

DB Systemtechnik
Activity Report
2017/2018



Our knowledge – **Your success**

We have decades of railway experience
We offer all services from a single source
We understand every vehicle
We are able to test every vehicle
We manage the approval process for you: anytime, anywhere
We are a railway undertaking (incl. vehicle fleet and train drivers)
We master the railway system



Die DB Systemtechnik:

Spearheading development and mastering interfaces

In 2017, DB Systemtechnik set its sights firmly on the future under the auspices of the new Digitalization and Technology Board Division. This has turned us and our over 800 employees into a key player charged not only with technical work, but also a growing number of strategic and planning tasks. We have more than 5000 orders on our books and are finding success both within Germany and far beyond its borders too.

Since it is independent and neutral, DB Systemtechnik has committed itself to developing the railway into a sector that is fit for the future and to finding solutions to new problems. Operator roles that were previously integrated are being separated out, thus increasing the number of players on the market and leading to more interfaces whose various technologies and processes all need to be mastered. The Vehicles Steering Committee has been created to address this last point and has already taken many decisions that prove just how essential it is.

Alongside its full range of rail engineering and testing services, DB Systemtechnik is developing more and more products for predictive and preventive maintenance, which is becoming increasingly important in the quest to achieve seamless rail transport. Globalisation of the markets is seeing new manufacturers pushing into Europe. DB Systemtechnik runs tests for their vehicles throughout Europe, checks how they interact with the infrastructure and takes care of all aspects of approval management.

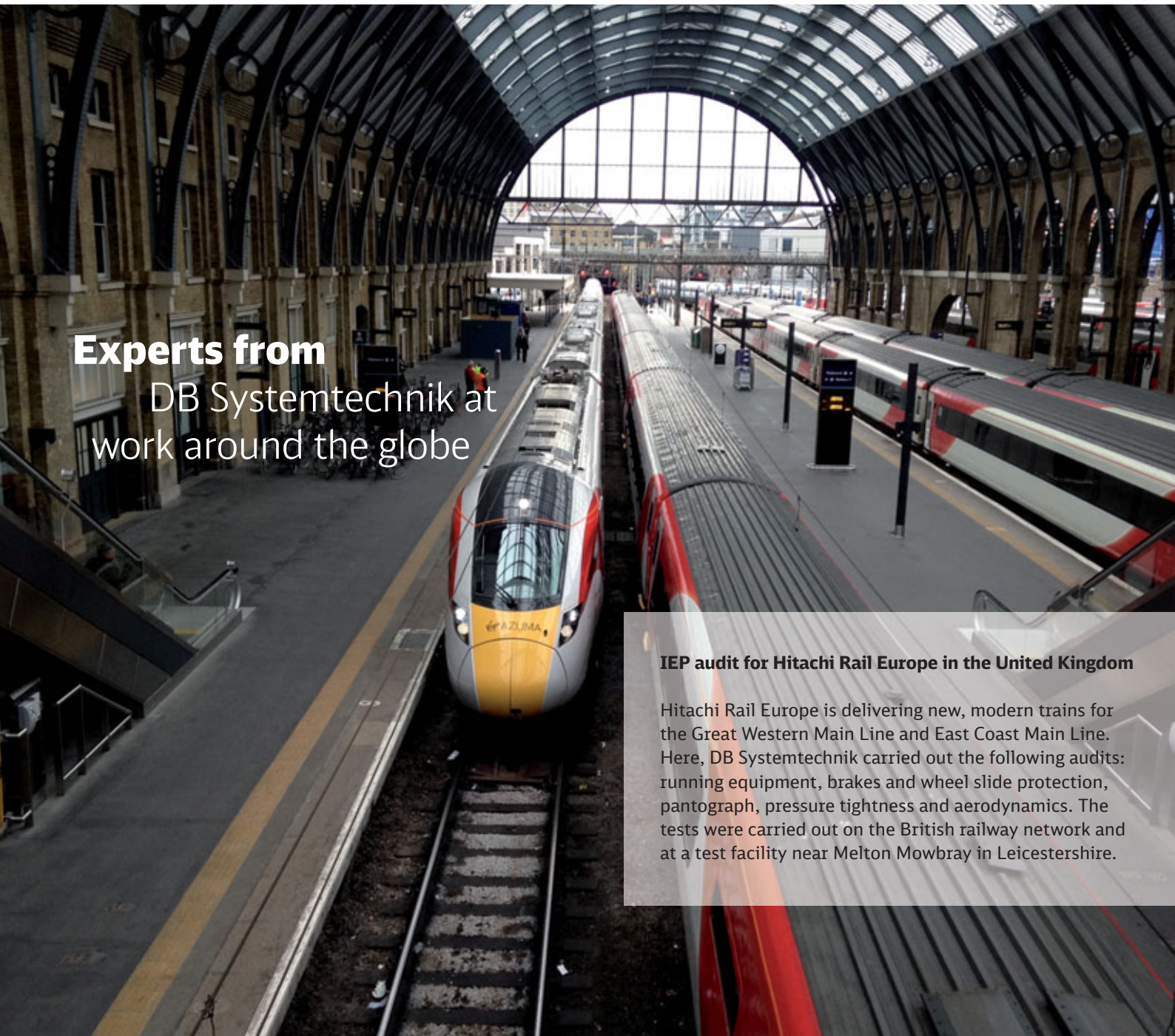
You will find information about this and much, much more in our activity report, which we have been producing for many years now and which will give you a brief glimpse into what we do all over the world day in, day out.

A handwritten signature in blue ink, reading 'Hans Peter Lang'.

Hans Peter Lang
Managing director
CTO Deutsche Bahn AG

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Experts from
DB Systemtechnik at
work around the globe

IEP audit for Hitachi Rail Europe in the United Kingdom

Hitachi Rail Europe is delivering new, modern trains for the Great Western Main Line and East Coast Main Line. Here, DB Systemtechnik carried out the following audits: running equipment, brakes and wheel slide protection, pantograph, pressure tightness and aerodynamics. The tests were carried out on the British railway network and at a test facility near Melton Mowbray in Leicestershire.



ICE 4 meets Giruno in Switzerland

In September 2017, two new vehicles came face to face during their approval journeys at Solothurn in Switzerland. Both high-speed trains must complete a demanding set of tests to obtain approval for use in the country. For the ICE 4, DB Systemtechnik was commissioned by Siemens to test the running equipment and pantograph, as well as conduct EMC and ETCS tests. On the Giruno, DB Systemtechnik performed aerodynamic and running tests for the manufacturer Stadler. These tests use highly sensitive measurement wheelset sensors to record and assess transport safety, track load and ride comfort.



Overhead line measuring instruments for Australia

American company ENSCO delivered rail maintenance measuring instruments to a major Australian rail company. DB Systemtechnik provided the equipment for measuring the following properties on the overhead line: dynamic interaction between the pantograph and overhead line, height and lateral deflection of the contact wire, wear on the contact wire as well as its position and lateral distance from the catenary supports. Manufactured in Munich, the measuring instruments were installed in northern Italy in a measurement train produced by Geismar Donelli. Commissioning of the measurement systems and the technical training of the customer's staff took place in Brisbane, Australia.

Shunter with battery in Minden

A battery-operated shunter (type EL 16) has been purchased for Minden. The older vehicle was completely overhauled and is now used mainly for shunting movements in the measuring hall. This makes it possible to reduce the diesel emissions that were previously generated during shunting operations in the hall.



Photos: Dr. Kai-Uwe Nielsen, Martin Loibl, Thomas Kwitschinski, beide DB Systemtechnik



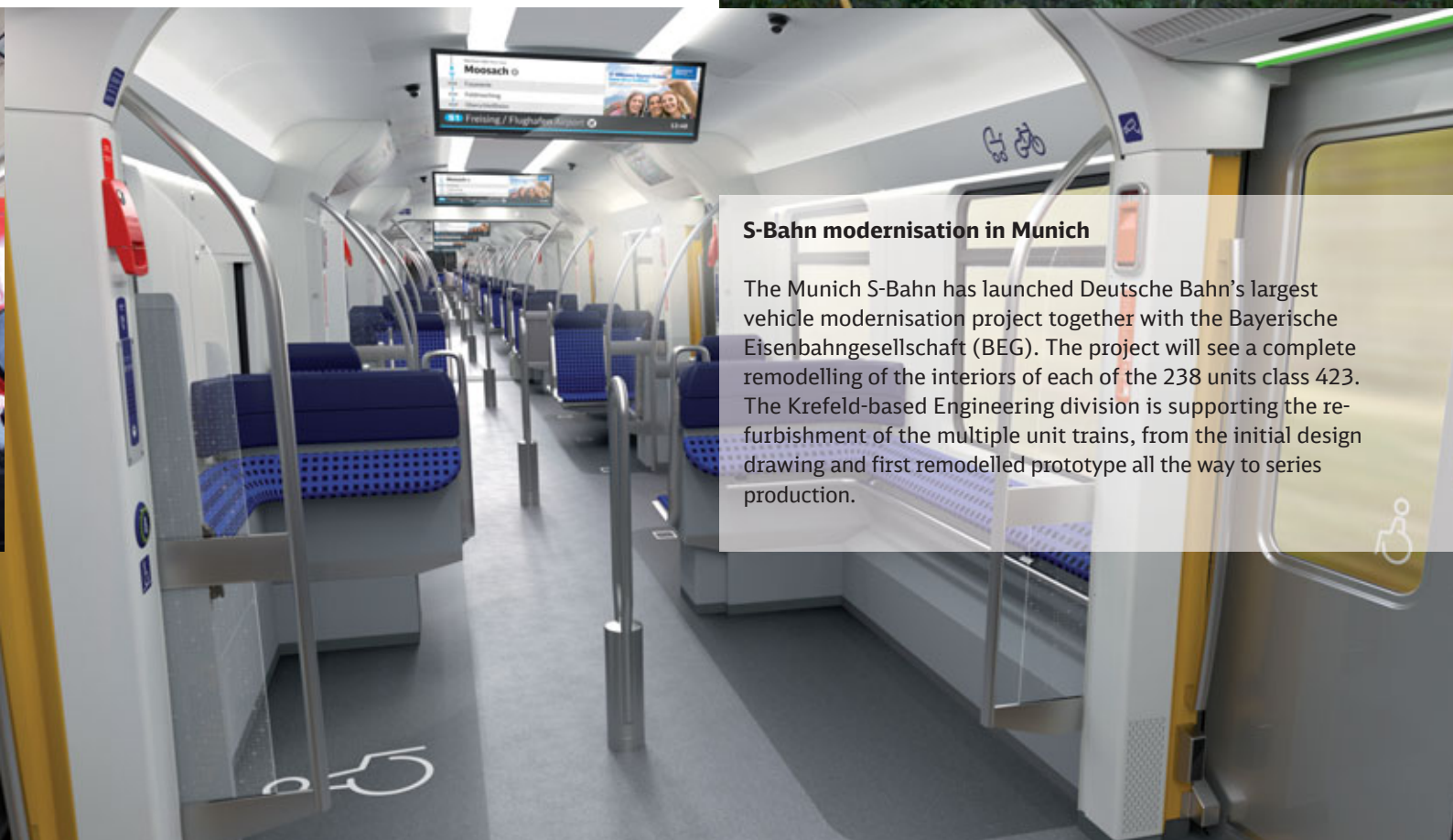
Swedish Metro in MEiKE

At the environmental chamber in Minden, a range of tests were carried out for Bombardier on a MOVIA C 30 for the Stockholm metro. The vehicle was the first 70-metre-long train to undergo testing in the MEiKE environmental chamber. The tests focused on the air conditioning of the passenger area and driver's cab, as well as the heat transition coefficient (k value). The vehicle also underwent functional tests on the doors, windscreen, wipers and signal horn, as well as on the wheel flange lubrication under ice and snow.

Sweden

Taurus tests in Sweden

As part of the electrification of the Danish rail network, Banedanmark and Hector Rail conducted tests in Sweden with a TAURUS test locomotive in June 2018. Together with support from DB Systemtechnik and the Swedish rail authority Trafikverket, the locomotive was prepared for its future testing activities in Denmark on the high-speed line between Haparanda and Kalix. DB Systemtechnik was responsible for monitoring the contact wire uplift. Alongside this, the vehicle was fitted with acceleration sensors to measure the vehicle dynamics.



S-Bahn modernisation in Munich

The Munich S-Bahn has launched Deutsche Bahn's largest vehicle modernisation project together with the Bayerische Eisenbahngesellschaft (BEG). The project will see a complete remodelling of the interiors of each of the 238 units class 423. The Krefeld-based Engineering division is supporting the refurbishment of the multiple unit trains, from the initial design drawing and first remodelled prototype all the way to series production.

GTO



GTO diagnosis - Innovative solutions for the ICE 1

DB Fernverkehr commissioned DB Systemtechnik to find an innovative solution to significantly reduce drive faults in the ICE 1 until the old GTO drive modules are replaced. The current ground fault monitoring system switches off the drive once a threshold is reached.

DB Systemtechnik developed and integrated a measurement system that constantly monitors, records and transmits these values, so that they can be analysed and assessed. The aim is to enable preventative maintenance measures before the drive unit switches off. The data evaluation system, verification and design optimisation are still in development. Preparations to fit the system as standard in a sub-fleet are also ongoing.



CTM 2.0 in double-decker IC

An ICE 2 fitted with measuring instruments has been travelling across the Deutsche Bahn railway network for over 13 years, delivering data every day to assess the condition of the superstructure (track geometry). Now, DB Systemtechnik has fitted enhanced measuring instruments in another train, called the “CTM 2.0”, for DB Netz and DB Fernverkehr. The sensors integrated in the axlebox of the double-decker IC have been continuously monitoring the track geometry (longitudinal level) between Bremen, Hanover, Magdeburg and Leipzig since the end of March.

