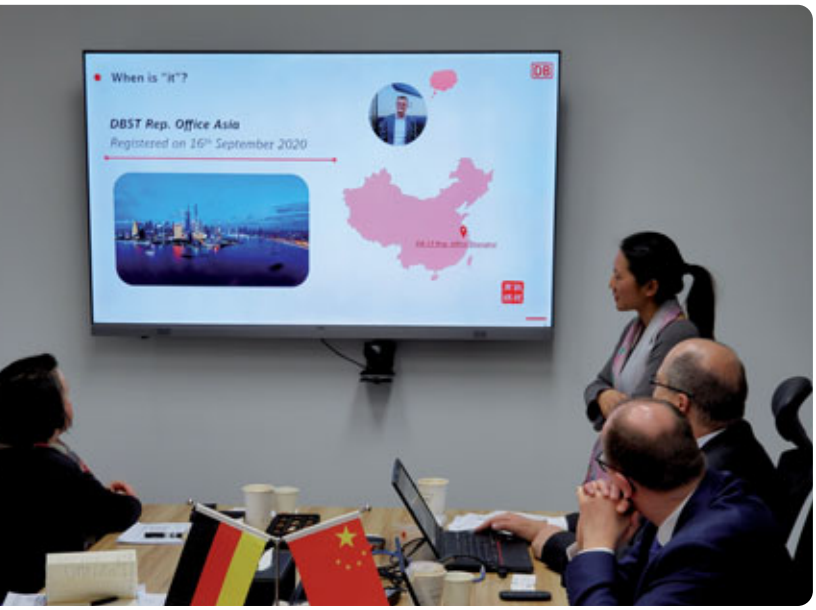
ICE-V restoration complete

By Spring 2021, the time had finally come. Following extensive refurbishment work, original decals restored the train to how it looked when it was first manufactured over 30 years ago.

This means that the ICE-V test vehicle, which was the Deutsche Bundesbahn's first move taking Germany into the era of high-speed rail, is once again the showpiece at our Minden site. It is a fitting reflection of our decades-long experience in railway technology.

FLEET

Germany



NEW OFFICES

China and Poland

Opening of new offices in China and Poland

To enable us to process our orders close to our customers and to keep in contact with them directly, we have opened additional offices in Shanghai in China and Bydgoszcz in Poland.

A real treat was organised as part of the Chinese New Year celebrations in February 2021, when a very special visit was scheduled.

Christine D. Althauser paid our colleagues a visit in her role as Consul General of the Federal Republic of Germany in Shanghai.

NEW TEST BENCH

Germany

New test bench: For the best torque

The rail vehicle construction work of today would be inconceivable without the use of bolted connections, with bolts also playing an important role in maintenance work and component replacements. Bolts are therefore the most important mechanical fastener in the railway sector.

A new test bench at our Minden site now helps our customers to work out the perfect torque. Our experts can use this bench to determine the friction coefficients of a bolted joint and even to separately establish the friction coefficients in the thread and below the bolt head. At the same time, the test bench is able to measure the torques, the pretension and the angle of rotation.

There are many reasons for testing bolted joints on the test bench. They range from procuring replacements for original bolts or lubricants that are no longer available; to material safety, environmental protection or occupational safety concerns; to investigating damage sustained by bolted joints; or even simply because the person responsible for maintenance is looking for the best instructions on how to handle the bolted joint.

Photos: Xing Liu, Kristin Heinrichsmeier, Patrick Kuschfeld

RAIL CAMPUS OWL

Minden

Rail Campus OWL: Partnership is signed

An innovation ecosystem unique throughout Germany is being built close to Minden railway station and our site on Pionierstrasse: Rail Campus OWL. The project is being launched by the region's universities, industrial partners WAGO and HARTING, as well as Deutsche Bahn including DB Systemtechnik and DB Cargo. The town of Minden and the district of Minden-Lübbecke are also partners in the project.

At a parliamentary evening held in April 2021, the partners confirmed their commitment to the Rail Campus OWL by signing a memorandum of understanding (MoU).

The Rail Campus OWL project will bring leading rail technology experts from business and research together at a single site, and it will provide future managers and specialists with access to courses that will prepare them for a new era in rail transport technology.

Further information is available at www.railcampus-owl.info

Illustrationsen und Photos: DB Systemtechnik

VR technology on S-Bahn Hamburg

Virtual reality is playing an increasingly important role in vehicle conversions. This tool can be used to visualise potential designs for customers and also helps with installation testing or design-based quality assurance.

The first VR model for visualising a high-level design was used to great effect in the "S-Bahn Hamburg Class 472 Interior Design" contract. The successful VR representation of what the passenger area will look like served as a basis for the client and the end customer (the city of Hamburg) to hold discussions and make decisions.

Upcoming projects will not only include visualisation, but will also offer users the opportunity to enter virtual vehicle models, take a seat and experience the vehicle's interior design as a passenger.

VIRTUAL REALITY

Germany

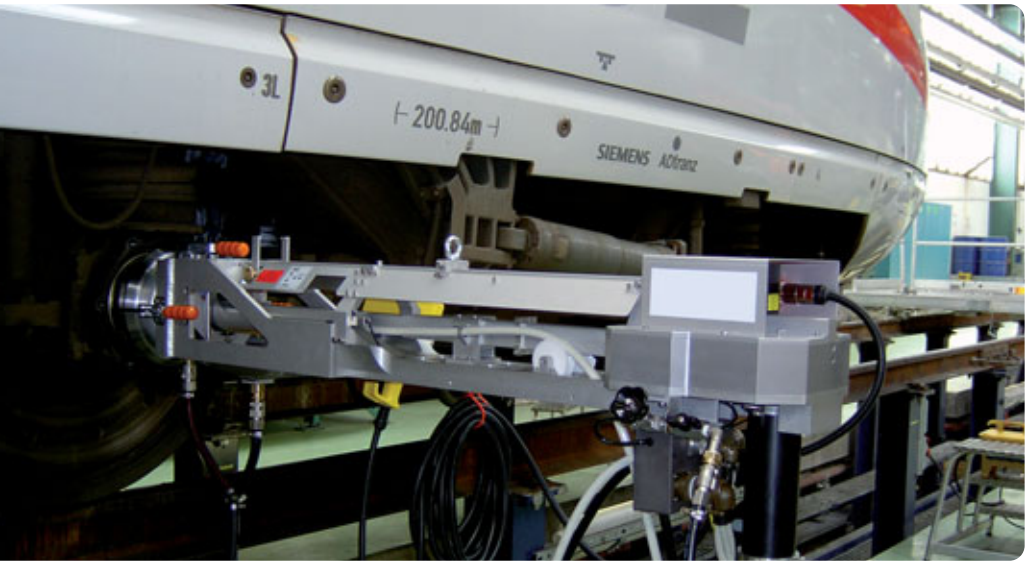


Photo: DB Systemtechnik

New edition of VDV Recommendation 889

As proposed by the Association of German Transport Companies (VDV) Committee for Railway Vehicles, our experts have drawn up published VDV Recommendation 889 as a universally accessible code of practice for "Non-destructive Testing (NdT) of Rolling Stock and their Components" for the entire railway sector.

In May 2021, the new edition 3.0 was published, which now also includes NDT specifications for "mechanised ultrasonic testing on hollow axles".

VDV RECOMMENDATION 889

Germany

First major contract in the Balkan region

We are pleased to have won our first major contract in the Balkan region this year and to be able to support Serbia Railway in putting the new Belgrade–Budapest line into operation. Modification and modernisation work is set to deliver a line speed of 200 km/h over a length of 184 kilometres. To ensure this goal is met, we will test vehicle dynamics, ETCS, the overhead line, GSM-R and electromagnetic compatibility (EMC), among other things.

NEW BUSINESS

Balkans

New S-Bahn Berlin with MIP in scheduled service

After a two-year test phase, the first trains went into scheduled service on the S47 line in Berlin on 1 January 2021 – and our mobile integration platform (MIP) is on board too. The MIP software, which has been tried and tested over many years, has been adapted and functionally expanded for Class 483/484.

The MIP deals with train-to-land data communication for many processes that are already in use on other vehicle classes, as well as new functions such as diagnostic data, traveller information systems (RIS), radio-controlled provisioning, vehicle location, automatic passenger counting, audio/video transmission, train information/vehicle condition and driver assistance systems.

Class 483/484 is also the first class in Deutsche Bahn's regional and local transport fleet to deliver its diagnostic data via the MIP and the universal data gateway (UDG) from day one. This IT system is also managed by our experts and transmits key data directly to the maintenance management system.

Photo: DB AG/Volker Emersleben

MIP IN SCHEDULED SERVICE

Berlin

TRAMLINK

Switzerland

Photos: Bernmobil, DB Netz/Norbert Leindl

Procurement support pays off!

When 82 new double-decker trains were placed into service as scheduled for the Rhine Ruhr Express, it showed just how worthwhile it can be to provide technical support while new vehicles are in the manufacturing phase. We use technical controlling, also known as procurement support, to help client bodies or operators by carrying out inspections during construction. They are mainly performed on the rail vehicle manufacturer's premises and result in high-quality series production with first article inspections and follow-up inspections. Deadlines for putting vehicles into service can therefore be met and the earmarked funds can be used as planned.

The Swiss urban transport operator Bernmobil is the first tram operator to put its faith in procurement management.

The first new trams are scheduled to start operating in Bern as early as 2023, with up to 12 more vehicles entering into service each year thereafter. By the beginning of 2025, all 27 vehicles in the TRAMLINK fleet should be in operation.

To ensure that the urban transport operator can keep to this tight schedule, our engineering experts will supervise the construction of all 27 newly procured low-floor trams and their components In the meantime, other operators have begun to follow the procurement support model. For example, an urban transport company in North Rhine-Westphalia and a transport association in Saxony have turned to us for assistance. We are supervising the development and construction of new tram vehicles and local transport multiple units for these operators too.

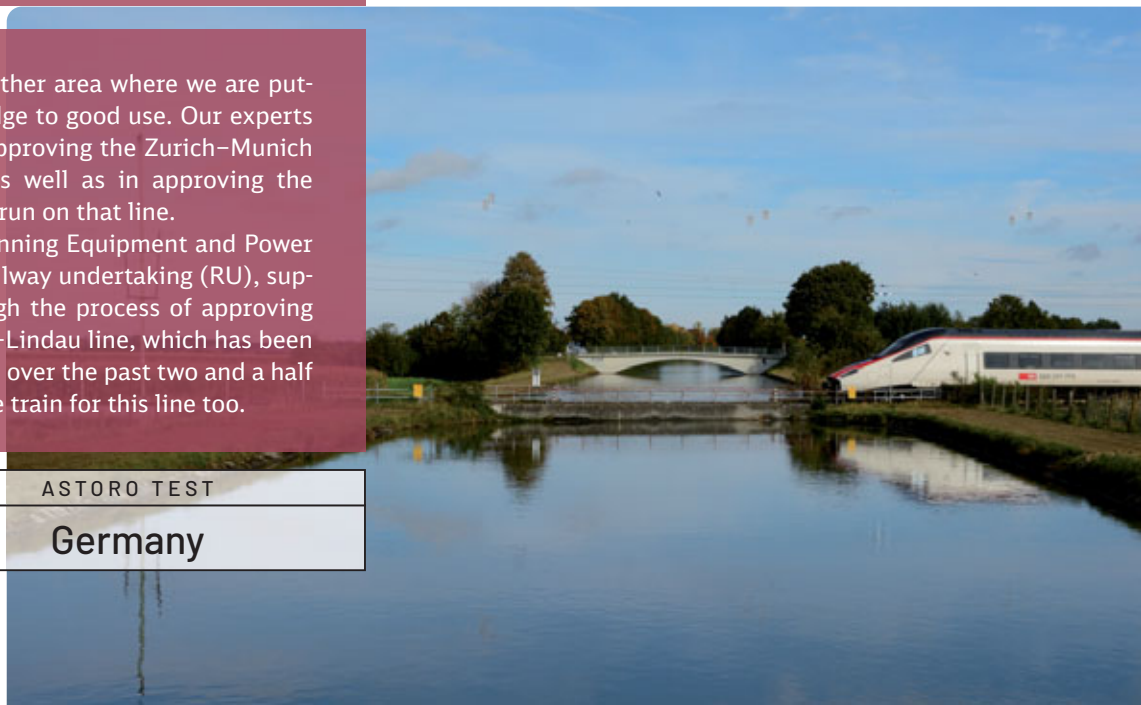
Upgraded line 48 opened: Tests with the Astoro in the Allgäu region

Shorter travel times is another area where we are putting our specialist knowledge to good use. Our experts were heavily involved in approving the Zurich–Munich line and overhead line, as well as in approving the Swiss ETR 610 (Astoro) to run on that line.

The test teams from Running Equipment and Power Systems, along with our railway undertaking (RU), supported DB Netz AG through the process of approving the 150-kilometre Munich–Lindau line, which has been modernised and electrified over the past two and a half years, and of approving the train for this line too.

ASTORO TEST

Germany



Support from Vossloh for monitoring switches in Sweden

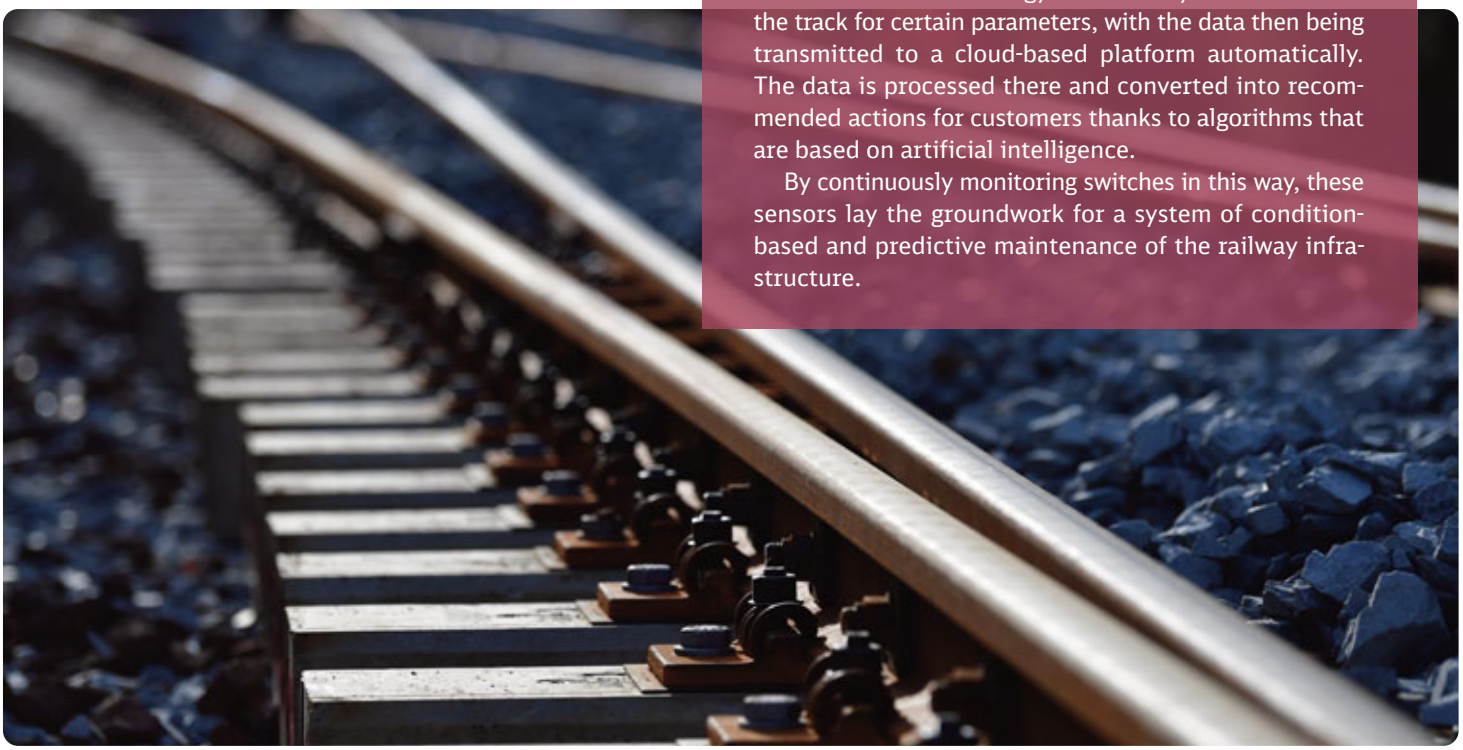
SWITCH MONITORING

Sweden

Over in Sweden, Vossloh subsidiary Vossloh Nordic Switch Systems AB has won a tender from Trafikverket, the Swedish Transport Administration, and brought us in as a project partner.

The multi-year contract includes condition monitoring for a total of 1,000 switches across the Swedish railway network. Sensor technology continuously records data on the track for certain parameters, with the data then being transmitted to a cloud-based platform automatically. The data is processed there and converted into recommended actions for customers thanks to algorithms that are based on artificial intelligence.

By continuously monitoring switches in this way, these sensors lay the groundwork for a system of condition-based and predictive maintenance of the railway infrastructure.



Virtual ETCS symposium

We were delighted to welcome over 120 participants to our first virtual ETCS symposium in June 2021. The attendees included not only a large number of railway undertakings and manufacturers of rail vehicles and railway construction machinery, but also client bodies and track infrastructure operators. Some of the topics covered were what experiences attendees had had and the challenges they had faced in integrating ETCS equipment into existing vehicles, as well as the associated work and challenges facing ETCS engineering. The online meeting also focused on the peculiarities of ETCS line acceptance and the ETCS vehicle network access test. But the real highlight for us was the opportunity to touch base with our customers.

ETCS-SYMPOSIUM

Germany

Photos: DB AG/Oliver Lang, DB AG/Max Lautenschläger

CBM data boxes for 87 CFL vehicles

We have helped CFL, the national railway company of Luxembourg, to monitor the vehicle batteries and door control systems of 87 vehicles.

An initial study established what sensor technology was present on the vehicles, as well as what data transfer and evaluation software was being used. For operational purposes, the state of charge of every battery on every vehicle had to be represented schematically.

The data transfer module also needed to be connected to the door control system to help with monitoring and maintaining the doors.

DATA BOXES

Luxembourg

Photo: Romain Laures

Virtual event on ECM certification

From June 2022, all rail vehicles in the European railway sector will be subject to mandatory ECM certification, a process with which we are already familiar from freight wagons. From this point on, every entity in charge of maintenance (ECM) must prove that it has a functioning and certified ECM system.

To ensure we are prepared for this obligatory date in good time, we held our first virtual ECM conference in March 2021, where the steps required to achieve ECM certification were presented.

