



DB Systemtechnik

Activity Report

2014/2015

Engineering expertise

Service quality

Innovation capability

Internationality

Neutrality

For people. For markets. For tomorrow.



Hans Peter Lang
Chief Executive Officer

The rail sector needs a
competent and impartial partner
 established throughout Europe.

The rail transport markets in Europe are opening up with widely differing levels of liberalisation. Both rail operations and procurement are becoming increasingly international processes. The separation of the roles of operators that were formerly integrated (keepers, maintainers and operators) is increasing the number of players in the market and resulting in new interfaces in the value chain. In order to cope with the increasing complexity, it is necessary to understand the rail system.

DB Systemtechnik is facing these challenges and offers a complete range of engineering and testing services for the European railway market.

For this purpose DB Systemtechnik offers tailor-made services for vehicles, their components, infrastructure and interfaces. For a year now we have also been actively offering our services to customers from the underground and tram market and will continue to consolidate these activities in future.

As has been customary for many years, in this performance report we would like to give you a brief overview of the activities that we have been carrying out for our customers within the DB Group, as well as for external customers in Germany or worldwide.



Contents
Activity Report
2014/2015

Content

01	Foreword by Hans Peter Lang
03	General introduction: The requirements of the railway both today and in the future
09	Approval of the Velaro Eurostar
12	Approval of the new-build line VDE 8.2
15	Optimised air-conditioning system for ICE 2
18	Essay: Committee work – building the basis
20	Products and know-how
23	Selected references
37	References of the ESG in England
40	Human resources report
46	Fairs and activities
48	Contacts

The requirements of the railway arising from **the market, operations and technology: today and in the future**

The general conditions of rail transport today are characterised by competition in every element of the rail industry.

In the German market, manufacturers are increasingly facing new competitors, some from Europe, but a growing number from Asia. It is only a matter of time before Chinese manufacturers enter the German market, equipped with European expertise gained from joint ventures. This trend will be boosted by the fact that the greatest barrier to market entry from the viewpoint of foreign manufacturers – the German approvals system – has lost much of its fear value due to reforms in recent years.

This competition will also have an effect on collaboration in the rail sector. The time has long since passed, when one major operator such as Deutsche Bahn AG effectively advanced the development and design of the rail system on behalf of everyone. On the one hand, a company in competition cannot afford to do this alone and, on the other hand, there are no opportunities for implementation, nor any authorisation for forcing through decisions even against the individual interests of other partners. Yet now of all times, this organising force, this common voice of the sector, is missing.

Unfair framework conditions for rail transport, such as the reduction in road tolls for lorries, toll-free travel for long-distance buses and high expenditure on energy are compromising the economy, while tough demands for safety cases are restricting flexibility, leading to expensive solutions for production in Germany and making international use of production resources more difficult.



A toll-free advantage:
the growing competition from
long-distance bus travel

Not even the latest technology is a substitute for political lobbying and entrepreneurial courage – in the development of one's own business model.

And even when introducing innovations, the sector is making things difficult for itself at present. It is therefore extremely important to win over and retain customers by means of new products. Here too, the necessary trials represent a significant barrier to a swift market launch. It does matter whether it is the cost of approving prototypes, or simply the high expense of organising tests which are, however, necessary from day one in order to bring new solutions reliably onto the rails.

No matter how variable the general conditions for each partner in the rail sector, e.g. for manufacturer and operator, the challenges are comparable. The following questions must be asked, however:

- How can costs be reduced?
- How is it possible to raise the quality of service provided at the same time as improving customer satisfaction?
- How will the respective business model stand up to future demands?
- How can innovations be brought quickly onto the market, offering functional reliability, yet avoiding bureaucratic hurdles?

and finally:

- How does one handle the general conditions that are difficult when compared with those of other modes of transport?
- How is the further development of the rail system organised?

Technology cannot deliver a decisive contribution for every challenge. Nevertheless, especially in the field of conflict between cost reduction, quality improvement and speed of implementation, technology can make a lasting contribution.

Four hypotheses attempt to answer these questions:

1. Cost reduction and quality improvement due to new forms of maintenance

Lower costs and improved quality are not a contradiction in terms. Both can be achieved without compromise by means of new maintenance procedures and processes – the technology necessary for this is already available. Needless to say, maintenance costs have long since been identified as an essential lever for reducing overall costs. This applies not only to the vehicle sector, but also to the infrastructure.

For conventional forms of developing maintenance programmes, such as extending the intervals, standardised methods and specifications exist for the creation of safety cases. The disadvantages of these conventional procedures are the large amount of time required, and also the challenge of developing components, if the extended intervals have reached the limits of the experience-based possibilities of the relevant components.

Modern vehicles, and also the infrastructure components, now have a host of diagnostic functions and it is obvious that this information should be used in an initial step for status monitoring and then for status-oriented maintenance.

Photo Credits: DB AG/Kai Michael Neuhoff



The information obtained and its practice-oriented processing describe the status of the fleet, using early indications of the impending loss of functions, and thus forms the basis for the prompt repair of defects. In this way the technical properties of the production resources can be used to maximum effect and the reliability increased. The step from monitoring to a consistent status-oriented maintenance, however, calls for a willingness among maintenance personnel to embrace change. This is the reason why in Great Britain, for example, monitoring systems are already widely used for existing vehicles, although the great potential of a consistent use of predictive maintenance has not been raised here, especially in the case of existing vehicles.

In this context it also makes sense to consider new forms of data and information exchange. If a series of 600 units is in service with a large number of operators, should not the information about the status and operational reliability then be shared? Is it not reasonable that even the largest operators, with 200 vehicles for example, should receive information about the operational behaviour of the entire fleet? And would this not reduce the cost of monitoring for every operator? Of course, there is sensitive information about which special confidentiality agreements can be reached.

And does it not also make sense to organise this monitoring on a cross-manufacturer basis, in order to permit best-practice solutions for the further development of the fleet?

DB Systemtechnik is working with partners on systems that can be implemented in existing vehicles, and on attractive business models for operators and suppliers. Together with partners, we will equip the first vehicles and openly put the benefits of the new procedures to the test.

Using diagnostics of a modern status monitoring system for status-oriented maintenance

2. Redesign and modernisation

In recent years, vehicle fleets have been noticeably modernised, particularly in the local transport sector. The greater attractiveness of shorter and fixed timetable intervals with the help of new vehicles is a key reason for the rising numbers of passengers.

Even vehicles purchased in the late 1990s are by no means nearing the end of their useful life. But to be able to continue offering attractive transport services, in order to meet the demands of the travelling public, especially in terms of passenger information services and communications technology, and in order to achieve more economical use through technical innovations in traction and control systems, refurbishment and technical upgrading is necessary. Even vehicles in use for more than 30 years can be upgraded for additional years of service. In this respect it is essential, in particular, to check the supporting structures that are subject to high dynamic loads for fatigue and corrosion damage.

The essential prerequisites for an efficient overhaul and refurbishment of existing vehicle stock are, on the one hand, good documentation of vehicle construction and the approval documents as a basis for the conversion and, on the other hand, the intelligent handling of approval requirements, in order to limit the expense to what is necessary.

Railway requirements
arising from

Market

Operations

Technology

today

and tomorrow

In questions concerning corrosion repair too, a sense of proportion is demanded. What level of repair is necessary for the remaining life of the vehicle and what expensive renovation work can, if necessary, be replaced for a limited period by additional maintenance work, e.g. regular checking for cracks?

It is precisely such questions that DB Systemtechnik has specialised in answering in recent years, offering solutions even for difficult general conditions.

Examination of installations by means of 3D scanning and practice-oriented conversions tailored to the specific conditions of use are an essential focus of our work. The use of the latest technology, such as 3D scanners of the installation space, is rendering the time-consuming conventional documentation obsolete, enabling some vehicle conversions to become economical again.

Photo Credits: DB Systemtechnik



3. Innovations

The public view is that our sector is not particularly innovative. In times of rapidly changing customer requirements, tougher noise-abatement legislation and increasing pressure to remain competitive, the introduction of technical innovations is the order of the day. It is essential to note here that, due to the long service life of the production resources, railway technology cannot be developed exclusively by means of new purchases. Refurbishments and redesigns are an essential aid to innovation.

This means the development of railway technology in future will take place primarily through innovation of components and subsystems – for which the necessary conditions must be met.

Until now, the main thing standing in the way of this was the requirement that approval-relevant changes are to be performed on the basis of the latest regulations, and the uncertainty of whether any additional requirements extended far beyond the actual changes to the existing stock. Due to the amendments to the German approval process, this situation has undergone positive changes. Fundamental innovations with reasonable approval costs are now also possible: the conversion of diesel locomotives or multiple units to hybrid technology, the retrofitting of air-conditioning systems with alternative coolants or the conversion of electrical drive systems from GTO to modern IGBT technology are all possible. We are currently working on all of these projects.

IGBT is an insulated gate bipolar transistor. It combines excellent throughput characteristics, a high operating voltage, robustness and almost zero-power control.



If the development of rail technology is now to be determined by the components and subsystems, then the conditions for pre-testing of this new technology must be established in trial platforms. An intensive pre-testing of new technology is absolutely necessary in order to reliably prevent innovation becoming an operational risk to an entire fleet – of which there are already sufficient examples. The formal expenditure on operational approval for the testing must take into consideration the actual purpose. It must not be the case that the expense for the approval of a time-limited trial corresponds with that of a series approval, especially as trial platforms are often not identical to the type of the future series. In our judgement, the new approval process provides the necessary freedom in this respect. The manufacturer of an innovative subsystem still requires a trial platform, for a limited period and with a clear obligation to restore its original status after the trial period.

DB Systemtechnik has therefore assumed the duty of accompanying and supporting manufacturers of innovative subsystems and components:

in the selection and preparation of suitable trial platforms, in the cost accounting for conversion and approval, in the installation design, the trial itself, and finally the restoration of the original condition.

4. New forms of collaboration in the sector

The liberalisation of rail transport has led to the individual partners focussing on their own best interests in the role-play. Even Deutsche Bahn can no longer perform its role of all-embracing creator of the rail system; it lacks the authorisation to make regulations and, more importantly, to implement them.

And so we see that it is becoming increasingly difficult to meet challenges, in particular at the interface between infrastructure and vehicle. Especially when either the representatives of the infrastructure or the vehicle operators have to accept not inconsiderable costs. All representatives of our rail sector must have a shared interest in operating an efficient rail system that meets the requirements of safety and economy in equal measure. Only then can the railways withstand sustained competition from other modes of transport.

All of these represent challenges for a rail system of the future. Success will only come if the challenges are faced together with a competent partner who keeps an eye on the overall system.

