Annual Report 2011 / 2012

Reports of the Federal Highway Research Institute

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Federal Highway Research Institute

The Federal Highway Research Institute (Bundesanstalt für Straßenwesen, BASt) was founded in 1951. It is a practice-oriented, technical and academic research institute of the Federal Government with a focus on the road sector. It covers diverse research subjects resulting from the relationship between road, people, and the environment. Its function consists of improving the safety, environmental compatibility, economic viability, and efficiency of roads.

BASt provides scientific support to the Federal Ministry for Transport, Building and Urban Development (Bundesministerium für Verkehr, Bau und Stadtentwicklung, BMVBS) in decisions on technical issues and transport policy. It is instrumental in developing regulations and standards and plays a leading role among the top institutes within the network of top research institutes in the road sector. Its functions also include consultancy and expertise activities. BASt provides expert opinions on the quality of services and assesses the quality of products. It conducts tests, provides approval and offers training seminars.

Its headquarters have been in Bergisch Gladbach since 1983 on premises covering about 20 hectares, including ten experimental halls and large-scale test facilities, some of them unique in the world.

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Message

The increase in traffic on German roads is a fact. The research by the Federal Highway Research Institute (Bundesanstalt für Straßenwesen, BASt) is indispensable for providing a functioning, safe, economically viable and ecologically compatible road system into the future. Based on my own experience with and in BASt, I can say it is a competence centre for the entire range of research in the road sector, covering intelligent solutions for the road of the future, active and passive vehicle safety, ecological and economic aspects of roads and vehicles, and questions about human behaviour in road transport. The disciplines represented by BASt work hand in hand to run as smoothly as a well-oiled engine. And just like a well-oiled engine BASt never stops. It keeps on working to continuously develop further and improve. This and its excellent networks make BASt an important international research institute. It supports the Transport Ministry with expert knowledge in issues of transport policy.

With its President Stefan Strick, whom I had the honour to usher in to his new office, BASt continues to walk along this forward-looking path. There is no better case in point than the "Roads in the 21st Century – Innovative Road Construction in Germany" joint research project by the Federal Ministry of Transport, Building and Urban Development and BASt. Roads in the 21st century will need to meet new challenges, and the course must be set today.

In this spirit I look forward to continued good cooperation with BASt and would like to thank everyone at BASt for their commitment to developing joint strategies and measures for the future.

I wish every reader of the BASt annual report 2011-12 an enjoyable read.

Rainer Bomba
State Secretary at the Federal Ministry for Transport, Building and Urban Development


Sicherheit
Risiko

Stefan Strick
President of the Federal Highway Research Institute

Introduction

Before I start to introduce the work of BASt, allow me to share a little anecdote with you. When I entered into office in November 2011 State Secretary Rainer Bomba joked in his speech that I had "only" the second best job in the world. Today – more than a year after becoming President of BASt – I must contradict: I am not the one who has "only" the second best job.

I had an exciting first year at BASt. I met a lot of people and got to know a multitude of subjects. I had the opportunity to deal with many new topics, all of them intriguing. My previous work at the Federal Ministry for Transport, Building and Urban Development was advantageous, as I had already worked with many of the BASt staff before.

As is traditional at BASt, the past two years saw a lot of unflagging and in-depth research into all road-related fields. The 33 expert essays you will be reading on the following pages will give you an understanding of the broad range of tasks BASt fulfils. I would like to briefly introduce a few of them to pique your interest.

Let us take the "Safety in tunnels" subject for example. The behaviour of drivers during emergencies in tunnels was the focus of research in the scope of the SKRIBT und SKRIBT^{Plus} projects. The study revealed that people in such situations often react wrongly or too late. The data collected helped develop new concepts to improve behaviour in tunnels during emergencies, resulting in a BASt film on correct behaviour in road tunnels. Studies already completed prove that the safety in tunnels can be improved significantly through targeted measures.

BASt also attaches importance to safety in other research areas. New safety systems in vehicles have been deployed, for example, to improve braking in emergency situations. It is still difficult, however, for end consumers to compare different systems, as no suitable assessments exist such as in the context of Euro NCAP. BASt's involvement was instrumental in the ASSESS (Assessment of Integrated Vehicle Safety Systems for Improved

Vehicle Safety) Euro project that focused on a uniform assessment procedure and legal issues.

Many European countries agree: alcohol, drugs, and medicines are a danger to safety on European roads. Aiming to analyse the situation in more detail and to develop suitable counter measures, the European Commission approved the largest research project to date on improving road safety: DRUID (Driving Under the Influence of Drugs, Alcohol and Medicines). The project spanned five years and was coordinated by BASt, involving institutes from 18 European countries. It resulted in a comprehensive stock-taking and concrete proposals for measures to be taken.

In its work, BASt focuses not only on safety issues in road traffic, but to a great extent also on expanding and maintaining the entire road infrastructure. The article “How to build in the future: road construction without petroleum?” deals with the question of how to maintain and expand our roads against the backdrop of scarcer and more expensive resources. As the asphalt volume built into the pavements of motorways alone is about 130 million tonnes, the answer to the question above is vital for the future of the German road network.

The action “on” the road is also important to BASt. There has been an increasing lack of parking spaces for lorries on German motorways. An pilot concept for intelligent traffic systems displaying free capacities has been installed at motorways. BASt developed a new control approach: so-called compact parking increases the capacities and uses them more efficiently by parking lorries in rows according to their planned departure time.

Lorries are BASt’s focus in another project too: a field trial with longer goods vehicles. The field trial started in January 2012 and is supervised scientifically by BASt. It aims to explore the opportunities and risks involved in using longer heavy good vehicles, including a concept on how to meet the challenges of the increase in freight transport.

The great range of subjects and projects and not least the results achieved by the staff in different sections and offices shows the commitment of BASt employees in the past two years. I am delighted that some of them - in addition to their day-to-day work - have used the opportunity to work towards their PhDs, accepted teaching assignments at universities, received awards, or been appointed to important offices.

Many events and meetings were used to meet others and strengthen contacts so that we were able to expand our network within the national and international research community.

I am proud to be the president of this federal institute and I hope that you will find this annual report as inspiring as I do. ■

Infrastructure: safe, intelligent and sustainable

Safety in tunnels

Economically efficient housings

“Smart” bridges

Fast sealing on bridges

Innovative structural scanner developed

Asset management for roads

Safety in tunnels

Accidents or fires in particular occur in tunnels very rarely. But if they do, their consequences can be devastating. Many people do not know how to act when a fire breaks out in a tunnel. Rather than escaping from the tunnel, they succumb to the fatal illusion that they are safe in their cars, or hesitate to leave their cars behind. A major fire in the Mont Blanc Tunnel in 1999 caused the deaths of 39 people, 29 of whom had remained in their vehicles.

Under the consortium leadership of BASt the SKRIBT and SKRIBT^{Plus} "Protection of Critical Bridges and Tunnels" (Schutz kritischer Brücken und Tunnel) projects have investigated human behaviour in emergency situations and how it can be improved.

User behaviour

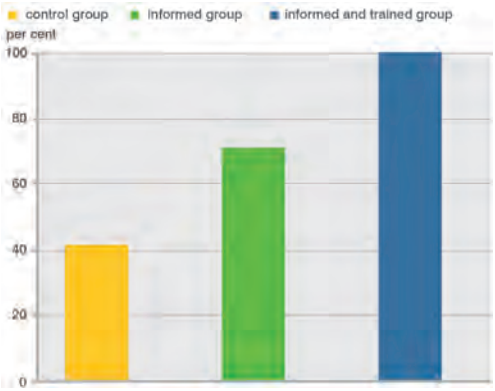
An analysis of the Mont Blanc fire and other accidents has shown that people who are close to a fire's source are more likely to leave their vehicles and get out of the tunnel than people who are caught in the traffic tailback and cannot see the fire for themselves. The latter tend to remain seated in their cars.

They react, if at all, only when the danger seems to overwhelm them and starts frightening them, for example, when thick smoke from the fire reaches their cars. This delay in their reaction can have life-threatening effects because every second counts in an incident.

The Psychology Department I of the University of Würzburg, a partner in the SKRIBT und SKRIBT^{Plus} projects, conducted several studies to find out how to improve tunnel users' behaviour in case of emergencies. One group of trial participants received the BASt flyer on "Correct behaviour in road tunnels" as information, a second group was additionally trained in a virtual driving simulator, while a third control group received neither information nor training. One week later, these three groups were confronted with an accident involving smoke generation during a field study in the Engelbert Tunnel at Gevelsberg.

The behaviour of the different groups differed significantly. Those participants who had been informed and trained all left their vehicles, while some others, especially from the control group did not leave their cars or even tried to turn them around. Only 42 per cent of the trial participants in the control group tried to find the emergency roadside telephones and/or went to the emergency exits. Among the informed group 71 per cent of the participants did so and even 100 per cent of all participants in the additional training.

Those who had received both information and training reacted substantially more quickly than the others. On average they



Percentage of trial participants finding emergency roadside telephone and/or emergency exits

Time lapse between seeing the incident and leaving the car

Graphs: University of Würzburg

left their cars 20 seconds earlier than participants from either other group.

Better information

The information from the written material led to a safer and faster behaviour. BASt has produced a film called “Wie verhalte ich mich richtig im Tunnel / What´s my correct behaviour in a road tunnel” to provide better information to tunnel users. The users learn how to best behave in case of an emergency in a road tunnel, and how to save their own lives and the lives of others. In individual episodes the film shows and explains how to behave in the following situations:

- Before entering the tunnel
- In the tunnel
- During a traffic jam in a tunnel
- When the user’s car breaks down
- In case of an accident
- When a fire breaks out in the user’s own car
- When a fire breaks out in somebody else’s car

Moreover, the safety installations in road tunnels are illustrated and their use explained in a manner that is easy for everyone to understand.

This film has already been distributed among the associations of German driving instructors and was well received. It is also available on the BASt YouTube channel under http://www.youtube.com/user/BASt20111.

BASt tunnel model

Tunnel model

A 1.5 by 3 meter model of a tunnel was developed for training purposes. It can be used to simulate fire scenarios and to illustrate and explain correct behaviour in different situations.

The model was also used for user surveys revealing another simple way to improve behaviour. Most people were not familiar with the term “tunnel control centre”.

Hearing the announcement: “this is the tunnel control centre speaking, please leave your vehicles …” does not prompt them to leave their cars, as they do not acknowledge the tunnel control centre as an authority. It would be advisable to replace the term: “this is the police/ fire brigade speaking” so as to put more emphasis on the instructions to follow, thus persuading people at risk to flee their vehicles.

Outlook

Another decisive factor in self-rescue is the social aspect. It can have an adverse effect on a person’s behaviour (“why should I flee when the driver in the car in front me is staying?”). It can, however, also have a positive effect if other people display correct behaviour.

In this context an initial study using virtual reality has already been conducted in the SKRIBT^{Plus} project. The trial participants were confronted with a tunnel full of smoke. They were in a smoke-filled tunnel either alone or together with another virtual partner, a so-called agent. This agent ran to the emergency exit, or in the opposite direction, or remained passive.

The agent’s behaviour had a clear influence on the trial participant’s behaviour. If the agent ran in the wrong direction, more users ran in the wrong direction themselves and if the agent ran towards the emergency exit, more users did the same. If the agent remained passive, not only did this behaviour make fewer users run to the emergency exits, but it also made them wait much longer before fleeing. This clearly indicates the problem caused by tunnel users remaining passive and thus having an adverse effect on other people’s behaviour. This influence will be analysed more closely in the course of the project. ■

For more information see www.skribt.org

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Economically efficient housings

When building a new federal trunk road or extending an existing one, sections that are especially sensitive are increasingly built within housings to protect local residents and the environment from traffic emissions. Applicable technical regulations stipulate that fundamentally housings must be equipped like tunnels, irrespective of whether they are fully closed or have wall or ceiling openings. This requires the housings to be designed to have similar operational and safety equipments.

This, however, gives rise to the justified question why housings made of glass allowing daylight or housings with openings and fresh air circulation need to be equipped like tunnels in their daily operation as well as in cases of fire. Individual studies have shown that depending on the type of housing some of the equipment such as emergency exits, mechanical barriers or video surveillance systems can be omitted without reducing the housing's safety.

These studies, however, did not conclusively state whether cost-intensive operational equipment can generally be disregarded without any safety loss if specific structural principles are complied with when housings are built.

Saving potential

Regular studies have shown the existing saving potential and how open housings can be built and operated more economically. The studies were based on general housing types which were compared to a tunnel with a rectangular profile built according to applicable guidelines (reference tunnel).

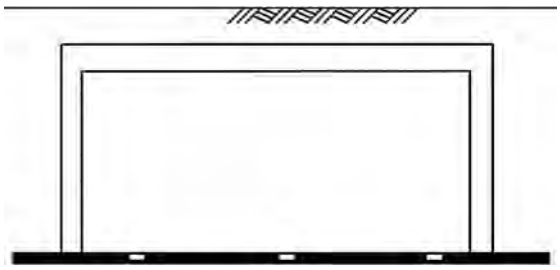
Risk analyses were the basis for deriving minimum requirements for constructing and operating various housing types. Modifying a variety of structural details helped to define how structural measures may be used to replace elements of operational equipment.

Risk mitigation in case of fire

The structural properties of open housings usually reduce risks in case of fire as fumes do not get trapped and can thus possibly be prevented from spreading throughout the housing's interior. However, the individual structure of the housing determines to what extent such spreading can be prevented.

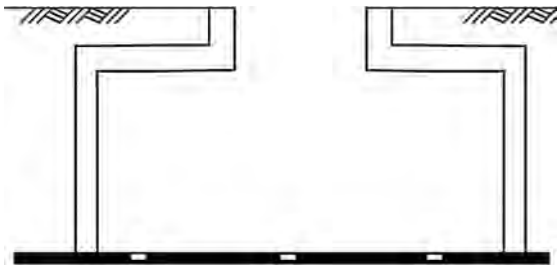
The openings should be as large as possible for the fumes to ventilate naturally. Another positive effect can be achieved when the ceilings are inclined with rising pitches towards the openings on the sides. The steeper the ceiling, the better the positive effect on the spreading of the fumes.

Housings with openings on their walls provide an escape route for people who are physically fit and can climb through them. However, with oncoming traffic it may be difficult to reach them safely. Emergency services can also use the openings for their access. Neighbouring lanes should be closed to traffic in case



Reference tunnel / closed housing

Housing with side openings (open / partially open)



Housing with ceiling openings (open / partially open)

of an incident if it is intended that they be used as escape or access routes.

The studies have shown that if structural elements are optimised in their design they can be used to replace elements of operational equipment. The reduced need for housings with a standardised open design in equipment with operational elements was defined. In all other cases, a reduction of the equipment requirement is not conducive to the housing's safety.