30 years ago - World record speed with the ICE-V

On 1 May 1988, the ICE-V, the prototype for Germany’s future high-speed train, set a world record for wheel rail vehicles with a speed of 406.9 km/h, a milestone in the development of ICE transport. Scheduled ICE transport began just three years later in 1991. The ICE-V that set the record consisted of two power heads and two intermediate trailers containing the measuring instruments. After several ramp-up runs, the record-breaking journey took place in the Sinntal valley on the new-build line between Würzburg and Fulda, which was still under construction at the time.



Approval tests for Alstom iLint

DB Systemtechnik was commissioned by Alstom to conduct TSI approval tests on the brakes of the world’s first power car with fuel cell drive. The main aim of the tests on the Coradia iLint was to check the interaction between the conventional pneumatic brake and the electro-dynamic brake fitted in this vehicle family for the first time.

The hydrogen-powered Coradia iLint Train received approval from the Federal Railway Authority for passenger transport in the German rail network on 11 July 2018.

Test run for Desiro HC in Bavaria and eastern Westphalia

DB Systemtechnik is monitoring the production of the four-part Siemens trainset for Rhein-Ruhr-Express (RRX) until its approval. The engineering and testing services provider is also conducting detailed approval tests with the pre-production vehicles for Siemens. Up to four RRX trains were on the tracks simultaneously for the measurement runs, which focused on running equipment, brakes, torsion dynamics, service management, pantograph, and acoustics.



Photos: Joachim Wegner, Martin Loibl 2 x

“Innovative freight wagons” project

Field tests for the “innovative freight wagons” project have been under way since March 2018. DB Systemtechnik was commissioned by the Federal Ministry of Transport and Digital Infrastructure (BMVI), together with project partners VTG and DB Cargo, to conduct a series of tests across several months. The aim is to find out whether goods wagons with innovative technology are quieter, more energy efficient and more cost effective than those used currently. The test train with 23 vehicles consists of twelve wagons of different types fitted with innovative technology, alongside eleven normal goods wagons as reference vehicles.



Lead article:

**The vehicles
steering committee**



More suppliers create more competition.
But more frictional losses and conflicts of interest too.
Defining problems and implementing solutions.

The Vehicles **Steering Committee**

The rail sector today is home to a wealth of different rail companies and new roles. These new roles include that of the local transport authority, which orders regional and local transport services.

Once self-contained value chains are increasingly being split into separate components, e.g. ownership, operation and maintenance of production assets. The result is a very modern rail system based on the needs and interests of customers and organised and operated by a diverse range of companies. We are experiencing continuous growth in transport volume. In passenger transport, disused lines are being reopened and attractive services offered even away from the major cities.

But where there is light, there is also shadow.

The many stakeholders in the rail system naturally pursue their own interests, which do not necessarily align. In the past, their mission was to ensure public supply. Today, they must prevail amid fierce competition. This naturally creates conflicts that need to be resolved.

Who has an overview of the smooth functioning of the rail system as a whole with its myriad technical systems?

Where are solutions being developed to solve potential conflicts of interest, e.g. between infrastructure managers and train operators or between approval bodies and operators and maintenance providers?

And how is it ensured that operational rules, e.g. on braking systems, are applied equally to all train companies?

Policymakers have not provided answers.

The Lenkungskreis Fahrzeuge (Vehicles Steering Committee) closes this gap and is key to answering these questions.



Core responsibilities of the steering committee

- Continuous coordination with the parties involved
- Formulation of technical regulations where gaps have been identified or due to new findings from disruptions and reportable incidents
- Established as a body for clearing up disagreements arising during the approvals process



Steering Committee: **Participants**

In the age of state railway companies, no such body was needed.

Central government departments had the task of balancing the interests of infrastructure managers and rail operations. Technical decisions, too, were taken with a view to the system as a whole, with overall responsibility for Germany's railway system lying in the hands of the Bundesbahn's Management Board. Though non-state-owned operators existed even in those days, they did not yet play a big role in terms of total transport volume.

Close cooperation between the national railway companies allowed for international services. A thoroughly effective system from a technical perspective, but one with other shortcomings. With government subsidies covering the deficit, there was a lack of economic incentive. Given the absence of competition, passengers were treated less as valued customers than as an inconvenience. One has to wonder, however, whether some of the technical achievements of those times – the electrification of the German rail network and, later, the dawn of high-speed rail – could be replicated today.

So what is this steering committee, who is involved in it, what are its tasks and what is the role of infrastructure undertakings?

It might be tempting to see the committee's tasks as the preserve of the infrastructure undertakings. After all, their infrastructure is used by all train operators, making them seemingly predestined to set the technical and operational rules. But it must not be forgotten that infrastructure undertakings have their own interests. Their managers are equally obligated to the profit motive for their part of the railway system. Where trains meet track, technical challenges frequently throw up two key questions:

Who should take action: those responsible for trains or those responsible for infrastructure? And who should bear the costs?

A degree of mediation is required to find a solution that brings maximum benefit. The task of solving the issue cannot be handed to a traditional standards organisation, as simply standardising everything often makes little sense. Instead, the steering committee aims to deal only with matters that genuinely require regulation.

It always considers the impact on the institutions forced to implement the solution.

There must be a reasonable balance between regulation, technical necessity and operational and commercial im-pact.

In its current configuration, the steering committee comprises all the relevant stakeholders for the rail sector: Manufacturers (represented both by their association and individual companies nominated by the German Railway Industry Association (VDB)) and operators (their Association of German Transport Companies (VDV) and the RUs DB Regio and DB Cargo) as well as the Association of Freight Wagon Keepers in Germany (VPI).

Infrastructure undertakings are represented by the DB Netz rail safety managers as well as a representative from production. Non-publicly-owned infrastructure managers are involved via the Association of German Transport Companies. The Federal Railway Authority sends employees from its infrastructure and vehicle departments, and a representative from the Federal Network Agency contributes on regulatory aspects. The European dimension is growing in importance in the context of the requirements in the Fourth Railway Package.

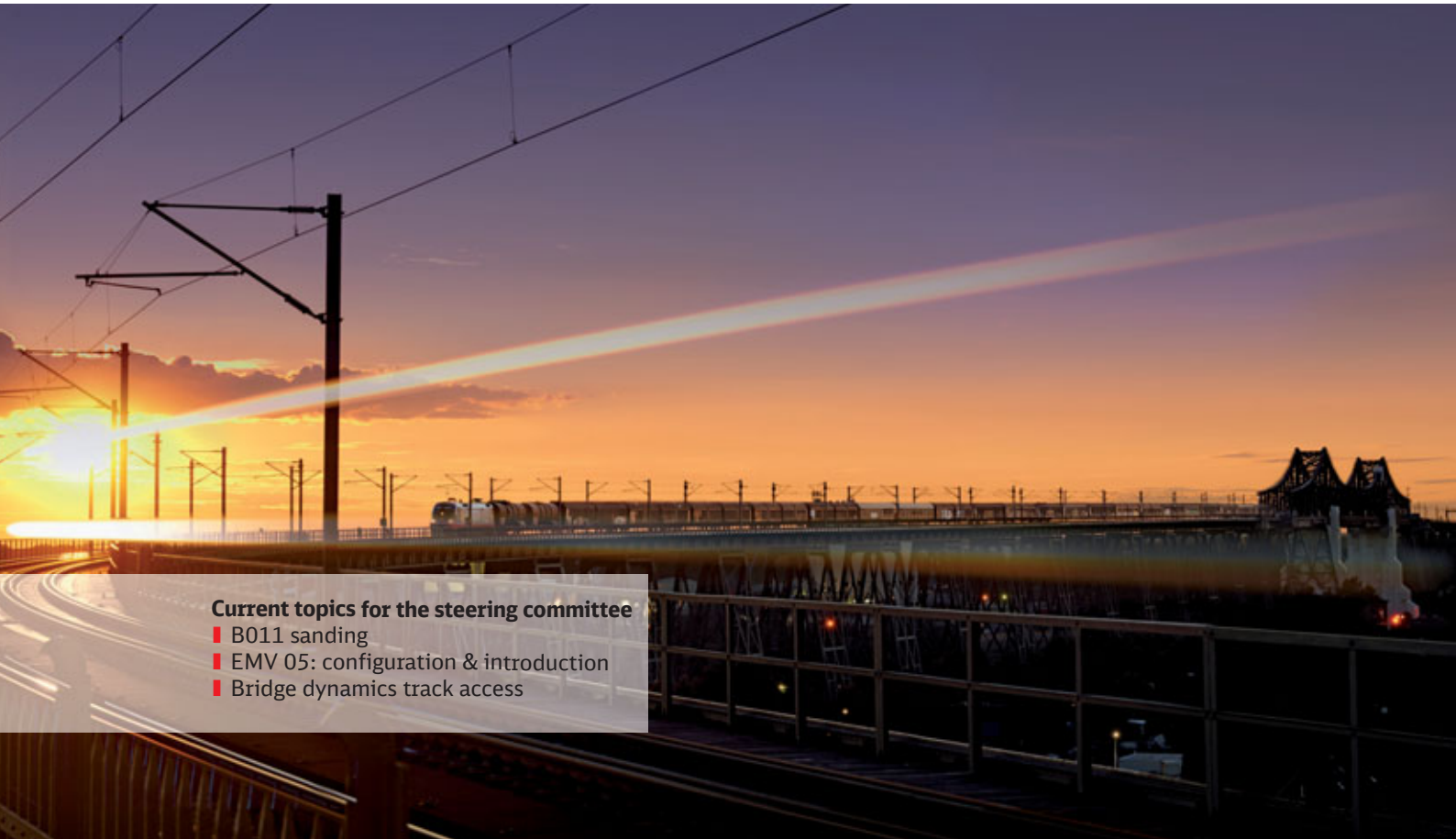
Decisions by national bodies must be compatible with the European framework and national solutions also embedded at European level. A representative from the European Union Agency for Railways is therefore on the committee. Eisenbahn CERT (EBC) also participates, representing the interests of European regulatory approval. Political aspects are covered by a representative from the Transport Ministry, and a representative from Deutsche Bahn technical department represents the interests of the rail system as a whole.

The members elect the committee chair every five years. The current chair, who has been in this post for several years, is Peter Lang, Chairman of the Board of Managing Directors of DB Systemtechnik.

There is broad agreement that the rail sector needs planning certainty and legal certainty for the supervision and operation of vehicle development and approval processes. The role of the group is therefore to consult and find solutions where processes are not yet agreed or have been a source of controversy.



The rail sector needs planning and legal certainty in order to conduct and monitor its vehicle development and approval processes.



Current topics for the steering committee

- B011 sanding
- EMV 05: configuration & introduction
- Bridge dynamics track access

Where supervision or regulation is concerned, the committee aims for consensus followed by binding implementation of its decisions.

This makes it a central part of the liberalised German rail sector, which works on the principle of self-organisation. In the procedural rule issued on 5 June 2013 on planning certainty in the approval process, the steering committee is explicitly mentioned as a disagreement-resolution body.

The committee's role can be illustrated by the example of "sanding". Sand is used to help trains gain traction or brake effectively in areas of poor adhesion. The drawback is that excessive sand where wheel meets rail can create an insulating effect, meaning that the track circuit infrastructure used to detect trains no longer works safely.

Analysis showed that this safety-critical problem at the interface between vehicles and infrastructure could affect not only one type of train but potentially the whole of the rail sector. The operational measures already taken were insufficient for the long term, and no existing technical solution was available. Finding a solution for the existing fleet, not just a rule for the approval of new vehicles, was therefore essential. A clear case for the steering committee.

When reviewing whether the most cost-effective solution should be sought on the rail vehicles or rail infrastructure – a typical step in solving interface problems – it was found that the network contained a very large number of existing systems. This meant that a train-based rather than a track-based solution had to be found. Using the knowledge and experience of the whole sector, from RUs to infrastructure managers and manufacturers, the issue was discussed intensively and sometimes heatedly from technical and operational standpoints in order to find an innovative solution.

This example and the multitude of other issues discussed by the steering committee show how diverse rail technology is, and the importance of this sector-wide committee. Asked about their mission, all members are passionate about the goal:

It is all about making rail transport more effortless – and doing so with passion.

Lead article:

Modern
exterior vehicle cleaning



Modern Exterior Vehicle Cleaning

Systems, planning and operations

Dirt is not just dirt. The composition of dirt on a train is much different to that on road vehicles, and requires special cleaning technology as a result. The main reason for this is the high number of rail links from wear caused by friction between the wheels and rails.

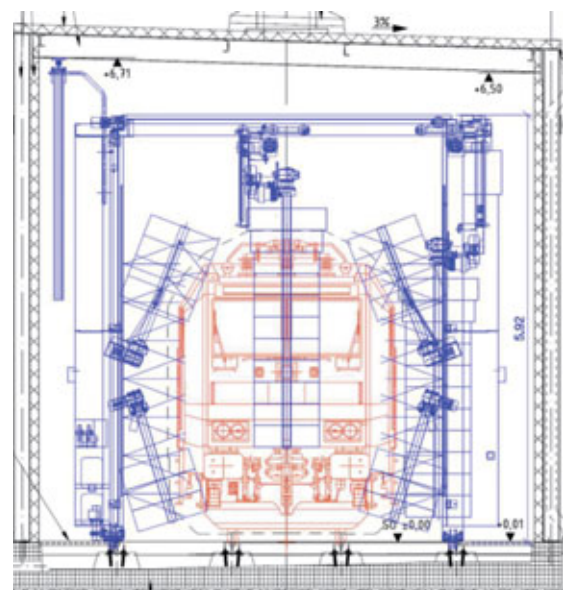
Regularly cleaning the outside of the vehicle helps to both polish the rail company's image and avoid paying contractual penalties and damages to those involved.