We also had the pleasure of welcoming smaller railway undertakings with an interest in the topic to the event, as they too have to prepare for the ECM set-up including certification.

ECM SYMPOSIUM

Germany

Air conditioning of rail vehicles: The latest trends and innovations

Air conditioning of rail vehicles: The latest trends and innovations

Climate change and dwindling resources are megatrends in the transport sector. Cutting energy consumption is a key aspect of positioning DB AG as the most environmentally friendly mobility service provider there is.

The railway sector has formulated appropriate targets in response. Air conditioning systems are the second-largest consumer of energy on trains, so there is lots of potential to make savings: possible energy-saving methods have already been identified, but not yet implemented across the board. Coming up with innovative ways of controlling the climate in rail vehicles will therefore be an important step towards achieving environmentally friendly, reliable and economical railway operations, while also improving passenger comfort.

In future, a new generation of rail vehicle air conditioning systems will emerge that use natural refrigerants such as CO_2 or propane. These new systems will differ from previous conventional systems, for example, in terms of their thermo-dynamic process and the pressure level to be controlled, or in terms of particular factors relating to fire protection. But alongside these technological challenges, the development and testing of new air conditioning systems also opens up great opportunities on issues such as cutting energy consumption, diagnostics and condition-based and predictive maintenance.

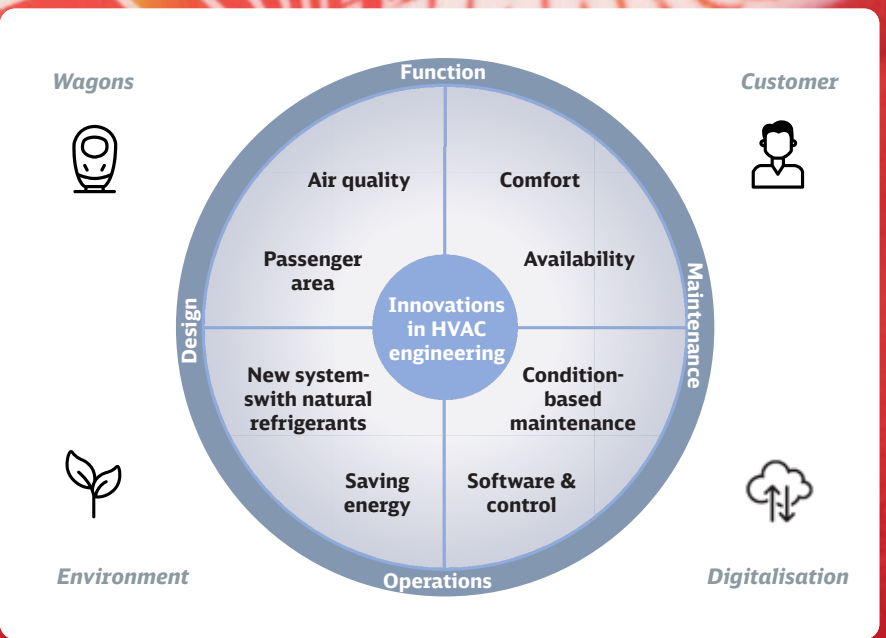
The air conditioning system is the largest consumer of energy after the traction system and is responsible for **up to 30% of a train's energy consumption**. This means there is potential for making significant savings, e.g. through improved part-load behaviour, heat pump applications and optimised control and regulation. The air conditioning system also makes a good pilot project when introducing new maintenance concepts due to the low safety implications and the large amount of process data that can be recorded. From the customer's point of view, too, it is high time for some innovation in this area.

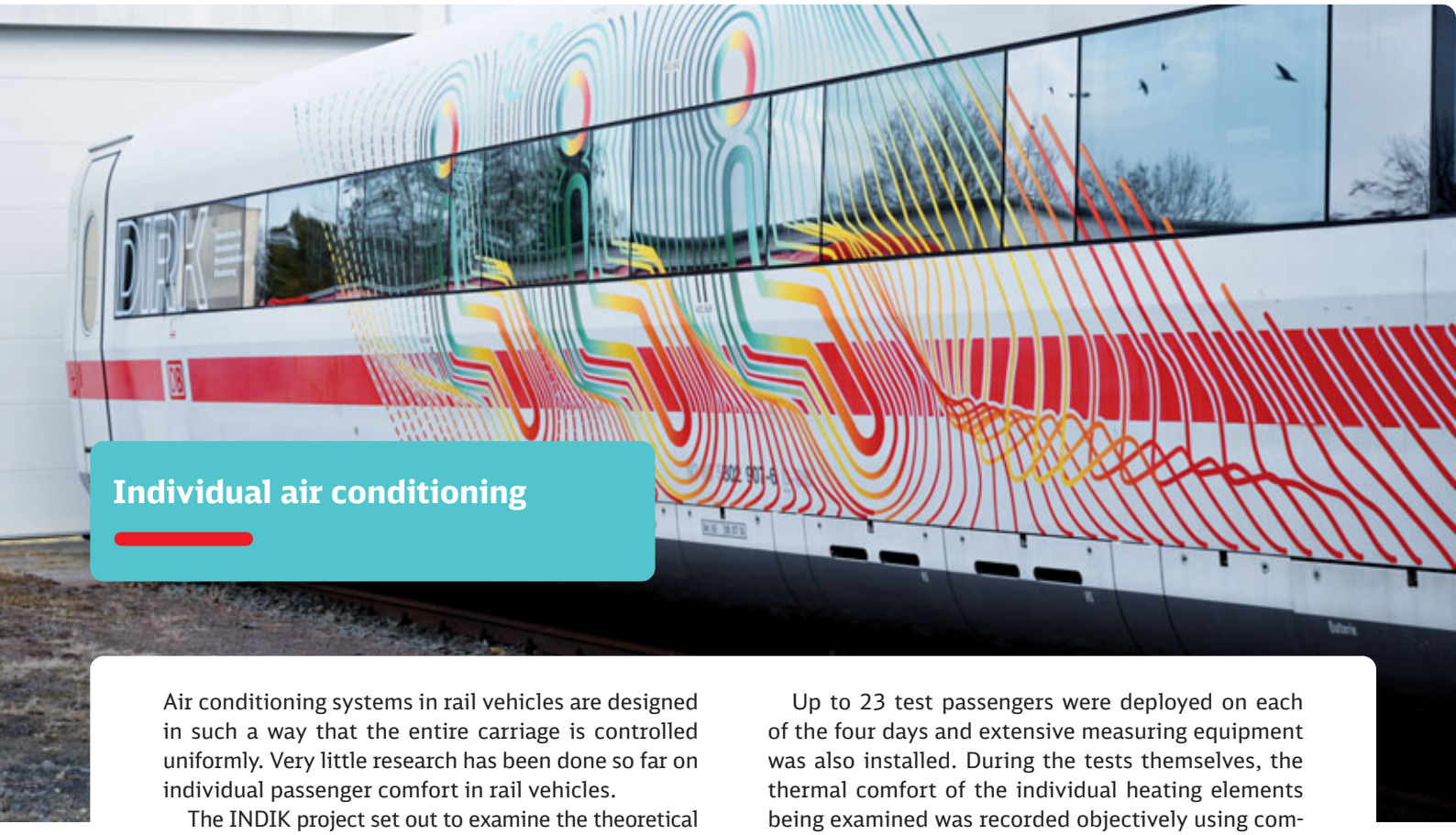
Our customers are placing greater demands on the trains of tomorrow as regards the high-tech features and comfort they will offer. And for rail vehicle air conditioning this means, among other things, that **air-conditioning concepts must be individually controlled**; there must be **a suitable level of pressure comfort**; and, against the backdrop of the ongoing COVID-19 pandemic, **excellent air quality must be ensured**.

In order to master these wide-ranging areas of innovation in the field of rail vehicle air conditioning, DB Systemtechnik has significantly expanded its air conditioning simulation and testing infrastructure in recent years. Our simulation models include the cooling process, the control system and the thermal conditions in the passenger area. We also have a new air conditioning test bench (LUDEK) in Munich for performing laboratory tests on and optimising rail vehicle air conditioning systems. To enable us to test new air-conditioning concepts for the passenger area, an ICE open coach has been converted into a stationary demonstration vehicle for innovations in passenger comfort and air conditioning (DIRK), which we operate at the Minden site together with the German Aerospace Centre (Deutsche Zentrum für Luft- und Raumfahrt, DLR). In conjunction with the MEikE rail vehicle climatic chamber, this provides DB Systemtechnik with unique tools for conducting climatic investigations and coming up with innovations.

Below we will use three examples to show not only the innovative approaches being taken by the railway sector as a whole, but also the relevant expertise we have here at DB Systemtechnik.

Photos: Martin Loibl, DB AG/Oliver Lang





Individual air conditioning

Air conditioning systems in rail vehicles are designed in such a way that the entire carriage is controlled uniformly. Very little research has been done so far on individual passenger comfort in rail vehicles.

The INDIK project set out to examine the theoretical potential for improving an individual's thermal comfort through individual air conditioning. Supplementary tests were also carried out into the potential for saving energy in individual heating mode, i.e. when the average temperature inside the passenger area is lowered and only those seats that are actually occupied are heated.

The tests were preceded by extensive theoretical preparatory work such as research into standards, research into individual air-conditioning concepts in other modes of transport, requirements for a system to be used in rail vehicles, and the drawing up of a test plan. The tests themselves were conducted in May and June 2021 in the DIRK climate test vehicle and in the MEikE climatic chamber at DB Systemtechnik. In the DIRK, 22 seats were equipped with two individual air conditioning systems, each made up of three infrared (IR) panels and a two-part seat heater. The individual air conditioning could be controlled at each separate seat via a tablet.

Up to 23 test passengers were deployed on each of the four days and extensive measuring equipment was also installed. During the tests themselves, the thermal comfort of the individual heating elements being examined was recorded objectively using comfort test dummies and subjectively in the form of feedback from the test passengers. The temperature in the climatic chamber was set to 0°C for the tests. In the DIRK, among other things, the interior temperature of 23°C, which is normal in heating mode, was lowered by 2°C. The test passengers were then spread throughout the ICE coach, where they could feel the temperature and set it to a level that was comfortable for them. The measurements were carried out using a thermal human model and an IR camera, other test dummies and conventional temperature measurement technology. How much energy was being consumed by the air conditioning system was measured too. In addition, DLR carried out CFD simulations in parallel (calculations of the fluid dynamics).

By the end of August the test results had been analysed: they showed that an individual air-conditioning concept is effective overall. The results will be incorporated into future projects to improve our passengers' comfort and increase our energy efficiency as well. This is another step along the road to achieving fully carbon-neutral mobility in the future.

Photos: DB AG/ Oliver Lang, DLR

Air quality

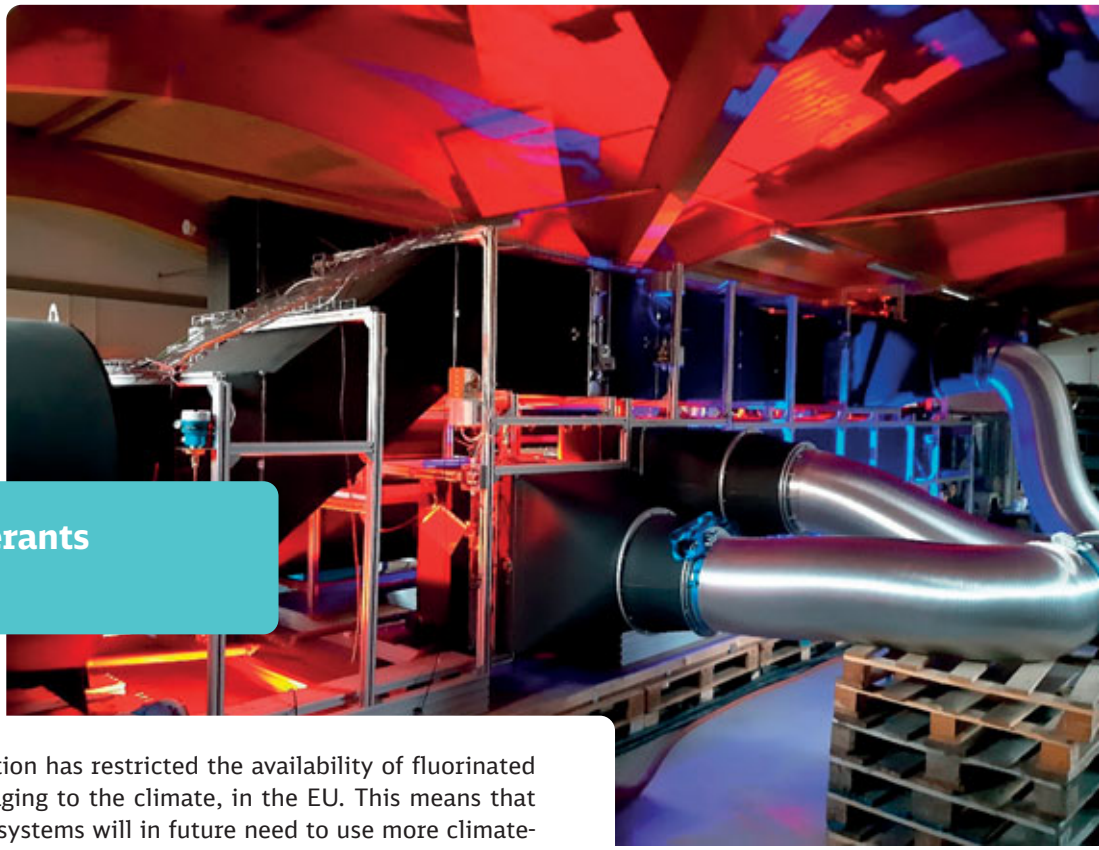
LUQAS is another project on which Deutsche Bahn and DLR worked together, looking into air quality in rail vehicles. The project investigated how aerosols and droplets disperse throughout the passenger areas of rail vehicles in view of the ongoing SARS CoV-2 pandemic.

The first step was to develop fleet-specific research scenarios and draw up test and simulation specifications. Criteria for assessing how well the results can be transferred over to other vehicle classes were then defined, along with possible remedial actions.

Based on theoretical preparatory work, extensive flow and dispersion measurements were then taken and corresponding CFD simulations were performed in the DIRK stationary demonstration vehicle and the MEikE climatic chamber in Minden. The experiments used a tracer gas measurement technique, particle sensors and various optical flow measurement techniques with an aerosol source.

By evaluating and analysing the resulting data, we were able to assess what impact the air conditioning system, climate control measures and various relevant parameters have on how aerosols spread throughout the passenger areas of rail vehicles. This then enabled us to make recommendations to vehicle operators without delay in order to restore passengers' confidence in rail travel as quickly as possible.

Photos: Julius van Diepen



Alternative refrigerants

Since 2016 the F-gas Regulation has restricted the availability of fluorinated refrigerants, which are damaging to the climate, in the EU. This means that cooling and air conditioning systems will in future need to use more climate-friendly alternatives to the R134a refrigerant they relied on in the past. Deutsche Bahn is turning to natural refrigerants such as propane and carbon dioxide, which are currently being evaluated in trial projects with various manufacturers of air conditioning systems. The HLK-Natur (HVAC Nature) project, looking into the "simulation and testing of natural refrigerants in rail vehicle air conditioning systems", was launched at DB to investigate these issues.

DB Systemtechnik was commissioned to provide technical support for the project and to carry out process simulations.

As a first step, a requirements catalogue was drawn up for the new air conditioning systems that were going to be designed. Failure mode and effects analyses (FMEA) were conducted to identify at an early stage any potential technical faults with the new air conditioning systems that were going to be procured, which run on the natural refrigerants R744 (CO_2) and R290 (propane). A risk assessment (HAZOP analysis) was then produced. DB Systemtechnik advised the manufacturing companies as they designed the new air conditioning systems.

The air conditioning systems running on natural refrigerants were then modelled and simulated based on the design drawings. The design and concept were evaluated and optimised.

The new air conditioning systems then underwent type tests and test bench tests at the manufacturer's premises as well as measurements in the MEikE climatic chamber, always under the watchful eye of experts from DB Systemtechnik. Since the testing was closely monitored, the data was continuously analysed and everyone involved was consulted, this project meant that knowledge was shared extensively both within the DB Group and with suppliers – an arrangement that was mutually beneficial. By analysing the data collected in detail, it was possible to identify useful ways of optimising future procurement processes even at this early stage.

The risks associated with switching technologies and moving to natural refrigerants have been minimised for all those involved, since the new systems have been qualified in a number of ways (through simulations, on the test bench and in the climatic chamber) as part of their testing.

20 years as an accredited testing laboratory: The noise measurement car

20 years as an accredited testing laboratory: The noise measurement car

It was a matter-of-fact message from test manager Edgar Bergstein: Noise measurement train – 9 June 2021, 10:58 am, line 6363-1 km 35.5, just before Dornreichenbach, 1,000,000 km. But this message tells of the 20-year history of a train, a test method and the people connected with it.

Noise control method:
"Specially monitored track"

In order to reduce noise emissions from passing trains, some track sections are subject to special regulations. The "specially monitored track" (SMT) method is defined in the planning approval procedure when building a new or converting an existing line. With this method, DB Netz AG undertakes to check the acoustic quality of the tracks on these lines every six months after completion. If the quality of the rail surface is no longer sufficient, i.e. it has become too rough, this track section is reground using a rail machine tool. The method has been regulated in law since 1998, when the Decree on Noise Control along Railway Tracks (Verfügung zum Lärmschutz an Schienenwegen) was issued by the German Federal Railway Authority.