Cost benefits

Additional cost-related studies have shown that housings with oncoming traffic and including side or ceiling openings with pertinent structural design can reduce cost by 45 per cent compared to a tunnel provided the calculation takes their service life into consideration. The results of the studies are the basis for updating the technical regulations and can be used by highway authorities and planners for their decision-making processes in drafting new structures or refitting existing ones. The findings will make it possible in the future to make fundamental comparisons between different housing types to see how elements of operational equipment can be replaced by structural measures. ■

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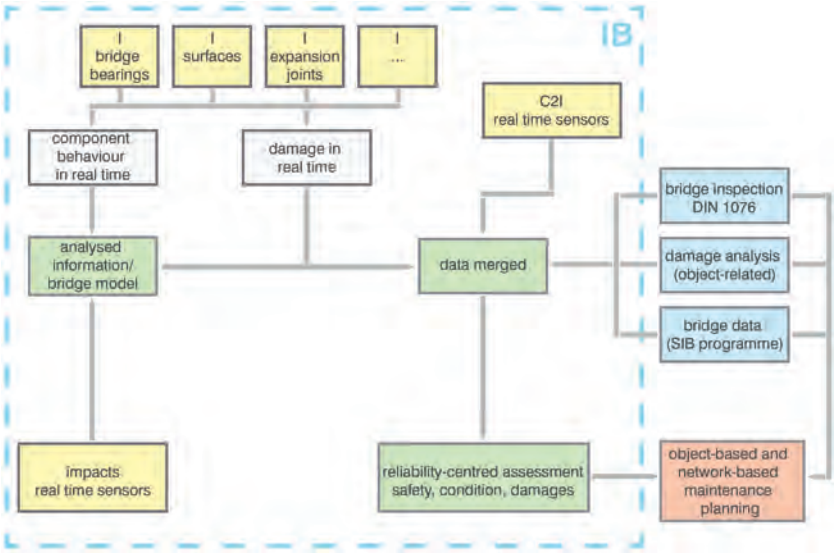
“Smart” bridges

Germany’s network of trunk roads will need to meet new challenges in the near future. Its structures are aging and the budgets for repair and maintenance measure are not likely to be increased in the future. The situation is aggravated by increased traffic, the impacts of climate change, and new quality requirements for sustainability.

New innovative approaches need to be integrated into maintenance management and continuously improved, in order to maintain a reliable road network. This holds especially true for bridges. Current maintenance management is mostly damage-based and reactive in nature because damages are only discovered once they have become visible during routine inspection. This procedures, however, reaches its limits as soon as the bridge’s load capacity is rendered inadequate by an increase in traffic, or deficiencies are structural in nature, or allowance needs to be made for limited funds. All these cases require detailed knowledge about the actual condition of the bridge in question and more reliable projections. This calls for new approaches to assess the bridges’ actual condition in real time. Measures can be carried out as needed based on detailed information. Not only existing bridges could benefit from such an approach, but also new bridges for which an efficient system is now being set up for maintenance planning in the future.

Objectives

Against this backdrop, BASt has decided to set a new focus in its research: smart bridges. An adaptive system is to be developed that will provide relevant information about changes in impacts or resistance for assessing them holistically in real time.



Integrating smart bridges into the existing maintenance management scheme

In addition to inspections of construction works, a sensor system is an appropriate assessment and analysis tool to make information available to determine the actual condition of bridges in real time. Measuring devices can provide information on future damage and likely changes in the structure’s condition. This type of information has not been available previously. Cases in point are chloride concentrations, spallings, cracks, fractured pre-stressed steel, moisture penetration, and corrosion. The basis for an anticipatory and reliability-centred maintenance management can be created by using this data in combination with forecasting techniques and information already available in existing databases. The data retrieved by various sensors is merged and evaluated holistically by a reliable expert system. It will then be integrated into maintenance planning for the entire network as well as the individual object.

Since every bridge in Germany has more or less its own character, future systems need to be adaptable so that they can

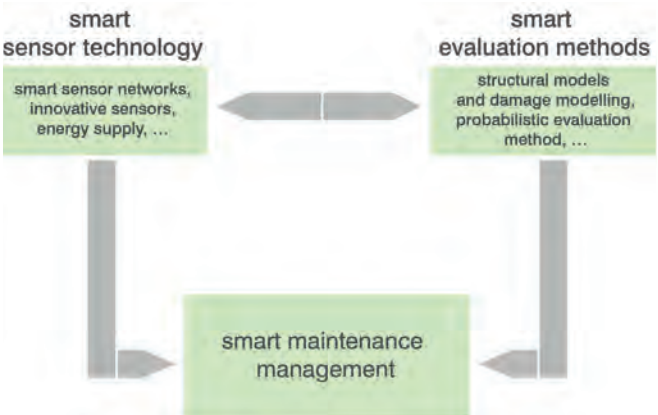
be tailored to the bridge in question. Construction methods and geometries can be prime relevant aspects, especially in the case of existing structures. Additionally, the year when the bridge was built, its load history, as well as structural deficiencies and previous damage can play an important role.

The main feature of a system of smart bridges is that it comes into effect at an earlier stage than conventional monitoring. A smart bridge reacts even before any damage occurs and before its use is jeopardised, i.e., ideally at the start of its service life. The system consists not only of the measurements alone, but also their evaluation and projections in real time. If necessary, a corresponding expert software system should automatically alert users, administrative authorities, and owners. This could pave the way to automated reactions in the future (adaptive structures).

A multitude of components and aspects interacting with and influencing each other need to be taken into consideration within the complex system of smart bridges. Most aspects can be attributed to one of the following component groups: smart sensor technology, smart evaluation methods and smart maintenance management.

Component groups of smart bridges

Though each component group has its own separate function, they are intricately linked to one another. The data measured by means of smart, wire-less and energy-efficient sensors is fed into the evaluation models. The latter in turn determine to a great extent what the sensors need to be able to provide in terms of measurement parameters and sampling rates. These two groups are an integral part of the regularly updated maintenance management system. The current deterministic approach will be complemented by reliability-centred methods.



Research

The system of smart bridges will be established gradually in a series of research projects. Projects on smart evaluation processes are focused primarily on concepts. One of the main questions is to find out how individual components and the damages to them are inter-related and how their influence on the entire bridge can be determined. Their correlation is to be described using reliability theory. To enable this, it is important to know what damages can become relevant and what parameters are needed to record them, or how the interaction between the components' functionalities can be described.

Projects exploring the use of smart sensor technology will focus on how the concepts can be put into practice at the structures themselves. The sensors to be employed need to be suitable for use on or in bridges. They must be able to withstand all the impacts they will be exposed to at the bridge. Sensors and sensor networks should be wireless if possible and be energy self-sufficient, because cable-ducts in or on bridges can become vulnerable spots, and power supply cannot be provided everywhere. The projects will also research data management, in addition to sensor technology itself.

Expansion joints to be used as smart components in the future

Including sensor technology in constructing bridges is a relatively new idea about which we do not have much experience. There is a great need for research. This is why the sensor aspect is the subject matter of separate development projects. Two on-going projects, for example, focus on what information can be gleaned from measuring data at expansion joints and bridge bearings and how suitable sensor technology can be integrated at those points. Two other projects help develop sensor networks and concepts for data processing in real time. The projects' main feature is that they are put into practice at bridges so that their results can be demonstrated and viewed on site.

In the design of each project the main question is how to incorporate the results into the existing maintenance management scheme, as that will be the basis for smart maintenance management in the future. Additional projects are needed to specify the interface to the maintenance management, i.e., the bridge management system (Bauwerks-Management-System, BMS).

The research projects on smart bridges that have already been planned are scheduled for the time period between 2010 and 2015. The findings of all the projects will be combined and feed into constructing a prototype "smart bridge". ■

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Fast sealing on bridges

Due to a significant increase in traffic flows, repairs on bridge deck surfacing result in traffic obstructions. This calls for repair systems that use up little time while causing only a minimum of disruption to road users. The standard type of construction for sealing systems on bridges described in part 7, chapters 1-3 of the Additional Technical Terms of Contract and Guidelines for Civil Engineering Works (Zusätzliche Technische Vertragsbedingungen und Richtlinien für Ingenieurbauten) takes several days and up to several months' time because of its multiple-layer method and the construction materials used, including curing times. An alternative sealing system is currently being tested. It does not require many days' work, usually not more than a weekend to replace bridge deck surfacing. It is an asphalt framework with a large number of voids that is installed first, and its voids are subsequently filled with flexibilised epoxy resin (hohlraumreicher Asphalt mit nachträglicher Verfüllung, HANV).

System set-up

The asphalt framework with a thickness of about 1.5 to 2 centimetres is installed and then rolled on lightly. The voids are flooded with flexiblised epoxy resin as soon as the framework is installed, while the asphalt is still hot. The epoxy resin is then spread across the surface with the help of rubber scrapers until all the voids are filled and no more resin can be absorbed. Due to its low viscosity, epoxy resin thoroughly penetrates the framework. The heat from the asphalt not only lowers the resin's viscosity, but also accelerates its reaction rate. This makes the resin harden faster.

For a fast construction process, but in particularly for the purpose of guaranteeing sufficient bonding between the sealing layer and the additional asphalt layers, these are installed "hot on fresh" even before the sealing layer has

Installing rolled asphalt layers before sealing system is fully cured

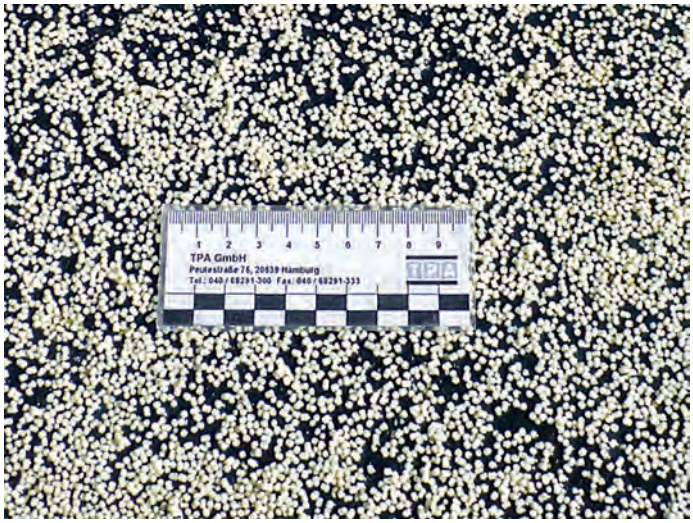
completely cured, but after the asphalt framework has cooled down enough to allow the installation equipment to be driven on it. Based on previous experience, this is usually the case within one and a half or two hours after the filling was first started.

Function

The asphalt framework becomes stable when its voids are filled. This has a particularly positive effect when the asphalt's temperature increases during use, as the mechanical properties of epoxy resin change less due to increasing temperatures than the properties of the asphalt's bitumen do. The extensive filling of the voids ensures this layer's watertightness. The system acquires a certain crack bridging property by being filled with epoxy resin, but this does not correspond to the crack bridging property of sealing systems for bridge deck surfacing on concrete pavements as required in the Technical Terms of Delivery for Construction Materials, Parts 1 to 3 (Technische Lieferbedingungen für Baustoffe). If the epoxy resin filling is installed correctly, it creates an excellent bonding with the concrete layers resulting in better tear and shear strengths. Test carried out by both the ASPHALTA testing and research laboratory and the Federal Institute for Materials Research and Testing (Bundesanstalt für Materialforschung und –prüfung, BAM) have shown tear strengths of more than 1.5 N/mm^2 under good installation conditions.

Advantages

These sealing systems have the advantage of being much faster to install than conventional systems. The individual layers can be applied without much delay between them. The epoxy resin base does not need to fully cure as the asphalt framework's heat installation accelerates the curing process and post-curing occurs. Additionally, the open voids of the asphalt framework prevent blisters from forming when the sealing layer is installed. Because of the sealing layer's thickness and its special design, it can even be installed in the case of large waviness while other sealing systems would require a scratch coating to level the surface. The sealing layer can also compensate for unevenness in the concrete substrate without concrete replacement. However, it needs to be understood that this levelling method is more expensive than concrete replacement.



Mixing in Statiflex Granulat

Boundary conditions

This construction method is mainly the method of choice when bridge deck surfacing needs to be renewed over a weekend. This entails specific requirements which need to be taken into account already during the planning phase.

Stable weather conditions are necessary for the time when the substrate is prepared and the sealing layer is installed. Precipitation would be particularly bad in the specific interval between the asphalt framework's installation and its flooding with epoxy resin. The rainwater would fill

the voids in the asphalt framework and impede the epoxy resin's penetration. As the resins employed have a relative density similar to water, the epoxy resin cannot displace the rainwater from the voids. Composite examination under poor installation conditions and partially water-filled voids showed a considerable decrease in tear strength. Once it is installed, the asphalt framework can be filled after a sufficiently long drying time provided that no more moisture is left in the framework.

For the renewal of the bridge deck surfacing to be safely completed within a very short period of time, two sets of vital installer equipment need to be available; this is to ensure that an immediate replacement is at hand should a piece of equipment break down.

It is also important to refrain from using mastic asphalt for the intermediate or top layers of asphalt that are installed directly on top of the sealing layer. As the sealing layer has not fully cured at that time, gases could be released and cause blisters.

The problem of how the surface of a poor concrete pavement can be repaired swiftly and lastingly has not yet been resolved. It is, however, important considering the limited time frame available for the repairs. When planning a renewal of the bridge deck surfacing, it is highly recommended to examine samples of the concrete pavement for its condition and if necessary plan additional measures.

Before the installation company starts its work, project-specific instructions should be developed in coordination with the client covering the needed equipment, human resources, and logistics. Together with the executing companies ASPHALTA Prüf- und Forschungslaboratorium GmbH has compiled a quality assurance plan for the required inspections of self-monitoring and monitoring by third parties. The plan is continuously updated on the basis of practical experience.

Additional application

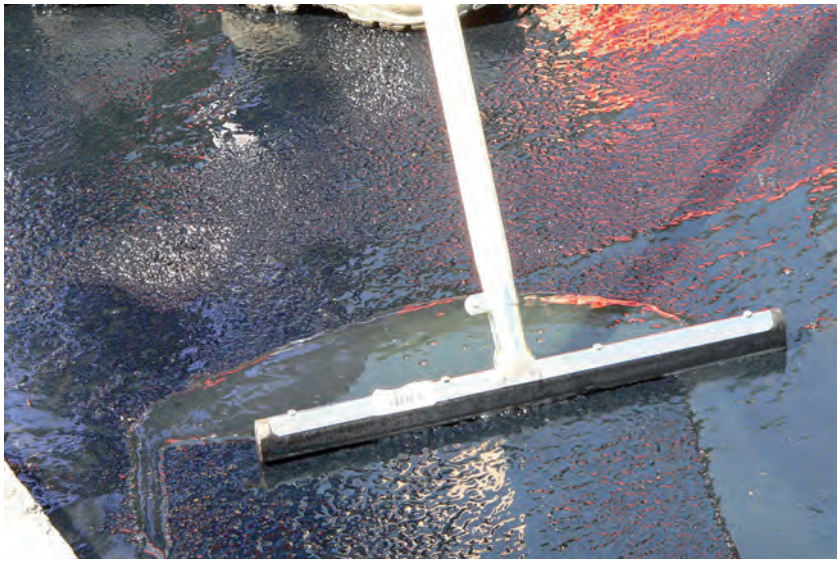
In addition to providing a fast sealing method for sealing concrete substrates, a modified system offers the possibility to increase the deformation resistance of heavily frequented traffic areas on bridges. The asphalt framework filled with flexiblised epoxy resin differs from conventional surfacing using rolled or

Increasing pavement stability at bus stops

mastic asphalts in its higher resistance to deformation on the basis of increased temperatures. Areas subject to intense use such as bus stops, bridges, or tailback sections in front of traffic lights are made more stable when the surface pavement uses synthetic resin filling. The deformation potential is minimised at the same time. For this to happen and depending on the substrate in place, the bridge deck surfacing needs to have its entire thickness - or at least its top layer - improved by an asphalt frame work filled with synthetic resin.

Conclusion and outlook

To date, these systems have been used to seal about 30 objects. They were primarily applied to main traffic arteries in towns and cities or to engineering works that are important transport hubs, which could not be closed to traffic for a length of time or where traffic could not be diverted easily. The studies carried out when these measures were implemented have supplied enough data to compile a set of regulations comprising the material requirements and the method implementation.