As a result, the first step in developing efficient and cost-effective exterior cleaning technology for rail vehicles is to determine the requirements for this cleaning, based on the specific market conditions. Turning these requirements into planning specifications for procuring the necessary structures and systems, as well as optimising these when in use, is a difficult task. It requires an understanding of vehicles, systems, operations and supply processes. DB Systemtechnik has been active in this area for many years, and makes its expertise available to all rail companies and systems operators as a service.

How to clean a train

Cleaning the outside of a train requires a plan to achieve the cleaning objectives. As cleanliness is often very much in the eye of the beholder, the requirements are described in quantitative and objectively describable terms. The requirements must first be determined and organised into so-

called cleaning priorities, in order to limit the workload. This step takes the specific surfaces into account, i.e. the absolute (measurable) and relative (subjective) level of dirt. The operating conditions are also considered, along with the specific characteristics of the vehicle and fleet. In terms of the vehicles themselves, the main factors are the condition of the surface, the complexity of its contours and similarity of the vehicles in the fleet.



Photos: DB Systemtechnik

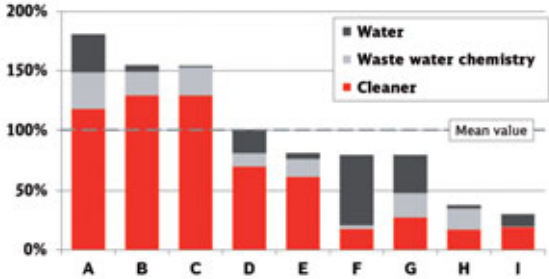
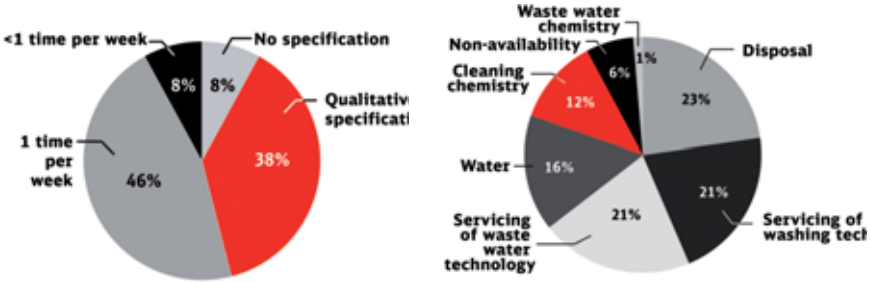
The results of this analysis, along with considerations of the operational and vehicle-related requirements, form the basis of the cleaning plan. The main parameters are also defined, such as the number and arrangement of the brushes (cleaning work), the pH value and dosing of the cleaning agent (cleaning chemicals), temperature control and treatment time. The treatment time can be influenced by the washing speed and the geometry of the system.

Cleaning frequency

DB regional trains are usually cleaned once per week. The cleaning frequencies are often set out in the specifications of the ordering organisations. Premium long-distance trains are cleaned more frequently. A full cleaning plan also needs to specify the conditions under which cleaning can be postponed and how to handle the vehicles in this situation, in order to take account of operating disruptions and other pressures.



A modular systems catalogue was developed for exterior cleaning facilities. This illustrates the process of implementing the system. Here, the cleaning plan is transmitted into different variants with approximate cost estimations, taking the local production conditions into account. The facility plan centres on determining the functional components. These include the washing, control and conveyor systems, wastewater treatment, housing and technical building equipment.



Keeping on top of costs

The keys to keeping overall service life costs of an exterior cleaning facility low are proper budgeting before starting the project and keeping strict control of requirements in the planning phase. In regional transport, budgets are calculated when preparing bids for the respective transport tender. This means that even at this early stage, infrastructure planning expertise and up-to-date knowledge of the machinery and construction markets are necessary, in order to create the conditions for the facility project to be economically successful. DB Systemtechnik has data-based tools that make it possible, in a relatively short period of time, to develop facilities that take the local conditions into account and accurately estimate costs.

System control

To minimise the complexity of the controls for exterior cleaning facilities, modular control systems are designed and successfully fitted on both newly purchased and retrofitted facilities. DB Systemtechnik’s concept for exterior cleaning facilities features a uniform structure with changeable entry levels. The shape and design of the vehicle is parametrised at process control level. The parameter lists, which include both vehicle and facility parameters, can be edited and expanded for new train configurations.



Feature	Version	Facility class				
		1	2	3	4	5
Work stations	Rubbing brush work station - fixed	✓	✓			
	Rubbing brush work station - traversable			✓	✓	✓
	Washing off brush work station - fixed		✓			
	Washing off brush work station - traversable			✓	✓	✓
	Pre-cooling and pre-heating work station					✓
Traction	Own traction	✓				
	Shunting locomotive		✓			
	Shunting system/battery-operated shunter			✓	✓	✓
Design	Open	✓	✓	✓		
	Enclosed				✓	✓
Control	Brush delivery, compressed air	✓	✓			
	Drive systems controlled by motor current			✓	✓	✓
Waste water treatment	Filtration	✓	✓			
	Flotation		✓	✓	✓	✓
	Water reclamation				✓	✓
Cleaner	Neutral	✓	✓			
	Acidic/alkaline		✓	✓	✓	✓

Alternative uses for exterior cleaning facilities

Exterior cleaning facilities can be fitted with systems for a range of additional functions. Most enclosed facilities now feature de-icing systems, for example. Integrated warm water sprinklers or hot air nozzles can be used to de-ice a large number of vehicles. Warm water connections are planned for manual de-icing of smaller fleets.

Graffiti is usually removed on separate work stations, as the solids and cleaning water used to do so are collected and disposed of separately. In 2016, however, a wastewater treatment module was developed in Cologne-Nippes that allows contaminated cleaning water to be treated and directly disposed of into the municipal waste water network.

Different performance classes

The parameters that influence each project mean that decisions about the various facilities are always made on an individual basis. Despite this, the facilities are divided into five different performance classes using the bill of quantities to be processed and the necessary investment.

The first performance class covers simple facilities that can efficiently process up to 700 metres of vehicle per day. The trains are driven into and through the facility and washed completely in at least two cycles, although no automated front cleaning takes place. Using neutral cleaning agents allows for cost-effective wastewater treatment without the need for neutralisation. The more powerful facilities in performance class 5 are highly automated, provide reliable cleaning quality and are extremely flexible in terms of contour geometry, operating programme and cleaning agents. Within DB, these class-5-facilities are mainly reserved for ICE trains. The facilities used by DB Cargo and DB Fahrzeuginstandhaltung are mainly class 1 and 2. Regional trains are mostly cleaned using class 1 to 4 facilities, depending on the needs of the respective vehicle.



Constant optimisation

During operation, the focus is on systematically improving facility performance. This usually begins by improving the cleaning quality. After collecting and validating specific empirical values, the focus switches to reducing operating costs. Thanks to its planning activities in project planning and consulting for operators in all phases of the facility life cycle, DB Systemtechnik has comprehensive experience of facilities in all performance classes and from all manufacturers. This experience helps both develop effective optimisation measures for existing facilities and determine a targeted improvement process for planning and requirements management across all facility generations. Cost factors that can be influenced during operation include consumables, for example.

Adjusting the specific quantities of service fluids can achieve five-figure savings every year. Unplanned facility downtimes can also lead to additional costs in the form of contractual penalties or damages. All exterior cleaning facilities must be thoroughly cleaned and ventilated on a regular basis, in order to prevent downtimes caused by corrosion to the washing systems, structure or concrete elements. Longer downtimes or under-use of the facilities have a negative effect on their reliability.

Typical effects include silting in the wastewater line or cleaning agent dosing system, which can be difficult to remove. Regardless of the facility type or manufacturer, the control systems are a frequent cause of failures. Making the required changes to the control software is a time-consuming process.

As a result, DB Systemtechnik provides its full range of services in many projects to the entire rail sector.



References

Experts from DB Systemtechnik are currently working on countless projects at all stages of planning and implementation. While the focus in the past was on new facilities, activities now revolve around renovating and adapting washing systems for rail vehicles:

- Locomotive cleaning facility in Seelze: New washing system, new underfloor cleaning system, wash hall insulation, installation of heating and ventilation system
- S-Bahn exterior cleaning facility in Munich-Steinhausen: New washing system and wastewater treatment unit
- Diesel locomotive cleaning facility in Kempten: Adjustment of washing system to allow the hall to be used for PESA diesel locomotives
- Double-deck passenger train exterior cleaning facility in Cottbus: New washing system
- Facility in Augsburg: Condition assessment and upgrade plan
- New facility in Kiel: Retrofitting of de-icing systems
- Wash cabin in Kassel depot C: Renovation feasibility assessment
- Traction unit exterior cleaning facility in Dessau: Variant assessment for new facility location
- Additional cleaning and brush portals ("ARA Light") for long-distance trains in Hamburg-Langenhfelde: Location finding and feasibility assessment
- Exterior cleaning facility in Hof: New washing system and adjustment of the operating concept to the new vehicle fleet



DB Systemtechnik
reference projects
2017/2018



Crosswind validation for the new Aller Bridge

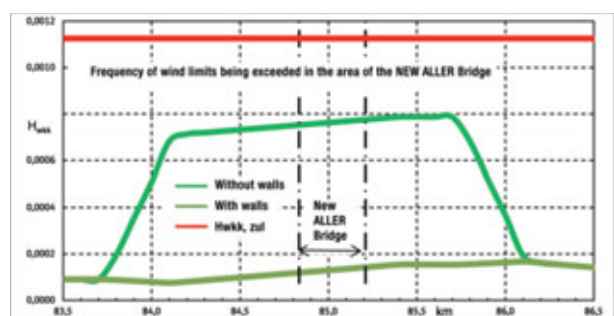
The old railway bridge over the river Aller near Verden was equipped with a wind alarm system. When the system was triggered because the wind exceeded certain speeds, this reduced the speed of freight trains and could even hold them up.



During construction, it was necessary to check whether a wind alarm system had to be reinstalled on the new Aller Bridge. To this end, DB Systemtechnik carried out the safety case for crosswind according to GL 807 with the help of numerical simulations. The simulation is based on wind data and geographical conditions.

Analysis of the simulation showed that, despite increased approved travel speed, the new bridge is safer because of its non-removable walls. The frequency with which the defined wind limits were exceeded has been reduced by around one fifth.

By dispensing with a wind alarm system, DB Netz can save the one-off costs of re-installation as well as the long-term costs of operating and maintaining the system.





Testing comfort and functions on the CAF Urbos tram

To check the climatic conditions in the driver's cab and passenger areas, climate tests were carried out on a tram from Spanish manufacturer CAF in DB Systemtechnik's MEiKE climatic chamber in Minden. The driver and passenger areas were equipped with measurement technology in accordance with EN14750-2 and EN14813-2.

The climatic chamber test was then performed in a temperature range of -20°C to $+35^{\circ}\text{C}$. The presence of people and the effect of sunlight in the driver's cab and passenger area were simulated using heating mats, evaporators and a bank of lamps. The energy consumption cycle (duty cycle) and the heat transfer coefficient (k-value) were also determined.

In addition, various functional tests were carried out, including on brakes, pantographs and doors in various kinds of adverse weather conditions.

The comfort and function test in the climatic chamber helps reduce the number of faults when new vehicles are introduced. It also ensures correct operation of air conditioning and vehicle systems under different weather conditions and increases vehicle availability. Determining the k-value and the energy consumption will also provide CAF with proof that the vehicle meets any agreed energy requirements.



Predictive Maintenance of the new Berlin suburban trains

S-Bahn Berlin is procuring new 483/484 class suburban train (S-Bahn) vehicles for operation in the "Teilnetz Ring" transport contract. The vehicles are equipped with an extensive diagnostic system. It is also planned to implement elements of PM/CBM (predictive/condition-based maintenance) when the vehicles are put into operation.

PM and CBM are underpinned by technical expertise and analytical capabilities designed to detect and repair damage at an early stage, preventing or minimising downtimes. This serves to increase the availability and reliability of vehicles and air-conditioning systems. Furthermore, a functioning PM/CBM system enables the operator to accurately predict the optimum time to perform maintenance measures instead of using inflexible cycles. Significant cost-saving potential is exploited without restricting safety or availability aspects.

When it came to selecting components and parts to be "monitored" predictively, S-Bahn Berlin called in support from DB Systemtechnik.

As the engineering and testing service provider for S-Bahn Berlin, DB Systemtechnik used its high level of technical expertise to make the right recommendations regarding which data to consider and where it should be transferred to, and also to develop a maintenance strategy. The following results were achieved within the scope of the commissioned consulting service:

- Project timetable/design time line developed for implementing PM for S-Bahn Berlin's new class 483/484 vehicles
- Draft concept derived for vehicle CBM/PM measures for the pilot technical discipline "passenger area air-conditioning system"
- Initial draft concept developed for standard-compliant handling of DIN 27201-1 to support predictive maintenance

Following drafting of the concept for CBM/PM measures for the passenger area air-conditioning system in the vehicle, other technical disciplines are also to be considered.





Maintenance analysis for Voith Maxima 40CC

Havelländische Eisenbahn (HVLE) intends to further develop the existing maintenance program for its V 490 class (Voith Maxima 40CC) rail vehicles. DB Systemtechnik was commissioned to carry out a preliminary study. The experts from Kirchmöser performed an initial assessment of the suitability of the maintenance records and maintenance data provided (maintenance concept, maintenance program, manufacturer documentation, records of maintenance performance, relevant operating data, vehicle malfunctions) and determined improvement requirements for the intended optimisation goals (e.g. subsystems and components).