Project highlights

2014/2015

Photo credits: EUROTUNNEL; Illustration: DB Systemtechnik



Approval Velaro Eurostar

The moment finally arrived on 16 November 2014. At precisely 23:10, the new VELARO Eurostar train (Class 374) built by Siemens, departed from the Calais TGV station to travel through the Channel Tunnel, to emerge about 40 minutes later on the English side.



Months of preparation had already passed for project manager Nicolas Meunier and his colleagues at DB Systemtechnik, to enable this journey to be made, as well as the journeys undertaken prior to this day in Great Britain. As far back as 2013, DB Systemtechnik had been commissioned by the manufacturer Siemens to look after the approval of the train in Belgium, the Netherlands, in the Channel Tunnel and on High Speed 1 (HS1) in Great Britain. Even at that time, with support from Belgorail, which is responsible for the operational processing of the journeys in Belgium, measurement runs for the braking and pantograph technology were taking place.

The Eurostar takes just 21 minutes to travel from Ashford, the British border control point, to Calais Fréthun. In 2014 approximately 10.4 million passengers used the Eurotunnel.

Selected project highlights

Photo credits: EUROTUNNEL, DB Systemtechnik



"I had to attend more than 30 meetings, before we were finally able to run the train in the Channel Tunnel and on HS 1 in England", says project manager Nicolas Meunier, emphasising the number of parties involved who had to be brought together in one place before things could really take off.

Siemens, Eurostar, Eurotunnel, French and British authorities, DB Schenker UK, Network Rail High Speed and SNCF: they all had to play their part in order for the trial runs to take place.

Things became just as international on the train itself and in some cases there were ten different nationalities on board. After much wrangling and countless iterations, the approval for carrying out the measurement runs on HS1 was finally issued by the operator, Network Rail High Speed, in early November 2014. This set the course for the scheduled performance of the measurement runs. DB Systemtechnik was represented by its pantograph test team and two train drivers who had previously received special training for HS1. DB Schenker Rail (UK) acted as the rail transport company. Nicolas Edwards, manager of the train drivers at DB Schenker and manager of the "Royal Train" acted as head of testing.

Also on board were two experienced traction inspectors from Eurostar whose special knowledge of the route provided valuable support to the project team when planning and executing the measurement runs.



Over three nights, high speed test runs at between 80 km/h and 230 km/h took place between the Dollands Moor marshalling yards at the English end of the Channel Tunnel and Lenham, which is located about 30 kilometres away. Although the train had already covered several thousands of kilometres at high speed in France and Belgium, a number of functional and braking tests had to be performed in order to convince Network Rail High Speed that the speed could be raised without any danger. Once this had been done, the train was able to travel the entire HS1 route to London Stratford at a speed of 230 km/h.



The last third of the line totalling 110 kilometres passes through two single-line tunnels of around 10 kilometres in length, which place particular demands on the aerodynamics of the pantographs due to their very small

The particular challenge here was the transfer of the 17 person measuring team that finished its shift at 5:00 am and had to be back in the train on the French side at 6:30 pm. Travelling by ferry would have taken too long and using the Eurotunnel shuttle trains without a car is theoretically not possible.



cross-sections. Following the measurement run, the train was towed from London by four Eurotunnel diesel locomotives ("Krupps") to the Calais Fréthun stabling facilities on the French side of the tunnel. The crowning event of the week was then the first full journey through the tunnel.

Thanks to the extraordinary helpfulness of EUROTUNNEL, however, it was possible to transport the entire team by minibus on the shuttle to the other side of the Channel within three hours. Arriving punctually at 6:30 pm, there was time for all the preparations to be made. Colleagues from the SNCF AEF Test Centre, who were responsible for the operations on the French side, also turned up. The measurement run itself was very successful and all the necessary measurement data on the pantographs and TVM 430+ train protection systems could be recorded. The pressure on our pantograph testing laboratory was particularly great, because the tunnel operator had only made the channel tunnel available for one measurement run in each direction. The return run through the tunnel took place two weeks later. In the meantime, further pantograph test runs at 300 km/h and one run into the London St. Pancras terminal took place.

This successfully closed another chapter on the activities of DB Systemtechnik in respect of the Velaro Eurostar.

Photo credits: DB Systemtechnik



Approval of the new-build line VDE 8.2 Erfurt – Leipzig/Halle

The new high-speed line (NBS) between Erfurt and Leipzig/Halle is designed as a double-track electrified railway line for high-grade passenger and freight transport. The approval and acceptance of the new high-speed line requires that testing and recording, drawn up by DB Systemtechnik, be carried out on the basis of standards and guidelines.

Running technology

The "partial release" of the track superstructure on the basis of DB Directive 820 is being performed with the aid of the ICE S. For this purpose, it is equipped with four measuring wheelsets (two in the power car, two in the intermediate car). In addition, a large number of accelerometers mounted on the bodyshell, bogies and wheelsets provide information on vibration response.

Key facts about the new high-speed line

Overall length	123 km
Tunnels	3 with a total length of 15.4 km
Viaducts	6 with a total length of 14.4 km
Maximum speed	Designed for 300 km/h



On behalf of DB Projektbau, extensive measurement runs at up to 330 km/h were performed with the ICE S in September 2014 and in April/May 2015. This HSR measurement train operated by DB Systemtechnik, which acts as a reference vehicle for the ICE and IC trainsets, consists of two ICE 2 series power cars and two intermediate cars with ICE 3 bogies.

The instrumented wheelsets record the forces transmitted through the wheel to the rail. As the running characteristics of the vehicles are known (reference), the measured vehicle reactions allow conclusions to be drawn regarding possible irregularities in the track superstructure. When approving new routes, as in this case, the measurement runs are performed with a safety margin of 10%. In other words, the maximum speed during the test was 330 km/h. This was achieved by gradually stepping up from a starting speed of 160 km/h. The runs took place on both directions of the double tracks.



Overhead lines

Tests were also performed to determine the interaction of pantographs and overhead lines, with the following objectives:

- Verification of the correct design of the overhead line by means of rest position and uplift position measurements (actual/target comparison)
- To record the quality of the dynamic interaction between pantograph and overhead line according to TSI by means of contact force measurements at up to $V_{\max} = 300$ km/h using the ICE S short train (four-section) with one lifted pantograph and measurement of the contact wire uplift at overhead line support points
- To record TSI compliance regarding interaction of the pantograph and overhead line for EC certification of the new overhead line types on the route by means of contact force measurements at up to $V_{\max} = 300$ km/h with two retracted pantographs spaced 200 metres apart (ICE S long train, ten-section) as well as contact wire uplift measurements.

As the measurements with the ICE S took place together with the running technology tests at up to $V_{\max} = 330$ km/h, pantograph-overhead line data is also available for speeds up to 330 km/h. In addition to these measurements, the aerodynamic response of pantographs in tunnels was also examined at the above-mentioned speeds and the results were analysed and assessed alongside measurements in Austria in an international working group.

Load testing of bridges

The approval and acceptance of new bridges on a high-speed line requires corresponding testing and recording to be carried out on the basis of standards and guidelines. The necessary load testing runs with heavy ballast trains and a high-speed train were organised by DB Systemtechnik. On behalf of DB Projektbau, extensive static and dynamic measurement runs were performed with heavy freight trains in September 2014 and in May – July 2015.

- with axle loads of up to 22 metric tons and
- a gross weight per train, including locomotives, of 1,000 metric tons

at speeds of up to 100 km/h. The high-speed train passed over the structures at up to 300 km/h. DB Systemtechnik performed these runs on its own authority as a railway company.

Commissioning of tunnels

In the case of very long single-track tunnels and a solid subsurface structure, the phenomenon of micro-pressure waves (sonic boom) can occur. This situation arose for the first time in 2006 on the Nuremberg – Ingolstadt route. Following this, and under the leadership of the Aerodynamics department of DB Systemtechnik, the regulations for new tunnel structures were amended.

Selected project highlights



To minimise the micropressure waves therefore, hood structures were incorporated into the planning of new tunnels. The sound pressure levels were forecast for the noise pollution locations of these hood structures. During the measurement runs with the ICE S, the sound levels were measured near the tunnel portals and at the specified noise pollution locations near the mouths of the Bibra, Finne and Osterberg tunnels, in order to verify compliance with the sound level at the noise pollution locations previously forecast by DB Systemtechnik.

During high speed trials, the predicted aerodynamic effect of the hood structure was likewise tested. In addition, aerodynamic stresses on installations in the tunnels and the compliance with the limit values were verified. This was done by networking twelve aerodynamic measuring sections over about 30 kilometres of tunnel with the aid of the latest network technologies.

Acoustic measurements

During the planning of the Unstruttal bridge, with regard to the acoustic emissions, the bridge supplement demanded by the legislator for noise protection measures was not taken into consideration, as it was assumed that no drumming would be generated due to the construction method. In order to check this, the first informative sound measurements were taken here during the high speed trials with the ICE S.

Due to the huge dimensions of the bridge (total length of 2,668 metres) and the embankment position beyond the ends of the bridge, a standard-compliant installation of the microphones at the sides of the bridge and to the sides of a comparable "open track" reference was not immediately possible with the existing means. After various tests, using appropriate test facilities, of one reference test section and of the production of a microphone mounting for the bridge, it was possible to perform the tests properly.

ETCS/GSM-R

The new line VDE 8.2 is being equipped with the ETCS train protection and the GSM-R network is being used to transmit data between the vehicle and the line. ETCS Level 2 and 3, however, impose greater demands on the quality of the GSM-R data link that is used. Compliance with these parameters is to be verified end-to-end, using a suitable measuring system, according to the definition. This is the basis for the approval of the line. Following the measurements of the GSM-R signal (field strength) by the Radio Network Planning department of DB Netz AG, DB Systemtechnik examined the ETCS-QoS parameters.

The measurements were carried out using an ETCS-QoS measurement system from Siemens. The quality must be recorded at the line speed, so the measurements took place as part of two ICE S measuring campaigns.





Optimised air-conditioning system **for ICE 2**

As a result of high temperatures in the summer of 2010, there was an increased incidence of failure among the air-conditioning systems of the ICE 2. At times, a lack of air conditioning gave rise to very high interior temperatures in the ICE 2 trains, with the result that the health of individual passengers was detrimentally affected, trains were cancelled or had to be evacuated and the media response was correspondingly negative. As a result of these events, the Air Conditioning department of DB Systemtechnik was commissioned by DB Fernverkehr to analyse the causes of failure and initiate a project to strengthen the air-conditioning systems for ICE 2 trains.