Spreading epoxy resin

Additional tests are currently underway on, for example, how to optimise the bonding between the sealing layer and the asphalt layer above by sprinkling specially designed plastic granulates over the sealing layer. They are incorporated into the resin during the hardening process; when hot asphalt is added they melt and powerfully bind the layers to one another. This is a considerable advantage, if weather conditions do make a “hot on fresh” installation possible. ■

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Innovative structural scanner developed

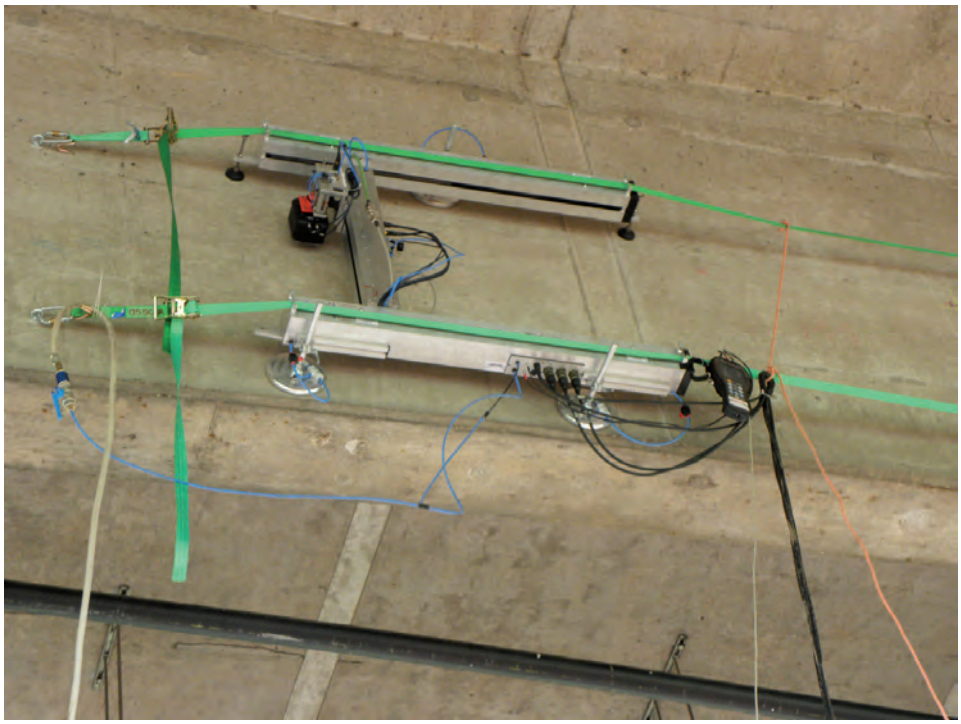
The OSSCAR (On-Site SCAnner) joint research project was completed in June 2011. A new scanner system was developed for automated non-destructive testing of structures during this project part of the InnoNet programme funded by the Federal Ministry of Economics and Technology. The joint research consortium consisted of the BASt, the Federal Institute for Materials Research and Testing (Bundesanstalt für Materialforschung und –prüfung), the Frauenhofer Institute for Non-Destructive Testing, and ten partners from industrial corporations and small and medium-sized enterprises (www.osscar.eu).

Motivation and starting point

There are about 39,000 bridges and other civil engineering structures along Germany's network of trunk roads. Their condition has a significant impact on the economy. Damages can have far-reaching economic effects. Increased stress due to an increase in traffic, aging of the bridges' fabric, and problems in the stability of older bridges have triggered the need for systematic maintenance. Detailed information about the condition of the bridges and other civil engineering structures is indispensable for reliable maintenance planning. This is ensured by carrying out regular bridge inspections according to DIN 1076. Bridges and other civil engineering structures are subjected to a comprehensive major inspection every six years. This major inspection is followed by a "minor" inspection after three years in the form of an extended visual inspection. If necessary, additional tests are carried out in the context of an object-related damage analysis (objektbezogene Schadensanalyse, OSA), usually consisting of non-destructive testing (zerstörungsfreie Prüfverfahren, ZfPBau) procedures.

Diagnosis

Numerous ZfPBau procedures have been developed and improved over the past few



Scanner with suction base fixture and securing straps on the longitudinal girder of a pre-stressed concrete bridge

years. Ultrasonic procedures, for example, as well as radar and eddy current procedures are available for identifying/determining the inner structure of a component. These different procedures have their own specific strengths and weaknesses.

The eddy current test provides information about the top reinforcement layer and thus is good for very detailed data on bridge deck surfacing. This procedure is independent of the component's moisture content and can also be used for green concrete.

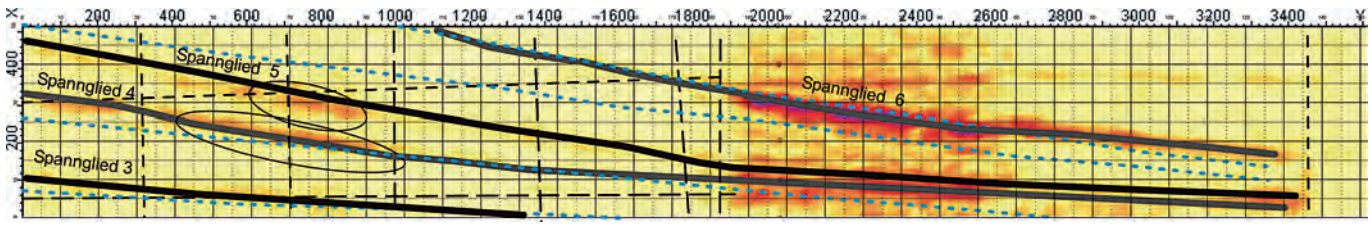
The radar procedure has a deeper penetration depth for dry concrete than the eddy current procedure, and makes visible lower layers, metal tendon ducts, and other metal parts. If the structural component is not too thick, its rear wall can also be seen by radar. This method is less advantageous when the components are moist or the reinforcement is densely laid out, thus shielding off the areas behind it.

An even deeper penetration depth is possible using the ultrasonic procedure; it can generally manage components that are 1.5 metres thick or even thicker. The resolution, however, is very restricted for individual reinforcement bars. This procedure's strong point is its ability to transmit waves through metal objects, so that information can be obtained about the state of injection of the metal tendon ducts.

Developing the OSSCAR scanner

As the procedures show good results in different fields, a combination of them would make sense in order to collect as much information as possible by pooling all the results. Each procedure will have to use the same measurement grid for the data from the different methods to be merged and displayed in a uniform coordinate system. The narrow measurement grid of 2-3 cm required for the ultrasonic procedure to provide a meaningful image is hardly possible in hand measurements. The OSSCAR scanner was developed to enable automated inspections employing a combination of eddy current, radar, and ultrasonic echo.

The scanner was developed with a particular focus on using standard measuring devices without any modifications. This would make the devices usable for manual measurements and would prevent the need to purchase two separate systems. The data collection software is of a flexible design and can be complemented by additional devices at a later stage. The sensor brackets were adapted so that no offsets occur between the different procedures. The scanner can be dismantled and used flexibly. It can be attached to the structure in a non-destructive way by its suction base. Its software allows scanner control, data collection and data processing in one programme. The data can also be further processed in other programmes. After receiving specific training, technicians can



Juxtaposing the tendon courses as shown in the status plan (light blue broken line) with the results of the reconstruction by means of radar and ultrasonic tests (black and grey lines)

use the scanner independently in all the steps necessary up to producing an initial image on site.

Application and use

The results of the scanner tests show that they are consistent with reality. Special evaluation procedures (SAFT reconstruction with phase evaluation) help to identify areas where injection defects at the tendon ducts are suspected. To verify them at the structure itself, the measured data was used to prepare a drawing of the actual position of the tendon before plotting it in a 1:1 format.

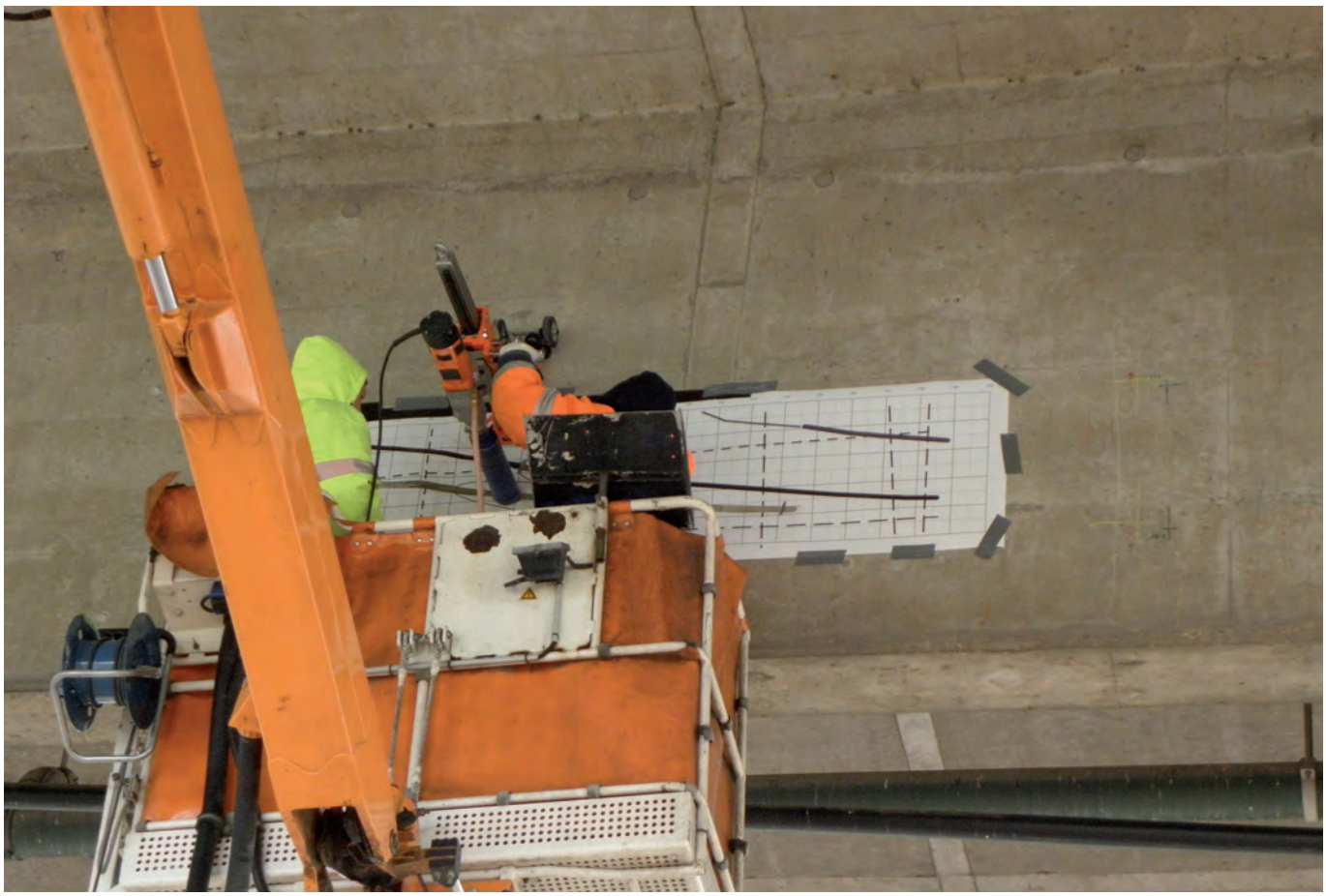
This plan of the suspected spots was attached to the bridge. Core samples from the suspected spots showed that the injection mortar was of a mealy consistency and did not reach the upper edge of the tendon duct, thus classifying as an injection defect.

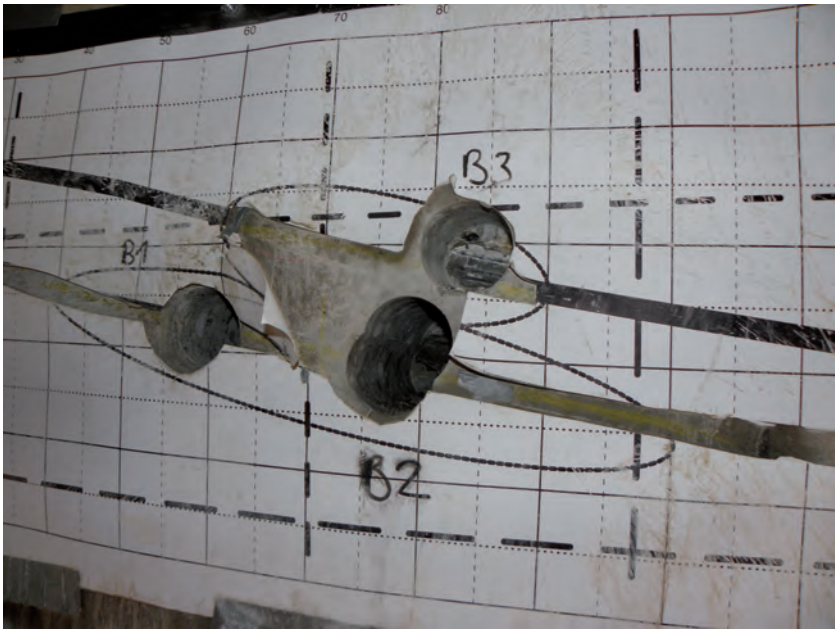
Informing the expert public

The BASt was responsible for the sub-project “Application and use”. Highway authorities staff and experienced bridge inspectors were interviewed in the context of specifying the requirements. The interviews revealed that the persons were not yet aware to the desired extent of the possibilities and limits of non-destructive testing procedures. Measures were taken to outline the benefits of ZfPBau to users who had no experience with them. These include: improved planning certainty and structural safety, detection and evaluation of defects, and cost savings as a result of needs-oriented maintenance.

The curriculum was developed for a seminar on “Modern testing procedures in structural diagnostics”. In this two-day seminar the participants learn about the theory and practical application of conventional ZfPBau procedures (rebound

Plan of suspected defects is fixed to the structure





Sampling cores from the suspected spots

hammer, proof of reinforcement, potential field measuring) as well as modern ones (radar, ultrasonic, impact echo). The pilot seminar was held at the BASt in November 2011 and is now on offer at various VFIB training centres (www.vfib-ev.de).

Conclusion

A structural scanner was developed in the OSSCAR joint research project. It offers considerable advantages over previous approaches to automate ZfPBau procedures and compared to manual methods. Its strengths lie specifically in combining three different testing procedures using congruent measuring fields, thereby enabling the data to be merged. The system is technician-based and first images can already be generated on site. Additionally, the data can be processed on the basis of the most powerful algorithms currently being applied in the field of science. ■

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Asset management for roads

Functioning transport systems are a basic prerequisite for national economies and their mechanisms as well as their growth. Differentiated regional value added chains are only possible when goods and people are mobile. [1] Official projections assume that the demand for transport will increase for both passenger and freight transport. This forecast is substantiated by the assumption that the demand for transport will continue to be coupled to economic growth. The projected economic growth will necessitate that the trend towards higher mileage in freight and passenger transport continues. The road infrastructure's quality needs to be maintained and its efficiency adapted to current requirements using the restricted funds available.

Set of requirements

The transport system's efficiency, reliability, and economic viability are not the only objectives. Other essential factors are road safety, environmental compatibility, and the regional impact. The provision of the infrastructure is to take all these relevant aspects into account from the sustainability perspective. According to a general understanding of sustainability, the term means that the needs of this generation are met without having an adverse effect on the needs of future generations [2]. The idea of sustainability leads to the following

possible requirements that road transport infrastructures need to fulfil:

- efficiency,
- significance for the national economy,
- ecological compatibility and
- social compatibility.

There are positive and negative interactions among the various sets of requirements. An efficient infrastructure can, for instance, have a significant ecological impact. Interactions can also be of a time-based nature. A decision taken today may incur considerable costs in the future and be a burden on future generations.

The multitude of different requirements and their interactions mean that throughout the entire lifecycle of a road infrastructure decisions need to be taken in a plethora of contexts (e.g. construction, operation and maintenance) and by various administrative bodies.