This method has enabled DB AG to reduce the noise emissions caused by rail traffic along the line by three decibels (a kind of "track maintenance discount") in its forecasting. This means that noise barriers can be built lower and shorter when used in conjunction with SMT, for example. Around 1,450 kilometres of track are currently monitored using the SMT method in Germany

Deploying the DB Systemtechnik noise measurement car

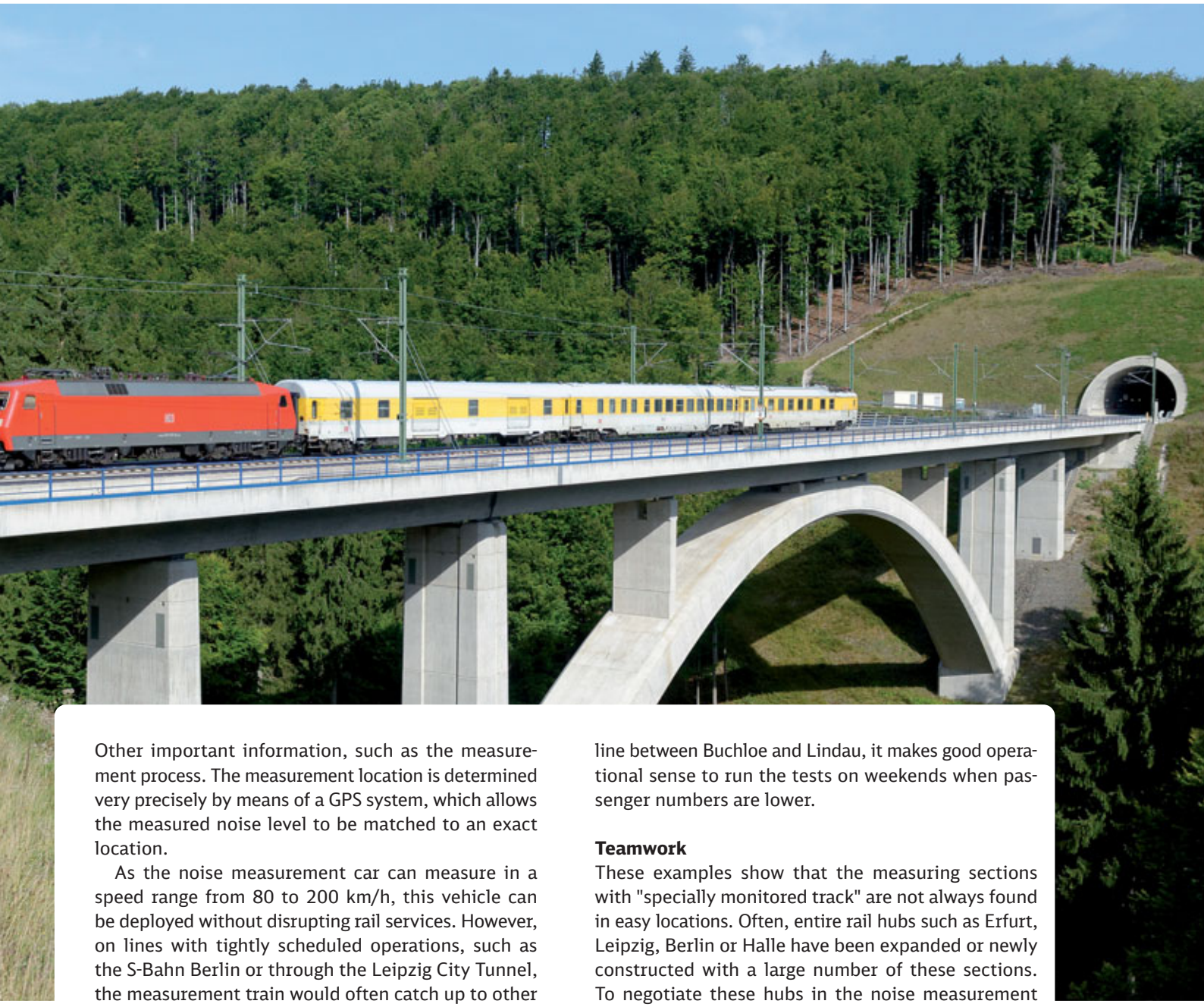
The check is carried out every six months using the specially developed DB Systemtechnik noise measurement car. This is positioned in the middle of a measurement train, which consists of a DVT and a buffer coach between the locomotive and the track recording car.

A wide variety of traction units are used, depending on the type of line. In addition to electric locomotives, which are deployed most commonly, certain measurement sections are also located on non-electrified lines or now also increasingly on lines that are subject to full ETCS supervision. The train can travel at a maximum speed of up to 200 km/h, while the driving trailer delivers effective push-pull operation. The two biannual measurement campaigns are conducted every year between March and July and between September and December. The train is on the move all over Germany for about 28 weeks of the year – and that figure is growing.

The track recording car itself is designed to measure the noise emissions of two wheelsets, which are excited as they travel along the track. The intensity of the excitation depends on the surface roughness and the vibration properties of the track superstructure. Both wheelsets in a bogie are unbraked to minimise wear. Continuously monitoring the wheel treads ensures that the roughness is always kept at a constant low level. An anechoic lined chamber above the measuring wheelsets contains a microphone. This device is located above an opening in the car floor and records the rolling noise. The measurement signals are processed by computer in real time and stored digitally. At the same time, the measurement engineer supervising the test can listen to the rolling noise directly and view measurement curves and spectral analyses.

The measured values show any deviation from what has been specified as a good running surface condition, based on the definition provided by the SMT method, as a sound level in decibels.

Photos: DB AG/Frank Barteld

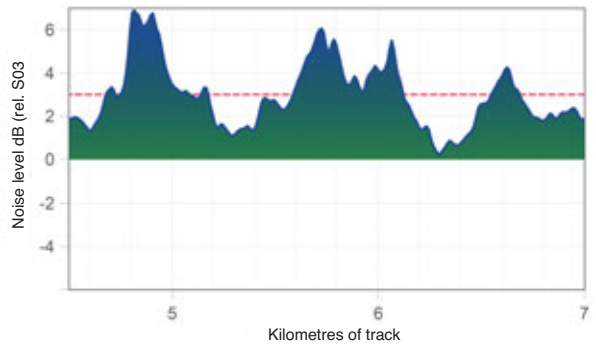


Other important information, such as the measurement process. The measurement location is determined very precisely by means of a GPS system, which allows the measured noise level to be matched to an exact location.

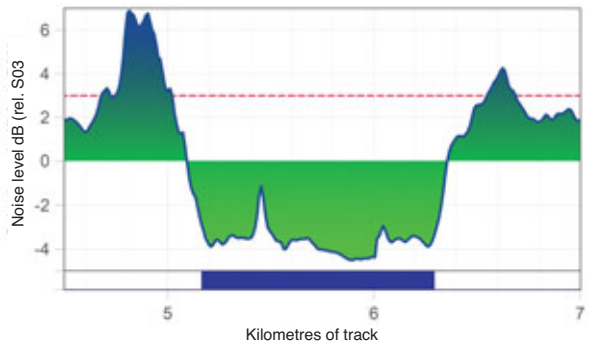
As the noise measurement car can measure in a speed range from 80 to 200 km/h, this vehicle can be deployed without disrupting rail services. However, on lines with tightly scheduled operations, such as the S-Bahn Berlin or through the Leipzig City Tunnel, the measurement train would often catch up to other trains, which would stop it from recording any more measurement data. To avoid this scenario, measurement runs on such lines are conducted at night and during non-operating periods. On long single-track sections too, for example on the recently electrified line between Buchloe and Lindau, it makes good operational sense to run the tests on weekends when passenger numbers are lower.

Teamwork

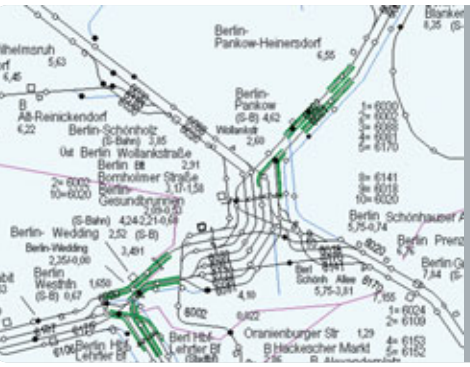
These examples show that the measuring sections with "specially monitored track" are not always found in easy locations. Often, entire rail hubs such as Erfurt, Leipzig, Berlin or Halle have been expanded or newly constructed with a large number of these sections. To negotiate these hubs in the noise measurement train and take successful measurements, our train drivers and test managers not only need technical skills, but also a talent for negotiation and, last but not least, stamina.



Sound level curve provided by the noise measurement car: untreated rail surface



Sound level curve provided by the noise measurement car: with SMT section (blue) with a ground rail



Line map of the Berlin-Gesundbrunnen hub with SMT sections (marked in green)

Photos: DB Systemtechnik

When the test manager says "The measurement section is to be measured from km 1.7 of the line from Moabit into the tunnel tube along the R-track to Berlin Central. We need a long signal overlap for the 80 km/h and also have to take into account the line change point and the alternating directions of the kilometre markings," then you know there is more to organise than just the timetable.

Intensive discussions are held with the dispatchers and the signallers. The latter must set the desired route at an appropriate time. But after a successful test run, everyone is ultimately very happy and the team often spends their well-deserved downtime together in a restaurant, beer garden or even hosting their own barbecues.

However, everything does not always go according to plan, and that is when quick action is required. If a measurement run is cancelled due to a line closure or any other technical issue and a new ad hoc timetable is required, the dispatch office is always ready to spring into action so there will be no delays whatsoever. Unfortunately, the weather does not run to a timetable – it might suddenly snow on the Cologne–Rhine/Main high-speed line while crossing the Westerwald region in October, for example. Thankfully, the snow usually thaws and disappears quite quickly, so a valid measurement can be taken on a later trip. Snow is known to absorb sound and would distort the result.

Accredited test method

A snow-free line is one of the boundary conditions stipulated in the accredited test method. The noise measurement method has been recognised by DAkkS, the German national accreditation body, in accordance with the requirements of DIN EN ISO/IEC 17025 since 2001. The track recording car's odometer has been running ever since, clocking up one million kilometres in the 20 years it has spent as a testing laboratory – and it is adding more than 50,000 kilometres to that total every year. This achievement is a reflection of the incredible skills of the whole team, without which the noise measurement runs simply could not be a success. After all, the end goal is to present valid measurement data for all the sections scheduled to be covered in a particular turnaround cycle once the work is complete. This is what we want to deliver and also what our customers expect from us.

Rolling noise and rail corrugation

The noise emissions caused by a rail vehicle when it passes a noise pollution location are made up of drive noise, rolling noise and aero-acoustic noise. While drive noise dominates the emission level at low speeds of up to around 80 km/h, rolling noise characterises the sound level at higher speeds of up to 250 km/h. At speeds above this, the noise components caused by air turbulence, e.g. from the pantograph, add to the overall level.

Only rolling noise was considered in the SMT method. Rail corrugation was identified as the main cause of the rolling noise. Rail corrugation is a phenomenon which sees the longitudinal profile of a straight track change, with a corrugation length of between 10 and 100 mm and a corrugation depth (amplitude) of up to 100 μm. The greater the amplitude of the corrugation, the stronger the vibrational excitation caused by the wheelsets rolling over the track. By eliminating the corrugations using rail machining processes specially designed to smooth the track in the longitudinal direction, thetrack is made smooth again and the rolling noise is reduced to a minimum. The noise measurement car was ultimately developed as a way of conducting this "measure – grind – measure" process effectively and at the same time economically. Its technology is able to measure the roughness of the rail indirectly, irrespective of the running speed and the type of track superstructure.

DB Systemtechnik reference projects 2020/2021

High-speed test runs with the Velaro Novo

Testing new technologies always requires going beyond the limits of existing systems. To this end, high-speed test runs at speeds of up to 360 km/h were recently conducted on existing infrastructure to test Siemens Mobility's new Velaro Novo high-speed train, the purpose of which was to ensure its safe operation while meeting all relevant rail operation regulations as well as the requirements of the Railway Commissioning Authorisation Regulation (EIGV) in relation to conducting test runs.

DB Systemtechnik was commissioned by Siemens Mobility to carry out this task, with experts from the Safety & AsBo department taking the lead.

In close cooperation with the Aerodynamics, Running Equipment, Operations/FOC, Overhead Line and Brake departments at DB Systemtechnik, among others, as well as experts from the vehicle manufacturer and infrastructure manager, comprehensive safety assessments were conducted for this highly complex technical project. Special features associated with the safe performance of these high-speed test runs were analysed and documented in multiple risk management procedures for vehicles, operations and infrastructure, each of which was subject to an independent safety assessment.

Comprehensive measures were then identified and implemented to enable DB Systemtechnik to perform the tests runs in cooperation with the infrastructure manager, and to test and measure new vehicle technologies for the customer.

Photos: DB AG/Oliver Lang


#seeitnovo
ens.com/velaro-novo

Determining wind loads on signal masts

DB Systemtechnik carried out aerodynamic measurements as part of a DB Netz AG study into the strengths of various types of signal mast.

The study wanted to determine the maximum meteorological wind load for the different types of mast. The idea was to collect data, then use it to calculate whether the signal masts can withstand the wind loads to which they will be subjected for their entire service life without sustaining damage. DB Netz AG identified three different mast types and measuring points to be investigated: narrow mast, mast with cantilever and tubular mast. DB Systemtechnik's aerodynamics testing laboratory fitted the signal masts with strain gauges and acceleration sensors. Permanent meteorological measuring points were also set up next to the corresponding signal masts.

Long-term measurements were carried out to determine the maximum wind loads. Over a period of five months, the wind speed, wind direction, humidity, temperature and ambient pressure of the signal masts, as well as the strain and acceleration torque, were continuously recorded.

After the end of the measurement period, the collected data was analysed. The very large amounts of measurement data involved posed a significant challenge. All wind events above Beaufort force 5–6 were filtered out to establish the maximum loads on the masts. The relevant wind loads were then calculated for the different types of signal mast.

As the study was only interested in the loads caused by meteorological events, loads caused by passing trains had to be removed from the data. The experts at DB Systemtechnik have developed a special filtering algorithm for this, which was able to remove the data related to passing trains.

This allowed the experts to uniquely identify the maximum wind loads for all three types of mast and also, as a result, the load on the signal masts due to extreme meteorological events. The data thus obtained will be used in the strength study and may be incorporated when designing signal masts in future.

Photos and illustrations: DB Systemtechnik

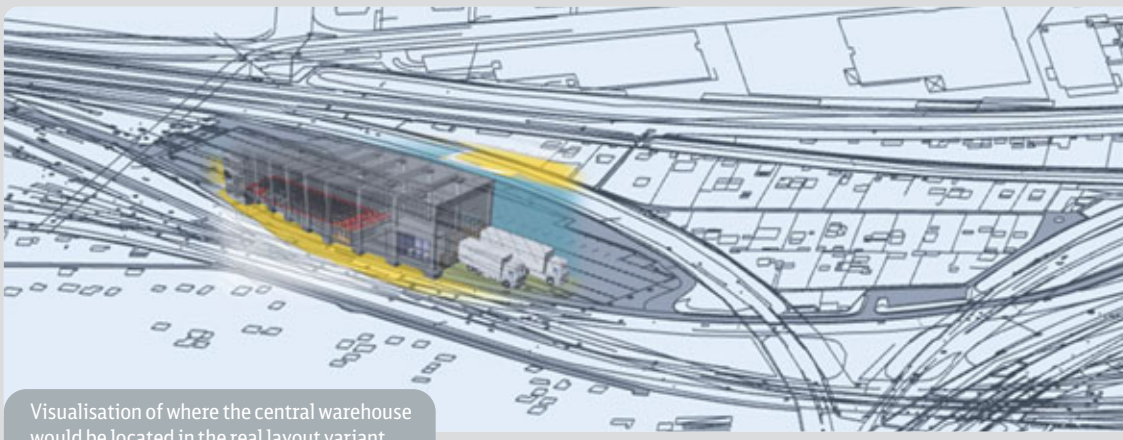
Optimising the mobility of things: A holistic concept for depots, warehouses and logistics

Not every depot site is recognisable at first glance: in some locations, different business units use maintenance facilities made up of various smaller depots that have grown over time. The warehouses for consumables, old parts and new parts have grown alongside them as best they can given their surroundings.

The site being considered in the study ordered into this issue is set to undergo serious modifications in the coming years. Extensions to existing infrastructure, a new plan for how different areas will share the space, and an expansion of the range of classes that will be maintained mean that the storage locations need to be fundamentally redimensioned and restructured as part of a holistic logistics concept.

The workshop designers at DB Systemtechnik in Kirchmöser were given this challenging task, which illustrates how infrastructure planning, production processes and machine technology are linked across all vehicle maintenance products.

They used material master and transaction data to calculate material flows, quantities and space requirements, and then to design the ideal layout for a central warehouse. Working together with the client, they translated this design into different potential variants of actual layouts and came up with the details of a preferred variant. In the interests of making transportation easier, an optimised transport route concept for delivering materials to the maintenance benches was developed and the use of specialised conveying equipment was proposed. If conversion and expansion work continues at the site, the result will form part of the basis for executing the subsequent planning tasks, which would then also include the construction of a new central warehouse at a directly adjacent triangular junction.



Visualisation of where the central warehouse would be located in the real layout variant

Increasing the limit interval on the WestfalenBahn

WestfalenBahn operates 13 six-car Class 445/446 KISS EMIL electric multiple units. The maintenance level "ISDG" bogie overhaul, which specifies a distance-based maximum interval of 1.2 million kilometres, forms part of the maintenance programme for first operators. In order to reduce maintenance costs, WestfalenBahn intends to change this limit interval to 1.5 million kilometres.

The first step in this project was to validate the previous limit interval of 1.2 million kilometres in accordance with the specifications as per EN 17023 in order to determine the degree of wear and tear on the current components based on their use in a multiple unit and on real-life findings, thereby proving that the previously valid limit interval fulfilled the safety requirements.

The challenge in this project was to work out the criteria for successful validation within a very short time together with experts from the respective specialist areas of bogie components.

In addition, the time that elapsed from the initial enquiry through to the offer and subsequent order, as well as the availability of multiple units, changed the boundary conditions of the systematic procedure announced in order to adhere to the project schedule.

Since only three multiple units were available for the evaluations of the bogie components, the joint approach was a key requirement in ensuring that determining the degree of wear and tear on the bogie components would result in successful validation. The modern, technical and reliable communication channels available not only facilitated project work from home but even made it possible, in the first instance, for specialist departments in separate locations to work efficiently together with the client.

The verified validation confirmed the positive roll-out potential of the intended limit interval change. The validation that had already been performed reduced the time and effort, both functional and organisational, needed to conduct further investigations to successfully verify the future limit interval of 1.5 million kilometres. Moreover, this validation is a process component in accordance with the specifications as per EN 17023.

Increasing the limit interval will enable WestfalenBahn to reduce the maintenance costs associated with bogie overhauls. With DB Systemtechnik as its partner, the client could count on the best possible legal certainty, along with an independent and reliable evaluation.

The services provided by DB Systemtechnik in detail:

- Developing a systematic procedure and compiling documentation in the validation plan
- Identifying, processing and evaluating maintenance data
- Specifically determining the degree of wear and tear on bogie components at 1.2 million kilometres (validation)
- Furnishing legally compliant proof of compliance so that maintenance specifications for bogies can be applied without restriction
- Ascertaining the roll-out potential of the intended limit interval change
- Documentation for validation by an independent body
- Achieving the (since implemented) requirement for conducting the follow-up order "Verification of the limit interval change to 1.5 million kilometres"

Photos: WestfalenBahn, DB Systemtechnik 2 x

Measurements for ICE 4 bridge trafficability

As part of the ICE 4 bridge trafficability project, DB Systemtechnik was commissioned to measure the dynamic properties of bridge structures.