An initial technical discussion with the manufacturers Liebherr and Siemens at the home of the ICE 2 trains in Berlin-Rummelsburg, as well as examinations of random vehicles in the depot revealed the following evidence for the failures of air-conditioning systems:

- Incorrect setting points of the high pressure switches
- Incorrect coolant volumes (in one case out of 29 vehicles examined)
- Overheated compressors
- Rotational speed coupling of compressors and condenser blowers
- Weaknesses in the software of the air-conditioning systems
- Thermal short circuit in the area of the condensers
- Reduction of the power supply in individual cases

These points of evidence were taken to work out possible upgrading measures and were subjected to an evaluation by calculation and measurement. DB Systemtechnik was able to perform both activities within a short time. In addition to these examinations on the vehicles, the diagnostic messages of all ICE 2 air-conditioning systems were subjected to a precise analysis to determine further causes of failure.

Selected project highlights

Photo credits: DB Systemtechnik



Frame with gasket

Ducting

Condenser without grating

Fasteners

On the basis of all these results, the following activities were identified for improving the reliability of air-conditioning systems:

- Reducing contamination of the condensers
- Replacing compressors
- Stronger condenser blowers
- Separating the rotational speeds of the compressor and the condenser blowers
- Condensers with internal bypass for power adaptation
- Changes to the air-conditioning system software
- Boosting the maximum operating pressure
- Reducing thermal short circuit on the condenser
- Ensuring a sufficient power supply of the air-conditioning systems

All these measures were then evaluated by experts from DB Systemtechnik, both individually and in combination, with regard to their effectiveness and their implementation in terms of deadline, technical and economic aspects.

In the first stage, verification by calculation was undertaken by two different air-conditioning system manufacturers. Some of these verifications were contradictory and referred to different operating points. Therefore, they were only conditionally comparable and suitable for use. Nevertheless, both calculation approaches confirm the basic effectiveness of the measures for stabilisation of the ICE 2 air-conditioning systems at high outside temperatures.

For further safeguarding and quantifying of the measures, therefore, investigations were carried out in a climate chamber. During this measurement campaign in the MEiKE climate chamber of DB Systemtechnik in Minden, an ICE 2 intermediate car was thoroughly examined with regard to the feasibility and effectiveness of implementing the upgrading measures.

Based on these examinations, two packages of activities were defined jointly with DB Fernverkehr, the vehicle operator, agreed and promptly implemented in the Berlin, Nuremberg and Hamburg depots.



Measurements in the MEiKE climate chamber

Short-term measures

- Basic cleaning of the power supply block on all vehicles and adaptation of the maintenance instructions
- Function check and, if necessary, replacement of the internal power supply block blowers as well as adaptation of the maintenance instructions
- Replacement of the compressors with most conspicuous defects
- Adaptation of the air-conditioning system software

Action to be taken in medium-term

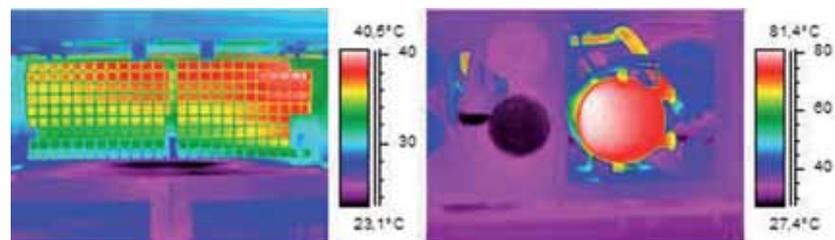
- Replacement of all compressors over ten years old
- Isolation of the speed controller from the compressor and condenser fan on the intermediate cars
- Fitting of sheet-metal ducts to reduce thermal short-circuiting at the condenser of the driving van trailer

The redesigning of the air-conditioning system makes the ICE 2 fit for several more years of service.

The short-term package of measures was fully implemented during the summer of 2011, observing the failure incidence and the availability of the ICE 2 air-conditioning systems. This measure alone achieved a significant increase in availability of the air-conditioning systems between July 2010 and August 2011. The medium-term actions were then implemented by the summer of 2013. All this led to a further increase in the availability of the air-conditioning systems.

Besides the technical improvements, operational optimisations to cope with air-conditioning system failures were implemented in the course of this project. The approach chosen by the air-conditioning experts, with its tight meshing of measurements, process simulations and engineering on one premises, formed the basis for successful upgrading of the air-conditioning systems and thus impressively demonstrates the high level of technical expertise at DB Systemtechnik.

Following completion of all measures, the function of the air-conditioning systems is stable, even in extremely high outside temperatures. Thus, performance in relation to thermal comfort will be ensured for the planned 15 years of additional ICE 2 service following the redesign.



Thermal images of condenser and compressor. As a result of wear, both components exhibited an avoidable additional heat input into the cooling circuit, which can now be ruled out by scheduled replacement of the compressors every ten years. The "thermal short-circuiting" of the condensers (right) is reduced by the new ducts.

Committee work: just an expense or the basis for the future of the railway?

Standardisation has traditionally been of outstanding importance in the rail sector. From the very start, definitions were necessary in order to permit technical compatibility of railway vehicles, their use on the respective infrastructure and their safe operation.

Development of standardisation was always marked by the technical possibilities, but also by the economic and political conditions. In the Europe of the last century, the respective state railway operators had created internal regulations that specifically represented their own technical, operational and infrastructure interests. Overriding principles regarding safety, technical and operational compatibility for international transport were drawn up within the International Union of Railways (UIC), where the fundamental research was also done.

With the advancing liberalisation of the rail markets, the rail administrations were exposed to competition, the responsibility for approvals was transferred to national (e.g. EBA) and European authorities (ERA), the rail industry was called upon to develop innovative and safe products that are economical in both technical and operational terms. The general specifications of the UIC lacked the democratic, cross-sector legitimation and the concrete solution specifications of the national railways lacked the functional character.

Technical standards also had to be created to underpin legal norms (laws, directives, regulatory provisions) of the EU and the nation states and in particular of the TSI (technical specification for interoperability) within the European standardisation organisations:

- CEN (European Committee for Standardization),
- CENELEC (European Committee for Electrotechnical Standardization),
- ETSI (European Telecommunications Standards Institute) and the
- German special interest groups DIN (German Institute for Standardisation) and
- DKE (German Commission for Electrical, Electronic and Information Technologies)

The standardisation institutes organise the creation process, lend support for the preparation, execution and follow-up to meetings, they carry out formal agreements and make the infrastructure available for the development of standards. Having formulated a standardisation application which, as a matter of principle, anyone can make, agreement is reached. In the subsequent enquiry the interested parties can call for experts to collaborate on the standard, who then create a draft (work item), which can be commented on and corrected in an enquiry. Following coordination and integration of the contents created in this way (comments resolution meeting), a decision about publication is made in a further enquiry (formal vote), so that there is always a democratic legitimation by all interested parties.

Photo credits: DB AG/Jet-Foto Kranert, DB Systemtechnik



It is generally to be noted that the amount of time and money spent on creating and coordinating a standard of sufficient quality is regularly underestimated.

DB AG has actively involved itself in this process from the start. Commissioned by the business units of DB Fernverkehr, DB Regio, DB Schenker Rail and DB Netz, the technology management group coordinates the collaboration, including that among the specialists at DB Systemtechnik, who frequently assume management functions on the national and international committees.

In this way it is possible, not only to anchor essential contents of the UIC data sheets in the standards, but also to transfer the requirements arising from the rail standards and the specifications and to have them made part of the international standard, while at the same time reducing the in-house expenditure on updating and provision. Over the last 15 years, 33 new Euro standards in the field of "Rail vehicles – Brakes" have been created in this way, three more are being prepared and a further twelve are being revised. It has therefore been possible to withdraw associated UIC data sheets and national standards, or at least condense them. They now only contain what could not be enforced in the CEN working groups. National or railway-specific peculiarities, often established by a process of historical growth, have thus been dropped or integrated so that the requirements are converging across Europe. As a result, among both operators and manufacturers, this leads to simplified invitations to bid, to greater process security, to lower risks in research and development, to shorter delivery times and thus to lower procurement and unit costs. With regard to the worldwide shipping, air freight and, above all, automotive industry, however, this European unification is still inadequate. For this reason, both the UIC and the European Standards Institute are increasingly getting involved on a global basis. In a recently established ISO working group, the first EN standards are to be applied on a worldwide basis.

In addition to these varied efforts at the level of ISO, CEN and DIN, topics relevant to approval in Germany are being handled across all sectors in the "Vehicles" steering group with its working groups and sub-groups. In many respects, this is breaking new technical ground and being set down in national technical regulations (NTR). It goes without saying that this must immediately be followed by acceptance into the international regulations. It is generally to be noted that the amount of time and money spent on creating and coordinating a standard of sufficient quality is regularly underestimated. Controversially, there is frequent discussion about whether a range of regulations, as presented in the example "Rail vehicles – Brakes", is a help or a hindrance.



The degree of compliance with standards of the current vehicle platforms, their unobtrusive operation and the growing global competition of the vehicle manufacturers, only made possible by this standardisation, demonstrate however that the path taken is the right one. The successful approval of the LL brake shoes, moreover, is proof of how important the assumption of leading roles in the relevant committees is, in order to exploit the opportunities of global integration and to help actively shape the future market conditions. DB Systemtechnik has the best conditions at its disposal for promoting this development.