Analysis

In an initial step BASt analysed existing national and international evaluation procedures and concepts. The analysis revealed that there is a heterogeneous understanding of what road infrastructure management is intended to accomplish. However, sustainable planning approaches for road infrastructure seem to have the following aspects in common. These approaches are driven forward nationally as well as internationally under the term “asset management” [3].

Asset management is understood to comprise:

- an integrated and holistic planning approach at every decision-making level, taking possible interactions into account
- a lifecycle-oriented planning approach with a timeframe that takes into account not only the short-term effects of decisions but also the infrastructure’s entire lifecycle
- a planning approach tailored to requirements while taking into account not only the aspects perceived by road users and their related costs, but applying a holistic approach that also includes relevant requirements by other user groups as well as project-related costs for the society at large
- a structured and adaptable planning approach that takes into account the relevant evaluation components at the different decision-making levels and during various lifecycle stages in a transparent and structured manner.

Working definition

This working definition for asset management in Germany was derived from the basic features outlined above:

- Asset management for roads means an integrated planning process that covers the entire lifecycle of highway facilities aimed at a user-oriented and cost-efficient provision of infrastructure and at fulfilling additional social requirements.

- It is based on a combination of principles of engineering with economically sound methods to ensure that highway facilities can fulfil diverse, sometimes competing requirements.
- Asset management for roads is a structured and adaptable management approach that provides tools to assess alternative actions and thus offers short-term and long-term investment strategies for both existing and future infrastructures.

The structure of an integrated planning approach can be developed and existing planning approaches further developed on the basis of this definition of asset management. ■

Picture: Tobias Volkenhoff, RWTH Aachen

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Roads: equipped for wear and tear and traffic loads


Climate change and road infrastructure
Frost is another wear factor for roads
Comparison of measurment systems for pavement bearing capacity
Vibrational load on cycle paths
How to build in the future: road construction without petroleum?
Quality control for exposed aggregate concrete surfaces
Multiple modifications of asphalt binders

Climate change and road infrastructure

Contrary to popular belief the climate of our planet has never been stable. Nonetheless, mean temperatures have increased relatively strongly, and as the CO_2 content in the atmosphere is still rising they are likely to increase even more. The question remains open whether the Baltic Sea will turn into a tropical region or the negative effects of global warming will prevail instead. However, it is certain that our road infrastructure will be exposed to higher temperatures and probably extreme weather phenomena such as gales and heavy rainfall.

All this is sufficient reason for BASt to address the following questions:

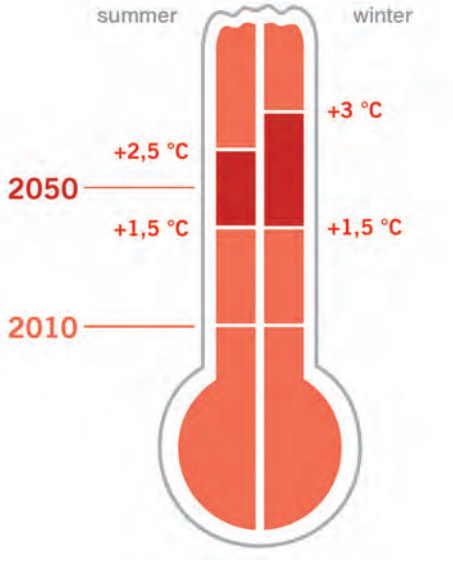
- How will our climate change?
- What impacts will it have on our road infrastructure?
- How can we create and maintain a well-functioning road network for the future?

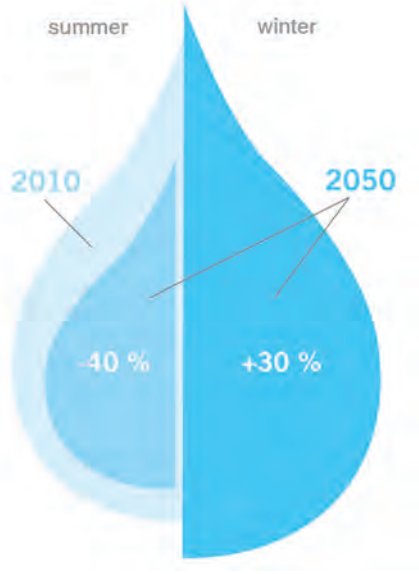
Of course, the last question in particular refers not only to climate change, as that is not the only future challenge posed to road infrastructure and road traffic. Globalisation, sustainability, technological changes, the demographic shift, and increased freight transport are additional challenges. Road infrastructure will have to adapt to all these changes. As roads have a planned service life of 30 to 50 years, and bridges and tunnels are intended to last for 80 to 100 years, it is important to adapt the guidelines for road and bridge construction today so they can withstand the impact of the projected climate change.

Inundated?

Initial impacts of climate change can probably be felt already now. In hot summers, for instance, there is more and more rutting on asphalt pavements and heat-induced “blow-ups” on concrete road surfaces.

Extreme precipitation can lead to roads and tunnels being flooded resulting in an increase of accidents. Nonetheless, the first question, “How will our climate change?”, is not easy to answer. This is only possible with the help of climate projections derived from global scenarios drawn up for its development. They are not definite – as it is the case with every projection. A climate model is projected on the basis of these scenarios depicting future climate developments at the





Temperatures will increase by 1.5°C to 2.5°C (summer) and 3°C (winter) by 2050. There will be 40 per cent less precipitation in summer and up to 30 per cent more in winter

Flooding below motorway A3 at the Königsforst exit

global level. In subsequent steps, this global climate is scaled down to regional contexts to provide information on the climate to be expected directly on or at the road or bridge.

Analyses and scenarios

A cornucopia of scenarios and models is available. This is why in the scope of CEDR Call 2012 BASt is organising a project at the European level aiming to harmonise the scenarios and models in use to at least make European vulnerability analyses comparable.

Selected stretches of the German section within TEN-T (Trans-European Network) were subjected to a vulnerability analysis in accordance with the methods developed in the scope of the "RIMAROCC" ERA-NET ROAD project. This analysis is a key component of BASt's strategy for adapting the road infrastructure to climate change (Anpassung der Straßenverkehrsinfrastruktur an den Klimawandel, AdSVIS). The strategy comprises 16 projects; eight of them have already been started. The risk analysis of significant freight and transit transport axes including sea ports (RIVA) is the central project.

Generally speaking, AdSVIS will provide the data base and methods for a nation-wide vulnerability assessment of Germany's road infrastructure. In addition, it will be used to develop adaptation measures to be tested at critical spots identified by the vulnerability analyses.

AdSVIS as a programme to develop a methodology will initially focus "only" on the respective network section and not yet on the entire network. Since the IPCC climate scenarios are updated in roughly five-year intervals, the vulnerability analyses will also be updated on the basis of changes in input data. Once a validated method is available, this update will become a routine operation, but guidelines and standards will need to be continuously adapted in the future.

The Federal Government pursues a cross-disciplinary approach in its strategies to adapt to climate change. The "German Adaptation Strategy to Climate Change" (Deutsche Anpassungsstrategie an den Klimawandel, DAS) was initiated already in 2008. In 2011 a guide for future action was introduced in the form of the "Adaptations" action plan. A "Vulnerability" network was established aiming to provide a uniform, cross-sectoral vulnerability assessment. This network of higher federal authorities is to ensure consistency in the methods applied in sector-specific vulnerability assessments, and ultimately to combine all the network analyses.

The global nature of climate change makes coordinating the projects, including the AdSVIS ones, with neighbouring countries a necessity. The Netherlands, for example, is currently conducting a project on the Dutch network, similar to

RIVA. Austria is planning a similar project. The adaptation measures, themselves, are also embedded in the (extended) European context through the “Forever Open Road” (FOR) programme within FEHRL. Its “Climate Change-Resilient Road” element is responsible for bundling all the existing projects and planning additional research and development.

The US Climate Change Scanning Tour organised by FEHRL expanded the perspective to include regions outside of Europe. US adaptation projects for climate change were presented at several stations from New York City and Newark, NJ via Washington DC to Baton Rouge, LA. These projects mainly focus on adapting to extreme weather incidents that have been occurring frequently in the US, and are likely to increase significantly in the future. ■

Climate change working group: From left to right, front row: Oliver Ripke, Ursula Blume, Stefan Höller, Carina Herrmann

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Frost is another wear factor for roads

Roads can be damaged severely by frost during freezing but also during the thawing process. The past few winters have shown visible damages in the asphalt pavement often resulting in pot-holes. The impact of frost on a road's lower substructure or subgrade is less known as it is not visible: if they are made of an unsuitable, i.e., frost-susceptible material, ice lenses or ice layers can form, causing the pavement to lift. However, in comparison the damages due to thawing are disproportionately more significant, because they can drastically reduce the load-carrying capacities of the substructure or subgrade. The road will then no longer be able to withstand the impact of traffic. During the thawing period, northern countries often close some roads completely for heavy-goods vehicles to prevent damages. Such an approach is not an option in Germany because of its traffic density. This is why concrete pavements are designed to make roads withstand the traffic loads unharmed despite a loss in bearing capacity. At the same time the pavement's thickness is optimised so that road construction fulfils ecological as well as economic requirements in a best possible way, in other words: the road is as thick as necessary and as thin as possible to make its unbound subgrade withstand traffic and climate impacts for a minimum of 45 years.

Ice lens

Frost impacts

Frost damages are only partly the result of a nine per cent increase in the pore water's volume during frost penetration, which is a well-known physical process: ice floats on water. However, the formation of ice lenses causes more damage. In simple terms, ice lenses are generated when the water contained in soil is drawn to the freezing boundary. It accumulates and grows into ice layers or ice lenses of considerable dimensions. The soil increases in volume and literally heaves up the road above. During thawing the ice accumulations loosen and change the consistency of soils susceptible to frost. As the soil thaws from above as well as from below, its still frozen lower layers do not allow the de-iced water to run off. This is the reason why the load-bearing capacity of the soil, which can turn into a mushy to liquid substance for a brief period of time, becomes profoundly reduced [1].

Frost-safe road construction

Frost damages are usually prevented by constructing a frost-resistant road pavement. This means that the materials used are frost-resistant and the chosen thickness ensures that the ice layer is below the pavement during the thawing phase, thus allowing the melted water to run off freely. This makes a weakening

of the soil impossible. However, for ecological and economic reasons the road pavement's thickness needs to be optimised, using as little material as possible. Additional factors come into play and differing climate conditions across Germany need to be taken into consideration.

Ever since it was founded, BASt has employed sophisticated technology and focused intensely on researching weather impacts, in order to construct frost-resistant roads. The frost index (FI) is used to measure how harsh a cold spell is. It is defined as the product of daily average air temperature and frost duration [°C•d]. It is an arithmetically positive figure, e.g., a cold spell of 10 days of frost and an average air temperature of minus 5° C results in a frost index of 50°C•d. Complex computer-based calculations proved that there is a clear correlation between frost index and frost penetration depth [2, 3].

Due to Germany's different types of geography the frost penetration depth and thus the frost index varies from region to region. They are influenced by geographical latitude and longitude, the region's location in reference to the sea, its altitude and microclimate conditions, such as northern slope location.

The decision on the minimum thickness required is based on the experience that partial frost protection suffices to prevent frost damage. This means that there is no frost damage and the road pavement is frost-resistant if its thickness covers about 60 per cent of the maximum frost penetration depth. During the thawing phase the frozen water barrier would not be located in the pavement and the runoff would be unimpeded when suitable, i.e., frost-resistant material is used in the construction above the zone.

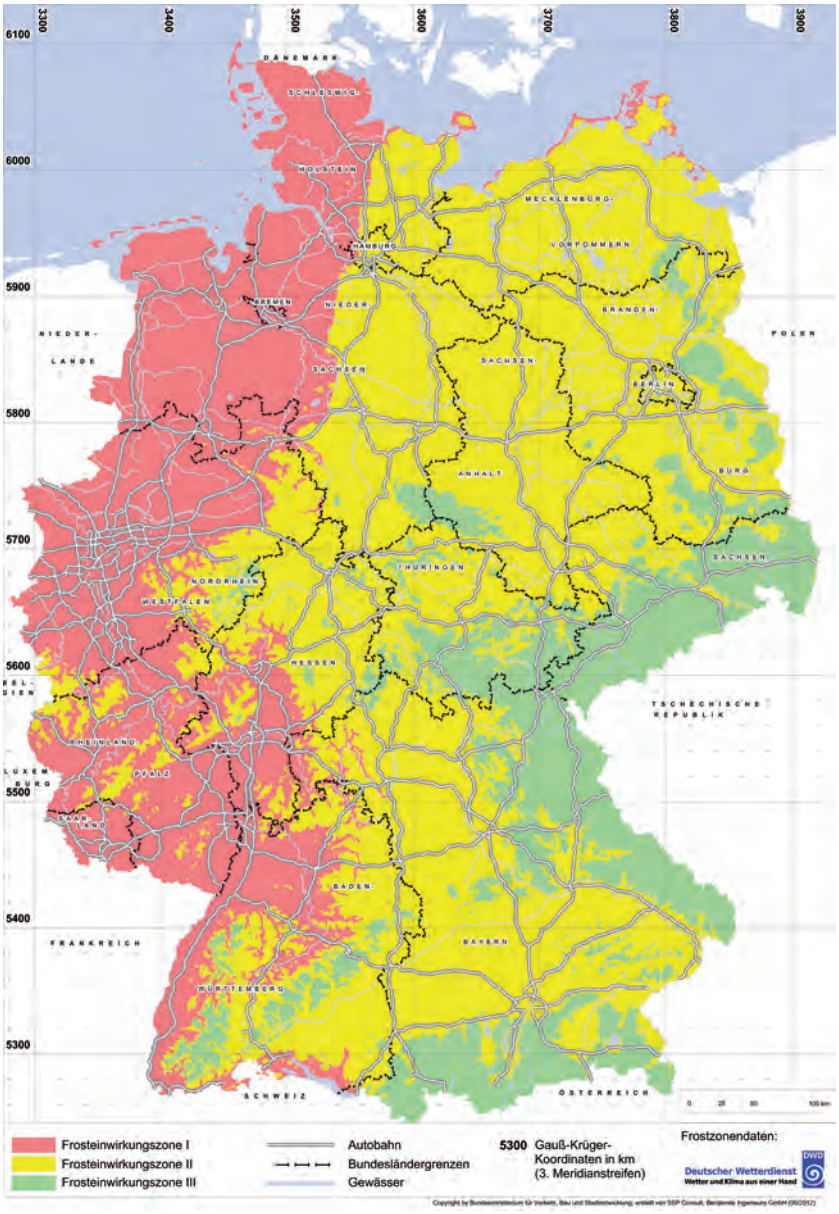
Frost zone map

Three different frost zones were established to take Germany's various climate conditions into consideration when planning the thickness of the road pavement to correspond to the frost impact. Until now the basis for determining the design of frost-resistant road pavements was the map of frost impact areas in the Federal Republic of Germany based on the frost indexes FI of the winter of 1962-63. This map was incorporated into the "Guidelines for the standardisation of pavement constructions for traffic areas" (Richtlinien für die Standardisierung des Oberbaus von Verkehrsflächen, RStO). The temperature zones on this map were based on the winter of 1962-63 which had a very long-lasting cold spell and during which the maximum frost penetration depths were measured to date with few regional exceptions. After Germany's unification, the map was amended and revised, adding the new Länder.

The frost impact zones take into account large-scale climate differences in Germany for determining the thickness of frost-resistant road pavement.

This map was relatively inaccurate as only a limited number of weather stations supplied data for calculating the highest frost indexes in the winter of 1962-63. It did not include specific climate influences, and the road planners needed to fall back on long-term experience and local knowledge for their decisions, but often these did not exist. Some Länder developed their own frost zone maps [4, 5]. A nation-wide update was urgently called for.