In this context, we conducted standardised measurements on more than 1,000 bridge structures and partial bridge structures in Germany between 2014 and 2020. The measurement results were included in DB Netz AG's proof of compliance to determine the structural safety and serviceability of bridges and viaducts when an ICE 4 train passes over them. This was based on the special wheelbases of the ICE 4 train.

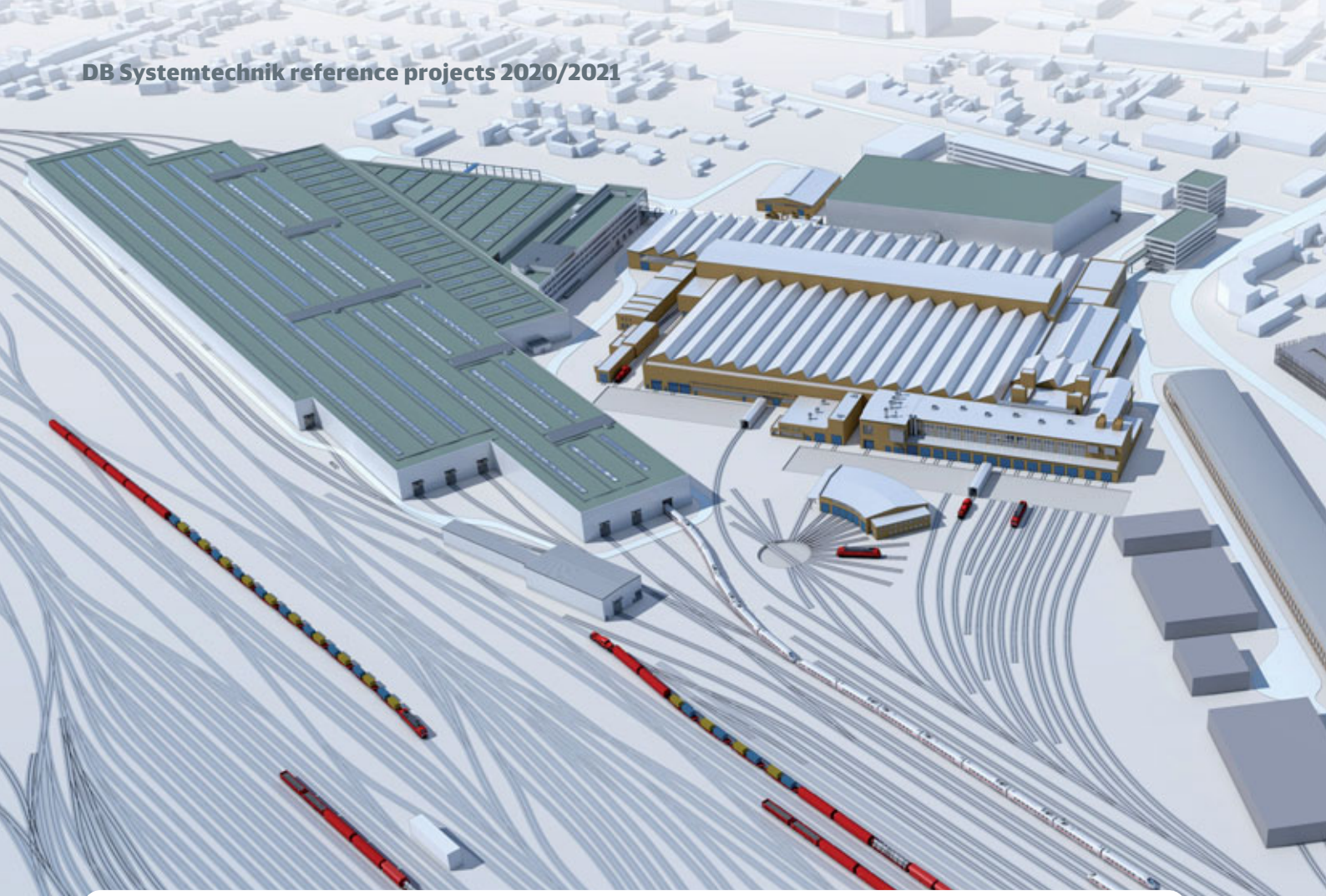
The relevant specialist departments within DB Systemtechnik succeeded in standardising the extraordinarily large number of bridge structure measurements both from an organisational and functional perspective. Moreover, they conducted these measurements annually, on schedule and in accordance with the agreed quality requirements. The strongest vibrations (the first natural bending frequency) of the partial structure and their decay behaviour (the associated attenuation) were measured.

One of the biggest challenges of this project was planning when to take the measurements as some of the bridges crossed dual carriageways or motorways, which had to be officially closed in order to conduct the measurements. In addition, the issue of overhead lines had to be taken into consideration at rail line crossings. At these points, it was not possible to take measurements on the underside of the structure.

To ensure professional integration of these services for the customer, project management was implemented in compliance with the IPMA standard.

The standardised procedure then made it possible to forecast and plan the time and effort involved. Any changes to the customer's plans during the year could be implemented at very short notice. Furthermore, professional project management ensured smart service provision on time, within budget and in compliance with the agreed quality requirements.

DB Netz AG, in collaboration with DB Systemtechnik, was finally able to incorporate bridge trafficability for rail vehicles, within the scope of technical access to the rail network, into its regular business.



Next-generation maintenance depot

Strong Rail means increased transport capacity and more modern rolling stock. For depots dedicated to heavy vehicle maintenance, this implies increased volumes as well as shifts within Deutsche Bahn's product portfolios, both of which can generally no longer be handled by existing production facilities. In the electric multiple unit (EMU) segment, the launch of ICE 4 alone is expected to double the requisite overhaul capacity for high-speed rail (HSR). This, in turn, prompted DB Fahrzeuginstandhaltung to construct a new purpose-built overhaul depot for ICE trains in Cottbus.

The workshop designers at DB Systemtechnik in Kirchmöser were involved in the project at an early stage in order to establish the production-related basis for overhaul processes in accordance with the latest standards.

Together with experts from DB Fahrzeuginstandhaltung and the overall design coordinator from the DB E.C.O. Group, decisions were made in relation to defining both the overhaul concept and the production facility concept. These were then gradually incorporated into the layout designs.

In 2021, DB Systemtechnik planned the mechanical engineering side of the new depot in more detail. The new purpose-built depot for EMU maintenance will have production tracks that are 500 metres long and suitable for the maintenance of 13-car ICE 4 trains, that is, individually in a line on new work stations designed for individual vehicles. Bogies and vehicle bodies will be reconditioned in the adjoining sections of the maintenance shed with an adjacent logistics centre. The vehicle bodies will then proceed to a new painting facility. Once a train has been completely overhauled, it will be put back into operation on an indoor track that is 400 metres long.

The multiple unit depot is part of the overall project to expand the facility at Cottbus. Thanks to the production of hybrid vehicles, a double-track multi-purpose maintenance shed for multiple units, an administration and technology centre as well as locomotive production, Cottbus will become DB Fahrzeuginstandhaltung's largest production facility, with a target workforce of over 1,200 people in 2029.

Photos: DB Systemtechnik 2 x

Creating a specialist book on freight wagon brakes

The new specialist book on freight wagon brakes covers and addresses a very specific area of rail vehicle engineering. It will be used primarily for training purposes in the area of freight wagon brake maintenance at DB Cargo in Europe. However, it will also serve as a compendium and be used for self-study. The last edition of the specialist book on freight wagon brakes, published approximately 25 years ago, referred only to the functional part of the freight wagon brake.

Therefore, the training department at DB Cargo, in conjunction with the Brake department at DB Systemtechnik, developed the idea for a new specialist book. They wished to incorporate the area of maintenance into a specialist book on freight wagon brakes.

This has provided DB Cargo with an up-to-date and highly efficient means of training new employees on freight wagon brakes as well as training some employees to become qualified brake maintenance technicians. It can also be used as a compendium to disseminate knowledge. The different technical approaches to freight wagon brakes had to be evaluated for the specialist book on the basis of current technical relevance in order to create a contemporary, up-to-date specialist book that covers all relevant freight wagon brakes in the entire sector. This was an important aspect for DB Cargo.

A key aim of the specialist book is to provide a detailed description of the technical structure of freight wagon brakes and the workings of the mechanical and pneumatic components of various braking systems. A step-by-step description of the individual parts and components is provided in the relevant sections. Basic functions are outlined and additional explanations of the various types of maintenance are provided, ranging from condition-based maintenance to a scheduled brake inspection.

Bringing operational and technical framework conditions, in-depth knowledge, and maintenance rules and regulations together in this way is completely unique. DB Systemtechnik can now look back on its successes in the areas of maintenance, engineering and training development. This contribution to safe, undisrupted rail operations was made possible thanks to a strong pooling of specialist expertise from different specialist areas.

Photos: DB Systemtechnik 3 x, Edgar Bergstein 2 x

Engineering and design for S-Bahn Hamburg

As part of the Digital S-Bahn Hamburg project, in addition to a trackside upgrade, four S-Bahn suburban trains have received a technology upgrade in the form of ATO (automatic train operation) over ETCS.

DB Systemtechnik's High-Speed Train and EMU Competence Centre provided the installation engineering for the components supplied.

Siemens, as project partner, supplied the necessary components, including a balise antenna, radars, ETCS and ATO computers, and a driver machine interface (DMI), all of which had to be integrated into S-Bahn Hamburg's existing Class 474.2 vehicle in compliance with Siemens' stringent installation guidelines.

These vehicles had only limited space, which in some cases was wholly unsuitable, and needed creative solutions. From an implementation perspective, this involved, among other things, redesigning the flange lubrication system and the obstacle deflector as well as ascertaining the vehicle's mass in order to draw conclusions about the brake control unit.

Solutions needed to be developed so that the requirements concerning the space available for the ETCS central processing units could be specified for the first tier supplier, and the ETCS brake activating unit could be integrated into the existing pneumatics. Furthermore, the technical requirements and labour law provisions regarding non-ferrous spaces or EMC specifications had to be observed. The workplace requirements of train drivers (for example, redesigning the driver's console in order to integrate the DMI) also had to be taken into consideration.

In December 2018, DB Systemtechnik began the process of reviewing the vehicle documentation. By summer 2020, the first vehicle was completed and had commenced test runs. All of this was achieved in just 18 months thanks to the agile collaboration between Deutsche Bahn and Siemens. Designers from DB Systemtechnik and engineers from Siemens worked together on this project in a collaborative workspace.

Thanks to the design expertise gained with future technologies and their deployment of agile project management, DB Systemtechnik's design team, with support from internal departments, was able to recommend itself for follow-up Digital Rail for Germany projects such as Sensors4Rail and Digital Customer Experience Hamburg.

Digitale Schiene Deutschland

Leaktightness tests on a sliding tarpaulin wagon

DB Cargo, in conjunction with other wagon manufacturers, has developed a freight wagon (m² wagon project) that can be fitted with various superstructures by means of a modular system. One variant is a sliding tarpaulin body, which is suitable for transporting moisture-sensitive paper rolls, for example. In addition, the tarpaulin body of another sliding tarpaulin wagon has been modernised.

These superstructures underwent a leaktightness test against snow and rain, which was conducted in DB Systemtechnik's MEikE climatic chamber in Minden.

This involved a water jet test in which the sliding tarpaulin wagon was sprayed with water both head on and at an angle in order to simulate rainfall during a headwind. In addition, the climatic chamber was cooled down to -25°C. Different environmental conditions were simulated through the use of artificial snow and fans to simulate drifting snow and wind. These tests enabled the wagons to undergo a leaktightness test under extreme conditions.

The results were then documented in a final report and given to the client. They provide information about possible leaks and the need to improve the sealing design.

Wagon with front-mounted ventilation unit

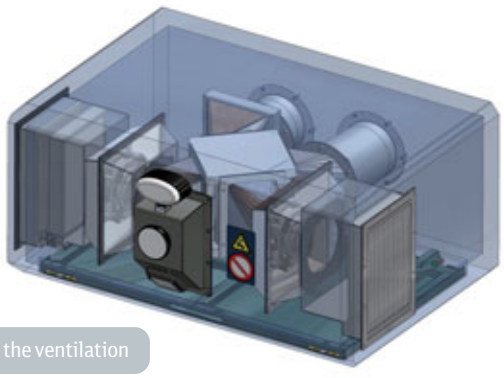
Duct system for distributing fresh air inside the vehicle

Developing a ventilation system for DB Netz AG's emergency crane train

The finishing materials used in the interior of the two crane escort vehicles that accompany the recovery train, namely AOC-WWE (application-oriented container for living, workshops and energy) and AOC-SSA (application-oriented container for sleeping, and washing), may release volatile components harmful to health into the indoor air. These volatile pollutants should be transported to the outside by a high-level air exchange system in order to achieve better air quality within the rooms.

DB Netz AG therefore commissioned the Aerodynamics & Air Conditioning department to assist in the development of a ventilation system.

The ventilation unit was mounted onto the front exterior of the car. The air drawn in by this unit passes through an air filter, a heat exchanger and the fan into an air duct system. From there, the filtered and pre-heated fresh air is transported to the individual rooms via air-intake valves.



Structure of the ventilation

The stale air is extracted via ceiling valves in the individual rooms and transported back into the ventilation unit via a separate air duct system. In the unit, the exhaust air passes through another air filter, another fan and the heat exchanger into the open air.

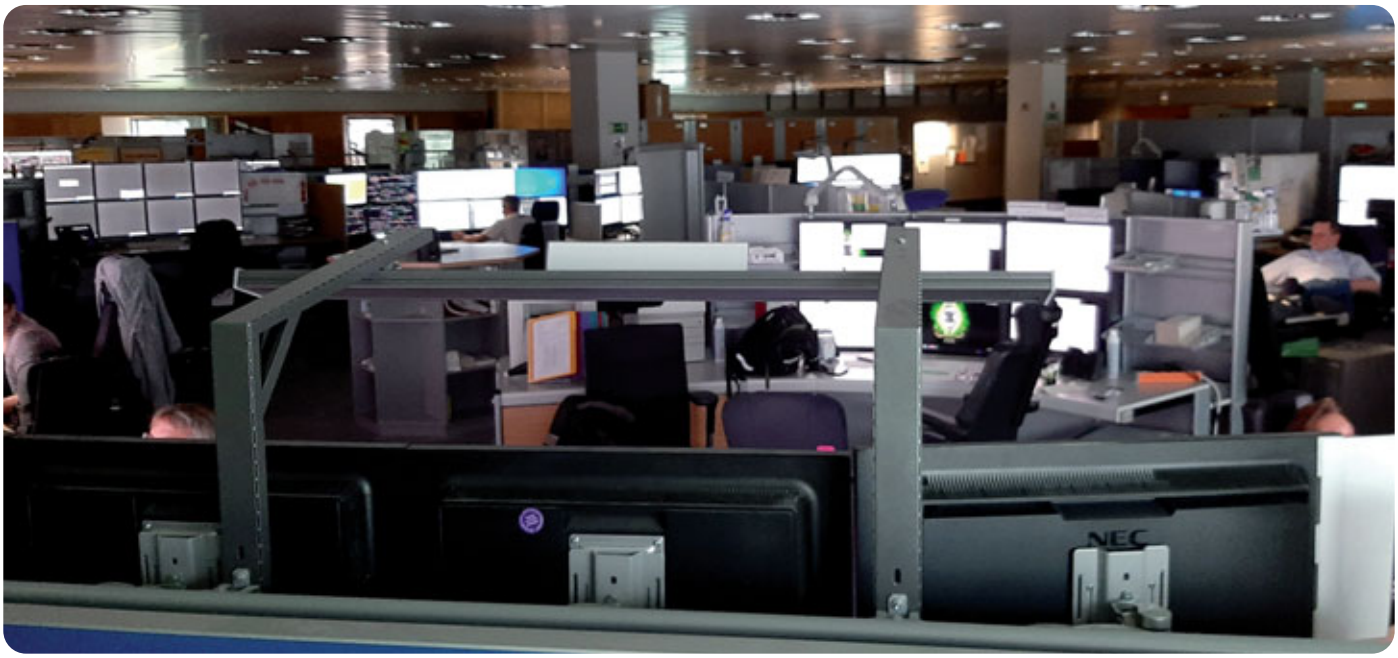
The heat exchanger pre-heats the fresh air by extracting the heat contained in the exhaust air. In winter, the cold fresh air drawn in is also pre-heated by an air heater to prevent cold draughts in the rooms. The cars have heating convectors for winter operation and a separate cooling system for summer.

A special challenge here was to combine the two existing heating and cooling comfort systems with the ventilation system in such a way as to avoid air short circuits or mutual interference. Thanks to intensive ventilation of the individual rooms, the pollutants are transported into the open air, thus ensuring good, healthy indoor air quality.

Conditioning and filtration of the fresh air not only provide pleasant thermal comfort but also ensure compliance with occupational health and safety regulations.

Photos and illustrations: DB Systemtechnik

Assessing the air quality of operations centres and signal boxes at DB Netz AG



In the course of this Coronavirus pandemic, the operations centres at DB Netz AG came under the spotlight and needed to be assessed in terms of their air quality as well as the ventilation and air conditioning systems used in both operations centres and signal boxes.

As a result, DB Systemtechnik's air conditioning experts, in cooperation with DB Netz AG, visited all of the operations centres and a select number of signal boxes in July 2020. Subsequently, a checklist to improve air quality from the perspective of a potential risk of infection was drawn up on the basis of the current condition of the ventilation and air conditioning systems in the operations centres, along with the condition of the working areas, and given to DB Netz AG.

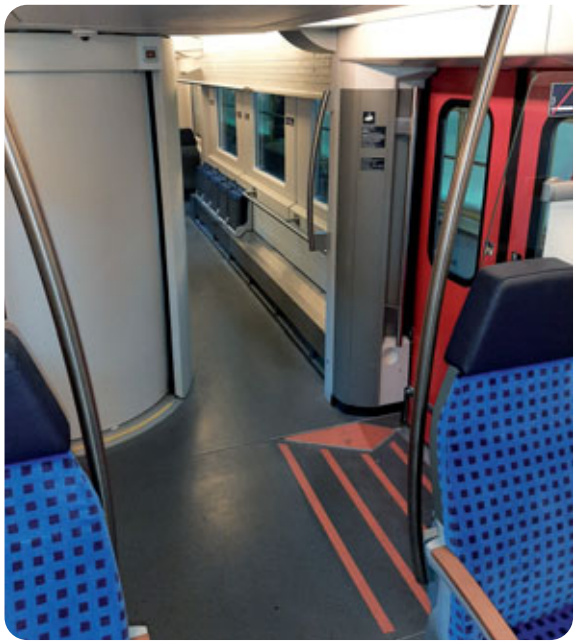
In addition, the indoor air quality of each operations centre was assessed in relation to characteristic indicator values, namely CO_2 content, fresh air supply per person, and time and rate of air exchange.