Product group **Engineering**

- Consulting, technological consulting
- Accident and damage analyses
- Construction support for new vehicles
- Refurbishment for rolling stock
- Design of components, type modification
- Damage and accident repair
- Obsolescence management
- Type support, support of production resources, fleet management
- Procurement support services
- Supplier qualification, product qualification
- General studies
- IT use and diagnostics
- Software support

Product group **Maintenance**

- Depot planning and intralogistics
- Development and support of maintenance concepts
- Non-destructive tests and test systems
- Coating systems, corrosion protection and cleaning chemicals for rail vehicles
- Fire protection in rail vehicles
- Adhesive technology
- Welding technology
- Materials engineering
- Metrology, calibration

The products of **DB Systemtechnik** for engineering, maintenance and approval/tests

Product group **Approval/tests**

- Approval of vehicles
- Approval management
- Testing of vehicles
- General inspections
- TSI certifications (NoBo)
- AsBo services
- DeBo services
- Sales of measurement and diagnostic technology
- Tests of brake systems
- Tests of running gear
- Test of superstructure
- Tests of fatigue strength
- Tests of pantograph/overhead line
- Test of traction system
- Battery tests
- Test of oil and other lubricants
- Tests of electromagnetic compatibility
- SVO services, inspection centre
- Tests of aerodynamics
- Acoustics and vibration testing
- Air-conditioning system testing

**The expertise of
DB Systemtechnik for
vehicles, infrastructure
and interfaces**

Interfaces

- Acoustics and vibrations
- Aerodynamics
- Electromagnetic compatibility
- Electromagnetic fields (EMF)
- Interaction pantograph/catenary
- Safety
- Telecommunication
- Transmission systems
- Vehicle-track interaction

Vehicles

General vehicle

- ICE
- IC
- Locomotive
- EMU, DMU
- Freight wagon
- Passenger coach

Modul, Komponente, Bauteil

- Battery technology
- Bogies
- Brake technology
- Buffing and draw gear
- Coating systems and corrosion protection
- Coupler
- Data bus systems (train bus) for passenger traffic
- Energy supply
- Fatigue strength
- Fire protection
- Glue assembly
- Heating, ventilation and air-conditioning
- Lubricants, oils
- Materials engineering
- On-board electrical systems
- Pantograph
- Passenger information systems
- Running technology
- Tilting technology
- Traction technology
- Vehicle software
- Welding technology
- Wheelsets

Infrastructure

- Battery technology
- Lubricants, oils
- Maintenance shops
- Maintenance technology
- Materials science
- Passenger information systems
- Systems engineering

**Selected
reference projects**
2014/2015

Photo credits: DB Systemtechnik



Engineering of the redesign for the BR 425 Regio southeast

As part of the public transport contract with DB Regio, southeast region, twelve multiple units of type BR 425 have to be adapted to the requirements of the contract. The engineering group of DB Systemtechnik was commissioned by DB Regio to perform the redesign together with DB Fahrzeuginstandhaltung.

The vehicles were given a modified floor-plan and new seats with wall outlets. The first class coaches were upgraded with the use of carpets and leather seats with reading lamps. A new traveller information system (RIS) was also installed to improve the information for passengers. This system provides passengers with real-time information on arrival times at each stop and connection options, but also information about any delays. It includes new destination displays and passenger information displays. The trains have also been equipped with new interior lighting. New features included the door pushbuttons, which were adapted for TSI compliance. A baby changing table was incorporated into the WC. The vehicles were also equipped with a mobile signal repeater.

The activities of DB Systemtechnik began with the first designs, followed by invitations to bid for the necessary components. Once the order had been placed, work started on converting the first specimen vehicle, which was presented to the public in April 2014. The twelve multiple units themselves will be converted by the end of 2015.



The conversion work achieved a higher level of customer acceptance due to improved comfort and adaptation to the standard of brand new vehicles straight from the factory.



Pantograph tests on Velaro D in Turkey

Turkish State Railways purchased Velaro D multiple units from Siemens. The first of these was to enter service in Turkey during 2014. As the Velaro D multiple units approved in France have 25-kilovolt pantographs with bow widths of 1,450 mm, the Euro-bow pantographs (width 1,600 mm) used in Turkey first had to be aerodynamically optimised and then tested.

DB Systemtechnik was therefore commissioned to develop a test program for performing the relevant measurements for the vehicle manufacturer Siemens. The subsequent trials then took place in the second half of August 2014 on the high-speed network of the TCDD (Ankara – Konya and Ankara – Eskisehir) at a maximum speed of 275 km/h.

Three members of staff from the Pantograph/Overhead Line group were deployed in Turkey for a period of two weeks in August 2014. The measurements for TSI compliance of the interaction

between pantograph and overhead line made use of the cable contact force measurement system and the arc measurement system, as well as the optical uplift monitoring from DB Systemtechnik. In addition, video cameras and spotlights were installed for this purpose.

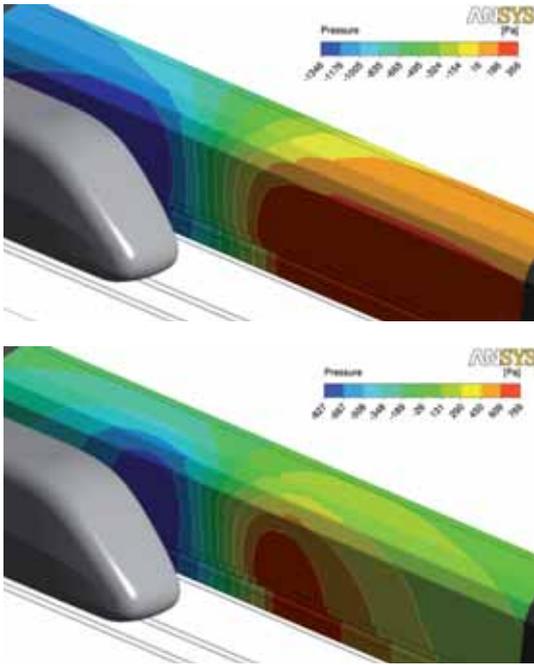
The tests serve to verify the TSI compliance regarding the interaction between pantograph and overhead line. It was thus possible in Turkey to continue the excellent collaboration with Siemens from many previous international projects. It was also possible to convince Turkish State Railways of the extensive range of services offered by DB Systemtechnik as a test institute and an approvals manager. The future aim of DB Systemtechnik, in addition to implementing a further increase in speed on the Turkish network up to 330 km/h (tests to be performed in 2015 and 2016), is also to market measuring systems and further services in Turkey.



Photo credits: DB Systemtechnik

The Ankara – İstanbul high-speed line has been fully operational since 25 July 2014. According to the timetable, the journey time is now down to 3.5 hours from more than six hours previously.

Technical regulations on aerodynamic loads



Accelerations and impacts that occur during operation of a rail vehicle cause stresses and deformations of the bodyshell. The design strength of the bodyshell therefore takes into account various load cases in accordance with the EN 12663-1 standard. The regulations also demand consideration of aerodynamic load cases for effects arising from passing trains, entering tunnels and strong winds. No such technical regulations existed for determining the air pressure and suction loads, leading to delays in the procurement and approval of vehicles. The Vehicles steering group, which coordinates authorities, rail operators and industry on questions of approval, therefore ordered its Aerodynamics work group to draw up some recommended practices.

Between 2012 and 2014, the gaps in the regulations were closed by aerodynamics and strength experts from DB Systemtechnik, working jointly with the VDV and the rail industry (VDB) in collaboration with the DIN FSF, who drew up recommended practices. The guidelines published on the EBA website in November 2014 contain determination methods and design criteria that simulate the German railway network.

This ensures that bodyshell strength is measured by uniform methods for the entire service life of the vehicle. The success of the German recommended practices is reflected in the plan to convert them into the European regulations.

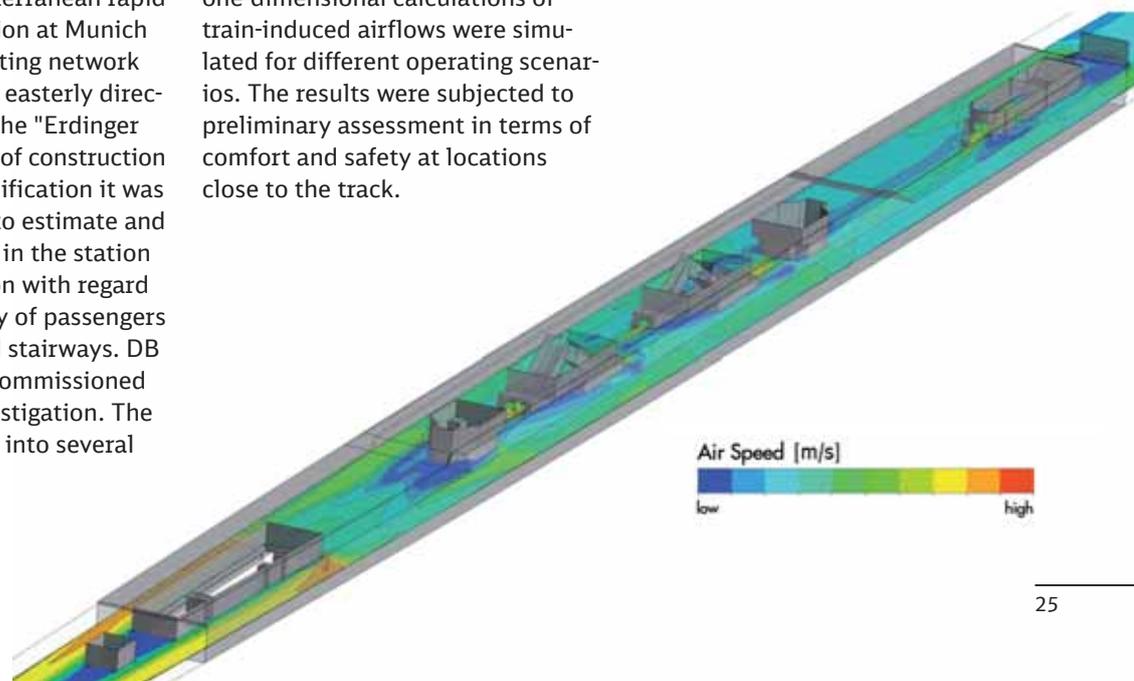
Examination of air pressure surges in the S-Bahn station at Munich Airport

Every train movement through a tunnel causes airflows which, in the case of subterranean transit systems, cause pressure surges at the stations immediately adjacent to the tunnels (piston effect). The planned new construction of a tunnel section to the existing airport tunnel system will connect the subterranean rapid transit (S-Bahn) station at Munich Airport with the existing network towards Erding in an easterly direction (completion of the "Erdinger Ring"). In the course of construction and operational modification it was the task of DB Netz to estimate and analyse the air flows in the station during train operation with regard to comfort and safety of passengers on the platforms and stairways. DB Systemtechnik was commissioned to carry out this investigation. The studies were divided into several stages.

As no benchmarks existed for the sensation of comfort or the steadiness of persons with regard to the air surge, it was first necessary to determine reference values for assessing the results of calculations in a comprehensive study of the available literature. This took place in preliminary studies of comparable projects.

In a second stage, based on a simplified numerical model of the S-Bahn station at Munich Airport, one-dimensional calculations of train-induced airflows were simulated for different operating scenarios. The results were subjected to preliminary assessment in terms of comfort and safety at locations close to the track.

As one-dimensional calculation procedures do not enable any local, site-related statements to be made regarding air speed in the relevant station areas, numerical 3D simulations of selected operating scenarios were subsequently performed and re-assessed. As a consequence of construction and operational modifications to the existing infrastructure, potential problems caused by air surges could be promptly detected, enabling discussions about possible countermeasures to be initiated.





Fire testing of wheelset shaft coating

Due to the introduction of the new European fire protection standard EN 45545, it is necessary for the first time to subject wheelset shaft coatings to fire tests. These coating systems are designed to protect against corrosion, however, and not for their fire protection properties. Possible consequences of this missing property would be the unsuitability of the coating on the basis of the standard requirements.