A research project of the German Meteorological Service (Deutscher Wetterdienst, DWD) explored a frost index with a statistical return period of 30 years



Frost zone map (Illustration: copyright with Federal Ministry for Transport, Building and Urban Development: developed by SSP Consult, Beratende Ingenieure GmbH (06/2012))

(FI30) for a 50-year period to replace the reference to the extreme winter of 1962-63 [6].

Weather data was studied from 221 representative weather stations holding assessable information from the winter of 1955-56 to the winter of 2004-05. The temperature distribution was confirmed by sound statistics, and de-coupled from extreme weather incidents. The frost index was calculated on the basis of a one-square-kilometre grid taking into account geographical position, altitude above sea level, and location in reference to the sea. The influence of the built surroundings is not significant in terms of statistics and was neglected. In general, the parameters for a frost-resistant structural design were established, with the exception of areas at high altitudes which need to be addressed separately.

The areas on the updated map that are marked red indicating a low frost impact (zone I) do not require any additions to the initial values stipulated by the RStO determining the minimum thickness for frost-resistant road pavement. The yellow zone II with medium frost impact requires an additional 5 centimetres to the standard minimum thickness and the green zone III with heavy frost impact an additional 15 centimetres.

A look at the new frost zone map shows that frost zone II dominates more compared to the previous version. This is due to the fact that the boundary between zone I and II no longer runs along Hanover, Schwerin and Greifswald, but has shifted to the west along Hanover, Hamburg and Kiel. Additionally, fringe zones in altitudes originally in zone III have now been assigned to zone II.

A quick, simple and accurate localisation is now possible by superimposing the frost zone map on the network of federal trunk roads, on maps of major cities, and on the map of the main water bodies. The new map also marks the borders between Länder and shows the latitudes and longitudes grid. The map is to be used in combination with the “Guidelines for the standardisation of pavement construction for traffic areas”, Volume 2012 (RStO 12). It has been available as a free download from the BASt homepage since August 2012. ■

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Comparison of measurement systems for pavement bearing capacity

The Traffic Speed Deflectograph (TSD) is a measurement system for assessing the bearing capacity of pavement structures, mainly asphalt ones. The road pavement is measured without traffic disruptions under a defined static wheel load of 50 kN (= 5 tons) at vehicle speeds ranging from 50 to 80 kilometres per hour. Laser sensors are used to detect the velocity of pavement deflections under the wheel load. Continuous data collection during the test drives ensures high data density, making it possible to identify other sections in the network with the same bearing capacity.

Conversely, the Falling Weight Deflectometer (FWD) is a system which measures the load-bearing capacity only on single selected spots; it requires a relatively high effort and causes traffic disruptions. The FWD is mainly used at project level or in smaller networks.

Objective

In the scope of a BASt project, the TSD and FWD systems were compared to one another. Their measurement results were evaluated in terms of homogeneous systems identified on the basis of load-bearing parameters for road structures. Separate measurements using TSD or FWD were carried out on selected sections of the network of federal trunk roads. The Danish Road Institute (DRI) was in charge of tests and evaluation of the TSD. Additional non-destructive measurements using geo radar (Ground Penetrating Radar, GPR) provided information on the road pavement design and the thickness of the bound pavement layers in the sections measured.

Falling Weight Deflectometer

Results

As various conflicts arose during the TSD measurements, a comparison of the TSD and FWD values in absolute terms is possible only to a limited extent. The data cannot be corrected subsequently due to the complexity of the influences on it. The results of the BASt trial were discussed with the producer and the operators, leading to an improvement of the TSD.

The TSD offers the possibility to determine the load-bearing capacity of asphalt pavements across the network in a non-destructive manner. It can also be used to provide data on a pavement's structural design (by means of GPR for example). The system is thus capable of contributing significantly to the identification of homogeneous sections of load-bearing capacity, which is of great importance for assessing the structural substance of road pavements in the context of maintenance management.

Conclusion

- Homogeneous sections can be differentiated with the help of the parameters of the different measurement systems.

- On the basis of TSD and FWD measurements alone, without any knowledge of the thickness and the design of road pavement structures, load-bearing capacities cannot be determined. The layer thickness should always be included in measurements aimed at defining load-bearing capacity (using GPR for example). All this data should be supplemented with additional information on traffic, materials, and ambient conditions.
- Compared to measurements from other external studies, the road pavements measured in Germany were relatively thick and thus very stiff. This is why the values resulting from the measurements are correspondingly low. They caused problems during the application of the evaluation method and calculation of load-bearing capacities using TSD data.
- On the basis of the TSD data the deflection parameters were calculated with the help of theoretical models. However, the methods were applicable only to a limited extent due to specific boundary conditions, and are considered critical.
- Longitudinal unevenness, bends, and certain driving manoeuvres can result in significant deviations between the dynamic wheel load and the static wheel load. While the load is known in FWD measurements, to date TSD measurements have not included the wheel load. This is why the TSD data does not suffice to determine whether higher deflection values are the result of a locally higher wheel load or of a weaker road pavement. Wheel load measurements are considered essential components of future TSD measurements. ■

Traffic Speed Deflectograph

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Vibrational load on cycle paths

Technical condition surveys and assessments (Zustandserfassung und –bewertung, ZEB) have become an integral part of planning maintenance for federal trunk roads, but for cycle paths they are still in their infancy. Initial technical measurements of the longitudinal evenness of cycle paths have been undertaken in Schleswig-Holstein and Brandenburg. An on-going BASt project is studying the requirements for cycle path maintenance [1].

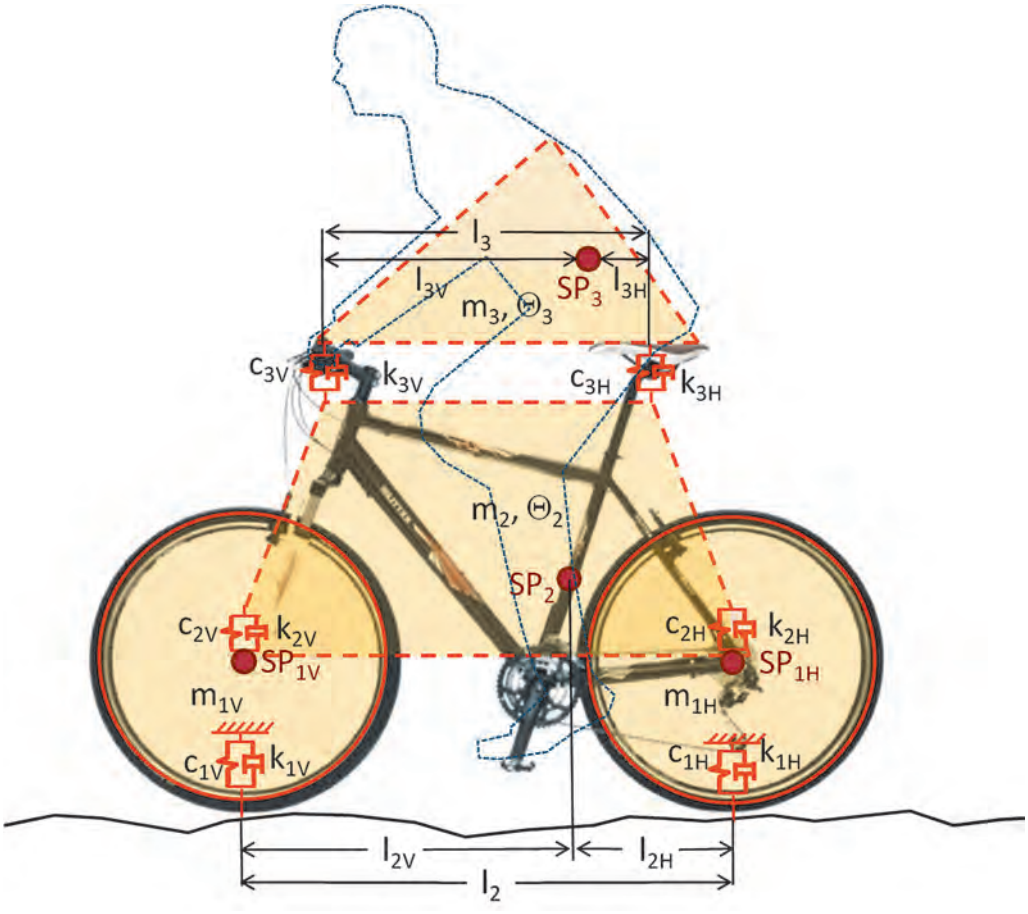
The vibrational simRad model

A bicycle model was developed for ZEB purposes to simulate various vibrational phenomena that have an effect on bicycles such as the vibrational load on the handlebar or saddle. The cycle path's vertical and longitudinal profile values are needed to feed the model with input values. Accelerations at various points along the bicycle can be measured as output values. An analysis of whole-body vibrations as defined by the Association of German Engineers (Verein Deutscher Ingenieure, VDI) in VDI 2057 [2] is also possible.

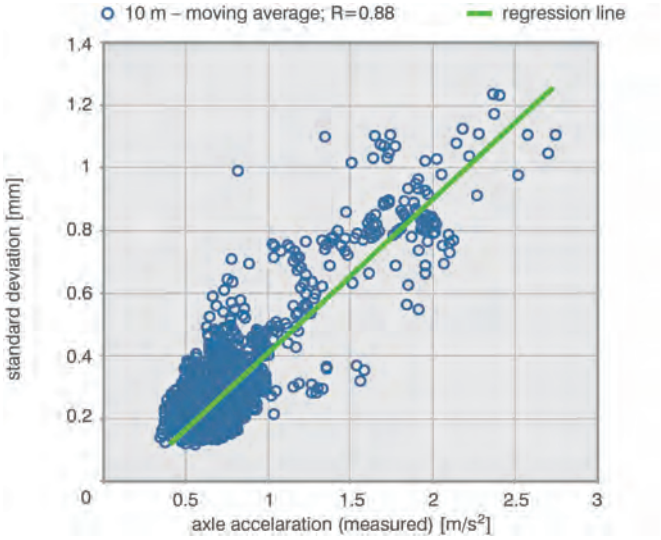
The vibrational model covers four masses:

- front wheel,
- rear wheel,
- frame
- the cyclist's upper body (torso) impacting the handlebar and saddle.

The cyclist's legs are supported by the frame via the pedals, and their proportional share in the total weight of the frame is taken into account.



Vibrational model of a bicycle



Correlation between measurements and S01 value

It can be assumed that vertical forces to have the most pivotal effect on the bicycle, and horizontal forces, introduced by tyre-surface contact, are significantly weaker than the vertical ones at constant speed and moderate road inclination. This is why the model was first designed to enable the analysis of vertical dynamics. Acceleration or braking is not part of the analysis. The vertical suspension characteristic of the tyres is already accounted for through the springs and dampers.

The tyres are linked to the frame through springs and dampers so that dampened front axle and rear axle constructions can also be taken into consideration. Springs and dampers are part of the saddle too. A cyclist's upper arms support his or her torso against the handlebar. They enable relative movements between the upper body and the handlebar, likewise supported by springs and dampers.

The bicycle model is capable of stroke and pitch movements, i.e., moments of inertia are allocated to each mass. Mass distribution as well as spring and damper constants correspond to details published in the references [3 bis 5], and are validated by means of trips over individual obstacles of known shape and height.

Validation

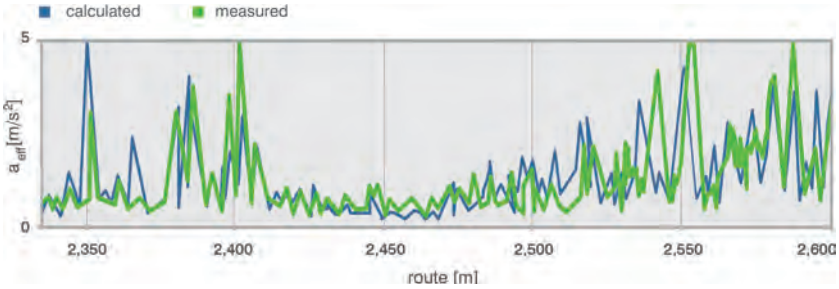
The model was validated using the Pedelec KTM ecross, 2011 model. Its frame size is 51 centimetres and its wheel size 28 inches. The electric motor is located in the rear wheel hub. The bicycle passed over various separate obstacles for validation.

Application

The model was first used on a road in Bavaria. The ZEB provided topical information on the longitudinal profile of the tested stretch of the road. The bicycle was used on the stretch, and the vertical acceleration of its front axle measured. The acceleration of the front axle was simulated using the information both from the longitudinal profile and from the bicycle. It was then compared to real-life measurements.

The results show that the measurements correspond well to the calculations; this is

Axle acceleration: measurement (green) and calculation (blue)



additionally supported by the correlation coefficient of R = 0.82. The bicycle's vibrational behaviour is well represented by the model and requires only few parameter adjustments. The acceleration measured at the axle closely correlates to the unevenness of the surface in a wavelength range below one metre. The unevenness can be described by the S01 standard deviation.

Conclusion

The bicycle model developed is capable of realistically representing the vertical accelerations on a bicycle's front axle. The experiments showed a good correlation between the measured and the calculated accelerations. The model also offers the possibility to determine the accelerations on other bicycle parts, such as handlebar and saddle, enabling an analysis of a cyclist's whole-body vibrations.

The SimRad bicycle model provides a tool for future assessments of cycle paths and analyses of the vibrational effects on the human body. ■

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How to build in the future: road construction without petroleum?

Sustainable development covers every economic sector and presents a major and complex challenge to civil engineering and road construction. The finite supply of certain construction materials, the efforts involved in extraction, processing and utilising, but also energy consumption and the emissions from transporting the materials to the construction sites need to be taken into account. Especially in road construction, large and bulky quantities are transported.

Germany's road network consists mainly of asphalt. The binding agent used in asphalt constructions is made in refineries by distilling crude oil. Petroleum is the earth's most depleted energy source. The global peak in petroleum, i.e., oil that can be explored, extracted and transported using conventional technology, will be reached in about 2020 [1]. If unconventional oil is used more intensely (ultra-heavy oil, oil sands, oil shale) the peak may be stretched to 2035 at the latest. From then on the availability of petroleum will decrease. In the medium-term we need to consider new schemes to make road construction sustainable. A study at the Technical University Clausthal commissioned by BASt investigated a number of possible scenarios [2].

Scenarios for road construction in the future

Base scenario: expensive and fewer oil resources

The prices for petroleum will inevitably rise if supply becomes scarce while demand increases in emerging economies. Complex extraction methods for both conventional and unconventional oil will accelerate this trend. A technical aspect plays an additional role in the case of bitumen. As refinery technology develops further, increasingly larger quantities of the distillation residue, bitumen, can be processed to fuel, making it an immediate competitor to petrol, diesel, and kerosene.

A massive rise in the price for bitumen seems unavoidable. This base scenario seems very likely in the medium term. The following solutions may be appropriate:

- using alternative construction processes, for example concrete roads
- increasing the service life of asphalt pavements
- reducing petroleum consumption, or focusing on using petroleum to produce long-lasting or vital goods
- improving the recycling ratio (see scenario A).
- using unconventional petroleum or petroleum alternatives (see scenarios B and C)

Scenario A: Using the road as a resource

According to sustainable lifecycle management once existing infrastructures, in this case roads, are no longer in use, they need to be seen as a new source of raw material. Considerable quantities of bitumen as binders are built into the asphalt of Germany's road network. In 2005, the paved surfaces of German motorways alone covered 269.04 square kilometres, of which 70 per cent were asphalt pavement. On other roads, almost 100 per cent of the pavements are asphalt ones. Assuming that the asphalt pavement of a motorway has an average thickness of 0.3 metres and a bulk density of 2.3 tons per cubic metre, the existing asphalt mass amounts to about 130 million tons. This needs to be added to the considerably higher quantities found in roads at federal, regional, district and municipality levels.