The results report, which also included a decision recommendation for establishing a further project for overall optimisation of the maintenance programme, was handed over to HVLE in August 2017 and explained in a joint meeting. Among other topics, the participants discussed the requirements for collecting and evaluating maintenance data and their significance for successfully validating the maintenance program currently used for the Voith Maxima 40CC.

The contents of the results report enable HVLE to use analogous approaches to handle maintenance data of other classes in its vehicle fleet. An internal review of next steps is currently under way at the customer.

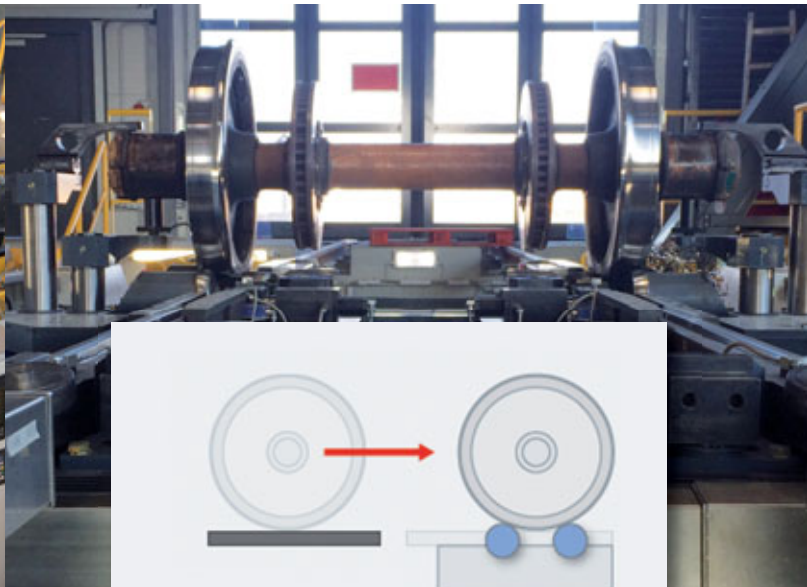
Correction algorithm for geometric wheel profile measurements

The geometric characteristics of the profiles of wheelsets on all long-distance trains are monitored at regular intervals during the journey by fully automatic measuring equipment installed in the track by DB workshops. Reliable determination of the inner surfaces of the wheels, serving as a reference for the measured variables, provides a starting point for the precise calculation of the wheel profile parameters. The reference surfaces tend to become smaller due to design changes to newer wheels. Changes to maintenance guidelines and wear on the inner surfaces of the wheels caused by track components also lead to changes in the inner surfaces of the wheels. Unlike in the past, evaluation algorithms can no longer rely on finding sufficiently large reference areas that are required for measurement at a specific position. This resulted in incorrect orientation of the reference systems, measurement deviations, a decreasing yield of valid measurements and, ultimately, frequent manual control measurements.

DB Systemtechnik was therefore commissioned by DB Fernverkehr to analyse the measuring systems. After determining the causes already described, the metrology experts in Chemnitz have developed a powerful, robust adaptive algorithm. This takes into account geometric boundary conditions known from the outset, as well as statistical properties of the measurement objects and measuring equipment and statistically verified limits for the measurement uncertainty.

Precise measurements are now also possible if the precise position of the reference surface is a priori unknown, the reference surfaces of the wheels are very worn and show faults due to indentations or adhesions, for example. The algorithm is patent pending and has been rolled out to all wheelset diagnostic systems at DB Fernverkehr.



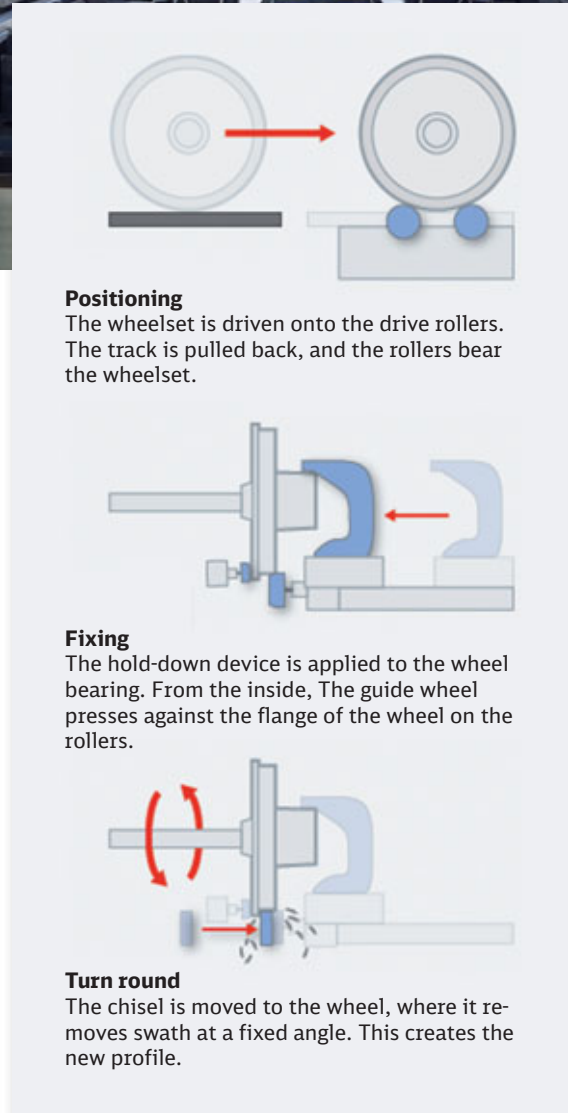


Improved performance in **light machining** of wheelsets

Rising vehicle mileages and the growing number of self-propelled wheelsets in passenger transport have led to a noticeable increase in the load on underfloor wheel lathes in recent years. As a result, the requirements for reliable availability of these systems and the importance of an efficient feeding and machining process are also on the rise.

Against this background, DB Systemtechnik was commissioned to analyse the process of wheelset machining on the tandem machines of long-distance transport in greater detail. In workshops with local system operators, technical and organisational approaches were developed that enable significant reductions in the total time from delivery to the maintenance depot to maintenance right through to handover of the vehicle to operations.

These include technical measures (e.g. creating the conditions for automated data transmission), organisational measures (e.g. feeding without dismantling) and the introduction of new machining strategies (fine or economic turning with a "zero cut" in the measuring circle plane). To increase the availability of DB Cargo's underfloor wheel lathe facilities, DB Systemtechnik first analysed the existing maintenance concept and developed a key figure system for assessing technical availability and performance.



On the one hand, this resulted in technical measures that were implemented in the systems. On the other, a new maintenance contract was drafted and put out to tender. This contract binds the maintenance provider closely to the performance of the underfloor wheel lathe systems by means of a quantified bonus/penalty regulation. One measure pursued in this context is the programming of a mobile phone app, which will enable unscheduled system failures to be reported and documented directly by the system operator and passed on directly to the system maintenance provider for response. This will allow the necessary information to be transmitted quickly and downtimes to be reduced.



ICE-T: reactivating the tilting technology

On various DB Netz lines, the condition of the infrastructure had to be examined for resumption of curve-adapted running with tilting ICE-T vehicles.

Vehicle response measurements were carried out on the main Frankfurt/Main – Passau and Frankfurt/Main – Dresden routes with a class 411 ICE-T and with DB Systemtechnik's VT 612. First, the reference vehicle for tilting technology, DB Systemtechnik's VT 612.9, was used to carry out inspection runs

with curve-adapted running to check the track geometry quality based on the vehicle response with wheel/rail forces.

In addition, the vehicle response of an ICE-T equipped with measurement technology was tested using acceleration measurements on the same routes. In cooperation with the overhead line measurement specialists, who simultaneously performed a test of the contact line (contact force and uplift measurements), it was agreed to restart tilting operation with the ICE-T on the routes tested as a result of the positive measured values.

This has significantly reduced travel times and improved connection options on some ICE lines travelled by the ICE-T.

Immediate action and remediation solution: "Class 422 smouldering fires"

Between September and December 2016, several smouldering fires occurred in the S-Bahn multiple units in North Rhine-Westphalia during service. In addition to disrupting operations and attracting public attention in the media, these incidents resulted in vehicle failures lasting several months and significant repair costs.

DB Systemtechnik's „AC EMU Competence Centre“ in Krefeld was tasked with examining the causes of the smouldering fires and with developing rapidly deployable corrective measures as quickly as possible.

The examinations revealed that several high-voltage short circuits had occurred on the roof of the multiple units involved, igniting the insulation between the vehicle body and interior.

The short circuits were caused by an overhead power line breaking, flashovers due to birds on the vehicle roof and flying sparks in the area of the pantograph, with the result that several different solutions had to be found.

As a corrective measure, the roof ventilators were grounded. Extending the existing protective plates under the pantograph offers additional protection in the event of flying sparks.

The previously uninsulated connecting tubes of the high-voltage line between the pantograph and post insulators were covered with an insulation shrink tube.

The sample conversions were supported by the Engineering DB Systemtechnik team, and the entire measure has now been successfully completed.





Figure 2 DB Systemtechnik noise

Acoustic monitoring of track quality

As part of the "specially monitored track" (SMT) procedure, the DB Systemtechnik noise monitoring car runs over a defined part (approx. 12,000 track-kilometres) of the DB Netz service network twice a year. In addition to monitoring the SMT sections, the acoustic measurement data obtained is used to prepare statistics on the development of the acoustic quality of the DB network and to monitor and qualify grinding measures and procedures. It should also be possible to use the data collected for other purposes in the future.

In cooperation with the Chalmers University of Technology in Goteborg, Sweden, DB Systemtechnik is developing a fully automated method for acoustic pattern recognition as part of the AMONTRACK research project. The basic idea of the AMONTRACK project is to use the measurement signals acquired in large quantities and at regular intervals (airborne and structure-borne noise signals) to gain information on other rail parameters and changes to them and to expand the range of services provided by the noise monitoring cars on this basis. The first step aims to identify non-acoustic objects such as surface defects, rail joints or cavities. In the second step, conclusions are also to be drawn on dynamic track parameters (track decay rate) and the acoustic condition of the running surface (and thus, indirectly, the quality of grinding measures carried out).

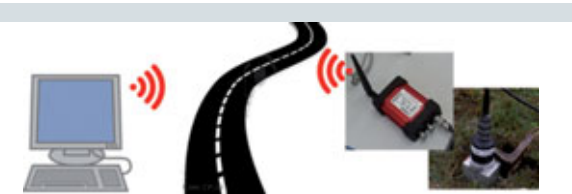
The AMONTRACK project is a 14-month Marie-Sklödowska-Curie measure, funded by the EU Framework Programme for Research and Innovation "Horizon 2020".

The project is divided into the following subprojects:

- Extension and validation of an existing simulation model based on the results of a measurement campaign carried out in the Roll2Rail innovation project
- Study of acoustic signatures of various track errors using the validated simulation model
- Implementation of a pattern recognition method to identify track faults in the measurement data of the SMT
- Feasibility study for indirect measurement of acoustically relevant track parameters such as track decay rate and rail roughness



Wheelset in the measuring bogie of the noise monitoring car with accelerometers on the axlebox



Vibration measurements Angermünde – Poland

In response to the new DB vibration guidelines GL 820.2050, DB Netz has commissioned DB Systemtechnik to perform vibration measurements on a 48-km route section between Angermünde and the German/Polish border to ensure the vibration forecast.

DB Systemtechnik's Acoustics and Vibrations testing laboratory measured vibration in buildings caused by the adjacent rail traffic reference buildings near the track as well as in front of the building. In addition, seven free field measurements were used to investigate vibration in the field. The locations of the building and open field measurements were always close to each other.

Some of the individual measuring points, on the other hand, were separated by busy roads or were located

far apart. This made it difficult to connect the measuring points by cable.

For this reason, DB Systemtechnik carried out the vibration measurements using a measuring system (MEDA Red-Sens) that allows measurement data to be transmitted to the central measuring computer wirelessly and over a greater distance (up to 150m). Using multiple measuring systems enabled the building and free field measurements to be recorded simultaneously, saving the client valuable time.

The fully automated train detection system, in conjunction with the fully automated vibration measurement, enables unmanned capture of vibration overnight.

In Sweden, Stadler Rail AG has offered the operator Västtrafik regional vehicles for the operation of long-distance routes.

The FLIRT Nordic regional trains already in service in Norway were to be deployed as long-distance trains in Sweden. In view of the project deadline, Stadler wanted rapid order processing with support from DB Systemtechnik's air-conditioning experts.

The documents provided by Stadler (requirements, description of climate, design calculation) were reviewed and checked for completeness. Västtrafik's air-conditioning requirements were compared with the description of the air-conditioning system of Stadler's FLIRT Nordic.

For the identified deviations, the DB Systemtechnik HVAC engineering experts have worked out solution proposals to supplement the description of the air-conditioning system.

Thanks to the outstanding communication between DB Systemtechnik and Stadler, the technical expertise of the climate department and the existing detailed knowledge of comfort standards in long-distance and regional and local transport, the requirements were met, and the desired processing was performed within the required time frame.

The offer was submitted with a complete climate description of the type required for a long-distance vehicle. For Stadler, the DB Systemtechnik inputs have minimised project cost and risk accordingly.

Offer support
Stadler FLIRT Nordic

At the Munich North marshalling yard, the class 290 with control is deployed for four tasks: approaching wagons and gently moving the shunting locomotive into position, carefully pushing the uncoupled wagons/wagon groups together, humping and shunting. Humping is partially automated (i.e. shunting locomotive driver with monitoring function). As part of the "Automatic formation yard 4.0" innovation project between the German Federal Ministry of Transport and Deutsche Bahn, a concept is to be developed for a fully automatic hump locomotive" that handles all of the individual tasks listed above.