To find a solution, DB Systemtechnik has formed a working group together with wheelset manufacturers, paint producers and vehicle manufacturers. To answer the question of whether present day wheelset shaft coating systems meet the demands for fire protection, DB Systemtechnik was commissioned by the paint producers to examine the wheelset shaft coatings in the accredited fire laboratory in Kirchmöser, Germany. Between September 2014 and May 2015, a total of twelve coating systems from four different manufacturers were tested. For wheelset shaft coatings with maximum thicknesses of up to 500 micrometres it was possible to verify that most coating systems conform to the requirements of the new fire protection standard.

In addition to performing the fire tests, the fire protection engineers from DB Systemtechnik helped to set up a line of argument with the aim of cancelling the obligation of testing for conventional wheelset coating systems in the standards committees. The final coordination discussions are currently taking place with the wheelset and vehicle manufacturers. Work should then commence on ensuring that, in future, the tried and tested coating systems designed for maximum corrosion protection can continue to be used. The fire protection properties should then be defined according to the actual risk of danger and not in accordance with a fictitious risk.

Exposure to noise at the workplace for foreman shunters

Measuring the daily exposure to noise in the workplace is one method of improving the health and safety of workers. Special attention is paid here to the activities that take place in areas subject to intensive noise, such as marshalling yards. As a result of health complaints among foreman shunters, therefore, DB Schenker Rail had measurements taken by DB Systemtechnik to determine the situation at the Ingolstadt depot. Nationally and internationally applicable regulations represented the basis for carrying out these measurements.

One particular focus was the description and duration of the activities of those concerned, which were made available by the client. Following an advance analysis of the noise-relevant activities carried out by the acoustics test laboratory of DB Systemtechnik, the foreman shunters were equipped with dosimeters and accompanied in their daily work in order to record and measure specific sound levels. Finally, to determine the actual exposure to noise, the measured values had to be harmonised with the activity profile by means of extensive calculations. Only then was it possible to verify statements to the effect that, for example, the coupling of vehicles with the opening of air valves or the screeching of wheels on tightly curved tracks in the immediate vicinity of those affected represented a particularly high proportion of received noise.

On the basis of all these results, protective measures could be derived for reducing the noise levels for employees.

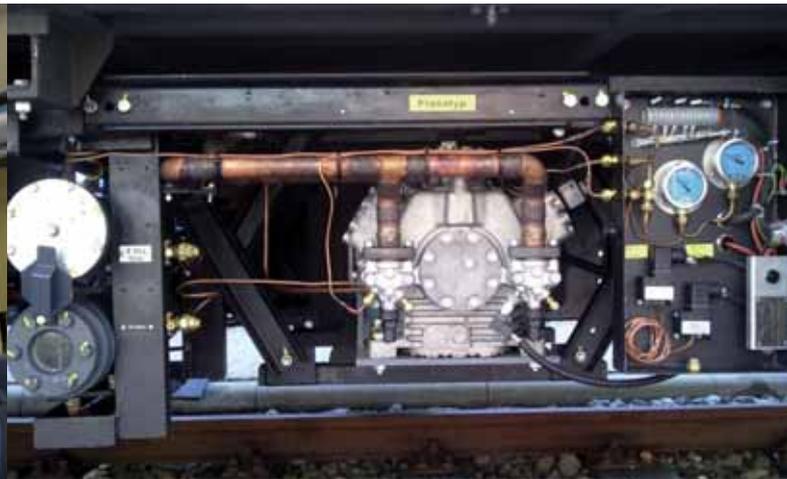


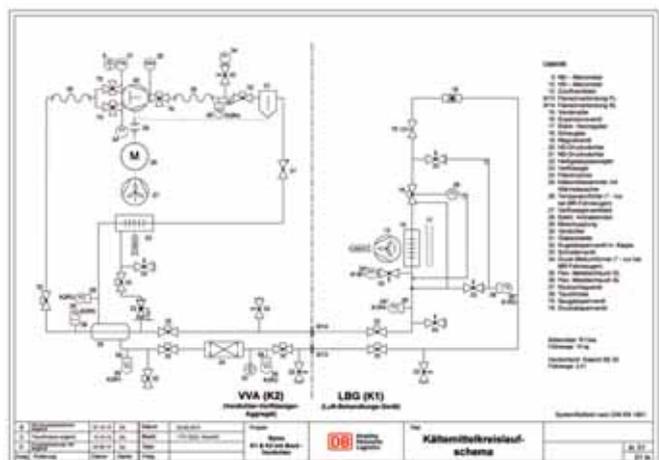
Photo credits: DB Systemtechnik

Performance examinations on the air-conditioning system of a Bp passenger coach

The motor that drives the air-conditioning system of a rail vehicle is the compressor. In the event of damage, replacements for the existing FT-33 compressors in second class passenger coaches could no longer be obtained, nor could any spare parts for refurbishment. This demanded a prompt investigation of possible alternatives. This came down to a choice between a new complete unit including power supply made by Liebherr, or fitting the existing unit with a new controllable compressor made by Bock. To enable both options to be assessed objectively, DB Fernverkehr commissioned the Air Conditioning department of DB Systemtechnik to examine the performance of the two alternatives with reference to the existing system.

In the first stage, criteria such as investment costs, economy and performance were taken into consideration. Whereas the new Liebherr system was available ready for operation, the converted system with the new compressor first had to be integrated into the overall system and the switching and control components had to be adjusted and coordinated. During this coordination, extensive testing took place regarding the system characteristics, such as overheating and excessive cooling, as well as energy consumption.

In addition, extensive tests and measurements of the regulating performance were performed in order to coordinate the software. The data and findings obtained from the alternative systems examined could then be compared with one another under identical conditions. The result of this extensive examination by the DB Systemtechnik air-conditioning technicians is the proof of the operational capability of the Bock FK50/980K unit in the existing air-conditioning system. A further benefit is the reduced energy consumption thanks to system optimisation and improved performance due to higher availability at outside temperatures in excess of 50°C.



Coolant circulation system diagram



New cardan shafts for ICE T

The existing, conventional cardan shaft used in the ICE T had a planned service life of 800,000 kilometres in the maintenance concept. These shafts were therefore always replaced before the first major overhaul (1.6 million kilometres) of the entire multiple-unit set. This resulted in longer installation and vehicle standstill times, incurring corresponding additional costs. In 2009, therefore, DB Systemtechnik was commissioned by DB Fernverkehr to come up with possible solutions.

After analysing the existing fleet and a cost-benefit analysis, a decision was taken jointly with the operator and the shaft manufacturer, to modify the design and thereby increase the service life of the cardan shaft to 1.6 million kilometres. This means that the cardan shaft is now replaced during the first major scheduled overhaul of the train. The experts at DB Systemtechnik produced the specifications for the redevelopment of the shaft by the industry. They also accompanied the testing and the introduction of the new components and validated the new maintenance interval.

The fleet has since been converted and the validation programme is running. By harmonising the maintenance interval, the amount of installation and maintenance work (on the shaft itself, as well) during maintenance is minimised. This helps to reduce the installation and standstill times. The corresponding savings far outweigh the additional costs for the more expensive technical solution.

Exposure to noise at the workplace for foreman shunters

Air-conditioning equipment must withstand a variety of weather conditions. On a double-decker driving trailer therefore, in addition to the tests relevant to the standard, function tests of the air-conditioning equipment and individual vehicle components should also be performed at extreme outside temperatures. Bombardier therefore commissioned DB Systemtechnik to check the function of the air-conditioning equipment. For this reason, various vehicle components were subjected to snow and ice tests in the MEiKE climate chamber of DB Systemtechnik at Minden, the wet cell was subjected to frost protection tests and a k-value measurement took place. It was possible to verify compliance with standard-relevant comfort parameters and the function of the air-conditioning systems and individual vehicle components at extreme temperatures from -25°C to +45°C. Furthermore, it was possible to verify the functionality of individual vehicle components after they had been exposed to snow and ice and to determine a k-value within the limits of the standard.

After intensive testing of the driving trailer over three weeks, the air-conditioning experts were able to present results that, with the exception of headwind tests, included a complete spectrum of climatic trials and function tests.



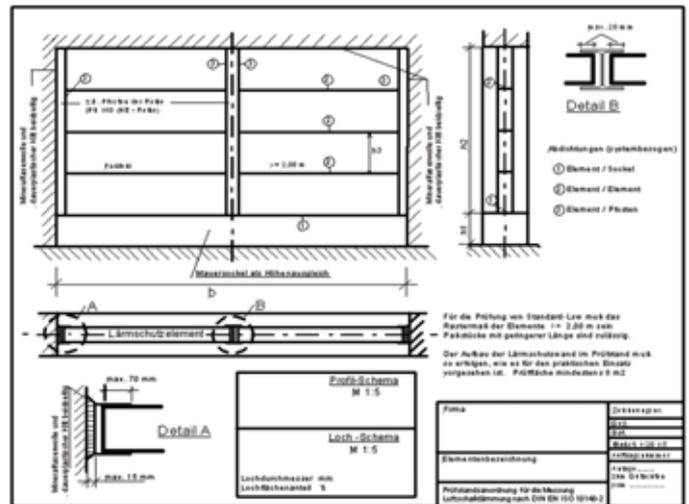
Photo credits: DB AG/Mike Schmidt, DB Systemtechnik

Velaro D: running technology approval in France

In order to operate in France, Series 407 vehicles (Velaro D) manufactured by Siemens require overall approval for the SNCF rail network. This approval called for running tests to be performed in France, which were to be based on dynamic tests already performed in Germany.

Siemens therefore engaged the services of the Vehicle Dynamics Test Laboratory and an assessor from DB Systemtechnik to provide support in drafting a corresponding test specification. Following preparation of the detailed test plans and several consultations with the specialists at SNCF and the French test centre AEF, which was responsible for the operational development, measurement runs were carried out on French tracks between May and July 2014. These test runs were performed partly on the conventional railway lines between Angers and Nantes up to a maximum speed of approximately 240 km/h and partly on two high-speed lines at speeds of up to 320 km/h plus a 10% safety margin. On one short section of track, a speed of 100 m/s was reached. No German-built train had ever run faster on French tracks.

Following successful completion of the very extensive certification tests with the Velaro D and a full report by the Vehicle Dynamics Test Laboratory of DB Systemtechnik, Siemens has now been granted approval by the French authorities.