As the construction of new roads will continue to become less important, large quantities of reclaimed asphalt are available for road maintenance. About 80 per cent of the asphalt is already recycled at present. Ideally, recycling could be increased to 100 per cent, i.e., roads to be renewed will be dismantled and the extracted material processed and then fully re-used. Before this can happen, some technical challenges need to be met as not all reclaimed asphalts are suitable for re-use. However, their properties can be improved by mixing them with additives such as rejuvenation agents to make them fit for re-use.

Other countries have not matched Germany's recycling ratio. If the ratio increased globally, it would lead to a significant reduction in the need for bitumen.

Scenario A presents state-of-the-art technology and can be applied more broadly in the short to medium term.

Scenario B: Using unconventional petroleum

Unconventional oil is a resource that cannot be produced by conventional exploration, extraction and transport technologies, and includes ultra-heavy oil, oil shale, and oil sands. The latter are mixtures containing petroleum of high viscosity, water, sand, and clay. This can already be considered natural bitumen when petroleum is classified according to its density. Oil sands have a bitumen content of about twelve mass percent. Canada, Kazakhstan, and Russia have large deposits that are already being extracted. This natural mastic asphalt may be used directly as an asphalt component, but initial tests have indicated that it is inadequately suitable. Extracting the bitumen from oil sands requires very complex, energy-intensive and thus cost-intensive procedures, and it would compete with fuel production. Scenario B is promising to a certain extent, mainly because the asphalt infrastructure already in place can be used, and it should be further developed through research.

Scenario C: Petroleum alternatives

When the prices for petroleum products increase drastically, the question of alternatives automatically arises, which is similar to the efforts to free road transport from its direct dependence on fossil fuels. Alternative asphalt binders from renewable resources such as rapeseed oil or pine oil can only partially replace conventional binders. Their use is currently restricted to repair measures on roads with a lower traffic load. However, such a use would compete directly with using the resources for food production or as energy sources, similar to what happens when bio fuels are used to replace fossil fuels. It is important to note here that many of the plastic materials that may be used as alternative binders are also petroleum-based.

This is why scenario C is a critical one. Extensive research will become necessary should this option be chosen.

Conclusion

The question of whether roads can be built without petroleum cannot be answered with a simple “yes”, but rather a “yes, but”. The base scenario of “very expensive petroleum” is very likely and can only be met with a combination of measures, for example, increasing the re-use of reclaimed asphalt and using partial alternatives to bitumen. It seems that to a certain extent road construction will remain dependent on petroleum in the medium term. ■

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Quality control for exposed aggregate concrete surfaces

The development of exposed aggregate concrete surfaces was a result of years of searching for a noise-reducing surface design for concrete pavements which at the same time provide a high skid resistance. In this type of construction the upper mortar layer at the edge of the top concrete layer is brushed out to expose the aggregate near the surface. The General Circular Road Construction 5/2006 introduced exposed aggregate concrete as a low-noise road surface in accordance with the "Guidelines for noise protection at roads" (Richtlinien für den Lärmschutz an Straßen, RLS-90) with a DStrO value of -2 dB(A).

Since the introduction of the Additional Technical Terms of Contract (ZTV) Concrete Road Construction (StB) 07 in 2007 exposed aggregate concrete surfaces have become a standard in road construction, so that currently the concrete surfaces of motorways or motorway-like federal highways are built almost exclusively in this way.

The top layer's concrete composition and the general production process need to be modified when an exposed aggregate concrete surface is to be used. The most essential changes are that the minimum cement content is higher (more than 420 kg/m^3) and the sieve curve different due to a maximum aggregate size. An aggregate mix of 0/8 mm (gap grading or grading with a continuous sieve curve) from a minimum of two aggregate sizes is necessary to produce exposed aggregate concrete. The aggregate needs to fulfil high requirements, including polished stone value, particle shape, and the percentage of crushed or broken surfaces. An exposed aggregate concrete surface requires special working methods compared to earlier standard surface construction. After the top concrete layer is installed, a combination of surface retarder and curing agent is applied to make it possible to brush out the mortar layer near the surface at a later stage.

BASt has conducted selected studies on concrete surfaces during construction, since the exposed aggregate concrete surface method was introduced. These include general tests, but also studies to determine the mortar layer's thickness, how much of the combination agent needs to applied, flowtable spread, fresh concrete temperature, and air temperature. Additional tests aim to evaluate or characterise the exposed aggregate concrete surface, such as the following

- documenting the macro texture by means of photographs
- identifying the texture depth (MTD) using the sand-patch method (SPM),
- determining the profile peak number,

Macro shots of three different exposed aggregate concrete surfaces

- measuring the skid resistance by means of the side-force measurement method (SFM) to determine the friction coefficient (μSKM),
- measuring the noise level (tyre-road noise) by means of the statistical pass-by method (SPB) and the close proximity method (CPX).

Evaluating the surface texture

The surface texture of an exposed aggregate concrete surface generally varies greatly from one construction project to the next. It is mainly characterised by brush-out depth and the aggregate used in each case, i.e., grading, aggregate shape and colour. According to applicable regulations the surface is evaluated on the basis of two parameters: texture depth and skid resistance. Current regulations do not require a direct, qualitative evaluation.

The texture depth (macro texture depth) is determined by means of a volumetric procedure, e.g., the sand-patch method, in accordance with the technical delivery specifications (Technische Prüfvorschrift, TP) for concrete road construction 2010 and the EN 13036-1 standard. The structure "road" ultimately needs to comply with the values stipulated in the ZTV Beton-StB 07 (texture depth: 0.6 mm to 1.1.mm). Measurements on 32 exposed aggregate concrete surface routes revealed that the majority of the mean texture depth ranges between 0.6 mm and 0.9 mm, i.e., the ZTV Beton-StB 07 requirements are basically adhered to.

Recently the number of profile peaks has often been determined in addition to the texture depth to gather more detailed information about the exposed aggregate concrete surface. This is done following the example of the Austrian regulations (guidelines and regulations for the road sector 08.17.02), which call, for example, for a surface with a maximum aggregate of eight millimetres to have 60 profile peaks during the initial and inspection tests. Each profile peak with a length of four millimetres and more is counted on a 25 square centimetre test area. The mean profile peaks of the surfaces studied have proved to be highly diverse. However, the counted profile peaks, which are more or less the aggregates showing above the mortar, do not provide any information on the spatial situation. A near-homogeneous distribution across the tested area might be expected at a value of about 60 profile peaks. Few profile peaks on a tested area indicate an inhomogeneous or suboptimal distribution.

Measuring skid resistance

The requirements in terms of skid resistance that a road surface needs to fulfil are of overriding significance because skid resistance is crucial for road safety. Limit values can be found in ZTV Beton-StB 07 stipulating what the skid resistance should be at the moment

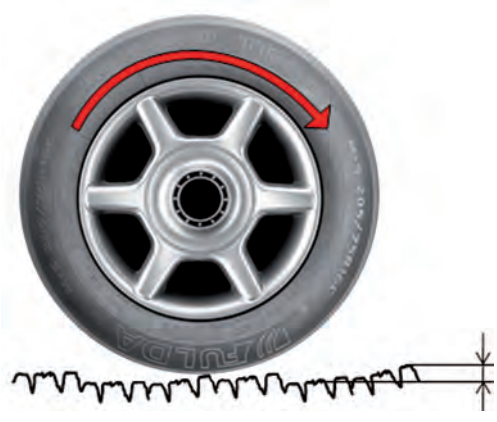
of acceptance and until the limitation period expires and compensation can no longer be claimed for defects. These skid resistance parameters can be measured at various measuring speeds using the side-force measurement method (SFM) in accordance with TP on skid resistance in road construction (Griff-StB). The results of the SFM measurements taken about six to twelve weeks after the road has been opened for traffic at a speed of 80 kilometres per hour have shown that exposed aggregate concrete surfaces consistently achieve very good skid resistance values. Their microroughness and in particular their pronounced macroroughness can be assumed to be primarily responsible for their positive skid resistance. The desired value of μSKM = 0.46 has been safely reached on all tested stretches. The experience of recent years has indicated that good skid resistance values can safely be reached at the time of acceptance since new road constructions have been using exposed aggregate concrete surfaces. Initial studies concerning the development of skid resistance over time until the warranty period of five years expires show high skid resistance levels throughout. This development is expected to continue for the rest of the concrete surface's service life.

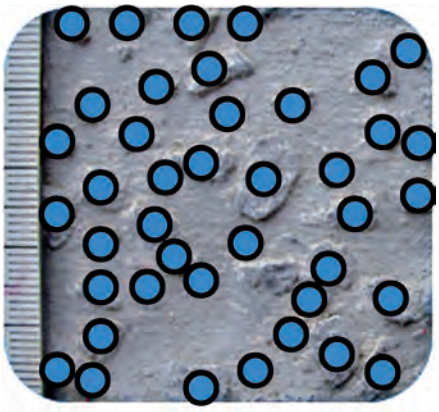
Measuring noise level

Various exposed aggregate concrete surfaces were evaluated between 2008 and 2010 on the basis of the statistical pass-by method (SPB). A total of ten exposed aggregate concrete surface stretches were tested in terms of their noise emission. A statistical evaluation of the measured emission levels shows that the tested surfaces show a reduction of 2 dB(A), including the tolerance range. The CPX method was used for the tyre-road noises to additionally assess the acoustic homogeneity of each stretch.

Correlation of texture parameters with surface properties

The single number value (MTD) defined in the regulations is used to determine the mean texture depth and to control surface homogeneity in terms of roughness depth. However, this value cannot be used to assess skid resistance. A surface's contact point density has an influence on its acoustic properties. This is why counting the profile peaks is a simple method to identify the support points in place for a defined area. A subsequent visualisation covering the entire area helps to describe how homogeneous an aggregate is in terms of its distribution on the surface. According to current





Influence of profile peak number on mechanical stimulation of tyres (left). Distribution of profile peaks on an exposed aggregate concrete surface (right)

knowledge the number of profile peaks has an influence on tyre-road noise. The number of contact points or density has a mechanical impact on how the tyres are stimulated. Conventional production technology is as yet not able to create a surface that reduces noise on the basis of a typical plateau-type design such as the surfaces of rolled asphalt.

Outlook

The results of the studies have shown that skid resistance can be safely reached at the moment of acceptance when new concrete roads are built with an exposed aggregate concrete surface. Exposed aggregate concrete surfaces fall into the category of low-noise road pavements In terms of noise emission. The results also show that the technical potential of these surfaces to further reduce noise has not yet been fully tapped. To date, tests focusing on texture design have shown that noise emission cannot be optimised at the level of texture depth as the only parameter. In the future, spatial texture parameters will be used to enable a more detailed description of the surface. The parameters can be deduced from the topography of the exposed aggregate concrete surface. Generally speaking, the optimisation potential lies in the aggregate and the texture design, which in turn is determined by the macrotexture. On the basis of what we now know it is advisable to determine the number of profile peaks, bearing in mind that no general evaluation criteria are available for a final evaluation. ■

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Multiple modifications of asphalt binders

The properties of bitumen can be improved by performing multiple modifications, thus making asphalt roads more durable. Empirical evaluation criteria already exist as non-modified bitumen has been in use for a long time. However, they do not exist for the binder once it becomes highly complex after multiple modifications.

Bitumen has been used as a binder in the construction of asphalt roads for more than 150 years. Its main advantages are its availability, relatively low price, and that it can be processed easily and quickly. The last aspect, in particular, helps limit traffic obstructions to a short time period.

Increased requirements

Over the past few decades the continuous increase in freight traffic has been imposing significantly higher technical requirements on asphalt roads. New asphalt pavements with more and more porous structures have contributed to bitumen reaching its limits in terms of long-term function. The costs and availability of bitumen have become another topic of discussion. Polymers improving some of bitumen's properties are being added to increase the service life of asphalt roads. The road's resistance to rutting can especially be improved by the effect of polymers. However, the entire plasticity needs to be taken into account to ensure that the asphalt surface can fulfil its function across a wide range of temperatures.

A mechanical load on a road surface can have a variety of effects depending on the duration of the impact and the temperature at the time. At high temperatures and long lasting impact the asphalt structure becomes deformed, causing rutting. Low temperatures and a short-term but high mechanical load increase the risk of cracks. Conversely, stress cracking may result if the asphalt pavement is exposed to low temperatures over a longer period of time.

Asphalt binders

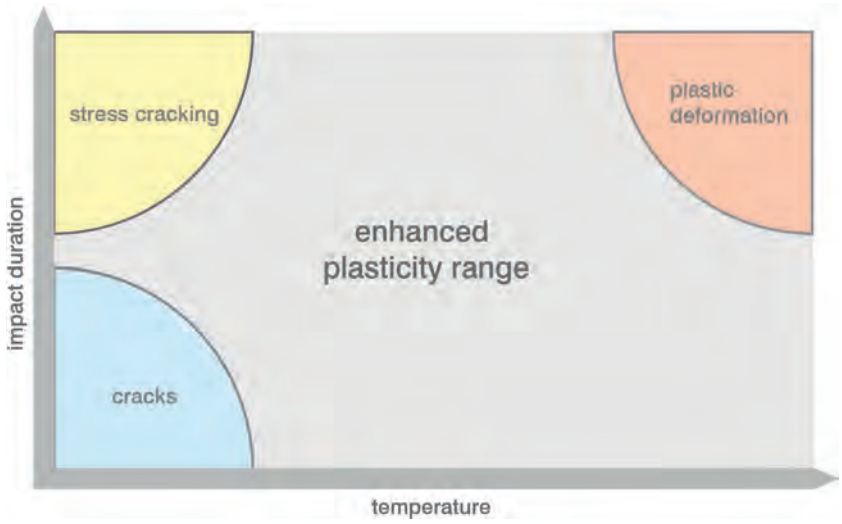
The asphalt pavement's response is due to a significant extent to the chemical and physical properties of the binder used. Experience has shown that a binder with a higher viscosity improves the road's resistance to rutting. However, lower viscosity is more beneficial at low temperatures. Bitumen's viscosity can easily be increased when polymers such as the conventional styrene butadiene styrene block copolymer (SBS) are added. It is much more difficult to increase the bitumen's plasticity range for lower temperatures at the same time. At this temperature range the properties of the base bitumen have the strongest influence.

Polymers

Polymers can be tailored to specific needs in terms of composition, molar mass distribution, structure, and cross-linking. It is possible, for instance, to add another polymer to improve bitumen's properties at low temperatures. Using a combination of polymers is nothing new as such. A combination of SBS and ethylene vinyl acetate (EVA) for example has already been used successfully in the past. Many more polymers other than EVA are suitable for improving bitumen's precise chemical and physical properties.

Additives

Bitumen can be modified by additives to improve other functions. For example, bitumen can be processed at lower



temperatures if paraffins and fatty acid amides are added. The bitumen's adhesion to poor rocky environments can be improved when special amides are added.

Combinations

A combination of polymers and additives can trigger complex interactions that have not yet been studied in detail. Experiments involving various polymer combinations have shown that an improvement of certain binder properties can have an adverse effect on other properties. The effects of binders after multiple modifications need to be tested and assessed holistically. Given the complexity of the system in question this is not easy to accomplish, but it is worth the effort. Multiple modifications can be used to tailor the binders to the needs of each individual application and are a necessity in view of the continuously rising technical requirements and economic restraints. ■

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Transport technology: dynamic, enviromentally aware and suitable for lorries

Field trial with LHVs

What is the actual weight of lorries?