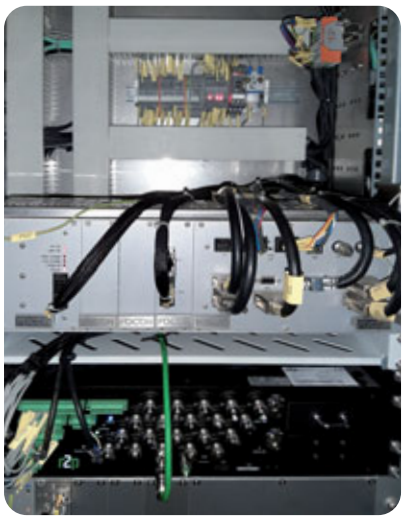
With DB Systemtechnik's experts providing advice, DB Netz AG procured decentralised air purifiers for individual signal boxes.

By visiting the operations centres, the air conditioning experts were quickly able to appraise the ventilation and air conditioning systems used there and subsequently make recommendations for action. Their assessment of the air quality in the operations centres resulted in a standards-compliant condition, thereby reducing the risk of infection.

Photos: Dr. Peter Claus

Photos: Martin Kuhlins





Redesign of E-Network Mainfranken nearing completion

In order to fulfil its six-year public transport contract for E-Network Mainfranken at the timetable changeover in December 2021, DB Regio Bayern needed to upgrade 39 of its Class 440 multiple units. These vehicles are operational on the transport network around Würzburg in the federal states of Bavaria, Baden-Württemberg and Hesse. Thirteen four-car and 26 three-car vehicles were therefore upgraded at the Hagen satellite depot of DB Fahrzeuginstandhaltung's Krefeld Maintenance Depot.

DB Systemtechnik's High-Speed Train and EMU Competence Centre, located in Krefeld, was commissioned to undertake the electrical and mechanical engineering for a new video system, a vehicle location system and the provision of the "radio to passenger" announcement feature in all coupled vehicles.

The contract also included an upgrade of the inter-car connecting lines as well as changes in the passenger area with the removal of six fold-down seats opposite the toilet and the subsequent sheathing and assembly of new grab poles. The installation of new luggage racks eliminated a small number of seats and gave passengers additional storage space for their luggage, while vandalism to the exterior was prevented by a new anti-graffiti coating. Furthermore, DB Systemtechnik was responsible for proof of compliance and the entire approvals process.

This vehicle upgrade enabled DB Regio Bayern to fulfil its public transport contract in a cost-effective manner without having to invest heavily in new vehicles. Ten vehicles have now been converted, with DB Systemtechnik's High-Speed Train and EMU Competence Centre supporting this conversion process on site and implementing any necessary design modifications at short notice.

Risk analysis of the platform at Hamburg Elbbrücken

According to regulations, platforms are to be built on the flat. If this is not possible, track slopes and platforms are permitted to have a longitudinal gradient of up to 30 tenths of a percent. At certain points, the Hamburg Elbbrücken station exceeds the maximum longitudinal gradient specified in Guideline 813, in part due to the installation tolerances of the components. Consequently, the permanent operating permit for this station was endangered.

To ensure safe operation, an in-depth risk management procedure was implemented in accordance with the Common Safety Method (CSM), with DB Station&Service AG commissioning DB Systemtechnik to conduct the technical studies.

The analysis examined critical areas that have an increased longitudinal gradient (>30 tenths of a percent) and identified risks to passengers, pushchairs/prams and wheeled suitcases/luggage trolleys. Appropriate countermeasures to reduce these risks were included in the analysis.

These included:

- Transverse gradients that steer rolling objects away from the track
- Ground markings and signage alerting passengers to the down gradient

  Low train speed in the station

Finally, the risks were compared against a reference platform in order to assess the safety of the platform at Hamburg Elbbrücken.

The analysis has shown that these measures were able to adequately mitigate the risks and therefore comply with the substantive requirements of Guideline 813. Once the procedure has been completed, DB Station&Service AG will be able to discontinue costly measures such as the deployment of station attendants and passenger guides and obtain the operating permit.

Photo: DB Station&Service/Stefan Möhrle

Electrification of the upgraded Munich–Lindau line 48

The travel time between Munich and Zurich is set to drop by one hour, from 4.5 to 3.5 hours. To increase the speed, the line has been electrified and vehicles with tilting technology will run on it in the future.

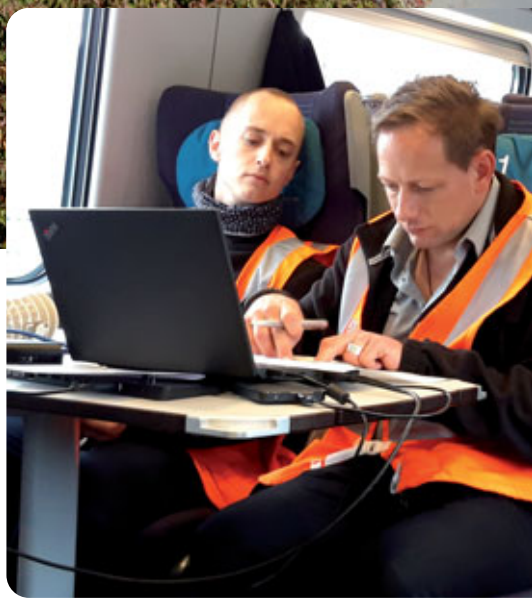
DB Netz AG commissioned DB Systemtechnik to carry out the partial approval for vehicle running behaviour of the line sections where there is an increased speed, as well as overhead line acceptance runs, using the SBB vehicle ETR 610.

The vehicle was equipped with measuring wheelsets and an instrumented pantograph from DB Systemtechnik. This equipment was actually fitted in Basel.

During the test runs, measurements were also carried out in relation to the ETR 610's technical network access on the German railway network. Stationary measurements were also carried out in parallel at each of six switch trestles in two points (Aichstetten and Wangen) in order to examine the forces that occur there.

As the approval runs were conducted at 10% above the future maximum line speed, the ungated level crossings had to be closed. More than 20 marshals were needed on the test sections for this.

In addition, confirmation runs were carried out with DB Systemtechnik's reference tilting technology vehicle (VT 612) for the routine inspection of running characteristics that will be conducted annually in future. This enabled the team to compare the measured vehicle reaction forces of the ETR 610 and the VT 612.



Photos: Norbert Leindl, Alexander Kerschgens 2 x

Photo: Pixabay

Digital Train Twin

The term "digital twin" can be applied to trains too. Actual data on the condition of the train and its components is collected in order to then compare it to target data. The benefits of this are two-fold: condition-based maintenance tasks can be identified and their scope reduced, while train availability can also be increased.

DB Systemtechnik is involved in subproject 1 (called Edge) of the Digital Train Twin project, which is based on the Class 429 Flirt ETSW. Edge is all about equipping the 28 vehicles in this DB Regio Mitte fleet.

The vehicles are to be equipped with the latest hardware so that their information can be transferred to Deutsche Bahn's cloud. Initially, this will be the vehicle's diagnostic data, but later it will also include direct engine and sensor values as well as systems connected to the vehicle bus, such as the air conditioning or door system. A first prototype vehicle was equipped with the hardware, tests were carried out and the data was transferred to the land side.

An additional coordination task was to integrate Continuous Track Monitoring (CTM), a DB Systemtechnik product, which monitors the railway infrastructure from the vehicle. This product has also already been jointly installed in the prototype vehicle and tested.

DB Systemtechnik not only dealt with implementation for this project, it also took on responsibility for managing the project and coordinating all the people and stakeholders involved, thus ensuring that information flowed as it should and customer requirements were met.

Photos: Fritz Trimpe, Burkhard Mittmann, Andre Kutschan

Measuring the driving power of a shunting locomotive

Prior to procuring new shunting locomotives, DB Cargo required information on the driving power of its existing vehicles. Therefore, together with DB Cargo, measurements were taken on a Class 294 shunting locomotive in Winter 2020/21. The Class 294 is used throughout Germany for shunting services, on the hump, for the delivery of individual freight wagons to clients with private sidings, and also for running movements made on the line.

DB Systemtechnik was commissioned to measure the torque and rotational speed on the output shafts of the mechanical drive train. These arise during regular operation of the locomotive.

DB Systemtechnik usually measures the torque and rotational speed on the axles to determine the load spectrum or maximum torsional load on each. Measurements on other rotating parts are carried out less frequently but just as successfully.

A particular challenge in this project, however, was measuring the output shafts of the auxiliaries. Unlike the output shafts that drive the wheelsets and ultimately ensure that the locomotive moves, the output shafts of the auxiliaries rotate much faster up to a peak of 3,500 rpm. By way of comparison, at its maximum permissible speed of 300 km/h, an ICE 3 axle rotates at approximately 1,700 rpm, i.e. only half the above peak value. In addition, the output shafts are located in the engine room of the locomotive, thereby providing very limited space in which to mount sensors and transmission systems.

Thanks to the experience gained by the experts at DB Systemtechnik from over 20 years of torque measurements on rotating axles, all challenges were surmounted, the necessary measurements were successfully taken and this data was given to DB Cargo who will now use it to co-develop and procure shunting locomotives in the future.

Stadler WINK approval project

Photo: Benjamin Reffay

The new and innovative two-car multiple unit for passenger transport from vehicle manufacturer Stadler needed to be approved. The WINK type vehicle (whose name comes from the German acronym for convertible, innovative short train for local transport) was to be operated by both diesel-electric power and electric only, and has additional batteries on the roof of the car for recovering energy. These enable the vehicle to be supplied with energy even when the diesel engine is switched off, making the vehicle even more flexible, e.g. when driving in stabling areas or when supplying the air conditioning system with power.

DB Systemtechnik was commissioned to carry out the running and brake system tests as quickly as possible for approving the vehicle in the Netherlands.

The measurements were taken according to European standards and conducted in Germany and Romania. From February 2020 to early April 2020, the experts from Running Equipment performed their final tests on the WINK at speeds of up to 176 km/h. Since the train did not feature German train protection systems, the vehicle running behaviour measurements were taken with the vehicle being towed by a coupling wagon. All running behaviour tests were carried out in compliance with stringent additional health and national requirements, and were successfully completed on time despite the pressure of deadlines and difficult conditions brought about by COVID-19. The new fleet of vehicles even started operating on Arriva Netherlands lines (Friesland and Groningen) that very same year.

Retrofitting the Class 66

Photos: DB Systemtechnik

Due to an increase in unscheduled repairs on engine assemblies of the Class 66 diesel locomotive, the French railway company DB Cargo France commissioned DB Systemtechnik in August 2020 to retrofit a preheater and a lubricating oil pump in a prototype locomotive.

The client's goal was to upgrade one locomotive in order to ascertain the scope and cost of the retrofit, to minimise unscheduled repairs and to lay the foundation for the series upgrade of the French Class 66 fleet.

The locomotive upgrade took place in a DB Cargo maintenance depot in Saarbrücken. Engineers from DB Systemtechnik in Cottbus travelled to Saarbrücken to instruct and support the fitters on site.

Thanks to great teamwork, it was possible to overcome some of the challenges encountered during the project, including the limited installation space within the locomotive, the language barrier with the client, as well as parallel installations undertaken by a French company.

Due to a high degree of flexibility and the many years of experience accumulated by DB Systemtechnik's employees, commissioning of the first prototype locomotive in the Saarbrücken depot was completed on schedule and to the satisfaction of the client. The data collected by the locomotive can be retrieved via a telemetry interface.

Within DB Systemtechnik, this project was also undertaken as a bachelor's thesis to promote junior engineers from the company's own ranks.

Boiler assembly of the AST preheater K35-50

Test object on the rig
Red: Mixed air inlet
Blue: Supply air outlet
Green: Cooling air inlet
Yellow: Cooling air outlet

Testing a driver's cab air conditioning system on LUDEK

In the driver's cab of various trains, thermal comfort is ensured by a Mahle air conditioning system that has been fundamentally redesigned to facilitate the use of the alternative refrigerant R513a in the drop-in process. The old refrigerant is therefore being replaced with this new refrigerant. However, a performance test is needed to validate these design changes. Usually, it is necessary to conduct expensive, time-consuming tests in a climatic chamber in order to test the air conditioning system in accordance with the testing standard for air conditioning systems EN 14813-1 for Zone II.

By providing an off-vehicle air conditioning system, it was possible to conduct the performance test on DB Systemtechnik's LUDEK test rig in Munich without the need for a corresponding vehicle to be positioned on the rig.

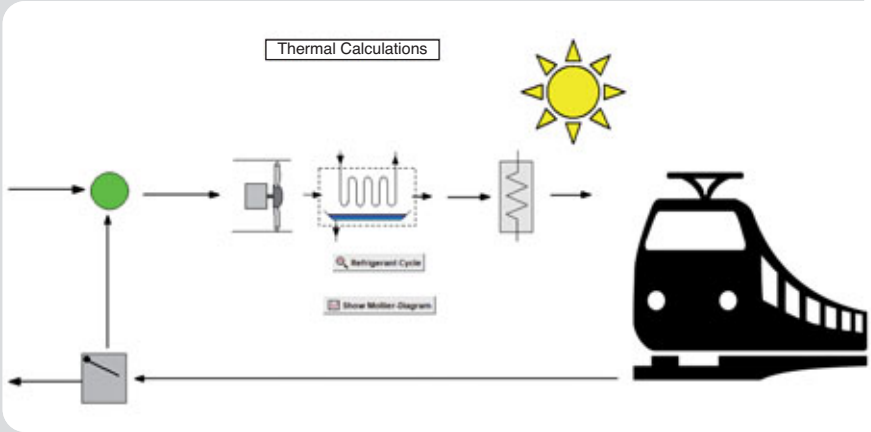
The integration of the air-conditioning system into the LUDEK's measuring circuit was implemented using adapted nozzles, through which the precisely simulated air conditions were supplied. In addition to the measured values, which are read out internally, the air conditioning system was fitted with further external measuring instruments. When used in conjunction with the sensor technology within LUDEK, these external instruments made it possible to monitor and log the relevant conditions within the system boundaries of the air conditioning system.

Compared to other testing equipment, LUDEK has a significantly lower thermal inertia as it no longer requires an entire vehicle to reach a stable measuring point temperature in the testing room and to remain at that temperature. This not only reduces the waiting times associated with reaching thermal equilibrium, but it also shortens the control time between measuring points, thereby resulting in a significantly shorter measurement time over the course of the entire project.

It was possible to prove the performance of the air conditioning system for use with the alternative refrigerant. By using a free-standing air conditioning system, unproductive vehicle idle times were avoided. A savings on the additional costs in relation to transport routes was also achieved. Thanks to this procedure, which was minimally invasive from an operations perspective, and the optimised measurement period, the air conditioning system could be validated at comparably low costs.

Photo: DB Systemtechnik

Process simulation for air conditioning systems



In rail operations, when there are technical problems on the vehicle side, the power supply for auxiliary consumers such as the air conditioning system on board is sometimes also restricted. If less power is available for air conditioning, the climatic comfort of the vehicle's interior is affected.

As a preventive measure for scenarios that would potentially involve a limited power supply, simulations can be used to calculate the temperatures that occur within the interior of the vehicle, thereby allowing critical external conditions to be identified in good time so that, in such cases, the operator can develop appropriate measures to ensure unimpeded passenger comfort.

DB Systemtechnik's air conditioning experts have used their own Engineering Equation Solver (EES) calculation tool to construct a static vehicle body model, including air conditioning, and to identify the conditions that would arise within the vehicle's interior under the following variable parameters:

- Outside temperature and solar load
- Occupancy and fresh air volume
- Available cooling capacity

The simulation makes it possible to estimate the different interior temperatures that arise, assess the impact of restricted air conditioning on thermal comfort, and gauge the effectiveness of any measures chosen, all before such a situation actually occurs in real life. Not only can the situation be better assessed in this way, it can also be avoided in the long term without the need to conduct more extensive vehicle measurements.

The simulation model constructed for this purpose can also be easily applied to different classes and scenarios, thus providing the vehicle operator with another useful tool for ensuring that passengers enjoy as pleasant a journey as possible without restrictions.

Photos and graphics: DB Systemtechnik

Noise barriers at the test site in Tüssling: The emission source is placed to the left of the grey noise barriers. The noise pollution locations are shown on the right-hand side.

Effect of mobile noise barriers on reducing construction noise

Due to the high level of construction activity in the area of rail infrastructure, which will continue to grow in the future, noise pollution from infrastructure works is increasingly becoming the focus of public discussion. The possibility of using mobile noise barriers to actively combat construction noise in a flexible manner was systematically examined within the framework of the I-LENA initiative, funded by Germany's Federal Government.

Five different designs for mobile noise barriers as well as two proposals regarding noise reduction cladding for fixed barriers were field-tested in Tüssling and Munich-Riem. Both technical and artificial sound sources were used in this project. The sound sources were positioned at different distances from the noise barriers. The sound field on the opposite side of the walls was then measured in detail.