For this concept, a class 296 diesel-hydraulic shunting locomotive was equipped in a first step with a computer system, consisting of three individual computers, and sensors. The sensors, which were selected by Nuremberg Tech, were used to detect objects (obstacles, persons and cars). Another project partner was Nuremberg-based company AAIT, which set up the connection between the sensors' evaluation computer and the locomotive's control sys-

tem. In demonstration operation, the functions of obstacle and car detection, and positioning were then demonstrated. The knowledge gained serves as a basis for drafting specifications and safety considerations. When new locomotives are procured, the specifications provide guidance on the functional requirements that must be met by the automatic locomotive control of the fully automatic hump locomotives of the future.

As part of this project, DB Systemtechnik delivered the engineering services for the electrical and mechanical installation of the computer and sensor technology as well as production support for the equipment of the demonstrator. In addition, the experts provided support in the event of component failures during trial runs and during demonstration operation (e.g. provision of test managers). The DB Systemtechnik services were rounded off by drafting of the technical specifications and the system description, and participation in developing the safety concept. Work is under way to represent current operations at the Munich North



Fully automatic hump locomotive VAL 2020

Exhaust aftertreatment for DB Netz Rail Vehicle and Machinery Fleet

The DB Netz Rail Vehicle and Machinery Fleet operates a wide variety of construction vehicles, most of them powered by diesel fuel. There are numerous regulations on exhaust emissions from diesel engines and preheaters both at EU and national level (e.g. for occupational health and safety reasons).

DB Systemtechnik was commissioned to summarise the legislation and guidelines on exhaust emissions and to identify their influence on the maintenance specifications for rail-bound construction vehicles. In a first step, extensive research into the current legal situation was carried out.

Building on this, a detailed report with clear and specific recommendations for action was prepared. Special customer requirements were addressed in two coordination meetings.

Based on the report, clearly worded maintenance documents can be created for the various vehicle classes and their components. The customer is informed about which provisions and laws apply and must be adhered to when maintaining its rail-bound construction vehicles. Existing maintenance specifications can now be optimised without violating legal requirements.





3D printing for safety-relevant components

Passenger and freight wagons are equipped with changeover devices, which are responsible for adjusting the brakes in line with the current operating situation.

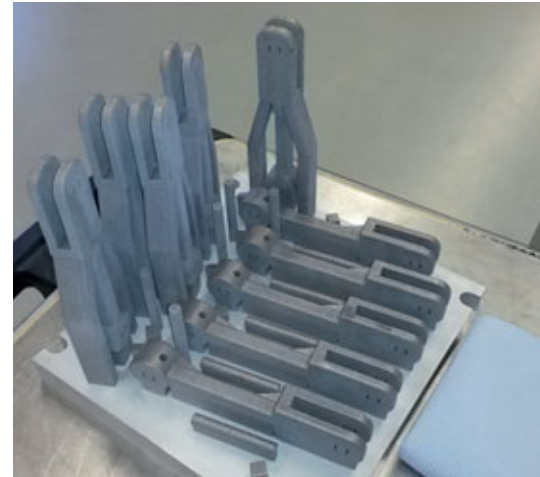
The G/P changeover device is used to change the brake position between "fast acting" (P) and "slow acting" (G). In the past, the changeover device, which is made of aluminium, occasionally broke. Procuring spare parts is very difficult because there is demand for only about five units a year.

As part of Deutsche Bahn's "3D Printing" Group project, this new application technology was also to be tested in an area relevant to safety. Because of the small size of the changeover device, the low demand for parts and the difficult procurement situation mentioned above, this part was an interesting use case from an economic point of view.

In consultation with the DB AG project officers, DB Systemtechnik has developed a verification concept designed to avoid possible anisotropy (directional dependency of the properties) of the parts. In the test itself, additively produced and, for comparison purposes, conventionally cast G/P changeover devices were subjected to fatigue testing to determine the fatigue limit of the G/P changeover devices produced using the two methods under the same load.

The results of the first series of tests showed that not all G/P changeover levers manufactured using additive technologies achieved the required number of load cycles.

Materials-based inspection of the G/P changeover devices in DB Systemtechnik's materials and damage analysis inspection division sought to answer the question



of whether additive manufacturing had an impact on the number of load cycles achieved in the endurance tests. After the components have been optimised, further test series will be conducted to enable 3D-printing components to be used in this application.





Extending the mileage of the DMU class 642's cardan shafts

The overhaul limit for the Class 642 vehicles is 1.3 million km. The mileage limit for these vehicles' cardan shafts is currently 1.1 million km or 1.2 million km, depending where they are installed in the vehicle. According to the maintenance schedule, the cardan shafts must be replaced before reaching 1.3 million km. This results in additional time and costs due to the time vehicles spend in the workshop. In addition, the vehicles are not available for operation during this period.

DB Systemtechnik was commissioned by DB Regio to investigate the possibility of adapting the mileage limit of the cardan shafts to the vehicle mileage of 1.3 million km. As part of a test, the cardan shaft continued to run in class 642 diesel/gas railcars (DMU) up to the vehicle overhaul limit of 1.3 million km. These cardan shafts were specially inspected within the IS 520-IS 550 scheduled maintenance levels.

In accordance with the requirements of DIN 27201-1 (procedures for preparation and modification of maintenance programmes), at least 25 units must be inspected, i.e. 25 cardan shafts.

For safety reasons, however, DB Systemtechnik checked approximately twice as many. When the vehicle overhaul limit was reached, these cardan shafts were removed from the previously defined vehicles and their wear behaviour was examined as part of the component overhaul at the DB Fahrzeuginstandhaltung depot in Kassel. For this purpose, the cardan shafts were first subjected to special incoming inspections, e.g. to determine the actual imbalance. Wear in the length compensation of the cardan shaft is also checked as part of a buckling measurement.

In the next step, the cardan shafts were disassembled to evaluate wear and tear to the trunnion bearings (rolling bearings of the cardan shaft) and the remaining components. The results of the diagnostic assessments were documented in a report.

If, as in this case, the values are below the limit values, the wear and tear allows the mileage to be extended safely. DB Systemtechnik has prepared a correspondingly positive technical assessment confirming the feasibility of the adjustment to the mileage limit.



Evaluation of modifications to locomotive software



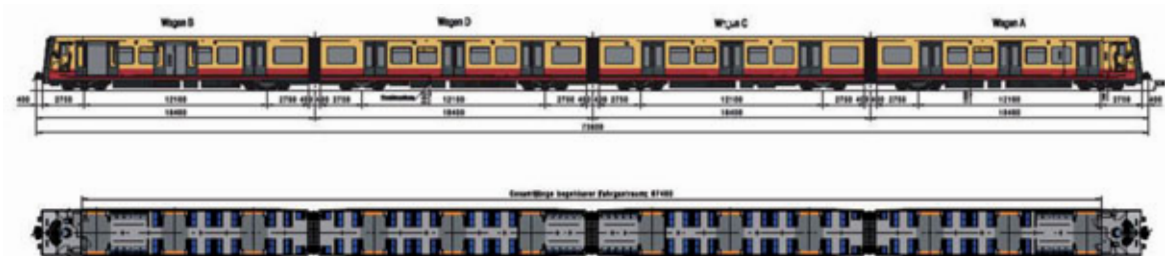
In the class 186 multi-voltage locomotive, transformers have overheated under certain operating conditions. The locomotive software was modified to prevent this overheating.

The DB Systemtechnik experts were commissioned by DB Cargo to evaluate the adjusted software at the end of the first year of operation. Various documents were inspected, including documentation of the dam-

age to transformers as a result of overheating and associated repairs, as well as the operating data and fault messages from the locomotives.

The evaluation was carried out on the basis of DB Systemtechnik's existing experience and expertise relating to the locomotive class and component. The positive assessment of the modified software was then recorded in a detailed report.

Acoustic procurement support for S-Bahn Berlin during the design phase



Deutsche Bahn has been awarded the contract for transport on S-Bahn Berlin's "Ringbahn" sub-network starting 2020. For operation of the public transport contract, a framework agreement was concluded with the consortium of manufacturers consisting of Stadler and Siemens, including procurement of 106 new S-Bahn vehicles as the first request.

Within the framework of the vehicle requirements, the authority has stipulated the subject of exterior and interior noise

in a contract and, because of its relevance for both travellers and residents, has given it high priority.

To fulfil these requirements, DB rolling stock procurement, as the performance provider for this procurement project, must consider the acoustic effects during the design phase. DB Systemtechnik was involved in the project to support DB procurement with expertise in all aspects of acoustics. The acoustics experts initially clarified and defined the

technical aspects of the contractual requirements. Next, the consortium of manufacturers' technical solution approaches and concepts were discussed and jointly adjusted.

Finally, the technical solutions were evaluated with regard to contract fulfilment, and existing potentials and risks were assessed.

As a result, the final design review was successfully completed.



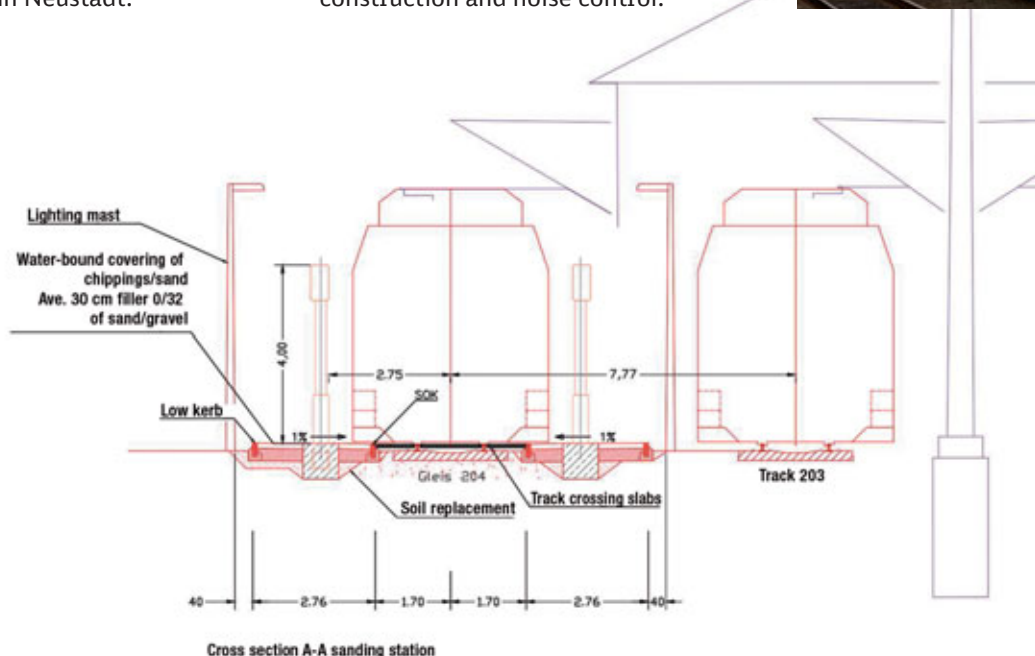
Planning of a service facility in Neustadt-Titisee

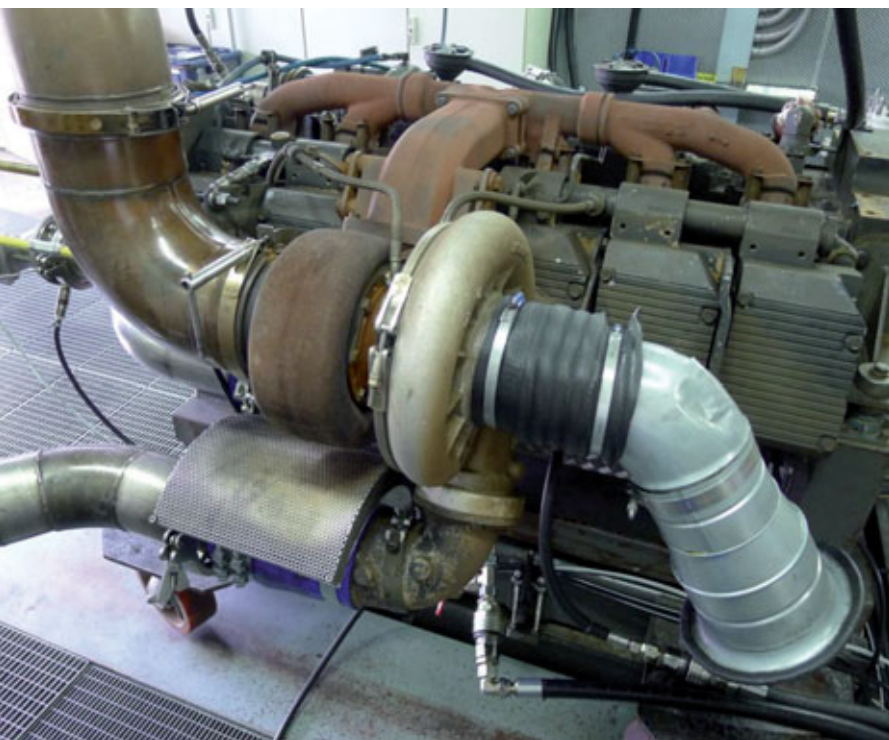
In the Freiburg im Breisgau region, the Breisgau rapid transit (S-Bahn) transport concept, with higher line speeds and more frequent services, will be implemented from 2020. Three and four-section electric multiple units of the Coradia Continental type will be used, whose new circulations will involve out-of-service times in the Neustadt-Titisee area. The provisioning of traction units requires the installation of service facilities to enable supply and waste disposal work to be performed.

DB Systemtechnik was commissioned by DB Netz to handle the planning of such systems in Neustadt.

These consist of treatment systems for providing fresh water, waste disposal stations for emptying WC tanks and sanding systems for refilling the brake sand reserves. Planning of shunting routes and the associated lighting systems is also included in the services aimed at creating an operable facility. Other sub-services include planning the preliminary design, draft and approval, including the obligatory application to the German Federal Railway Authority. In addition, the DB Systemtechnik experts provided support with their expertise in the areas of civil and underground engineering, electrical engineering systems, building construction and noise control.