Acoustic testing of a noise barrier

The conformity testing of noise barriers is being demanded by DB Netz in DB Directive 804.5501. The manufacturing company has commissioned DB Systemtechnik to perform this testing. The main element of this test is not merely the analysis of the necessary acoustic values, but also involves checking the plausibility and completeness of the documents submitted. This approval by DB Systemtechnik of the acoustic properties of the respective noise barrier element is a necessary condition when applying to DB Netz for a user declaration, in case the customer wants to offer the corresponding noise barrier system for use within the Deutsche Bahn network. For applications outside Germany, however, this approval still acts as a quality characteristic for the acoustic properties of the noise barrier.

These tests are performed by the DB Systemtechnik department for acoustics and vibrations. Discrepancies or missing facts were coordinated with the manufacturer in such a way that the documents, as well as missing dimensions, sketches etc. could be updated and completed. Necessary amendments of this sort occur primarily when corrections to the submitted documents become necessary after a test of the acoustic values in the echo chamber.

The sound absorption values and those of the noise insulation are often determined on different dates using different samples of the same noise barrier element, which in some cases leads to discrepancies in the weight specifications and dimension drawings. These are then detected in the course of the conformity check by the DB Systemtechnik department for acoustics and vibrations and coordinated with the customer.

After thorough inspection of all documentation required by the DB Directive, the customer receives a test report that confirms conformity from an acoustic aspect and, as a result of the test, approves the corresponding noise barrier element for use on the Deutsche Bahn network in terms of its acoustic properties.



Photo credits: DB Systemtechnik

Noise measurement on **car-carrying wagon Hccrrs 328**

As part of the EC certification of a new car-carrying wagon of type Hccrrs 328, noise measurements according to TSI Noise were to be performed on behalf of the manufacturer Waggonbau Niesky GmbH and a test report produced as the basis for performing the EC conformity test. From the customer's viewpoint, the measurements were urgently necessary, because the wagons had to be approved as soon as possible. For the measurement campaign, a suitable test route first had to be qualified and a measurement train assembled.

In order to meet the conditions of TSI Noise, the track in the measurement plane (microphone level) must conform to certain limit curves with regard to roughness of rails and track decay rate (TDR). This is checked by measurements of the rail surface roughness and the track decay rates (TDR). If the track does not conform, work on the track superstructure has to be carried out in the selected measurement section.

In order to organise an efficient project, all necessary additional services, such as locomotive drivers, locomotives and security personnel, had to be provided. The experts in the Acoustics department of DB Systemtechnik performed the necessary noise measurements. The test train comprised two locomotives (so that no additional work was necessary at turnarounds when shunting), intermediate cars for acoustically isolating the test object and locomotive, and the two Hccrrs 328 car-carrying wagons themselves.

On completion of the noise measurements taking into consideration all boundary conditions of the TSI Noise specification, the EC conformity check was performed on the basis of the accredited test report. The customer was therefore able to benefit from the fact that all operational and technical organisation was carried out by DB Systemtechnik.





Construction of new shed with sub-floor wheelset turntable system

The ICE depot in Munich currently has no sub-floor wheelset rotation system (URD) of its own, which causes considerable extra work in the dispatch and transfer of the vehicles. The physical location of the depot is cramped, and at the same time the approach tracks to Munich are very busy and there is only limited stabling capacity available. The URD, however, should be constructed as close as possible to the depot.

In collaboration with DB International, the experts from the Maintenance Infrastructure department of DB Systemtechnik started investigating various potential sites as far back as 2011. The decision for the current site was made by DB Fernverkehr in 2014 and the detailed planning started in May of that year. Special structural solutions were developed and a possible future expansion of the

depot was also taken into consideration. Feasibility studies demonstrated that in addition to the construction of a URD, an expansion of the stabling capacities is also possible. In terms of the overall project, DB Systemtechnik was responsible for the planning coordination, the feasibility studies, the planning of buildings and the specialist planning of the mechanical systems. DB International in Munich dealt with questions of measurement and specialist planning of road and rail traffic systems and overhead line systems as well as control and signalling technology.

The interfaces to the second rapid transit rail core route were also considered. While largely maintaining current operations, the construction in three phases should start in early 2016 and be completed one year later.



New yaw dampers for ICE 2 bogies

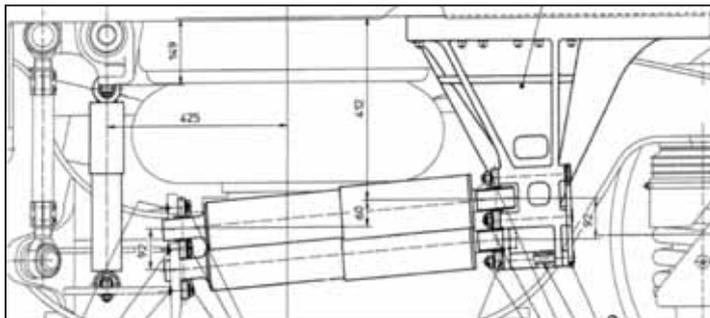
On the bogies of ICE 2 trains, yaw dampers are fitted along the sides of the cars between the bogie frames and longitudinal bodyshell beams. The effect of these is to counteract the turning of the chassis below the bodyshell, thereby dampening the torsional vibration of the bogie and guaranteeing a stable ride even at higher speeds. However, this also prevents the bogie from turning under the bodyshell when negotiating curves. The path necessary for turning in tight curves is enabled by the dampers only on reaching the permanently set discharge force. The damper forces that are introduced into the bodyshell result in high stresses on the vehicle structure in the long term.

For this reason the Driving Technology department of DB Systemtechnik was commissioned by DB Fernverkehr to investigate this problem.

The aim was to reduce the discharge force of the dampers in such a way that expensive repair work on the bodyshell could be avoided. In order that this situation could be achieved, the dampers had to be optimised so that their design was sufficiently stiff in the short lift range and so that the necessary damping forces could be built up for stabilisation. By means of theoretical investigations and test runs, it was possible to determine which level of force is essential in the dampers for a stable ride in the vehicle.

The result of this analysis revealed that despite a reduction of the discharge forces by 25%, safe operation is still possible at maximum speed. The solving of this problem significantly reduced the level of stress imposed by the damper forces on the bodyshell structure, thereby preventing consequential damage.

Photo credits: DB AG/Christian Bedeschinski; JET-Foto Kranert



Yaw damper construction for ICE 2



Redesign for the BR 420.8 of the Munich S-Bahn

Due to the electrification of the key S-Bahn route of the S2 line from Dachau to Altomünster and the necessary additional traffic on the S1 line from Munich Main Station to the airport, additional vehicles were necessary. For this reason, the BR 420.8 vehicles were to be converted so that this transport can be provided by the use of used and very reliable vehicles.

This necessitated a modernisation of the interior according to the specifications of DB Regio and S-Bahn Munich. The Engineering department of DB Systemtechnik was commissioned to plan the modernisation from the construction aspect and to accompany the conversion work. At the same time, the interior of the coaches was adapted to the current S-Bahn colour scheme. The floor covering was completely replaced to meet the specifications of the TSI PRM. The entry doors, ceilings, side and end walls were repainted, seating structures, door pillars and trim, waste bins and luggage racks were all recoated. In the multi-purpose area, folding seats have been installed for wheelchairs and pushchairs, as well as a cabinet for accommodating an entry ramp for wheelchair users, including requirement request.

The fire extinguishers are no longer kept on the luggage racks, but are stowed beneath the passenger seats for easier accessibility. The armrests in the former first-class compartment of the intermediate car and the dividing panels between first and second class have also been removed. The vehicles were fitted with a passenger compartment video monitoring system and were equipped with LED interior lighting. The ceiling area was fully soundproofed with mineral wool to reduce noise. In addition, LED lighting replaces the existing light source for the train headlight.

The preliminary design work by the experts at DB Systemtechnik began in the autumn of 2014 and the actual conversion work was carried out a few months later in the period between September 2014 and March 2015. During this period, 15 redesigned vehicles of type BR ET 420.8 were delivered to the Munich S-Bahn. This conversion work achieved a higher level of customer acceptance due to improved comfort and adaptation to the standard of brand new vehicles.



Photo credits: DB Systemtechnik



Passive noise protection on the Nuremberg – Ebensfeld line upgrade

When upgrading or extending railway lines, Deutsche Bahn must keep within traffic noise protection limits in order to comply with statutory regulations. With reference to the planned Nuremberg – Ebensfeld upgraded line therefore it is necessary to assess the prevailing noise situation there.

As part of planning approval, acoustic examinations have been carried out. The results show that the definitive limits of the German traffic noise ordinance (16th BImSchV), are exceeded in some areas despite the planned active noise control measures. This means there is justification for demanding passive noise protection on the buildings affected. The testing of the actual demand and its scope is the task of this project, which has been awarded to the Acoustics department of DB Systemtechnik.

At the start of the investigation an on-site tour of the affected buildings had to be made. The definitive factors for this were the noise rating levels from the acoustic investigations. The need for protecting individual rooms was assessed according to their position and use. The surrounding components were to be tested according to DIN 4109 to determine whether additional passive noise control measures are necessary, in order to comply with the noise pollution limits prescribed in the 24th BImSchV. The result of the test defined the actual demand for an acoustic improvement as well as the scope of this improvement.

Control monitors for the power supply to passenger coaches

In the IC passenger coaches operated by DB Fernverkehr, there are only limited options for reading out diagnostic data from the power supply systems and this is relatively laborious. As part of an upgrade with new power supply systems the data is to be displayed and evaluated by means of a ten-inch control monitor (MMI). As space is limited, the installation of this component is possible only with restrictions and is relatively complicated. On behalf of DB Fernverkehr, DB Systemtechnik devised various solutions for the installation of these control monitors in the Av, ARk, Bp and Bv coaches. When selecting the location for the monitors, the most important thing was to position them at locations easily accessible for the train attendant and for the maintenance personnel. For this purpose, for example, the rear of the S1 cabinet (BA 108) and the modified corner cupboard on the WE 1 (BA 186.7) were used.

The Engineering department of DB Systemtechnik prepared the design drawings for the conversion work, assisted with the sample conversion and created the necessary working instructions for the actual conversion work. Thanks to these measures, data can now be read more easily by the personnel, allowing fast and targeted diagnosis of errors and operating states.



LED signal lighting for the BR 101

Until now the signal lighting of the electric traction units has used only incandescent or halogen lamps. The replacement of incandescent bulbs therefore demanded a new solution for traction units.

The rapid development of LED technology in the lighting sector presented one potential solution for the vehicle lighting. The experts in the Engineering department of DB Systemtechnik were commissioned by DB Fernverkehr to execute the LED signal lighting project, in order to develop a long-term and sustainable solution. The first tests on a BR 101 locomotive were conducted jointly with TU Darmstadt (Technology University) in 2009. In a long-term trial over five years, full-LED light units were used and tested. After a positive conclusion of this project, the LED lighting was installed as standard in this BR series.