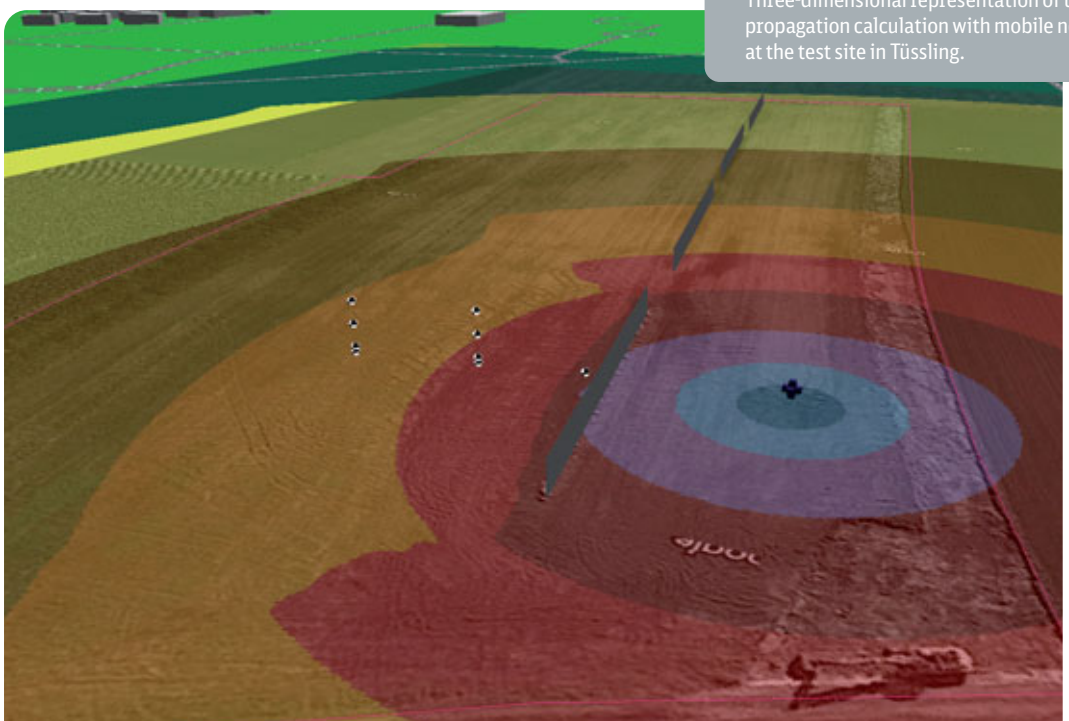
DB Netz AG commissioned the Acoustics testing laboratory at DB Systemtechnik to perform the measurements.

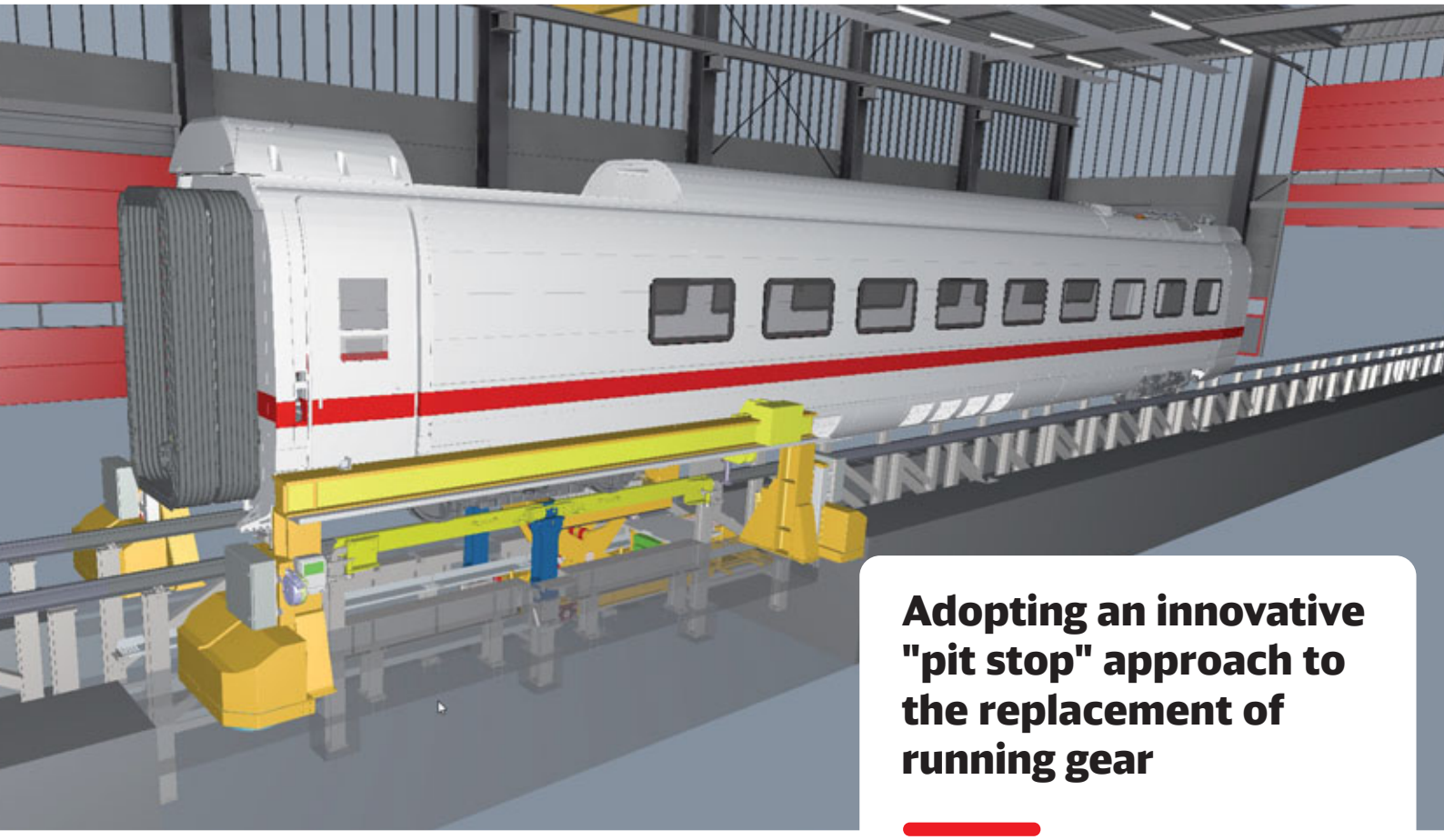
Afterwards, the Acoustic Engineering department at DB Systemtechnik conducted their assessment (post-processing).

In addition, sound power measurements taken from the noise sources were used to validate the measurement results by means of a comparative analysis within an acoustic model in Cadna/A.

DB Systemtechnik assisted DB Netz AG on this project for several years, from the initial exchange of ideas and planning steps right through to successful implementation. The full package offered by DB Systemtechnik involved developing the measurement concept, conducting and analysing the measurements, and subsequent post-processing.

Three-dimensional representation of the sound propagation calculation with mobile noise barriers at the test site in Tüssling.





Adopting an innovative "pit stop" approach to the replacement of running gear

Maintenance on availability-critical, long multiple units is focused on adopting a "pit stop" approach so that even complex work can be completed in the maintenance depot in the shortest possible downtime. In ICE maintenance, this means working on all four levels simultaneously, namely the roof area, interior, side area and floor underside. Ideally, it must be possible to replace components underneath the train without actually lifting or moving the train. This also applies to the essential and planned replacement of bulky and heavy components such as the wheelset and running gear.

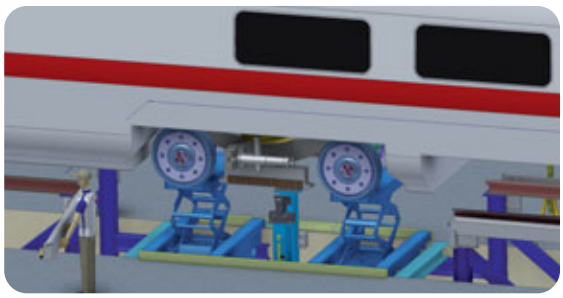
DB Systemtechnik's maintenance depot experts have developed an innovative mobile bogie replacement system that is based on its wheelset replacement technology. This new system will be used by the Berlin-Rummelsburg depot, which is currently undergoing expansion.

In Berlin, the traditional bogie replacement technology previously involved the use of a stationary system due to installation space constraints. Now, however, the new technology will facilitate the removal of a bogie by using compact engineering at the positions of the wheelset track bridges.

Scan here to watch a video of a bogie replacement

In order to provide the installation space required to lower the entire running gear, the bridges have been designed as double-track bridges. The lowering process is carried out by two coupled, longitudinally mobile wheelset changing devices that eject the running gear sideways onto mountings. For the first time ever, as a result of adopting this approach, half of an ICE 4's entire running gear can be replaced on track 551 of the Rummelsburg depot in just one night shift, without the train having to be moved or lifted. This paves the way for entirely new production processes in relation to light overhauls in the maintenance depot.

In accordance with the concept developed by DB Systemtechnik, the construction and installation of this equipment was put out to external tender. Commissioning towards the end of 2022 is eagerly awaited because other maintenance depots have already recognised the added value from the planning sketches alone and have expressed urgent interest in this new technology.



Illustrations: DB Systemtechnik

Fatigue test on the main frame of an agricultural machine

GRIMME Landmaschinenfabrik GmbH & Co. KG has developed a new EVO 280 bunker harvester for harvesting various crops.

In order to assess the overall service life of the bunker harvester's supporting structure, DB Systemtechnik was commissioned to undertake an essential laboratory-based fatigue test.

The fatigue test was subdivided into a static test and a dynamic test. To collect the data needed to determine the stresses and to calculate the comparative damage, experts from DB Systemtechnik first applied strain gauges to the bunker harvester's supporting structure, which were then used to determine the stresses in the structure.

Photos: DB Systemtechnik

During the **static test**, different loads were applied to the supporting structure, causing the material to be stretched and stressed. The test results were compared against a calculation model provided by Grimme Landmaschinenfabrik GmbH & Co. KG and the plausibility of these results was checked. Following verification of and agreement on these results, the customer gave DB Systemtechnik approval to undertake the dynamic fatigue test.

The **dynamic fatigue test** conducted on the main frame of the bunker harvester while it was positioned on the fatigue test rig consisted of 200,000 repetitions of the test sequence, which, in turn, comprised various load combinations and heights. The purpose of this test was to verify the fatigue strength of the machine's supporting structure for the duration of its overall target service life.

This laboratory-based fatigue test provided the customer, GRIMME Landmaschinenfabrik GmbH & Co. KG, with information on whether the sizing of its main frame is sufficient for its overall service life.

Optimising the galley refrigerating systems on the Class 403

As part of the redesign of the ICE 3 fleet, new galley refrigerating systems were developed for the on-board restaurants.

DB Fernverkehr AG commissioned the refrigeration experts at DB Systemtechnik to optimise the software for the deep freeze and normal refrigeration systems and to improve fault diagnosis.

The aim was to increase the overall stability and availability of the galley refrigerating systems during operation. The systems were set up and put into service in the DB Systemtechnik testing laboratory. A 40-inch refrigerated container was used to replicate external conditions. After appraising the cooling systems to see how they functioned, DB Systemtechnik worked together with an external software company to optimise the software to meet the client's needs.

In addition, fault formation rules were revised for more accurate diagnosticsin order to optimise maintenance and servicing of the refrigerating system. The revised software was tested for plausibility and functionality on the test bench and verified on the vehicle in a further stage.

By outsourcing the tests to the DB Systemtechnik testing laboratory, the software changes were verified independently of the vehicles, meaning the impact on vehicle availability was kept very low.

The improvements made to refrigerating system control and diagnostics will increase the stability and availability of the systems. It is also expected that the optimisations will reduce energy costs. Thanks to the optimised and expanded diagnostics, maintenance and servicing work will be carried out faster and, therefore, more cost-effectively in the future.

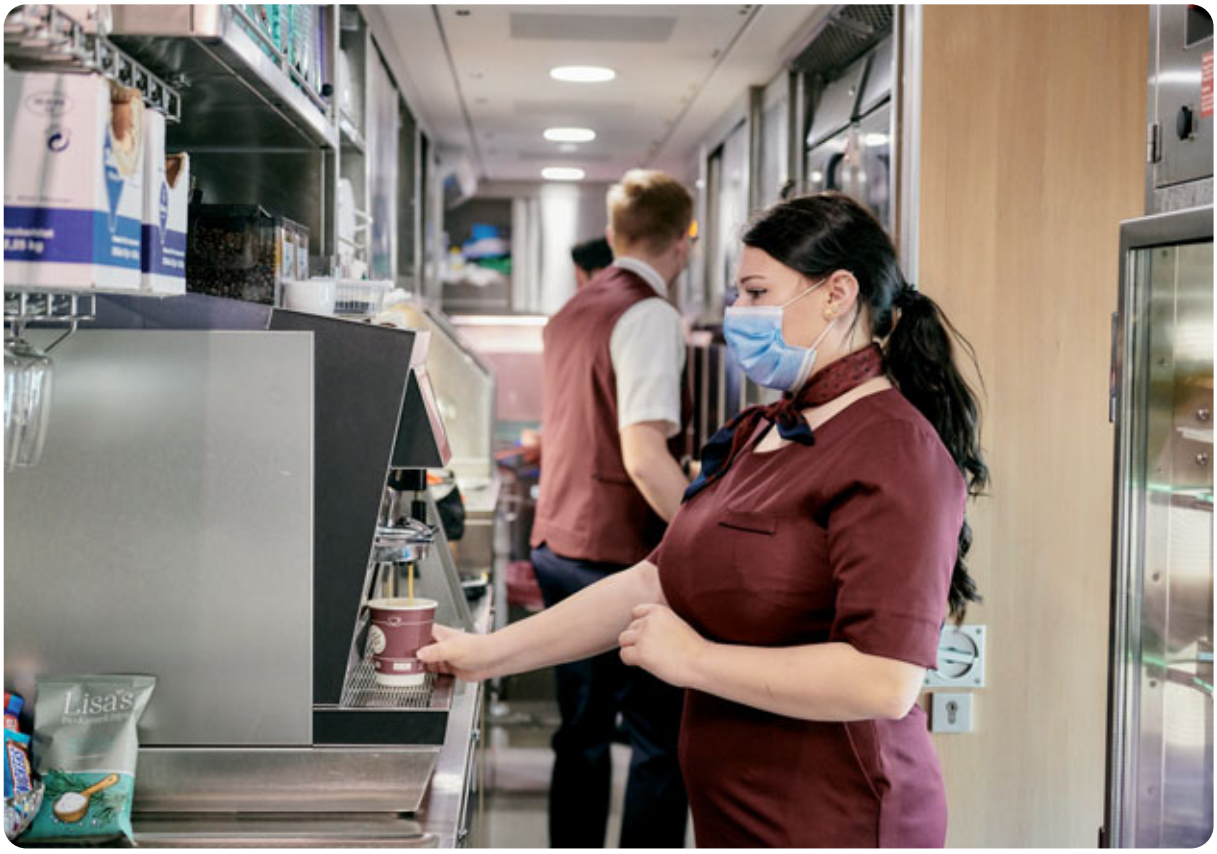


Photo: Leonhard Hörth, DB AG/Dominic Dupont

Redesign for the euregiobahn in Aachen

The new public transport contract awarded by Zweckverband Nahverkehr Rheinland (NVR), which came into force in December 2021, stipulated that 22 euregiobahn vehicles of Class 643.2 had to be upgraded. The vehicles were given new seat pads and paintwork. All the trains were also equipped with WiFi access and 12 USB ports (in the form of six double USB sockets) for charging consumer devices. In addition, the refurbished passenger screens show up-to-date arrival times and the corresponding connection options. The new video system is used for security surveillance and at the same time includes an automatic passenger counting system (APC), which documents when passengers board and alight. In future, this could be used to calculate the vehicle's occupancy rate in real time and inform passengers about what space is available via an app or via a platform display.

DB Systemtechnik was commissioned to undertake the engineering portion of the upgrade work.

The public transport contract was awarded in February 2020, which meant it was not possible to upgrade the vehicles in a DB Fahrzeuginstandhaltung (DB FZI) depot, as would usually be the case for a project of this size. This was because there was not enough time left before the timetable was set to change in 2021.

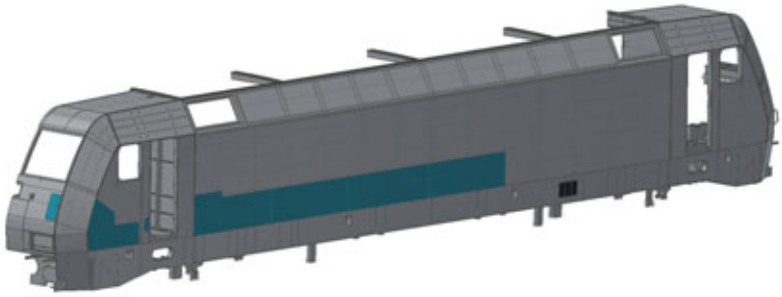
That is why euregiobahn, together with DB Systemtechnik, DB FZI and the DB Regio depot in Aachen, drew up a plan to carry out the modernisation work in the Aachen depot directly, without any interruption to service. The specialists at the Aachen depot received intensive support from DB Systemtechnik to ensure they were in a position to install the new technical equipment correctly.

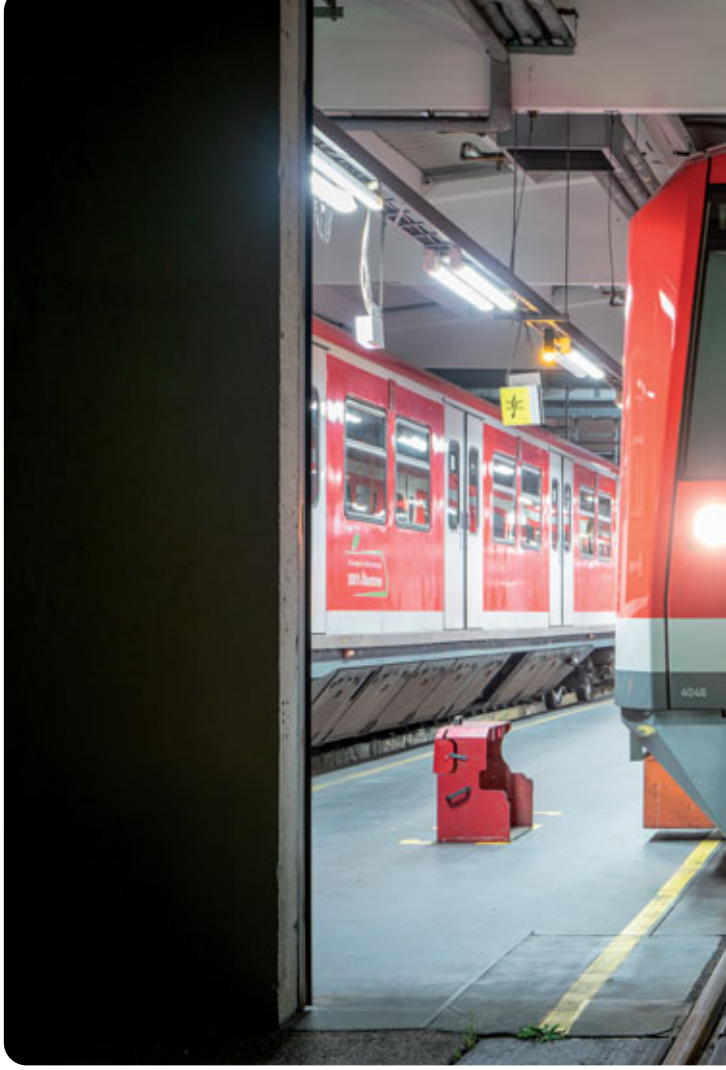
After the contract was awarded in February 2020, two prototype vehicles were upgraded between mid-2020 and the end of 2020. The subsequent series upgrade ran from January to September 2021, again with intensive support from DB Systemtechnik. Many tasks, such as the new upholstery and paintwork, were also handled as part of regular maintenance. On 24 September, the 22nd and final vehicle was successfully completed and accepted by the client body.