A preliminary cost estimate of the project scope, the invitation to tender for the planned measures as well as the selection, and participation in the award procedure were also included in the range of services. The project is scheduled for implementation in 2019.



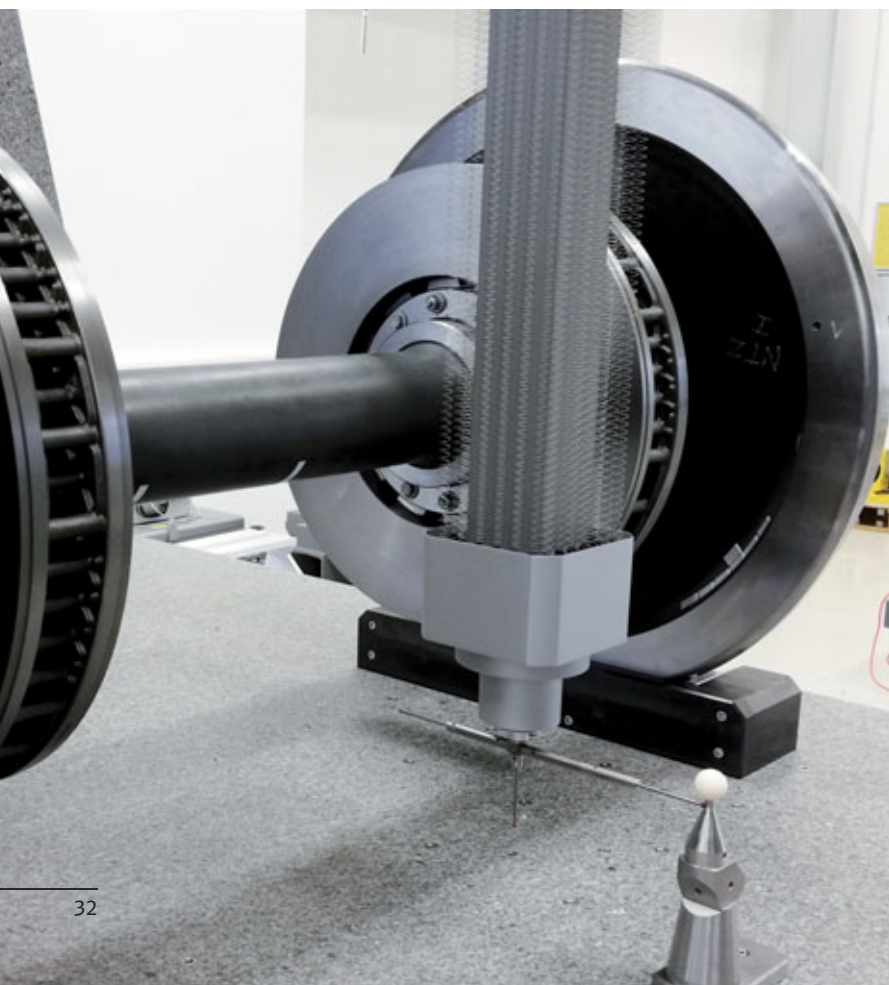


Increased mileage of the Class 612 drive module

Class 612 power cars are used in DB Regio's regional and local transport. The drive modules currently have a mileage limit of 925.000 km, corresponding to the mileage limit of the Cummins QSK 19R diesel engine installed in them.

Economic potential can be exploited by increasing the mileage of the class 612 drive module. This is why DB Regio wanted to examine and evaluate whether the current diesel engine and the drive module deployed offer potential for increasing mileage.

In accordance with the process for increasing mileage, DB Systemtechnik first assessed the safety situation. Next, three diesel engines with the current mileage limit were subjected to functional tests. Following functional testing, the diesel engines were broken down into their individual components and, together with the remaining components of the drive module, subjected to wear evaluation. DB Systemtechnik's service was rounded off by the submission of a technical assessment, including indications of risks.



Metrological testing of a new model of the **CALIPRI Wheel** series (C42 wireless)

In Chemnitz, railway components up to a volume of 3 m x 2 m x 1.6 m will be measured. The coordinate measuring machine of DB Systemtechnik checks very small form, running and bearing deviations up to the micrometer range on large, heavy and complex components in a short time. This non-contact wheel profile measuring system was subjected to a metrological suitability test. The measurement uncertainty was determined under conditions of use and matched with the requirements of workshop operation. The result of this investigation has shown that the requirements have been fulfilled and the new measuring system can now be introduced as a measuring system for wheel profile measurements at DB Cargo and DB Regio. It thus completes the range of railway-typical measuring devices (EWF measuring equipment).

Sound emissions from pantographs in high-speed trains

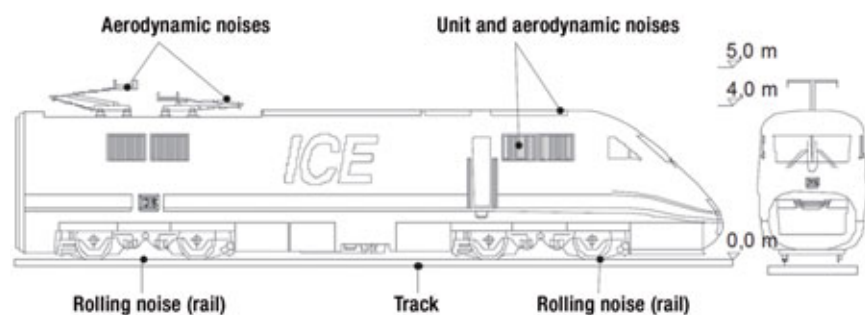


The track section between Offenburg and Riegel is to be upgraded for a maximum speed of 250 km/h as part of the new and upgraded Karlsruhe – Basel line. In this case, only long-distance passenger transport is to be regarded as relevant when considering the effects of rail traffic noise levels on residents. Local public interest groups are expressing reservations about the project because of allegedly increased noise pollution.

Among other things, it is argued that pantographs are the main sources of noise from long-distance trains and that the use of modern pantographs or a speed reduction can reduce noise pollution, in particular by reducing aerodynamic noise. DB Systemtechnik's Acoustics department was commissioned by DB Netz to identify all the relevant facts. By evaluating the results of acoustic measurements, the experts showed that rolling noise is the dominant noise source in the speed range from approx. 50 km/h to 250 km/h.

The influence of aerodynamic noise is marginal. This means that merely improving the acoustic properties of a pantograph in this speed range has no influence on the level of the total noise.

a lower speed would also result in reduced active noise control. Supporting arguments are provided by the results of acoustic measurements on the ICE 1 and ICE 3 regarding the influence of



The decrease in overall noise when speed is reduced from 250 km/h to 200 km/h is due solely to the reduced rolling noise. If the rolling noise is additionally reduced by the use of active noise control measures, the share of aerodynamic noise in the overall noise tends to increase. However, since speed is also an input variable for the scale of required active noise control measures,

pantograph noise on the total noise at 250 km/h and the results of the "son-RAIL" online calculation tool, which show the acoustic effect of reducing speed from 250 km/h to 200 km/h at different sound source heights. The examination provided enables the customer to better respond to objections to the planned measure based on pantograph noise.



Functional testing of a **switch system** in the climatic chamber

In the past, there have repeatedly been weather-related malfunctions of switches in winter. On behalf of DB Netz, tests and functional tests were therefore performed under documented and reproducible conditions in DB Systemtechnik's climatic chamber in Minden. The tests serve to ensure the basic function of the switch system.

The switch was equipped with temperature measuring points and subjected to various tests at temperatures between -20°C and 0°C. The functionality was also tested under exposure to snow and ice.

The functional tests carried out in the climatic chamber produced a data basis for the systematic analysis of weather-related malfunctions, which DB Netz can use for future development of measures aimed at increasing the availability of the switch functional system.

Measurement of **track decay rate** on slab tracks

To reduce the noise pollution caused by passing trains, the Nuremberg – Ingolstadt high-speed line and Allersberg station (Rothsee) were equipped with the Vossloh 300-1 rail fastening system.

The acoustic effect of the Vossloh rail fastening system can be proven by determining the track decay rate. The track decay rate describes the damping rate of the vibration amplitude of the bending waves in the rail in the longitudinal direction and provides information on the acoustic properties of a track. The lower the rate, the longer the vibrations caused by a train passing by, which indicates increased noise emissions.

DB Systemtechnik's Acoustics and Vibrations testing laboratory was commissioned by Vossloh to measure the track decay rate in accordance with DIN EN 15461:2011 in order to investigate and quantify the effect of the rail fastening system on rail damping.

For this purpose, an accelerometer was fixed to the rail and the rail was "tapped" with a pulse hammer at an increasing distance from the accelerometer. Based on the force pulse and the impulse response at the accelerometer, the transfer function was calculated for each impact position. The decay rates in each third octave band could then be determined from the transfer functions. The DB Systemtechnik service was rounded off by an accredited test report.





Approval tests for RRX using instrumented wheel sets

In 2016, DB Systemtechnik was commissioned by Siemens to perform the complete approval test of the ICx, which is now in passenger service as Deutsche Bahn's approved ICE 4. For running tests of the multiple unit, a concept was implemented which, by doubling the number of instrumented wheel sets used, enabled both the empty and loaded condition of the vehicle to be tested. A total of twelve instrumented wheel sets were successfully used, first in Germany and later also during running tests in Switzerland and Austria.

After all the running tests had been completed, the instrumented wheel sets were removed and stored by the owner.

Two of the total of eight drive/instrumented wheel sets continued to be used in 2017 and were operated as part of the running and approval tests of the multiple unit of the Rhein-Ruhr-Express (RRX). The client was again Siemens. The fact that the latest generation of DB Systemtechnik's "Type Minden" instrumented wheel sets no longer has to be modified in terms of design, enabling the series

design of the wheel sets to be used, repeatedly delivered benefits for the customer Siemens.

If, as in this case, the vehicle manufacturer adopts a platform concept, allowing instrumented wheelsets to be reused, resulting in significant cost and, above all, time savings in the approval process.

Siemens has taken advantage of these benefits within the scope of this approval project.





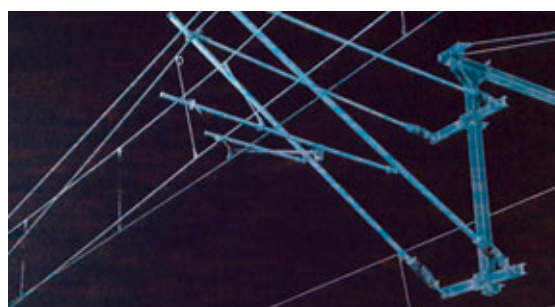
Malfunctions due to **damage to pantographs** due to hoarfrost

Particularly on the Cologne/Rhein (KRM) line, there was an increase in cases of pantograph damage to ICE-3 trains in early winter 2016/2017. These were caused by arcing on hoarfrost-covered overhead lines and resulted in major impairment to quality of operations.

DB Netz and DB Fernverkehr launched a joint project aimed at avoiding these impairments in the future and preventing similar difficulties when the new-build VDE 8.1 line goes into operation. The aim of this interface project (infrastructure/vehicle) is to reduce pantograph damage in hoarfrost situations, thereby increasing the operational reliability of the ICE fleet.

A cross-business-unit working group was formed, in which DB Systemtechnik assumed the leading and moderating function. Within the working group, the mechanisms involved were analysed and possible solutions developed. One key starting point was retrofitting the entire ICE fleet with arc-resistant contact strips; another was changing operating regulations. The team of DB Systemtechnik experts provided the persons responsible for the ICE with organisational support during field testing and carried out the accompanying operational monitoring of incidents and the systematic investigation of damaged parts.

To quantify influencing factors more precisely, an ICE-3 multiple unit was also equipped with the DB Systemtechnik arc detection measurement system and collected data in regular commercial operation during the winter of 2017/2018. Finally, a recommendation for changing regulations was derived from the understanding of the damage mechanisms, enabling fundamental and lasting improvements to be achieved in the construction of new overhead line systems in the future.





Class 407: problems with the external power supply

Since the introduction of the new ICE 407 class, which has the same wiring system concept as the class 412 vehicles, there have been a growing number of problems with the DC 670 V external power supply at the Frankfurt-Griesheim ICE depot. Some of the trains cannot be connected, as the system is automatically switched off by the intervention of various protective devices.

Components were destroyed in the rectifier system and in the on-board electrical system of some ICEs. Together with Siemens, AST and Gustav Klein, DB Systemtechnik has developed a retrofit solution for the DC 670 V external supply system in Frankfurt-Griesheim to compensate for the interaction between connected vehicles and the supplying converters. The effectiveness of this solution was proven by measurement. The compatibility of the DC 670 V external supply system is ensured for existing as well as new vehicles of the ICE fleet. This made it unnecessary to reprocur an external supply system in Frankfurt-Griesheim.

Based on the findings of the investigation to find a solution at the Frankfurt-Griesheim ICE depot, DB Systemtechnik developed a concept that prevents the interactions between different vehicles and between the vehicles and the rectifier system. This concept was documented as part of a functional statement of work for adapting other existing depots and also for the depots currently under construction or in planning that are tasked with maintaining other vehicles. The retrofit solution for the existing DC 670 V system is to be validated at the Berlin ICE depot. DB Systemtechnik is providing technical support for the implementation and acceptance of the DC 670 V converters of the new systems for the Cologne-Nippes, Hamburg Eidelstedt and Munich ICE depots.