Further series at DB Regio and DB Schenker will follow. The sample conversions necessary for this have been taking place in larger numbers since the end of 2014. Thanks to this innovative technological advance, not only the costs of materials for maintenance have been reduced, but also the lighting energy costs.



Photo credits: DB Systemtechnik



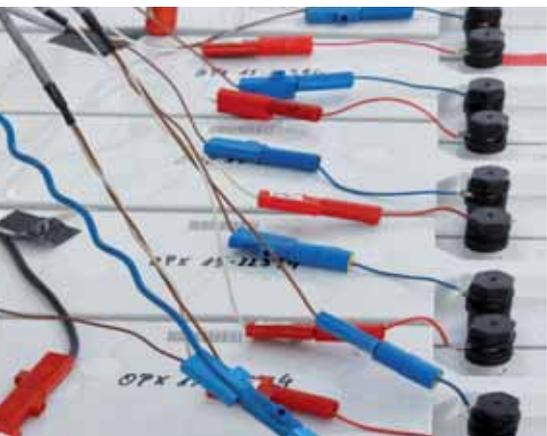
Munich S-Bahn: Construction noise and vibration

Reconstruction work on Line A of the S-Bahn rapid transit network in Munich, between Dachau and Altomünster, necessitated electrification of the route, upgrading of a double-track passing section in Schwabhausen, and the conversion of the Erdweg stop into an interchange station. Construction work was also necessary at the stations in Dachau town centre, Bachern, Kleinberghofen, Niederroth and Altomünster. In the course of planning the work, or while it was being executed, the requirements of the Federal Railway Authority (EBA) from the planning approval procedure were to be observed in regard to construction noise and vibrations.

The Acoustics department of DB Systemtechnik was therefore called upon

by DB Projektbau to carry out these investigations. This was determined in the initial stage by means of a conflict analysis of the two subjects. The forecast construction vibration and building noise is assessed on the basis of control measurements during the building work (in this case: pile driving of sheet walls and piles).

During the construction work itself the experts from the Acoustics department carried out short-term measurement activities aimed at securing evidence with 24 hours in the event of complaints from nearby residents. It was thus possible to monitor continuously during construction and to establish that the customer met all the EBA requirements from the project approval.



New batteries for vehicles

All DB rail vehicles are equipped with battery systems of various types. For a variety of reasons, battery systems undergo changes during the service life of the rail vehicles. For example, due to developments in the design of batteries or chargers, the original components are often not available at the time of scheduled replacement. Whenever a change is made, the system safety must be reassessed on the basis of the current standards and, if necessary, changes must be suggested for operation and maintenance.

DB Systemtechnik has now been commissioned to draw up suggested solutions with regard to the battery systems. Suggestions for changes were the prepared jointly with Corporate Purchasing, type support and responsibility of the transport departments, and the manufacturers of batteries and chargers.

The first stage for this was the generation of technical documentation for an invitation to tender. This, for example, explained questions regarding the acid concentration or the antimony content of the batteries. As a result, the necessary battery system was specified for each series of vehicles. In the subsequent invitations to tender, it was thus possible to evaluate the documentation submitted by bidders.

Thanks to collaboration with DB Systemtechnik and its specialist knowledge of battery systems, it is possible to guarantee a safe and economical operation of the systems by linking the tender process with the knowledge of the actual status.



Photo credits: DB Systemtechnik



Photo credits: DB Systemtechnik/ESG



ESG Rail and Railway Approval Limited (RAL) are subsidiary companies of DB Systemtechnik in Great Britain. ESG employs more than 100 people, including more than 60 specialist engineers. Railway Approval Limited (RAL) offers vehicle approvals and is accredited as a UK Vehicle Acceptance Body and internationally as a Notified Body Interoperability.

Selected ESG reference projects in England: **DRIVER ADVISORY SYSTEM (DAS)**

Driver advisory systems (DAS) are used by train operators to match the train speed optimally to the timetable. This in turn helps to optimise energy consumption, journey times and network capacity. DAS offers a real-time connection to the traffic management (TM) system of Network Rail (NR). In this case, Stagecoach South West Trains wanted to achieve a higher number of trains on the main section to and from London's Waterloo station without adversely affecting the punctuality of the trains.

In 2013, the ESG and Railway Approvals were commissioned by SSWT to install a driver advisory system in the entire fleet (249 rail vehicles) of the British Rail Class 498 operated by SSWT. In this project, ESG collaborated with Cubris as a partner for the delivery of the system. Cubris is a Danish company that has seven years of experience in developing and supporting the installation of DAS.

Cubris' own tried and tested "Green Speed" driver advisory system is installed in the entire fleet of Danish State Railways and has been in service there since March 2012.

In the first stage, 3D CAD models of the used areas of the vehicle were produced, as were detailed 2D production and installation drawings for the cabling, clamps and bracket assemblies. To obtain approval of the design, the first installation on one vehicle in each fleet was performed by ESG. This included not only the installation of the materials themselves, but also the testing and commissioning. The design packages were then submitted to Railway Approvals for inspection. On the basis of the Designated Body (DeBo) method, using a two-stage approach, all necessary tests were then carried out. By regulating the speed and avoiding conflicts with other SSWT trains, it was possible to raise the capacity of the network from 24 to 28 trains per hour on this route.



Photo credits: Wikipedia, DB Systemtechnik/ESG

Refurbishment of NIGHT RIVIERA SLEEPER

First Great Western (FGW), part of the First Group, operates trains on commuter, regional and mainline routes in the London region, South Wales and Southwest England. First Great Western's franchise was recently extended to March 2019 with an option for a further year. Part of the agreement for the franchise extension was the undertaking to modernise the fleet of sleeper coaches.

First Great Western issued an invitation to tender (ITT Event 435261 "FGW Sleeper") for refurbishing the Night Riviera Sleeper. Knorr-Bremse Rail Services (KBRS) was awarded the contract by FGW to overhaul the fleet of sleeper coaches, modify them for persons with reduced mobility (PRM TSI) and carry out improvements associated with the upgrading of the rest of the fleet. ESG was commissioned by KBRS to perform the design planning. Despite its modest size, the sleeper fleet is relatively complex, as it consists of coaches not only for daytime use, but also for the night services, which demands a unique and specially coordinated design.

ESG successfully completed the specific design for the refurbishment of the Riviera fleet. This included the reconfiguration of the sleeper cabins, the redesign of the sales counter, galley and cocktail bar, the reconfiguration of the cabins at the end of coach 1 for the storage of bicycles, luggage, surfboards, bed linen and towels, secure luggage facilities and other storage spaces.

The coaches continued to comply with the Rail Vehicle Accessibility Regulation and PRM TSI specifications. The sister company, Railway Approvals Limited, then carried out the testing and product certification in accordance with EN45011, TSIs, NNTRs and the "Department for Transport Compliance" matrix.

ETCS

The English rail industry is preparing for the introduction of the Level 3 European Rail Traffic Management System (ERTMS) to the entire rail network by 2025. The installation of the European Train Control System (ETCS) in the rail vehicles concerned is being performed by a joint organisation, the National Joint Rolling Stock Project (NJRP). The first phase of introduction involves issuing design contracts for the "First in Class" (FiC), design and installation for all passenger vehicles that will run as from 2019 on routes on which ETCS is being introduced. To this end, a program has been developed that, as part of the introduction strategy, assigns each vehicle class to a specific package.

As all FiC contracts are tendered individually, but not all vehicle operators have the corresponding resources or experience to participate in this project in such a short time, the ESG was requested to carry out strategic inspections of invitations to tender. The work performed by ESG was divided into two phases. Phase 1 consisted of the detailed and intensive testing of the bid from the technical, approval and delivery viewpoints.

Phase 2 consisted of a less intensive, but more detailed question-and-answer phase with ongoing surveys of the suppliers for this invitation to bid. ESG thus delivered a comprehensive report that contained the results of the inspections of the invitation to tender together with an indication of the need for technical improvements, or the entire programme.

Human resources report

2014/2015



Human Resources **personnel**

organiser, adviser, supporter and implementer in the fields of HR planning, recruitment, support and development.

HR Management at DB Systemtechnik takes a look back at two very exciting and busy years. The day to day personnel work was characterised by topics such as change management, recruiting and promoting young talent, development of existing staff and project management.

There is a wide variety of exciting careers at DB Systemtechnik. But they call for more than just a technical understanding: financial talent, planning and strategic thinking and competence in dealing with demanding customers are just as essential for successful project development.



Photo credits: DB AG/Christian Bedeschinski, DB Systemtechnik

Promoting qualified young talent: recruiting and employing young staff

A key element for future success is the training of qualified and talented young people. This starts with the recruitment of suitable applicants. Presence at various trade fairs such as the annual "Go@Future Training Fair" or the VDI Recruitment Day is therefore a key element of establishing contact with potential applicants. However, DB Systemtechnik is also committed to and actively involved in in-house DB events such as the "open day at the training workshop" or the "careers day".

Qualified young talent

One major event each year is the participation in the "Girls' Day". The aim of this day is for girls between 11 and 14 years of age to be exposed to the world of technology for a whole day. On average over the past two years, about 30 girls have taken part at these events in Munich and Minden. In addition to touring the facilities, they were allowed to take an active part in testing and to put their own technological affinity to the test.



Matthias Jäger

Onboard since: 1 Feb. 2015
Working as: Specialist adviser for jointing technology
Joined via: Direct entry

DB Systemtechnik, because ...

... I want to make my contribution to sustainable mobility. As one of the most environmentally friendly forms of transport, rail is in constant competition with road and air travel etc. With my colleagues at DB Systemtechnik I can come up with new ideas and designs to help advance the rail system.



Teresa Horvatic

Onboard since: 1 Sep. 2013
Working as: HR officer
Joined via: Time spent as

DB Systemtechnik, because ...

... first and foremost, I feel good and enjoy my day-to-day work in the HR team at DB Systemtechnik. In two years as a working student I was able to get to know the company and my colleagues very well. I had the opportunity to work on a wide variety of subjects within the HR department. Ultimately, the opportunity to work in an innovative company with many options for personal development motivated me to become a permanent member of staff after my studies.

There are many ways of joining DB Systemtechnik. The classic vocational training offer the best basis for qualified staff. For our new young academic intake, we rely on practical study in cooperation with the Bielefeld University of Applied Sciences, university internships, working student positions or the writing of a thesis. This way, the students can get to know DB Systemtechnik as an attractive employer and get a feel for everyday working life.