The excellent cooperation based on mutual trust between the various parties involved was very helpful in this project. The Aachen depot is now in the best possible position for maintaining the newly installed technology, thanks to the support it has received from DB Systemtechnik. This means the 22 redesigned euregiobahn vehicles will remain in the best of hands in the future, as they go into service with a fresh new look in December 2021, right on time for the timetable change.

Photo: Martin Bräutigam

Accident repairs: 3D model





Time and again, accidents on level crossings cause damage to rail vehicles. These vehicles are then transferred – depending on the extent of the damage – to a vehicle maintenance depot. The first step then is to record the damage and evaluate the measurement protocols.

Accident repair engineering work is performed at the depot by accident repair experts from DB Systemtechnik.

The front area and a side wall of a locomotive that had been involved in an accident had sustained significant damage. The locomotive body could not be repaired based on the manufacturer's drawings. Restoration solutions had to be developed for the specific damaged areas and repair drawings prepared with the help of a 3D model of the locomotive body. Since additional welds were required on the locomotive body in the area around the load-bearing structure, the mechanical strength had to be verified with the aid of calculation models. The restoration concept was confirmed based on these verification tests and the repair could be carried out.

DB Systemtechnik also provided support throughout the entire weld repair process at DB Fahrzeuginstandhaltung. This meant the experts were able to respond to any queries quickly and effectively. The fully repaired traction unit was handed over to the operator after a total processing time of just 37 weeks.

When it comes to performing weld repairs on traction units that have been involved in accidents, various specialist departments from DB Systemtechnik, DB Fahrzeuginstandhaltung and the vehicle operator always work closely together in order to return a safe vehicle to service as quickly as possible after an accident. In this case, repairing the locomotive body saves vehicle operators considerable time and costs compared to buying new.

Illustrations: DB Systemtechnik

Photos: Siemens Mobility GmbH/Ullrich Wirrwa 3 x

Digital S-Bahn Hamburg: First highly automated S-Bahn operation in Germany

Digitale Schiene Deutschland

Digital S-Bahn Hamburg was the first pioneering project of Digital Rail for Germany, the purpose of which was to put four highly automated, digitally controlled Class 474 S-Bahn multiple units into passenger service on the S2/S21 lines between Berliner Tor, Bergedorf and Aumühle in time for the ITS World Congress in October 2021. Acceleration, braking and stopping are performed by the Automatic Train Operation (ATO) train control system and the European Train Control System (ETCS) train protection system. The train driver only intervenes in the event of disruption or an incident.

DB Systemtechnik supported this innovation project from start to finish by providing extensive services, particularly in the following areas:

- Engineering and design
- Approval and safety management
- Subproject management
- Rail company for test runs

The challenging part of this project was the simultaneous innovation of changes to vehicles, infrastructure and operating regimes, all done within a demanding project timeframe with a fixed completion date that could not be postponed. This was performed in accordance with the new legal framework associated with the Fourth Railway Package.

Within the area of engineering and design, numerous design changes were made to the vehicle. In addition, technical drawings, parts lists, and strength and calculation verifications were prepared and compiled, along with the provision of other engineering services.

Two approval managers were responsible for planning, implementing and updating the approval procedures. They communicated with the national safety authorities and also coordinated and maintained close contact with the assessment bodies NoBo and DeBo.

Two safety managers, along with numerous other safety experts, coordinated the methodical implementation of several CSM RA risk management procedures in accordance with Regulation EU 402/2013. They also communicated with the AsBo.

A project manager took over the coordinating and subproject management role for approval & safety. In order to implement and document the project, the JIRA and

Confluence systems were used for the agile working method (scrum). Not only did DB Systemtechnik, as the rail company, conduct the first test runs, it also submitted the relevant application and provided train drivers and test managers for the test runs.

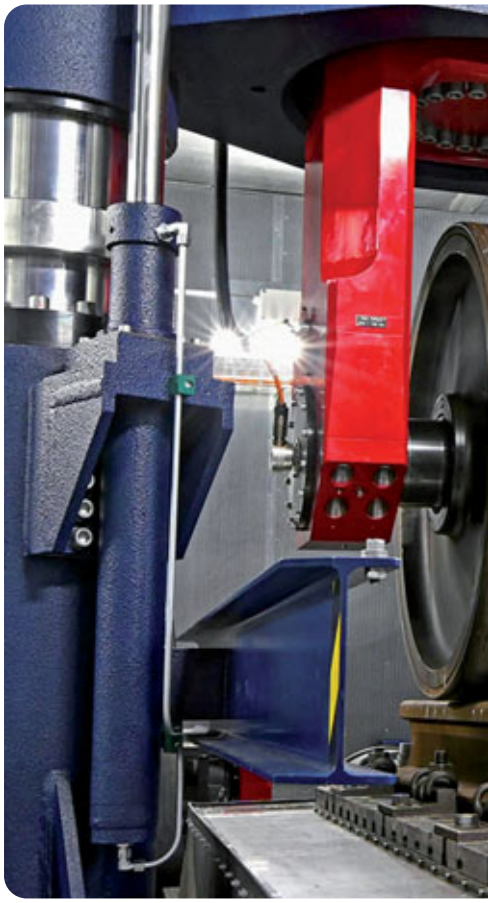
Thanks to the collaborative partnership enjoyed by DB Systemtechnik's experts and the other project members from the very outset, it was possible to surmount all content-related challenges and aggravating COVID-19 framework conditions within the short timeframe allocated to this project.

Bridge dampers for reducing noise emissions from bridges and viaducts

Bridges and viaducts emit a low-frequency noise component when a train passes over them. This noise from bridges is often perceived as very annoying by local residents.

In addition to other noise reduction measures taken around the track superstructure, the noise emitted by a steel bridge can be mitigated by deploying bridge dampers to increase attenuation. Bridge dampers are mass-spring systems. They are attached to the surfaces of the bridge that are emitting noise, where they reduce vibrations and, consequently, noise emissions. In previous tests with bridge dampers, however, not enough of a mitigating effect was seen on every bridge.

To gain a better understanding of the effects of bridge dampers, DB Systemtechnik, working together with DB Netz AG, set up a test system for them in its laboratory as part of the EU's In2Track2 project.



Front of the test system with three vibration pick-ups

Photos: DB Systemtechnik

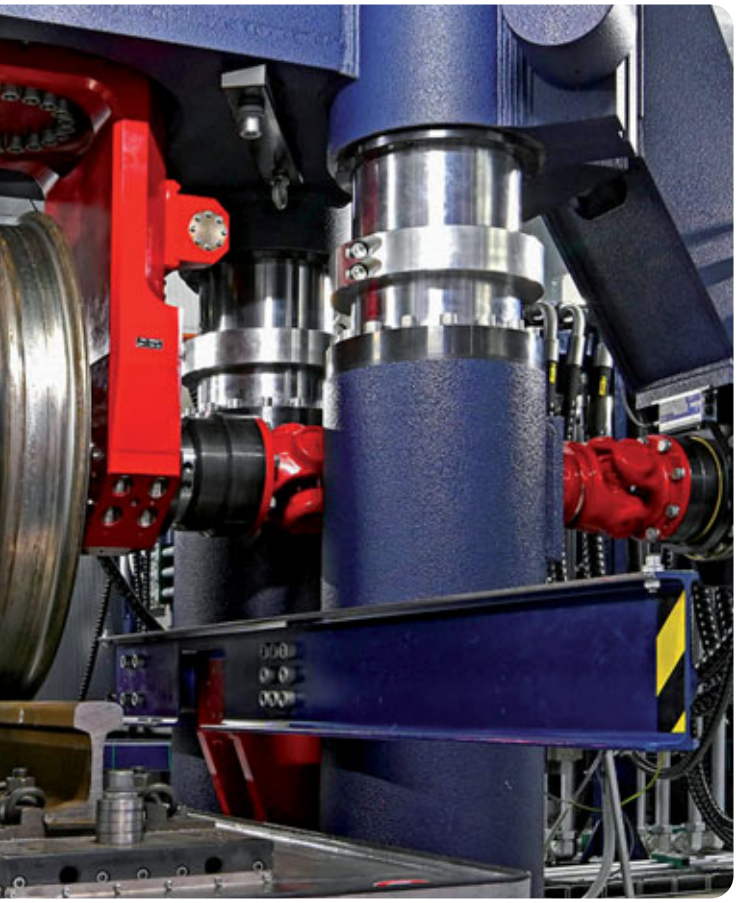
Rear of the test system with five bridge dampers

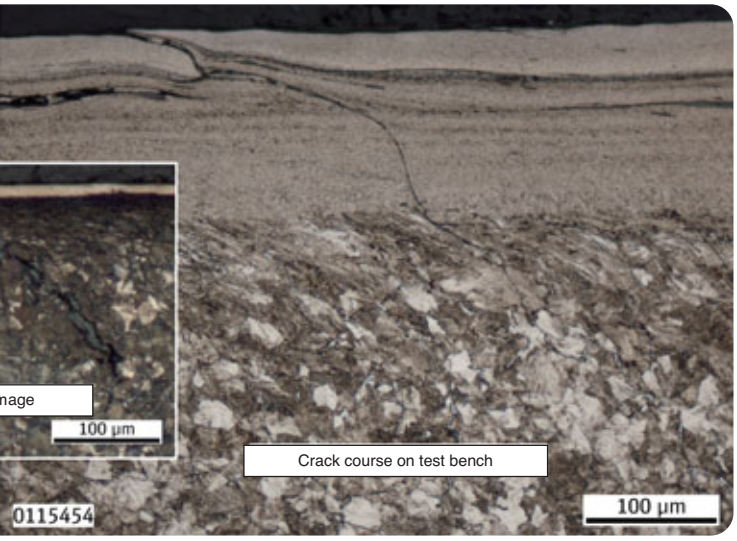
Initial tests investigated how varying the number of dampers and their mounting types affected the results. The key parameter for evaluating bridge damper properties is the loss factor, which indicates the extent of the structure's attenuation.

Overall, the investigations showed that bridge dampers are suitable for reducing the noise emissions of ballastless steel plate-girder bridges, but they need to be adapted to on-site conditions and have their effectiveness proven. DB Systemtechnik has therefore also developed a measurement instruction for adapting bridge dampers and proving their effectiveness on steel bridges. In future, the test system available at DB Systemtechnik can be used to prove the effectiveness of new dampers.

Crack course real dar

Multiple squats – Causes and countermeasures





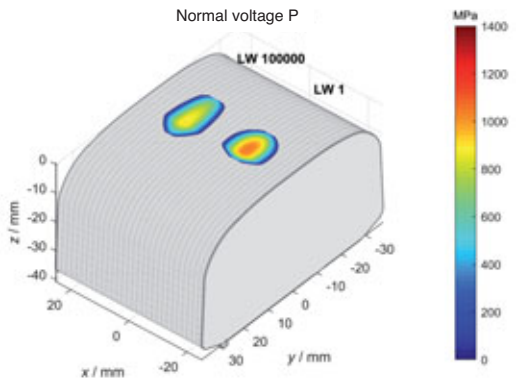
Photos und Illustrations: DB Systemtechnik

For about ten years now, the focus has been on a new type of rail defect: damage from rolling contact fatigue in the form of multiple squats. Up until then, the main concern had been head checks on the running edge of the outside rail of a curve. Our own damage analyses have shown that vehicle traction, higher-strength rail steels and rail machining all have a crucial role to play here.

Working on behalf of DB Netz AG, DB Systemtechnik is investigating these technical relationships as part of the "Multiple squats – Causes and countermeasures" research project. The aim is to lay the groundwork for an effective maintenance strategy to combat multiple squats.

Contact mechanics simulations were used to develop a testing scenario together with the Virtual Vehicle Research R&D centre based in Graz. This scenario was then deployed to specifically examine, under controlled and reproducible boundary conditions, individual parameters and their influence on the formation of squats on the new wheel-rail test bench in Kirchmöser.

Since the test bench, which went into operation in 2019, can apply longitudinal forces of up to 34 kN in addition to normal and lateral forces, it was possible to generate realistic squat cracks within a very short time, as predicted by the simulations. The first key area of investigation looked at how different rail grinding methods affect the initiation of squats, with a total of eight tests being carried out. Comparable on-line running tests would have taken much longer and cost the customer considerably more, while at the same time offering significantly less control over boundary conditions. The project will continue in 2021, when it will mainly focus on wheel/rail profile pairing, the influence of materials and the coefficient of friction.



Predictive maintenance for common crossings

A common crossing is an essential component of a switch. It ensures that the vehicle wheels run unhindered at the junction of two rail lines and is therefore a heavily used piece of infrastructure. Damage to common crossings may disrupt operations significantly and involve considerable costs.

Within its internal feasibility study, DB Systemtechnik has shown that it is possible to predict the condition of common crossings through the use of machine-learning methods.

This enables maintenance tasks to be optimally adapted to both the current and future condition, and for their service life to be increased by up to 50%.

Here, more than 20 different influencing variables were blended together and different models were trained. An intensive dovetailing and linking of rail expertise with data science expertise was required in order to validate these models. In addition, DB Systemtechnik was able to draw on more than 16 years of R&D and data recording with ESAH-Mobil (Electronic System Analysis in the Common Crossing Area), thus providing a unique data basis.

The feasibility study was successfully completed, confirming that there is potential for corresponding applications in scheduled operations. DB Systemtechnik will therefore develop additional and more accurate analysis and prediction models to create reliable predictive maintenance solutions for common crossings.

Photo and illustrationsen: Pixabay, DB Systemtechnik

Class 472 EMU: Creating a 3D design for the Sensors4Rail project

Scan here to watch a video that takes you on a virtual tour of the converted train

Digitale Schiene Deutschland

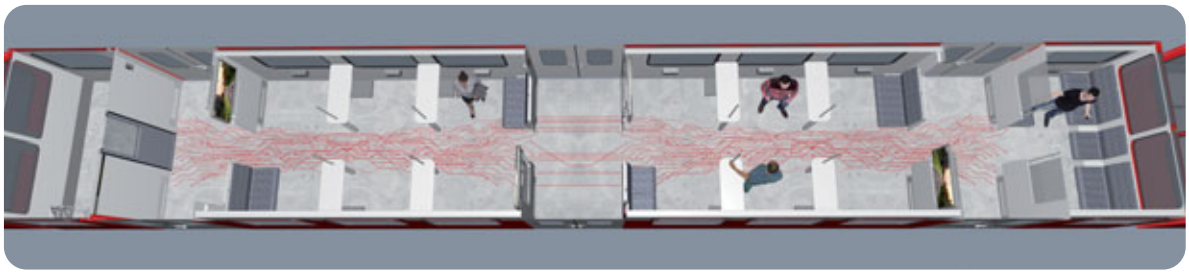
The purpose of the Sensors4Rail project within the framework of Digital Rail for Germany is to increase rail capacity through the use of accurate automatic vehicle location and environmental perception. A Class 472 experimental vehicle will be converted for this purpose and presented to a specialist audience at a congress. In addition to installing new technical features, the visual appearance of the older S-Bahn vehicle will also be optimised. To this end, the interior will undergo some technological modifications as well as being visibly enlarged and modernised.

The design experts at DB Systemtechnik were commissioned by DB Netz AG to develop a high-level concept for the interior of the entire vehicle (cab car and intermediate car).

In order to make the experience of sitting in the intermediate car more pleasant during the congress, some seats were replaced with standing tables and groups of four seats were replaced with groups of two. In addition, screens were placed in the interior, enabling passengers to observe the route during their journey.

Since the DB basic vehicle was quite old, there was no 3D database. Consequently, a 3D model had to be designed from the 2D drawings. A high-level concept for the vehicle's interior was then developed as a virtual reality model, along with some elements (seats, screens, etc.) modelled in simplified form. A simulated tour of the train as a video sequence completed the range of services provided by DB Systemtechnik.

Thanks to 3D visualisation, it was possible to provide the client with a view of the interior from all angles, which, in turn, facilitated a better and more detailed assessment of the designed concept. This 3D concept was then used as a basis for further activities as well as negotiations on implementing the project.



Photos: DB Systemtechnik

Quality and innovation in train-to-land communication

For more than 12 years now, DB Systemtechnik has been providing railway companies with a reliable and future-proof IT system for train-to-land communication. The mobile integration platform (MIP) system is a complete solution consisting of hardware, software and back office, including all the services that are required for operations.

DB Systemtechnik's services also include managing the communication networks (2G, 4G, 5G) and monitoring data flows from the servers on the train to the customers' land-side back offices.

Concepts have already been put into practice for the entire market spectrum (local, regional, long-distance and cargo transport) and are being used live in various multiple units, vehicles and locomotives in ICEs, in regional trains and on the S-Bahn.

Some examples of the type of data that is transferred:
- Seat reservations for long-distance trains
- Passenger information for displays
- Electronic working timetable for the train driver
- Vehicle diagnostics and condition data
- Petty cash data from the on-board bistro

The video data from the surveillance cameras on the train can also be accessed by the authorities. In total there are over 20 MIP applications that run on the platform itself or on the customers' vehicle computers.

DB Systemtechnik ensures that MIP applications will be developed and run, and MIP systems will be monitored, properly. This also includes SIM card management (cost control, volume monitoring) and technical monitoring including reporting.

In running the applications, real-time processes are used for audio/video and for transmitting diagnostic and process data. MIP also supports modern continuous data monitoring processes for condition-based maintenance.

Since 2020, new applications have been implemented for transmitting sensor and process data from the train control system in the various classes, especially for the ICE 3 and ICE T. These are also being deployed in DB Fernverkehr AG's new high-speed vehicles.

New applications, such as automatic passenger counting, were put into service on S-Bahn Berlin last year. Another innovation put into practice was audio/video data transmission, including for passenger assistance calls.

These technical solutions always have the same aims: to optimise rail operations for railway undertakings and to keep passengers better informed. This might concern repairs, dispatch control, provisioning or even lifecycle management. The experts from DB Systemtechnik then harness these solutions to identify the added value and optimisations they want to achieve in advance of each project and track them through to operation.

Measuring train-induced flow velocities in Switzerland

Aerodynamic measurements taken on the Kiesen platform by ultrasound anemometers

Aerodynamic tests needed to be conducted for the Bombardier Twindexx multiple unit (FV-Dosto, RABDe 502) and the Stadler SMILE multiple unit (Giruno, RABe 501) on the Kiesen platform of the Bern–Thun line.