Increasing parking space capacity for lorries on German motorways

Intelligent transport systems on the Trans-European Transport Network

Safe de-icing salt supply in winter

Monitoring guidelines for wildlife crossings

Noise emissions caused by driving over agglomerate markings

Intelligent transport systems on the Trans-European Transport Network

The potential of intelligent transport systems (ITS) to improve road safety and traffic flow, and to reduce environmental pollution can only be fully tapped if the ITS services are available on an on-going and continual basis. The European Commission has adopted an ITS Action Plan and an ITS Directive (2010/40/EU) to accelerate the implementation of ITS. Their concrete implementation is mainly organised in the EasyWay programme, which comprises about 150 road authorities and operators from nearly every Member State of the European Union. EasyWay is co-financed by the European Commission in the scope of a multi-annual programme for the Trans-European Transport Network (funding since 2007: 200 million euros, total investments: roughly one billion euros).

The services provided by EasyWay include traffic management services (responsibility lies with road operator), traffic information services (road operator cooperates), and specific services for freight transport and logistics. Additionally, EasyWay has expert and study groups on topics such as the harmonisation of variable message signs, the protocols for the harmonised exchange of dynamic traffic data (DATEX II), and on the infrastructure of information and communication technologies. BASt has committed itself to these three representing the Federal Ministry for Transport, Building and Urban Development (BMVBS), and is the coordinator of the expert and study groups for DATEX II. At the same time, BASt appoints the chairman of the Supervisory Programme Board of EasyWay for Phase 2 (2010-2012) through its president, Stefan Strick.

Harmonised implementation

EasyWay's key result has been the development of Deployment Guidelines (DG) for all the individual services. These DGs have a binding effect on future implementation phases. They are like voluntary commitments of all project partners to follow the Deployment Guidelines, 19 in total, to implement services in a harmonised approach that makes them eligible for funding. The DGs are not directly legally binding. However, they may be the basis for legal provisions at the European level (specifications of priority services under the ITS Directive) and thus part of them may become applicable in Germany.

BASt was commissioned by the BMVBS to assess the draft DGs from a German perspective with respect to their compatibility with German technical regulations. Furthermore, BASt has provided comments on the

opinions submitted by the Länder and technical organisations involved (Road and Transport Research Association (Forschungsgesellschaft für Straßen- und Verkehrswesen, FGSV), the German ITS advisory board) in the context of the EU consultation process. In successive phases, these comments were condensed into Germany's official opinion. The German position found its way into the DGs, including for those guidelines Germany was not involved in drafting, for example concerning variable message signs. Generally speaking, the DGs can be considered as a milestone in harmonised ITS implementation, the result of which must be seen as finding a balance between a common denominator that enables consensus among the European partners and striving not to dilute the high technical standard of the existing regulations in Germany.

Expert and study group on variable message signs

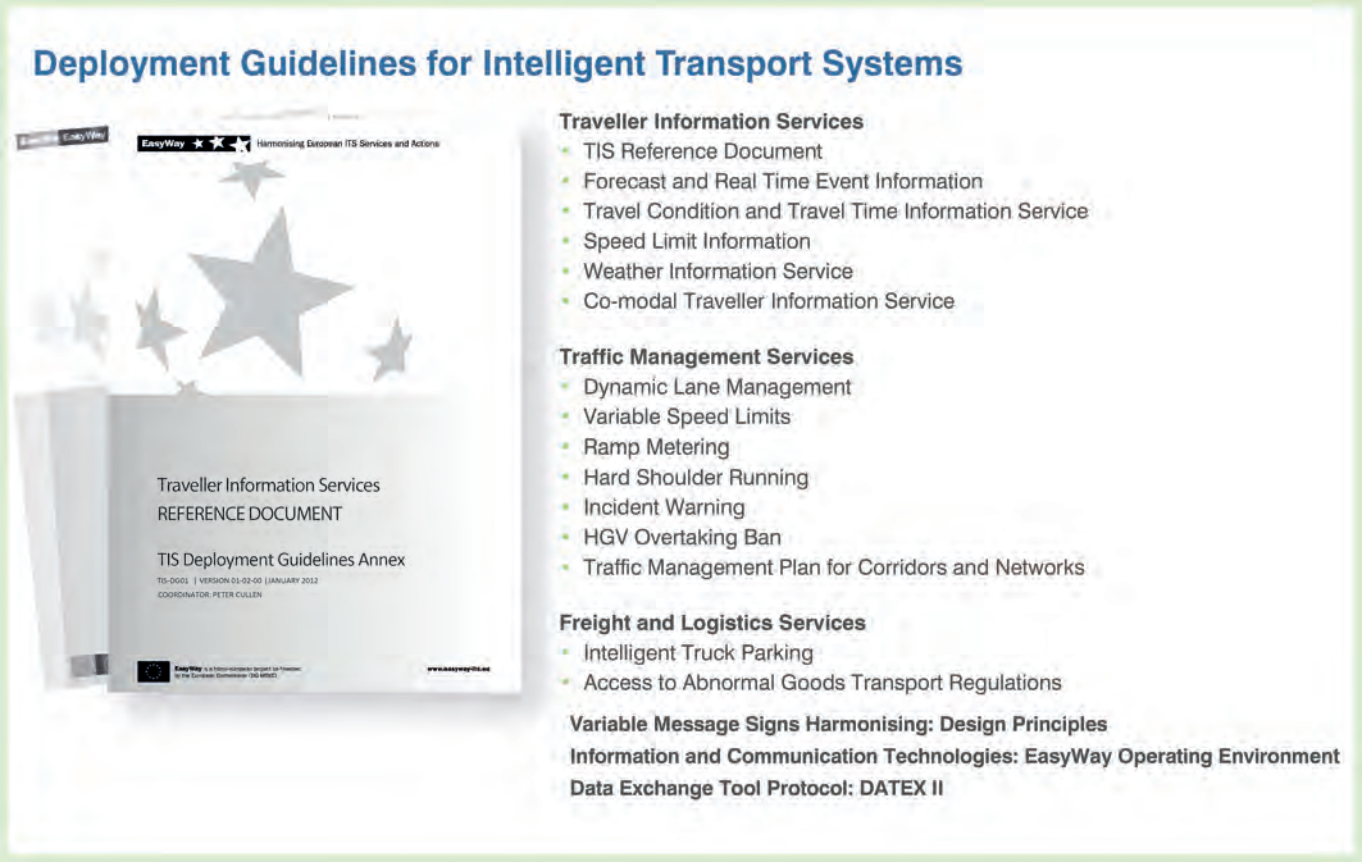
The expert and study group on variable message signs (ESG 4) has evolved from the Mare Nostrum project which implemented a first version of the "Working Books", a compilation of European variable message signs and display standards. BASt has been active in the follow-up to this project in EasyWay right from the outset, and has contributed in the following ways:

- BASt contributed considerably in preparing the DG for variable message signs including German positions.
- This led to a proposal submitted to amend the Vienna Convention on Road Signs and Signals with respect to variable message signs. BASt participated in the working group, and in cooperation with the BMVBS it prepared an opinion to be incorporated into the on-going UN-ECE consultations.
- Various additional tests have been conducted and evaluated at the European level concerning the suitability and comprehensibility of new variable message signs and display standards. On the basis of a driving simulator a new test was developed in 2012 which is about to be launched.

Expert and study group DATEX II

The expert and study group on DATEX II (ESG 5) focuses on (further) developing exchange standards for dynamic traffic data. Traffic management and information services call for a trans-boundary and trans-jurisdictional cooperation of the partners involved. DATEX II is thus an indispensable element for resolving the challenge of an ITS interface. The DATEX II results can be summarised as follows:

- One of the essential DATEX results in the period under review was the standardisation of mature parts of DATEX II (methodology, location referencing, traffic situations) as CEN Technical Specification 16157. DATEX profiles are included in most of the EasyWay DGs. DATEX II is quoted in the draft specifications for the ITS Directive as a data exchange standard.
- The bi-annual DATEX user forum (2012 in Stockholm, co-hosted by BMVBS/ BASt and the Swedish Transport Administration) showed that DATEX enjoys a growing public-private user community. Reports on its successful implementation are crucial for this event.



Overview of the range of services and the Deployment Guidelines

- In the context of a working group headed by BASt, EasyWay and TISA (Traveller Information Services Association) have illustrated the inter-operability of the DATEX and TPEG (Transport Experts Group) data exchange standards. The process for the entire value added chain for traffic information starting with data collection and ending with the user has been demonstrated at relevant conferences (ITS World Congress, ITS in Europe, EasyWay Annual Forum).

Project group co-operative systems

In the Co-operative Systems project group under ESG 6 (ICT infrastructure) BASt was in charge of conducting a stakeholder analysis, and participated significantly in the cost-benefit assessment process:

- The stakeholder analysis aims to identify the roles road operators may play in providing selected co-operatives services (including local hazard warnings, congestion warning, road works warning) as well as in describing expectations and viewpoints on roles and responsibilities.
- The expert assessment conducted from a road operator's perspective (criteria: quality, operating process organisation, service costs) identified strengths and weaknesses of different function schemes and role profiles. Overall, there is no clear preference for one of the options that covers all criteria. Hybrid communication solutions including Wi-Fi and cellular communication offer a plethora of applications and availabilities. They are the best possible way to fulfil different requirements, e.g., warnings

that are time-critical, or coordinating recommended routes with traffic management strategies.

- On the basis of an analysis of the opportunities and risks of co-operative systems, factors determining their success were identified, e.g., agreements on guidelines and strategies for route planning, further organisational development of PPPs (public-private partnerships), standardisation, clarifying the legal situation, compliance with privacy requirements, fostering awareness and acceptance of co-operative systems among the target groups.
- An estimate of the costs and benefits of bundles of co-operative services show that co-operative applications are economically viable for individual Member States as well as for the EU in its entirety. The largest benefits are generated from improving traffic flow and the resulting time gains. The ratio between cost and benefit is most favourable in areas where there are the most problems with traffic jams. Additional benefits can be attributed to improving road safety and reducing fuel consumption. ■

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Safe de-icing salt supply in winter

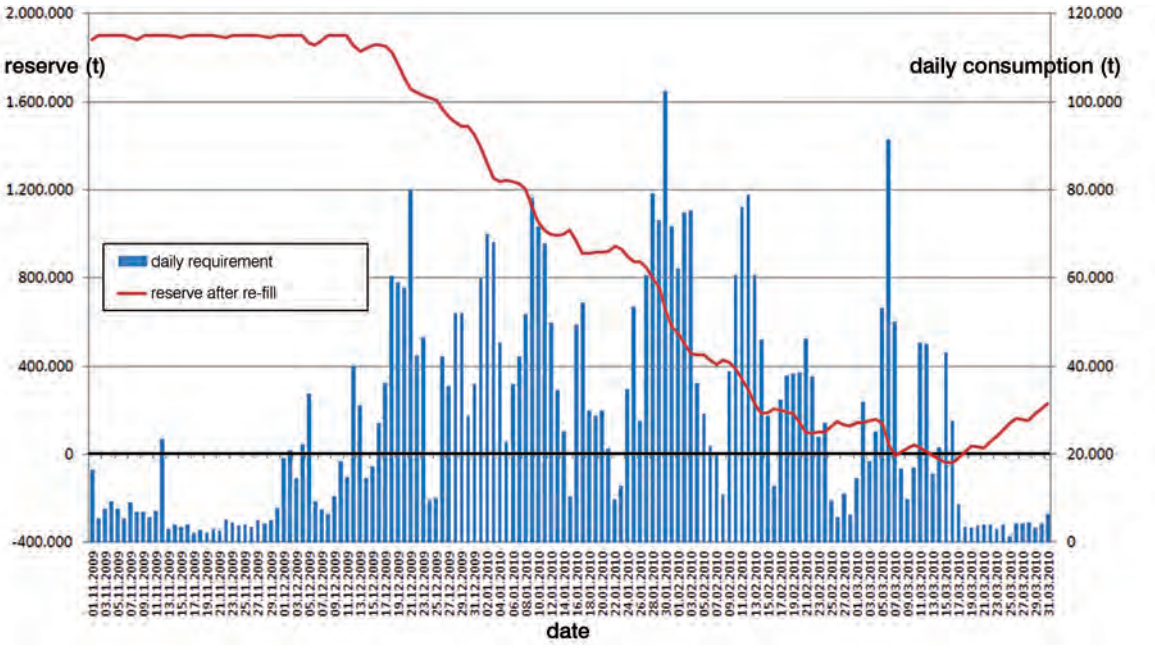
The winter of 2009-10 was characterised by several weeks of continuous snowfall, especially in December 2010. Not only were the mountains in Germany affected, but atypically also broad areas of the German lowlands. The snowfall caused major traffic disruptions even though winter services were working at full capacity 24 hours a day. In addition to clearing the snow, highway authorities had to apply a lot of de-icing salt to prevent traffic from compressing the snowfall into thick ice layers, as these would have impeded road transport to an even greater extent.

The winter weather covering large areas and lasting a long time led to significant problems in the supply of de-icing salt. Some of the main transit roads could not be treated fully as a consequence. In some cases parts of the motorway briefly had to be closed to traffic.

New model

A rethinking of the situation became necessary to ensure stable salt supply, so that the impact of extreme winter weather conditions on traffic could be reduced in the future. The initial task consisted of estimating the amount of salt that would have had to be supplied to keep the required winter services going. Conventional calculation models provide only relative comparisons of how harsh different winter periods are (winter harshness). Specific salt consumption cannot be derived from them.

A new model is to estimate how much grit salt is needed. This approach is based on climate data from the German Meteorological Service's more than 500 measuring stations. Necessary quantities can be estimated when this data is combined with data on the length of individual road categories (motorways, rural roads, city streets) and gritting scenarios for the different types of ice. The gritting scenarios have been established according to recommendations for the winter services about what the gritting density should be in grams per square metre depending on the ice intensity on the surfaces.



Estimated nation-wide daily consumption of de-icing salt in the winter 2009-10 according to a new calculation model and the development of a nation-wide reserves

In addition, the estimates take into account the winter servicing times for the different road categories (motorway, rural road, city streets).

A graph of the calculations illustrates exemplary estimates for how much de-icing salt would have been needed all over Germany in the winters of 2009 and 2010. Each column stands for daily consumption. This model estimates the highest quantity needed for that time to be a little more than 100,000 tonnes for all the roads across Germany (see figures on the right y-axis). The red line shows the development of the grit salt reserves at the various highway authorities. It is assumed to be 1.9 million tonnes (see figure left y-axis). This line includes re-supplies by the grit salt industry.

Reserves

The graph shows an idealised example of filling up the reserves with 30,000 tonnes every day from Monday to Friday. This is not necessary up until mid-December, because the quantities used are smaller than the quantities supplied. From mid-December to mid-March on very many days the daily demand exceeds the amount re-delivered. The reserves are continuously reduced and thus used up by mid-March. On some days the demand can no longer be met by the re-supplies.

The model calculations lead to various results. They show that de-icing salt needs to re-ordered immediately once it has been used. As the salt suppliers can only deliver limited amounts per day, they cannot catch up with re-supplies that have not been ordered immediately. The results also show that the initial reserve needs to be higher if re-supplies cannot be increased in quantity.

The model calculations together with the highway authorities' previous experience resulted in new figures for de-icing salt reserves. Many highway authorities have significantly increased salt storage capacities at federal and Länder levels. They have primarily set up centralised interim storages to supply the maintenance depots in a target-oriented and cost-efficient manner. This system is to become better adapted to region-specific requirements on the basis of additional model calculations for the various regions.

In harsh winters adequate supply with de-icing salt will be ensured not only by increased storage capacities. Some of BASt's research focuses on significantly reducing salt consumption.

Brine spraying vehicle in operation

Salt brine

BASt studies have shown that the use of salt brine can reduce salt consumption for many types of services. It is particular useful in preventive application for any type of ice. In most cases it is sufficient, the exceptions being heavy snowfall or black ice. The brine's retention time on the road pavement has proved to be longer than conventional wet grit. In the service applications mentioned above salt consumption can be reduced by up to 50 per cent. Wet grit disappears from the road pavement faster than brine. This would reduce not only costs but also

damages to the environment. Road safety would also be improved because of the longer retention time.