Introducing new personnel: Introductory guidance for experienced professionals and managers

To ensure a successful introduction of staff and managers at DB Systemtechnik, we offer a structured introductory phase with internal "getting on board" events and regular feedback meetings. In the course of these, expectations and requirements are clearly defined and conveyed in order to give new entrants the best preparation for everyday working life.

In addition, our in-house training providers DB Training and DB Academy offer various introductory seminars. While the training of managers takes place within the DB Academy, other members of staff are offered numerous training options by DB Training. The aim of these introductory seminars is to promote an understanding for the DB Group and interaction between the individual business units. New management personnel in particular attend "transition programmes" to receive training in the subject areas of management and strategy. But our specialist personnel also have the opportunity to take part in rail-specific introductory seminars, enabling them to familiarise themselves with the rail system.



Steve Goebel
On board since: 1 March 2014
Working as: Sales management adviser
Joined via: Direct entry

DB Systemtechnik, because ...

... for me, it is the epitome of a sustainable and sensible employer. It is actively contributing to the optimisation of the rail system and promoting innovations. I consider myself as part of it and through my work I am also contributing towards improving this sustainable and environmentally friendly transport system. My scope of duties is very varied, and includes conducting meetings with customers in the DB Group as well as contract negotiations on an international scale.

I like pointing out new approaches in the marketing of DB Systemtechnik and thereby making my contribution towards a successful future for our company. I appreciate the excellent working atmosphere, the friendly interaction with colleagues, the prospects and opportunities that our company offers.

Introducing new personnel



Jörg Rothhämel
Onboard since: 1 Oct 2013
Working as: Test laboratory team leader for acoustics, vibrations, aerodynamics and air-conditioning
Joined via: Direct entry

DB Systemtechnik, because ...

... the responsibilities fit my professional career. Moreover, I want to be part of a unit that is developing railways as a sustainable means of transport. At DB Systemtechnik, not only the infrastructure, but also the vehicles are considered as part of the overall rail system. Apart from DB being an employer of technical interest to me, I also see very good working conditions and development

Following the introductory period, we conduct dialogues with our staff and managers, in order to define tailor-made seminars and development modules. Regular training of management creates the basis for, and continually updates, a modern understanding of management. Through regular further training, members of staff are given the opportunity to consolidate their individual strengths and work on fields of learning in various areas of competence. This continuous development keeps both personnel and company at the forefront of knowledge.

The particular focus in the field of development is on the certification of our project managers in accordance with the IPMA standard. As a service company in the field of engineering and certification, we want to consolidate our project management competences, in order to achieve the greatest possible success for our customers' projects at the highest level.

Accompanying continuous changes: change management

To increase efficiency in companies, working and organisational processes are being changed at ever shorter intervals, coinciding with modified management structures and staff duties. The staff – both management and employees – have to adapt and find new roles, but also actively help to change the company.



Juan Garbayo de Pablo

Onboard since: 1 Jan 2015

Working as: Acoustics and vibration consultant

Joined via: Dissertation (air-conditioning technology)

DB Systemtechnik, because ...

... as a young engineer, I regard DB Systemtechnik as a very exciting company that allows me to devote myself to technology and at the same time make a contribution to society. In addition, as a service provider within DB AG, the company is involved in many technical areas of system development and approval. I find this aspect particularly exciting, as it enables employees to get involved with various fields of technology over the course of time. My current work in the acoustics department brings together my two passions of technology and music.



Antje Zimmermann

Onboard since: 1 April 2015

working as: Consultant for machines and systems, vehicle maintenance infrastructure

Joined via: Direct entry

DB Systemtechnik, because ...

... it gives me the opportunity to work as a factory planner. After more than 20 years as a factory planner at one of the largest printing machinery manufacturers in the world, I have sought a new challenge in a renowned company. The tasks and working environment appear very exciting and interesting to me and exactly as I had imagined. To this day I am still convinced I made the right decision, and my expectations have not been disappointed in any way.

Change management

The associated insecurity creates fields of tension and conflict and can also jeopardise the general success or even lead to its collapse. In order to give employees and management at DB Systemtechnik the optimum preparation for these processes of change and thus to create a basis for successful implementation, accompanying structured activities are drawn up, but feedback is also obtained. For example, on the rollout of new reporting systems, company-wide training courses were organised and carried out. By accompanying the introduction of a new project management system with change activities, such as an explanatory film, HR management is also setting new priorities.



Listening to the wishes of staff: the employee survey (MAB)

In order to detect and realise potential for improvement on a continuous basis, a Group-wide employee survey was conducted for the second time in 2014. All employees were given the opportunity to express their opinions, wishes and suggestions. The fields of action identified in the individual areas were then processed in workshops. The HR team controls the overall process of the survey and organises the follow-up workshops, as well as monitoring the follow-up actions to be carried out. After the last survey in 2012, about 200 actions were implemented to ensure improvements in everyday collaboration.

Supporting families: RasselBAHNde

To help reconcile the professional and family life of DB employees, every year Deutsche Bahn offers three weeks of full-time child care for children from six to twelve years of age. At three centres in Berlin, Frankfurt and Munich about 200 children discover that the railway can be fun during a varied programme of holiday events. Daily ventures ensure that the children are adequately entertained. And at the same time, the children can gain a little insight into the working world of their parents.

Supporting families



David Günthner

Onboard since: 1 Sep 2012
Working as: Technical product designer
Joined via: Transfer after studies to technical product designer in machine and system construction

Photo credits: DB Systemtechnik

DB Systemtechnik, because ...

... I was on the lookout for a company that could offer me the best training. It was, and still is, attractive and exciting to me to be part of the rail system and to play an active part in designing rail vehicles. In addition, I am impressed by the interest and support that DB Systemtechnik shows in the qualification of its staff. So my plan to complete my studies early was supported and I was finally accepted on completion of my training.



Kai Noormann

Onboard since: 1 Aug 2013
Working as: Dual student, Bachelor of Engineering, electrical engineering
Joined via: Integrated practical study

DB Systemtechnik, because ...

... .. it is an interesting employer for me, due to the variety of professional development opportunities. At the same time, what is particularly important to me is that good teamwork is demanded in certain areas. But the most important things for me, however are the different areas of measuring technology that DB Systemtechnik has to offer.

Fairs and events

2014/2015



Customer forums **2014/2015**



240 guests attend the DB Systemtechnik customer forums

"Functional rail transport – a shared interest!" This was the theme of the first DB Systemtechnik customer forum held in Munich in May 2014 and attended by 90 guests. After an introductory presentation by Hans Peter Lang, Managing Director of DB Systemtechnik, and a specialist presentation on the vehicle strategy of the German railways, the programme was completed with two external presentations. On completion of the technical programme, a podium discussion took place on the subject of the customer day.



As part of the accompanying technical exhibition, which included presentations by all the technical departments of DB Systemtechnik, there were also tours of the test laboratories at the Munich site. After much customer contact and intensive discussion, the event concluded with an evening social function in the relaxed surroundings of the machine hall at Munich Freimann.

A further 70 customers from within the DB Group attended the second event in Munich in November of last year. And in May 2015, another 80 guests met in Munich on the theme of "Requirements of the railways arising from the market, operation and technology: today and tomorrow".

Fotos: DB Systemtechnik



DB Systemtechnik at **Innotrans 2014**



DB Systemtechnik presented at three locations at Innotrans 2014. Apart from its appearance on the Deutsche Bahn Group booth and a booth shared with the EisenbahnCert notified body, the VT 612 tilting technology measuring train was presented in the outdoor exhibition space. This measuring train performs regular running technology inspections and partial approvals of the infrastructure. The train is also capable of performing regular overhead line inspection runs. In the measuring train, DB Systemtechnik presented its full range of test areas, specifically highlighting the subject of ultrasonic testing.

At the DB booth, DB Systemtechnik presented the complete scope of engineering areas, the activities in the field of the new-build line VDE 8.2 and also presented a model of the Meike climate chamber.

The booth shared with the EBC presented the activities relating to vehicle approvals and certifications. At the centre of the booth was an instrumented pantograph from DB Systemtechnik. The contact force measuring system required for this is an in-house development that has been deployed nationally and internationally for several years. This measuring system is used for the new approvals of vehicles and pantographs and also with regard to track approvals.

During the trade fair, cooperation agreements were also signed with the Japanese research institute RTRI and with Ukrainian Railways.



DB Systemtechnik **Board of Management**



Hans Peter Lang
Chief Executive Officer
phone +49 (0) 571 393-5435
fax +49 (0) 571 393-5645
hans-peter.lang@deutschebahn.com



Bärbel Aissen
Chief Finance Officer
phone +49 (0) 571 393-5700
fax +49 (0) 571 393-5645
baerbel.aissen@deutschebahn.com



Christoph Kirschinger
Chief Sales Officer
phone +49 (0) 89 1308-5105
fax +49 (0) 89 1308-7522
christoph.kirschinger@deutschebahn.com

Technical Contacts



Dr. Lars Müller
Head of Business Line Testing
phone +49 (0) 571 393-5405
fax +49 (0) 571 393-2409
lars.l.mueller@deutschebahn.com



Nils Dube
Head of Business Line Engineering
phone +49 (0) 89 1308-7470
fax +49 (0) 89 1308-7322
nils.dube@deutschebahn.com



Dr. Burkhard Schulte-Werning
Head of Business Line Maintenance
Technology
phone +49 (0) 3381 812-320
fax +49 (0) 3381 812-105
burkhard.schulte-werning@deutschebahn.com



Dr. Stephan Schubert
CTO, Innovation Management
phone +49 (0) 571 393-5436
fax +49 (0) 571 393-1218
stephan.schubert@deutschebahn.com

Sales Contacts



Sergej Samjatin
Director Business Development & Sales
(International)
phone +49 (0) 571 393-5442
fax +49 (0) 571 393-5645
sergej.samjatin@deutschebahn.com



Martin Horsman
Managing Director ESG
(Great Britain)
phone +44 751 505-4055
martin.horsman@esg-rail.com



Josef Rixner
Director Business Development & Sales
(Germany, Austria, Switzerland)
phone +49 (0) 89 1308-5464
fax +49 (0) 89 1308-7522
josef.rixner@deutschebahn.com



Jérôme Robin
Director Business Development & Sales
(France, Belgium, Luxembourg, Norway)
phone +33 178 42-3715
jerome.robin@deutschebahn.com



Published by

DB Systemtechnik GmbH
Pionierstraße 10
32423 Minden
Germany

Further information:

Website: www.db-systemtechnik.de

E-mail: systemtechnik@deutschebahn.com

Contact: Alfred Hechenberger

Subject to change without notice

Errors and omissions excepted

Last revised: February 2016