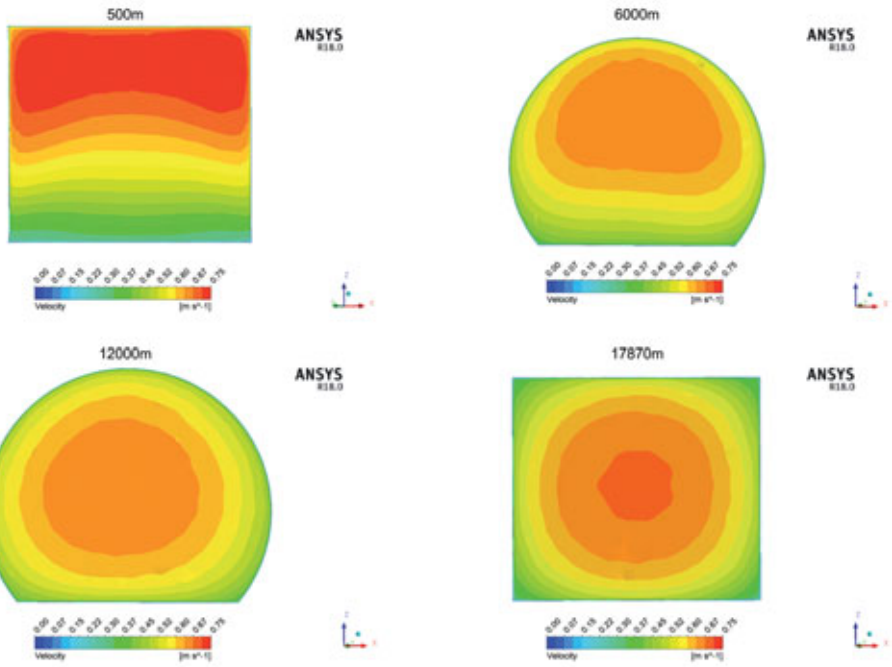
The measurements, which were commissioned by SBB, were needed to determine the train-induced flow velocities on the platform and the effect of that flow on passengers and infrastructure.

This data would then be compared against that for other measured regular trains and used to determine whether the relevant aerodynamic guidelines are being adhered to. The requirements for the tests were summarised in the customer-specific document "Zone de danger sur les quais Mesures anémométriques". The measurements also had to meet the requirements of DIN EN 14067-4 "Requirements and test procedures for aerodynamics on open track".

Thanks to DB Systemtechnik's in-depth aerodynamic expertise and the experience gained from previous measurements taken on the same platform, the experts were able to draw up a measurement concept that was perfectly tailored for the customer. The concept covered the customer's specific requirements as well as the general requirements of DIN EN 14067-4.

The measurement data was evaluated according to the same model used for the previous measurement, allowing the customer to compare the results.

Illustrations und Photo: DB Systemtechnik, Frank Wolf

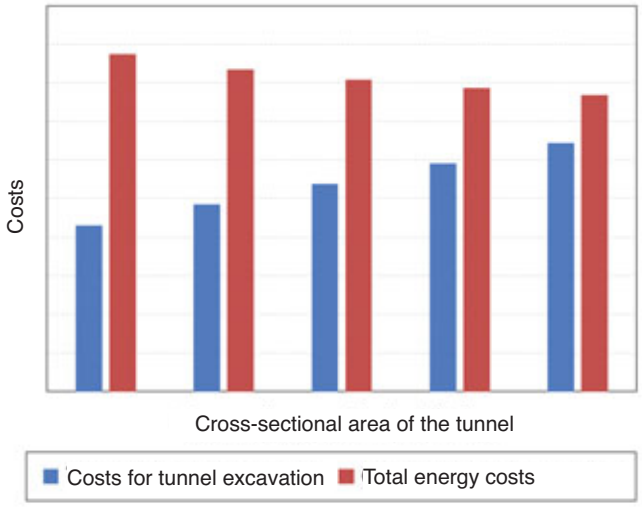


Aerodynamic expertise for the northern Brenner feeder line

The northern Brenner feeder line project has set out to answer a range of aerodynamic questions in relation both to tunnels and open track. The unusual thing about this line is the need to design very long tunnels (over 11 km), which are only partially covered by the current regulations.

DB Systemtechnik is supporting DB Netz AG during the route selection process and the preliminary design phase of this project until 2025 by providing aerodynamic expertise on the following topics:

- Tunnel aerodynamics: TSI 10 kPa criterion, pressure and flow loads, pressure comfort, resistance to motion
- Aerodynamic assessment of very long tunnels longer than 11 km according to Guideline 853.1002
- Micro-pressure waves (sonic boom)
- Encounters in relation to high-speed transport/regional transport/freight transport
- Pressure and flow loads on open track
- Crosswind on open track



So far, the project has looked at two blocks of aerodynamic topics during the route selection phase.

The aerodynamics experts were able to use simulations to show which **basic flows** are to be expected in the two **very long tunnels** that are currently being designed. Different meteorological scenarios were considered for this purpose:

- Summer and winter
- With and without the influence of wind

The aim was to evaluate the impact of the elevation profile of the long tunnels (over 11 km) and thus determine the impact of possible high or low points on the base flow right from the route selection phase. This would then enable the experts to utilise any potential for optimising the position and height of the tunnel structures at an early stage and include them in the later planning phases too.

In addition, **the tunnel cross section** was **analysed in terms of energy** and the impact of tunnel cross section/length on resistance to motion was calculated. This also included an estimate of future energy costs, which was drawn up taking several vehicle classes into account and in relation to the estimated investment costs.

Getting DB Systemtechnik and its aerodynamic expertise involved at an early stage meant design proposals and optimisations could be incorporated during the planning phase without incurring major costs. More aerodynamic topics are set to be considered, depending on how the plans progresses.

870 calibration processes for safe rail operations

Working on behalf of manufacturers and operators in the rail sector, around 60 measurement experts from DB Systemtechnik's Calibration and Testing Unit regularly monitor measuring and testing equipment to ensure it is functional and accurate.

In the safety-critical field, there is a particular focus on calibrating measuring machines and equipment, e.g. for wheelset machining, wheelset diagnostics, measuring tracks and a variety of mechanical and electrical testing equipment.

About 870 different calibration processes are used depending on the physical requirements. Twenty two of these processes are accredited, including in the disciplines of pressure, force, torque, voltage (AC/DC), current (AC/DC), resistance, oscilloscope measured values, stress ratio, time interval, frequency, temperature and gauge blocks. Every year, the specialists at DB Systemtechnik carry out around 60,000 calibrations, 20% of which are performed in the customers' workshops, but the majority in the company's own laboratories.

The tools used for calibration are high-precision measuring instruments, which the experts from the Calibration and Testing Unit deploy as dimensional or calibration standards. Certain measuring instruments, such as the coordinate measuring machine, are something really special because they can be used to check complex parameters with the very highest level precision. Large, heavy and complex components, for example reference wheelsets, can be checked quickly for very minor deviations in their dimensions, form, running and positions, down to the nearest micrometre.

DB Systemtechnik is in close contact with the maintenance technicians and manufacturers of this test equipment. Building on the regular maintenance and inspections carried out on the devices, DB Systemtechnik coordinates with these other parties to draw up a customised schedule for calibrating the equipment and does the corresponding work at its site in Chemnitz or on the customer in question's site. In this case, the inspection devices are then available to start taking measurements again as soon as possible after maintenance.

Approvals management for DDSV

Industrial company Duro Dakovic Special Vehicles (DDSV) has received an order to deliver 150 Uacns freight wagons used for transporting cement. The EC certification process was close to completion at the time of the request, but the data required for the application still had to be worked out before DDSV could finally start the process of getting the railway vehicle type approved. This was done in the one-stop shop (OSS) tool, use of which has been mandatory since the Fourth Railway Package was introduced.

DB Systemtechnik guided its customer DDSV through this process, while also reducing the time it took for the national safety authorities (NSA) and the European Union Agency for Railways (ERA) to deal with the application.

DB Systemtechnik provided support in the form of these specific services:

- Explanation of and research into the information to be provided on the application via the OSS
- Provision of a list of documents and evidence (incl. formats) to be uploaded via the OSS
- Monitoring of the process via the OSS
- Answering questions, in this context known as "issues", posed by the authorities via the OSS
- Coordination with the NSAs and the ERA

The applicant DDSV received fast and straightforward support, which meant the vehicle type-approval could be granted without delay in August 2021.

Photos: DURO DAKOVIC Special Vehicles, DB Systemtechnik 3 x

Detecting snow build-up on train bogies with the help of Artifical Intelligence

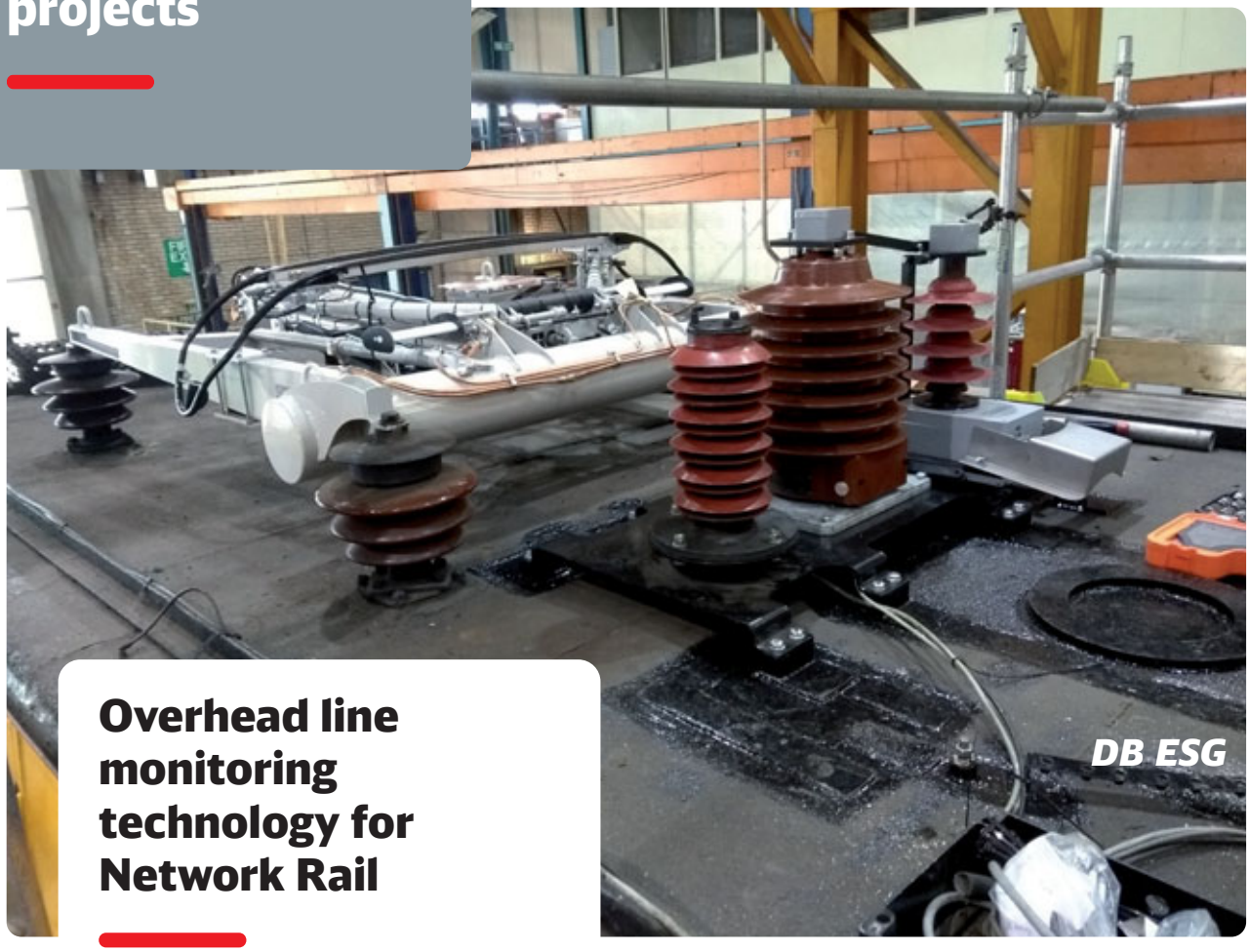
Certain adverse weather conditions can sometimes cause snow to accumulate in train bogie areas during the winter months. Any ice and snow that falls off during the journey may hit cables and signalling equipment in the track bed. And the faster a train is travelling, the greater the risk that infrastructure components will be damaged. Against this backdrop, therefore, tests needed to be conducted to establish whether trackside cameras and an AI-powered evaluation procedure would be able to determine the snow load in the bogie areas of passing ICE trains automatically.

DB Systemtechnik has developed a concept in which high-resolution images of the bogie areas of passing trains are recorded automatically and the image data is transmitted to a data centre via a mobile communications network, before being analysed and categorised with the help of AI.

A corresponding prototype system was set up on the new Cologne–Rhine/Main line and operated during the winter of 2020/2021. While this prototype was in operation, the images were rated manually according to the amount of snow they depicted and fed into the algorithm to train it. The trained algorithm was then checked by applying it to a test data set – where it had a success rate of over 75%. In other words, the algorithm correctly identified bogies that were covered in snow 75% of the time, even though only a few training images with snow had been available.

The idea is that, in a live system, rated images would be provided for each train in real time and the snow load would be indicated by a traffic light system. In future, any required operational measures such as speed reductions could then be introduced in a more targeted manner.

DB ESG reference projects



Overhead line monitoring technology for Network Rail

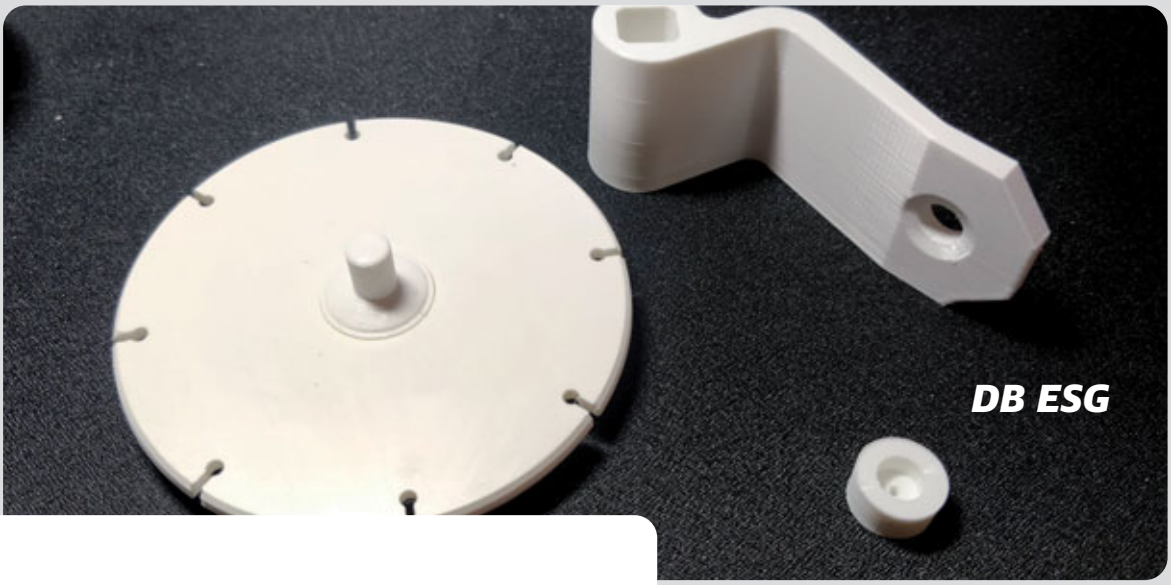
In November 2018, Network Rail awarded DB ESG a contract to supply DB Systemtechnik's tried-and-tested overhead line monitoring equipment with a view to improving Network Rail's existing infrastructure monitoring fleet.

Initially, the focus was on providing two monitoring systems for the Mentor mobile test coach, which is used to test, observe and record Network Rail's electrical network. The overhead line monitoring system that Mentor is equipped with is now working as intended and is regularly deployed by Network Rail to put new overhead lines into service and identify problems.

DB ESG is currently installing a single system on a British Class 390 Pendolino unit to cover a specific area of the network. This system provides daily data from normal passenger train operations. The regular collection and analysis of asset condition data is helping Network Rail transition to a maintenance strategy of "predict and prevent".

In October 2020, DB ESG received another contract from Network Rail to provide technical support for the overhead line monitoring systems on the Mentor and Class 390 Pendolino vehicles. This new contract covers the provision of support services over a period of eight years. In signing it, DB ESG has significantly expanded its offer to the market, now providing services that go beyond the normal warranty period.

Photos: DB ESG 2 x



Angel Trains and DB ESG turn to a digital manufacturing solution

DB ESG is currently working with Angel Trains, a UK rolling stock leasing company, on projects that utilise 3D printing methods (also known as additive manufacturing or AM) to address the challenges facing the UK rail sector, in particular the problems associated with obsolete parts. AM also has the potential to reduce costs and lead times for railway companies, as it allows smaller quantities of parts to be manufactured cost-effectively, rather than in mass production.

During the COVID-19 pandemic, this method also proved to be a way of solving supply problems, as parts could be produced quickly and reliably, while at the same time complying with the coronavirus lockdown regulations that were in force.

Train operator Great Western Railways had a problem with parts in six Microphor Spacesaver toilets in its Class 165 units.

This problem meant the toilets could not be used and an obsolete part had to be procured. Since the toilets were due to be replaced only six months later anyway, the train operator needed a cost-effective solution quickly so that the toilets could still be used until the end of that period. The ongoing pandemic made this situation particularly tricky.

DB ESG reverse-engineered the component, a toilet valve, to create a digital production design. The parts were produced using AM in three segments and then chemically smoothed to prevent waterlogging and degradation of the parts. After that, the segments were glued together to complete the final functional object.

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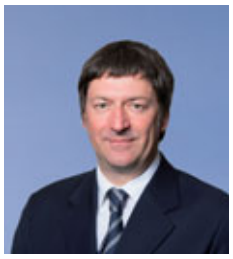

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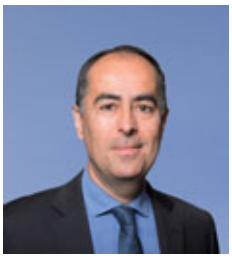

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Photos: DB Systemtechnik, DB ESG, RAG

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Subject to change without notice
Errors and omissions excepted
Last revised: December 2021