Designated Body (DeBo) certification for Euro Loco PH 37 ACai

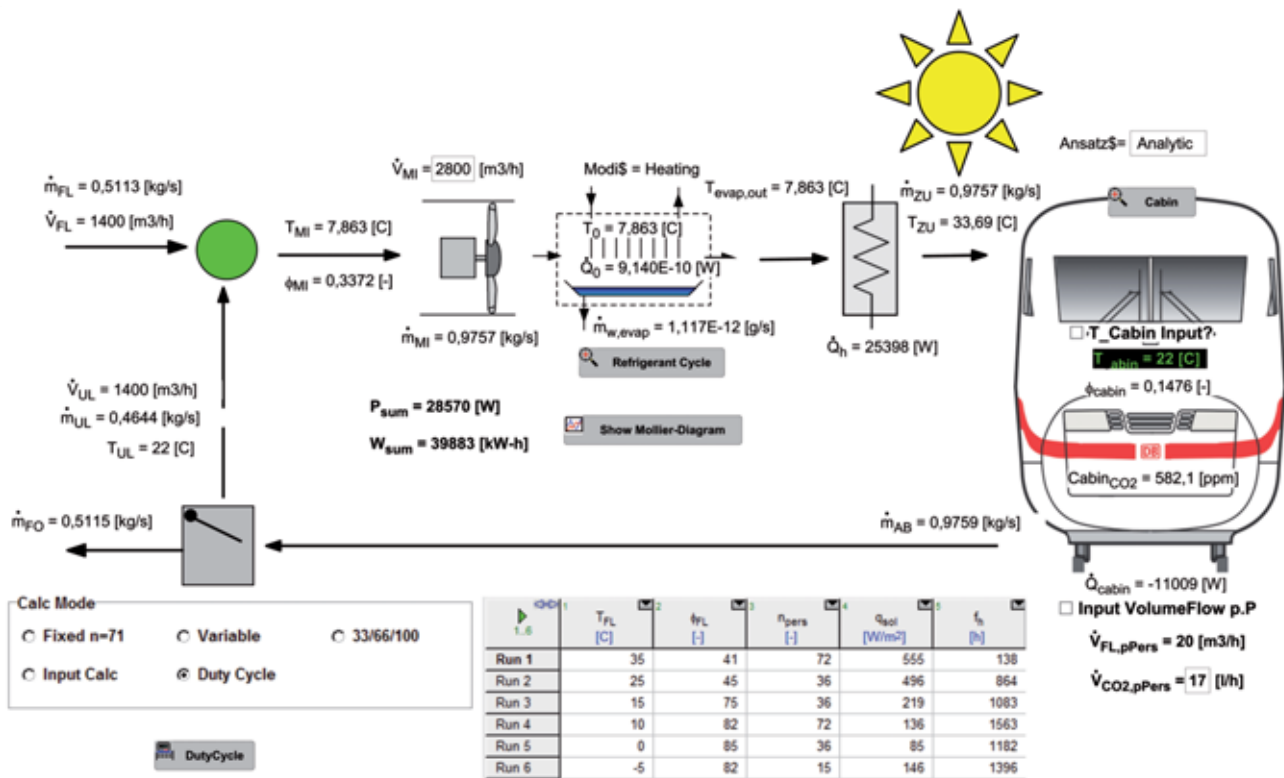
General Electric has commissioned SNC Lavalin in Great Britain to approve the new Euro Loco PH 37 ACai. This is a six-axle 2,750 kW freight locomotive with an operating speed of up to 120 km/h, which the operator, Heavy Haul Power, plans to use in Germany.



DB Systemtechnik has contributed a wide range of services to this project. First, braking and wheel-slide protection tests were performed by the braking systems test department in Austria. In addition, the Interim Designated Body issued the DB Systemtechnik inspection body with a certificate of compliance with the NNTR (Notified National Technical Rules) for Germany. For this, DB Systemtechnik provided its own expert reports and conformity assessment reports in the following areas: running equipment, braking systems, environmental protection (crosswind/aerodynamics), fire protection/evacuation and inscriptions.

These, together with seven more assessment reports, were then checked for compliance with the applicable NNTR for the project.

The manufacturer declarations and technical certificates in the four core areas for this diesel locomotive are currently being checked by the Federal Railway Authority as part of the approval procedure. This is the final step before authorisation to put the locomotive into service can be granted.



Energy-saving potential for air-conditioning systems

To optimise energy management in vehicles, DB Systemtechnik carried out a study in which multiple disciplines were examined. The result showed increased savings potential for air-conditioning systems.

Based on this study, DB Fernverkehr commissioned DB Systemtechnik to further delimit the energy-saving potential of an occupancy-dependent fresh air supply and free cooling for the use in a selected class. In addition, the cost effectiveness of a possible technical implementation was to be examined based on an indicative offer. To perform realistic calculations, DB Systemtechnik first conducted a document review of the air-conditioning systems and calculated the annual energy consumption of the class in question using the DC 2013 ("Duty Cycle 2013") energy consumption cycle developed by DB Systemtechnik. This has now become established as a useful tool for determining the annual energy con-

sumption of rail vehicle air-conditioning systems.

These calculations using the simulation model developed by DB Systemtechnik showed potential savings of approximately 18% with a continuous, occupation-dependent fresh air supply and approximately 15% with a three-stage fresh air supply compared to an occupation-independent fresh air supply. The savings potential of free cooling was also included in the evaluation by means of further calculations and simulations.

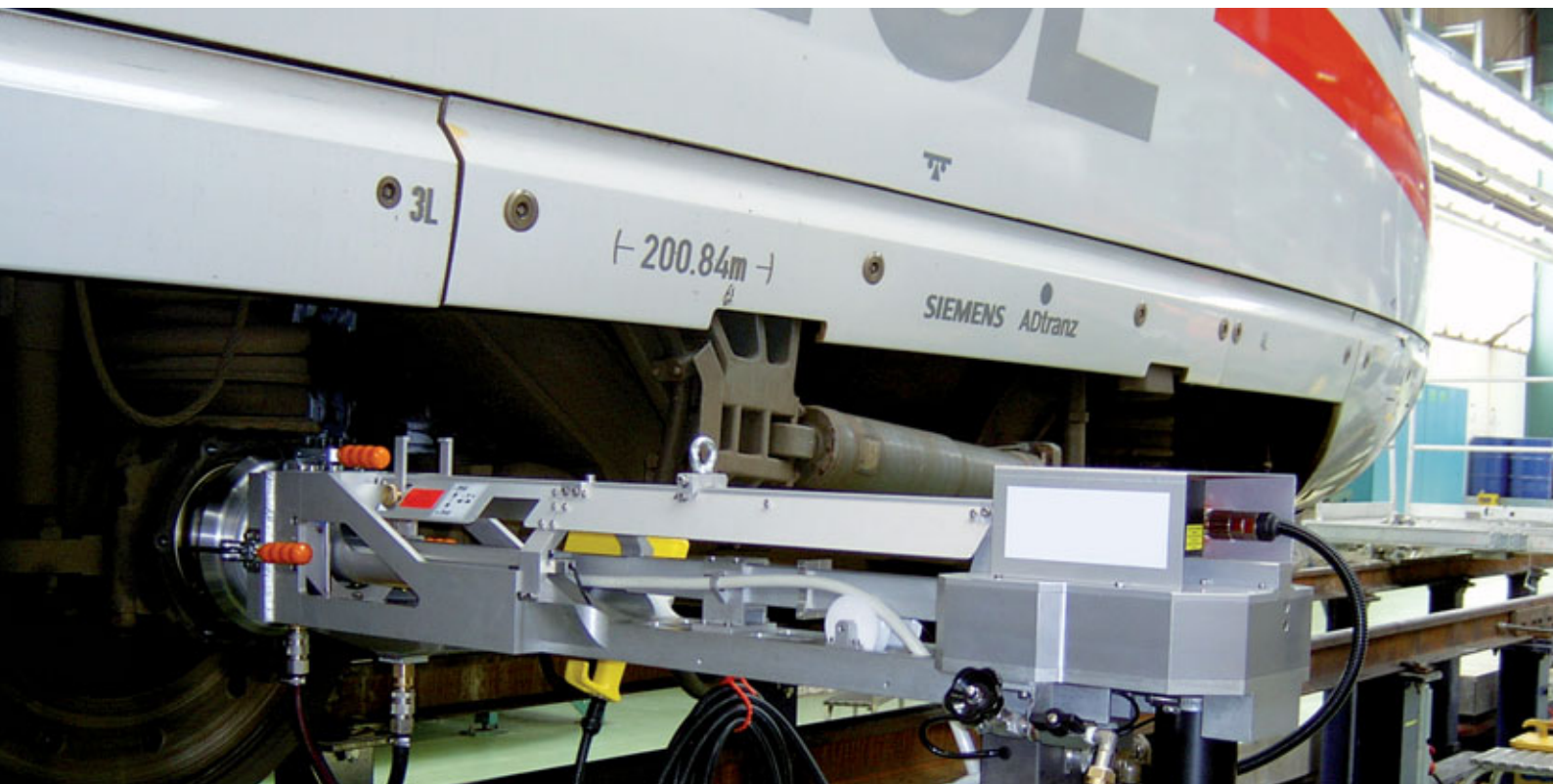
Based on total energy-saving potential of approx. 20%, an indicative offer for the implementation of the necessary technical measures was subsequently obtained, and a profitability analysis was carried out. With the calculations and cost estimates, DB Systemtechnik was able to identify reliable savings potential and make recommendations to DB Fernverkehr.

In addition, the steps recommended by DB Systemtechnik ensured feasible technical implementation, taking thermal comfort and air quality into account.

DB Systemtechnik's input therefore gives DB Fernverkehr secure economic advantages without compromising passenger comfort.

Definition: free cooling

Free cooling is possible if the outside temperature is lower than the temperature inside the car. The interior is cooled by the supply of ambient air without the air-conditioning system having to be put into operation, which saves energy. This form of cooling can be used only at lower outside temperatures. When outside temperatures are higher, the air-conditioning system must be used.



ECM certification

Conformity assessment of NDT inspection centres

To ensure the safety of national rail traffic, Entity in Charge of Maintenance (ECM) centres have been introduced in Europe. The ECM is responsible for the results of the maintenance activities it manages and requires an appropriate system to monitor them.

Non-destructive testing (NDT) is one of the safety-relevant activities performed during maintenance. This not only justifies the additional specific sectoral requirements, but also requires monitoring of the maintenance workshops where non-destructive testing is carried out.

The ECM fulfils this responsibility e.g. by temporarily authorising the NDT testing laboratories on the basis of a certificate of conformity in accordance with specified requirements for the performance of non-destructive testing on its vehicles.

The ECM either specifies its own criteria or makes use of generally accepted rules.

DB Systemtechnik has been carrying out approval procedures for workshops inside and outside DB AG since 2001, ten years before the ECM Directive was published. DB Systemtechnik offers conformity assessment of NDT testing laboratories as an inspection in accordance with the principles of DIN EN ISO/IEC 17020.

Five employees inspect maintenance workshops where non-destructive testing is regularly performed to determine whether the specified requirements are met. This statement of conformity is made in the form of an inspection certificate. Last year, DB Systemtechnik carried out around 20 inspections for internal customers and 10 inspections for external customers.





HVAC inspections prior to refurbishment of EMU Class 423



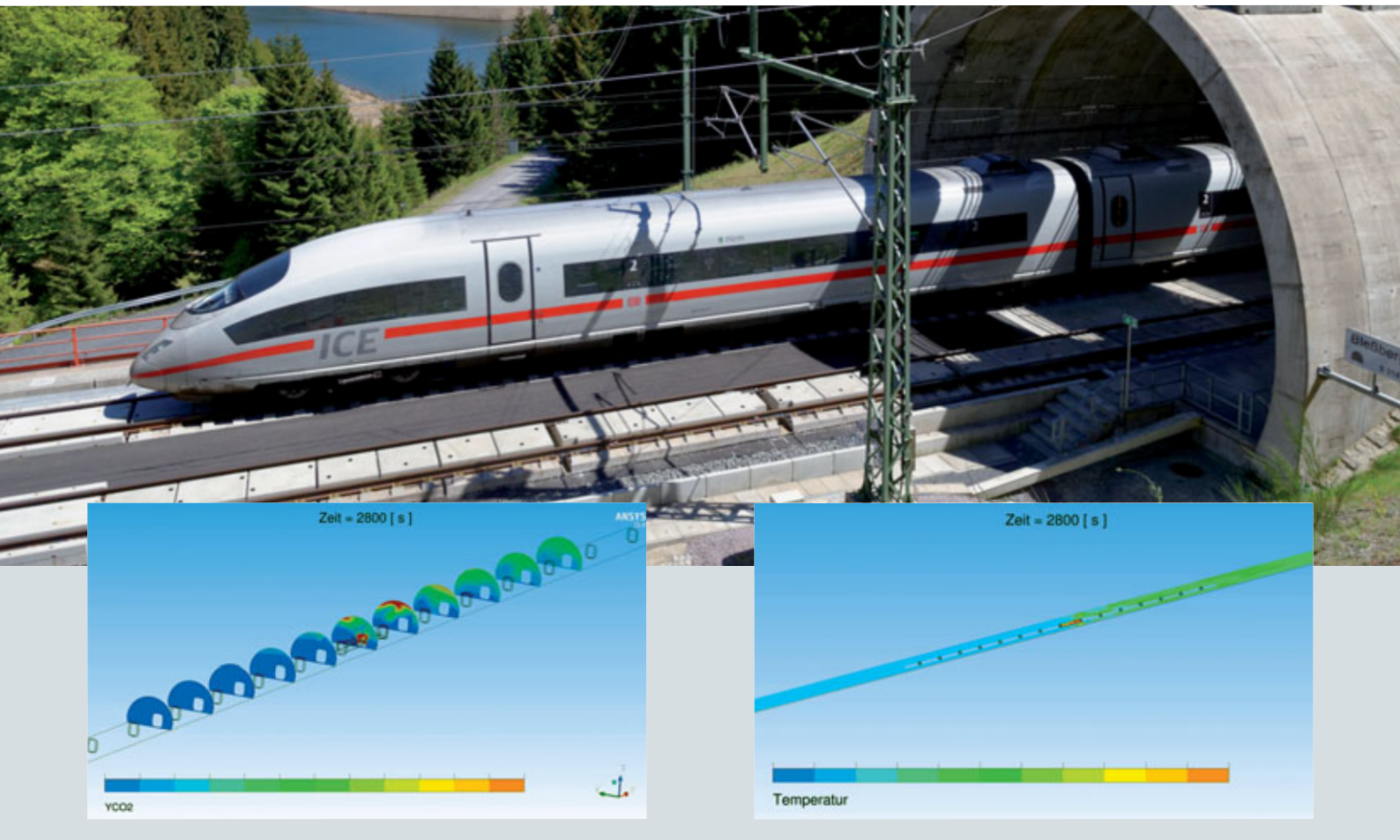
As part of the planned refurbishment of the multiple units class 423 of the Munich S-Bahn and the associated conversion measures, DB Systemtechnik was tasked with performing HVAC inspections. The plan was to use the results and CFD simulations running in parallel to evaluate the influence of the conversion on thermal comfort. This had to be ensured even after the conversion. Furthermore, negative effects of the conversion on passenger comfort were to be recognised and eliminated in advance.

In this project, DB Systemtechnik's HVAC specialists carried out measurements on an unmodified end car during cooling and heating operation. The actual values for air temperature and air speed in the pas-

senger area were determined and critical points relating to thermal comfort were identified.

In addition, a CFD simulation of the interior for the current state and for the newly planned design was created based on the measurement data. Comparing the measurements with the CFD simulation enabled the simulation results to be validated. To ensure thermal comfort, the experts proposed new air vents and analysed their influence on comfort.

The analysis and optimisation of the interior design was used to minimise the risk of subsequent changes ensure thermal comfort for passengers even before conversion work began.

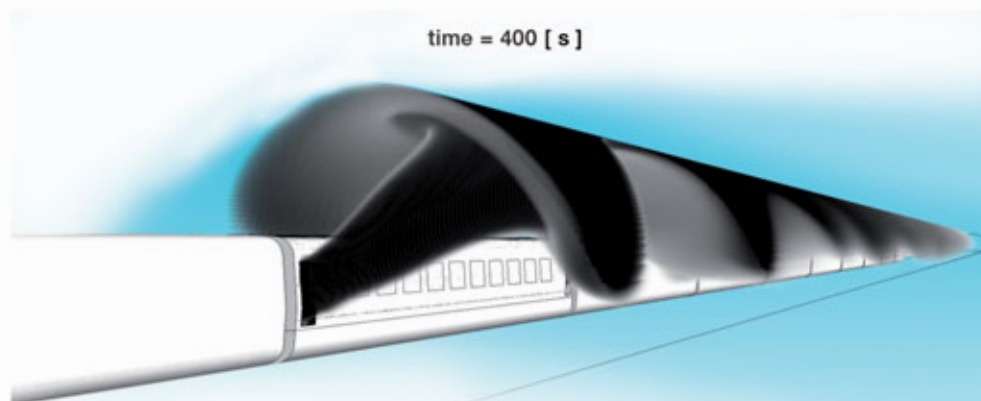


Smoke gas simulations for the new-build line VDE 8.1

In the procedure for changing plans for the VDE 8.1 new-build line, an "expert opinion on the propagation of smoke gases in tunnels taking into account the geographical conditions" was required. This should support the local fire brigades in determining their tactics in the event of a fire. DB Systemtechnik, in close cooperation with the Ministry of the Interior of Thuringia and the local Bavarian fire brigades, coordinated suitable

basic conditions and used these to carry out simulations in line with requirements. The results present local temperatures, optical smoke densities and CO₂ distributions in the area around the burning vehicle as a function of time. Based on these simulation results, it is now possible to precisely determine the firefighting tactics.

This includes statements on access to the seat of the fire through lateral rescue air locks and on the need for respiratory protection equipment. With the assumed basic conditions, the results can also be applied to other tunnels on the VDE 8.1 line.



ESG Rail
reference projects
2017/2018

Photo: Arriva



Conversion for **Arriva Train Wales**

A wagon of a two-car class 150 multiple unit of Arriva Trains Wales was damaged in an accident. To continue using the undamaged car while the defective car was being repaired, it was planned to integrate the former into another, two-car multiple unit as quickly as possible, thus putting together a usable three-part vehicle. Once the repair had been completed, it was intended to return the car to its original train.

ESG was commissioned to determine the amount of work required for the conversion. Two options were examined: putting the undamaged car (donor vehicle) between the vehicles of the two-car train or using as an end wagon. It was decided to use the first option, as this enabled all the necessary work steps to be carried out on the donor vehicle while keeping the multiple unit in operation. Another problem was the long delivery time for the required couplers.



The fastest possible solution was therefore to remove the rod coupler and the coupler head from the damaged carriage. These were installed by ESG Rail in the converted train. After the damaged car had been repaired, both trains were returned to their original configuration.

Services provided by ESG Rail:

- Expert opinion on vehicle and meetings with suppliers
- Technical inspection of the rod coupler with dye penetrant inspection to confirm the suitability of the existing coupler for continued use
- Creation of the conversion and inspection instructions
- Delivery of all materials for installation and assembly, except for coupler and coupler head
- Setting up and dismantling the three-car multiple unit as well as putting all vehicles back into their original trains
- Conformity certification for acquiring the operating license was performed by Railway Approvals Ltd., a sister company of ESG.



Turnkey delivery of **CCTV systems**

ESG Rail received an order from the British railway operator London Midland to supply various video surveillance systems (CCTV).



- Video system for monitoring the line in 26 class 323 and 40 class 350 vehicles
- Interior video monitoring for the class 323 units
- Video monitoring of the pantograph using a camera on the roof of a class 350/1 vehicle

The scope of the order included the following partial services: design, draft, procurement, installation, testing and commissioning of the systems. ESG was also responsible for approval of the systems and training of the operating and maintenance personnel. During the three-year operation of the systems, provision of the measurement data is ensured by WiFi connections.

In cooperation with Icomera, the supplier of the CCTV and the cameras, the project was completed during 2017.

Automatic and selective door control for Porterbrook Leasing

The rail vehicle leasing company Porterbrook Leasing operates class 458 vehicles with the Automatic Selective Door Operation (ASDO) system.



Since these five-car units often had to be operated as ten-car units to improve peak capacity, and some stations were unable to accommodate longer trains, they require a selective door control system to prevent doors from opening that do not stop at the platform. The system was based on the use of track-side beacons that are installed along the railway line and specify which doors may open at the individual stations.

As the fleet was to be deployed in an alternative network and under a new operator, ESG was asked to carry out a technical evaluation of the system. This evaluation included different approaches: the use of the current system, the use of an alternative with GPS function or a combination of the two solutions. This called for considerations regarding not only the condition of the vehicle, but also the possibility of providing additional technical equipment for the infrastructure. The evaluation included technical solutions as well as an overall assessment of the project.

Trade fairs
and activities



DB Systemtechnik
at the TRAKO
trade fair in Gdańsk



DB Systemtechnik showcased its full range of services at one of eastern Europe's largest trade fairs, as part of a joint stand for the states of Berlin and Brandenburg. Four colleagues presented a variety of products and services to a large number of visitors, with the focus on approval management and measurement instruments for overhead line and track geometry.

Acoustics day 2018
in Munich

In May 2018, DB Systemtechnik held its acoustics seminar for the fifth time at its site in Munich. Over 70 participants from various Bahn organisations gained insights into technical principles, the state of the art and the latest developments in acoustics and vibration.



Photos: DB Systemtechnik, Klaus Kleske, Matthias Stangl

2nd aerodynamics day

On 24 April 2018, aerodynamic specialists from DB Systemtechnik hosted the aerodynamics day in Munich. Over 35 participants took the opportunity to discuss and find out more about aerodynamic-related topics, as well as to network. The event provided a wide range of interesting topics, with presentations about crosswinds on the Filstal bridge, the special requirements for emergency exit doors in tunnels, the high-speed rail project between Gothenburg and Boras, and aerodynamic aspects of pantographs.



6th internal HVAC day

Almost 50 participants took part in the 6th HVAC day in Minden in March 2018. Speakers from across Deutsche Bahn gave a total of eight presentations on HVAC-related topics in areas like the environment, strategy, vehicles and operations. The wide spectrum of topics ranged from interim solutions and long-term measures for dealing with current coolant problems to HVAC activities in vehicle conversion projects and new methods for maintaining air conditioning systems.



Wheelset day in Minden

In October 2017, the wheelset team invited technical contact persons from all Deutsche Bahn organisations to a wheelset information day in Minden. 55 participants attended and experienced a wide-ranging programme. The event included ten presentations and a tour of the laboratories and test benches, impressively showcasing DB Systemtechnik's range of services.



Photos: Christoph Baumann, Thomas Kwitschinski, Grafik: DB Systemtechnik

DB Systemtechnik customer day in October 2017



Almost 150 guests attended the DB Systemtechnik customer day in Munich. The event began on the evening of 16 October with a joint visit to the museum of the Munich transport association.

The second day consisted of technical workshops on topics ranging from energy savings as a competitive advantage and vehicle modernisation to the reforms of the fourth railway package in vehicle approval.

IT-Trans in Karlsruhe

On 6 March, DB Systemtechnik joined DB Engineering & Consulting to showcase its services at IT-Trans in Karlsruhe, the leading conference for IT solutions in the rail vehicle sector. The focus was on diagnostic solutions for predictive maintenance.



Meeting in Kirchmöser: **VDV committee** Depots and Maintenance Facilities

On 19 and 20 April 2018, DB Systemtechnik hosted the 128th meeting of the VDV “Depots and Maintenance Facilities” committee in Kirchmöser. Representatives from various transport companies (including BVG, MVV, Hamburger Hochbahn, SSB and the transport operators of Leipzig and Vienna) joined the VDV and DB Systemtechnik to discuss the latest developments in bus and rail vehicle maintenance in local public transport and regional and local rail passenger transport. For DB Systemtechnik, the meeting was a good opportunity to present its range of services for metro and tram vehicles.



Cooperation between DB Systemtechnik – RTRI Japan

As part of the long-lasting collaboration between DB Systemtechnik and the Japanese rail research institute RTRI, a workshop was held with Japanese specialists in Minden in September 2017. The workshop focused on winter-related problems in braking. The event was attended by 16 representatives of the Japanese rail sector, as well as participants from German industry. The workshop featured highly technical presentations, which led to intensive discussions. As a result, the event was judged a major success by all who attended.



25 years of cooperation JR East and DB AG

In September 2017, Deutsche Bahn (DB) and the Japanese rail company East Japan Railway Company (JR East) celebrated 25 years of cooperation. Over the course of an entire week, over a hundred experts and managers discussed the latest developments and issues in the sector.

The event concluded with a celebration attended by Dr. Richard Lutz, Chairman of the Management Board of Deutsche Bahn, and his Japanese counterpart Masaki Ogata, Vice Chairman of JR East. Ever since the cooperation began at the start of the 1990s, staff from DB Systemtechnik have taken part in the annual expert conferences.

Here, delegates discuss issues like vehicle engineering, infrastructure, control and command technology, safety, digitalisation, station development and marketing.

DB Systemtechnik:
Our products
Your contacts

Testing

The 250 employees of the Business Line Testing support you with their comprehensive knowledge of systems, suitable test methods and tools, along with well-founded technical trial expertise.

Testing

- Vehicles
- Infrastructure
- Components

Approval

- Vehicle approval
- European requirements (TSI certifications NoBo)
- National requirements (DeBo)
- Partial releases for infrastructure
- Expert opinions
- Safety-critical changes (AsBo)

Measurement technology

- Sale of measurement and diagnostics systems

Engineering

With a total of 350 employees at various locations the Business Line Engineering support you in all topics of construction, engineering and digitization for vehicles and components.

Engineering design

- Design support:
 - New and existing vehicles & components
- Conversion and redesign
- Damage and accident refurbishment

Engineering

- Supervision of production assets
- Fleet management
- Procurement accompaniment
- Supplier/product qualification
- Conducting studies & expert reports
- Operating regulations
- Representation on committees
- IT use & diagnostics
- Accident and damage analysis
- Assessment of financial benefit (RAMS, LCC)

Maintenance systems

Our 150 employees of the Business Line Maintenance Technology are pleased to advise and support you in all engineering services for design, construction and optimization of all maintenance system elements in the field of railway technology and infrastructure.

Maintenance systems

- Development and supervision of maintenance concepts
- Condition-based maintenance
- Works planning and intra-plant logistics
- Testing and diagnostics equipment
- Non-destructive testing
- Metrology/calibration technology
- Materials engineering
- Welding and adhesive bonding

Consulting

DB Systemtechnik is the only provider of consulting services to be born of an overarching rail operator. We analyse your problems and design solutions just for you within the rail system as a whole, covering areas such as rolling stock, components and infrastructure. In doing so, we always keep your economic success in mind and have a laser-like focus on the financial aspects of the overall rail system.

System consulting

- Strategy and controlling
- Qualification
- Quality and management
- Environmental dimension
- General system issues
- Operations planning and implementation

Technical consulting

- Optimisation of the entire life cycle of rolling stock and components
- Procurement of rolling stock
- Vehicle maintenance
- Workshops

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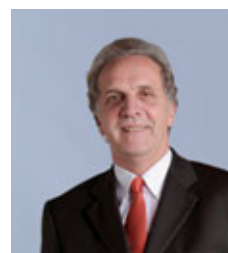
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Errors and omissions excepted

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