Had highway authorities applied de-icing salt brine in the snowy winter of 2009-10, they would have been able to reduce their salt demand by roughly 20 per cent. The supply bottlenecks would have been much less severe or would perhaps not have occurred at all.

The findings from this research have been incorporated into the winter services regulations of the Road and Transport Research Association (Forschungsgesellschaft für Straßen- und Verkehrswesen, FGSV).

BASt has developed a method for testing brine distribution so that machines can be purchased to apply the brine according to the desired distribution.

With the help of a scavenging and suction device an applied solution can be sampled and conductivity measurements can determine its quantity.

The brine distribution can then be extrapolated to smaller sub-sections and evaluated.

BASt offers this procedure for type approvals. Highway authorities can use the results of this procedure for their procurement decisions. ■

Scavenging-suction device for sampling de-icing brine

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Monitoring guidelines for wildlife crossings

Germany is a densely populated industrialised country with a well-developed intra-urban road network of 230,702 kilometres (as of January 2012). The high and growing traffic density in this network is responsible for an increase in the isolation, fragmentation, and deterioration of animal and plant habitats.

Roads form barriers and limit the ability of the disconnected populations to cross. As a result the residual habitats for wild animals have often become much too small. Accidents involving wildlife reduce road safety and put human lives at risk. [1] According to the German Insurance Association (Gesamtverbandes der deutschen Versicherungswirtschaft, GDV) about 243,000 accidents involving wildlife were reported in 2010 (five per cent more than in 2009) requiring insurance payments of 520 million euros.

The "Federal Programme for the Reconnection of Habitats" (Bundesprogramm Wiedervernetzung) prepared by an inter-ministerial working group intends to build wildlife crossings into the existing network of federal trunk roads to re-connect dissected habitats along the most important habitat corridors.

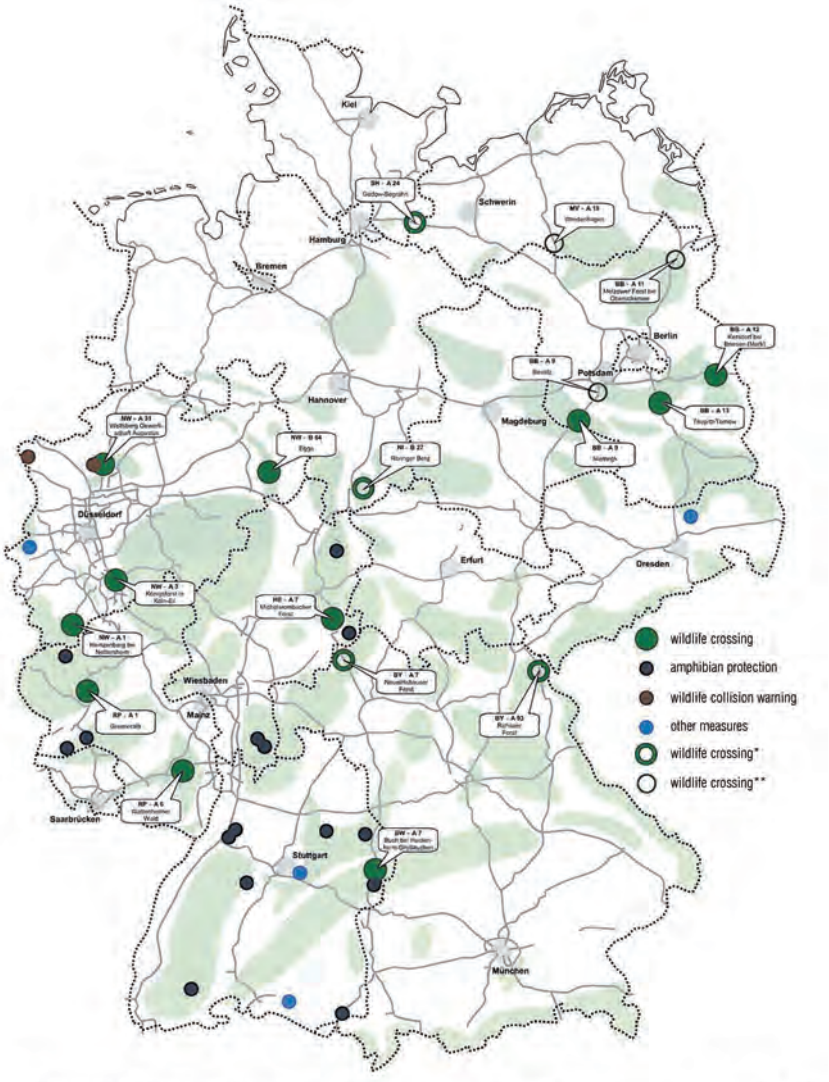
The construction of 18 wildlife crossings was planned in the run-up to the "Federal Programme for the Reconnection of Habitats" in the scope of the economic stimulus package II (Ensuring Employment and Stability in Germany Act 2009).

Selecting measures

Measures that can be carried out in the short-term were selected on the basis of existing specific expert planning at the federal and Länder levels. Additional studies at the local level confirmed that these selected locations were suitable for wildlife crossings. The measures aim to maintain biological diversity by reconnecting valuable parts of nature and landscapes dissected by an increase in the density of the road network.

An appropriate monitoring procedure is to be implemented to prove and document the measures' success. This proof will also be used to justify the funds employed. The monitoring guidelines commissioned by the Federal Ministry for Transport, Building and Urban Development (Bundesministerium für Verkehr, Bau und Stadtentwicklung, BMVBS) and

Measures defined in the economic stimulus package II to reconnect habitats at existing federal trunk roads



coordinated by BASt set minimum standards. Compliance with them will provide a quality-controlled result with the lowest possible effort. More complex monitoring becomes necessary when wildlife crossings are part of a planning approval procedure, and the projections are uncertain and require special evidence.

Procedure

Monitoring standards are established to enable a uniform evaluation which in turn focuses on suitability checks and simple checks to verify the presence of selected indicator types and target biotopes representing selected habitats. The scientific basis for these standards is provided by the research findings on habitat corridors in Germany compiled by the Federal Agency for Nature Conservation (Bundesmat für Naturschutz, BfN) available since 2011 [2].

At the beginning of the monitoring process the reconnection measure is documented in its planned version from the perspective of nature conservation. Its implementation is recorded. Another inventory of the biological function is carried out at regular intervals in the course of monitoring in order to test compliance with the planned measure. The success of the measure is assessed by means of an effectiveness control. Repeated inventories help to detect flaws such as damaged fences or the growth of unsuitable vegetation at an early stage and remedy them if necessary. The measure's success will be conclusively evaluated after 15 years.

Following common practice in some neighbouring European countries specially trained staff of the relevant authorities or sub-contracted external specialists can be made responsible for the monitoring. The individual monitoring steps will be documented using specifically developed checklists. Finally, the monitoring reports will be combined and subjected to uniform evaluation by BASt. ■

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[1] BMU (2012): Bundesprogramm Wiedervernetzung: Grundlagen – Aktionsfelder – Zusammenarbeit, beschlossen vom Bundeskabinett am 29.02.2012 (Federal Environment Ministry: Federal Programme for the Reconnection of Habitats: basics – action – cooperation), adopted by the Federal Cabinet on 29 February 2012

[2] Hänel, Kersten; Heinrich Reck (2011): Bundesweite Prioritäten zur Wiedervernetzung von Ökosystemen: Die Überwindung straßenbedingter Barrieren. (nation-wide priorities for reconnecting ecosystems: overcoming barriers set by roads) Naturschutz und Biologische Vielfalt, Heft 108, Bundesamt für Naturschutz, Bonn-Bad Godesberg

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Noise emissions caused by driving over agglomerate markings

The markings often used for Germany's roads provide improved visibility in wet conditions (type II markings). They are applied on motorways and other multi-carriageway roads, and also on accident hot spots. The structure of type II markings is designed to prevent a continuous water film from forming on the marking through precipitation. The reflex beads embedded in the marking can thus retro-reflect the light from a vehicle's headlights and make the marking visible in the dark. A pronounced retro-reflection can be achieved either by embedding larger glass beads into the marking fabric or by using a specific fabric structure. The most frequent type II marking consists of agglomerates. These are coarsely structured road markings consisting of individual parts in regular or irregular configurations.

Noise pollution caused by road markings

BASt initiated a study concerning noise pollution as a result of current problems in the German Länder with residents and noise emissions from vehicles driving over agglomerate markings. In contrast to road pavements that are subject to the "Guidelines for noise protection at roads" (Richtlinien für den Lärmschutz an Straßen, RLS-90), acoustic properties of road markings do not need to fulfil any requirements in Germany. The current research project aims to define requirements and test methods, as well as to develop new, low-noise structures. BASt is involved in preparing regulations in this regard at the European level.

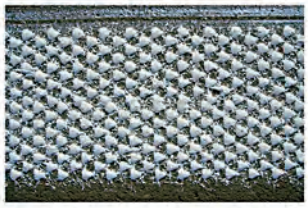
Study concept

An initial study on noise emissions included six different type II markings, among them four agglomerates of regular and irregular structures, as well as one smooth paint marking and one film marking. With the exception of the pre-fabricated film marking, all the other test markings consisted of cold plastic material.

Noise emissions of road surfaces are usually identified by means of the "statistical pass-by" procedure

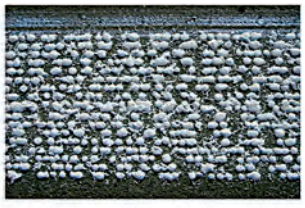
Profiled film type II

Smooth marking type II

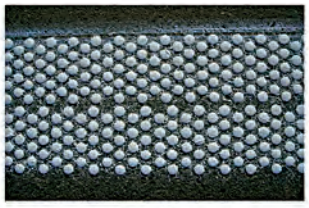


Regular drop-shaped agglomerate

Irregular agglomerate with lateral-structure



Irregular agglomerate longitudinal structure



Regular point-shaped agglomerate

Road markings examined

in accordance with EN ISO 11819-1 “Measurement of the influence of road surfaces on traffic noise – part 1: Statistical Pass-By Method”. This method measures the pass-by levels in flowing traffic together with the speeds of a statistically significant number of vehicles that can be acoustically separated. The study modified the statistical pass-by approach to be able to compare different markings. The markings on a test stretch were passed over several times by only one single vehicle at defined speeds each time. This approach is known as the “controlled pass-by” method.

Noise measurements

The maximum A-weighted sound pressure levels and the frequency spectra were measured for the markings at each speed in the tests – 30, 50, 70, 100 and 120 km per hour. Additionally, the pass-by noise was recorded at each pass-by.

The measurement results of the maximum A-weighted sound pressure levels and the corresponding logarithms of vehicle speed were subjected to a linear regression.

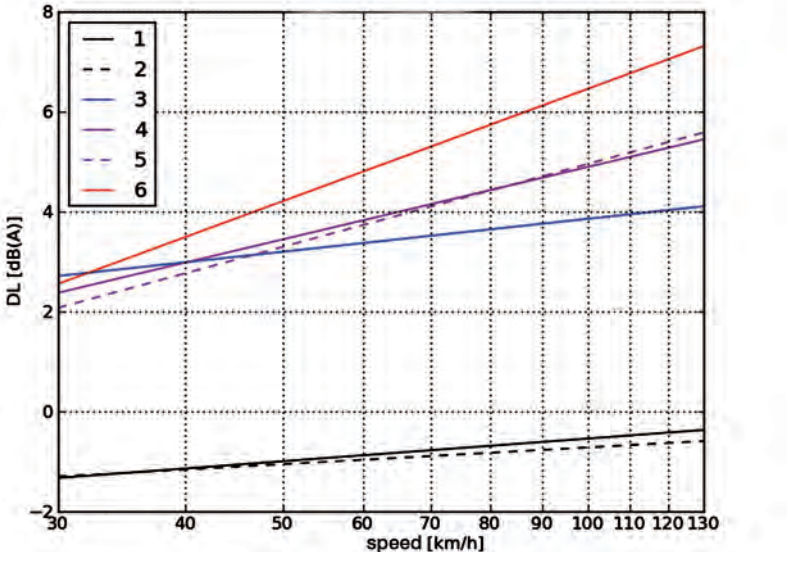
A mean sound pressure level was thus identified for each marking at all the speeds driven by the test vehicle. The level differences of the six tested markings were calculated in comparison to the original road pavement; in this way the markings were compared with each other. The measurements have revealed at least three different marking categories in the tested speed range from 30 to 120 km per hour:

- Markings (1 and 2) with a noise level of about 1 dB(A), below the original pavement.
- Marking (3) with a noise level of 3 bis 4 dB(A), above the original pavement increasing slightly at higher speeds.
- Markings (4, 5 and 6) with a noise level at high speeds of 5 to 7 dB(A), above the original pavement increasing intensely at higher speeds.

Additionally, a frequency analysis has shown that the two regular agglomerate markings have a side maximum shifting towards low frequencies, which in case of a point-shaped agglomerate marking causes a clearly audible tonal component, i.e. severe noise pollution.

Summary and outlook

Noise emissions when passing over markings vary greatly depending on manufacturing methods and surface structures. Especially agglomerate markings cause high noise pressure levels



Noise level differences from the original pavement for six different markings in relation to the speed of the test vehicle.

(1) Film (2) Smooth Agglomerates: (3) Regular drop-shaped (4) Irregular lateral structure (5) Irregular longitudinal structure (6) Regular point-shaped

and tonal components when passed over, leading to severe noise pollution affecting residents living near roads. The noise pollution can occur even if these markings are passed over only occasionally and although the mean level is not significantly raised by these short incidents.

The noise pollution can only be assessed objectively with the help of psycho-acoustic methods (loudness, roughness, sharpness, or fluctuation strength) and acoustic tests. A current project examines psycho-acoustic parameters of different markings and aims to define a minimum distance to residential areas. A classification between noisy and less noisy markings can also be envisioned. Such a classification would determine the area where they would be employed. There are plans to specifically develop low-noise agglomerate markings with an optimised texture.

Noise emissions at road markings, but also at pavement transits on bridges and rumble strips are not adequately taken into account in RLS-90 because RLS-90 uses mean levels only. By doing so noise from motorcycles for example or noise level peaks caused by individual fast vehicles are largely lost once their values are averaged.

BASt's "Low-noise road traffic 2" project is an example of a research study that has resulted in specific application recommendations. It developed diamond-shaped transits for bridges which provide a significant reduction in noise levels compared to lamellar bridge joints. ■

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Field trial with LHVs

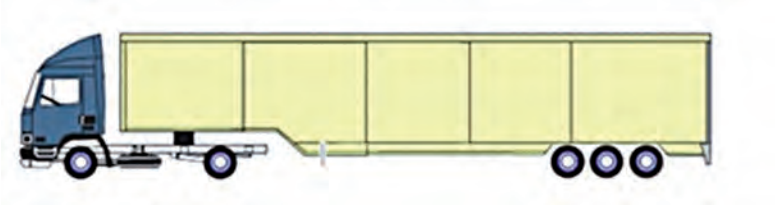
The Federal Ministry for Transport, Housing and Urban Development (Bundesministerium für Verkehr, Bau und Stadtentwicklung, BMVBS) commissioned BASt to conduct a scientific study accompanying its field trial with longer goods vehicles. The trial started in January 2012 and will take five years. It is part of the Freight Transport and Logistics action plan.

The BMVBS' Ordinance on Exemptions from Road Traffic Regulations for Longer Vehicles and Vehicle Combinations (Verordnung über Ausnahmen von straßenverkehrsrechtlichen Vorschriften für Fahrzeuge und Fahrzeugkombinationen mit Überlänge, LKWÜberlStVAusnV) dating from 19 December 2011, modified by the first amending ordinance of 5 July 2012, provides the legal basis for the field trial.

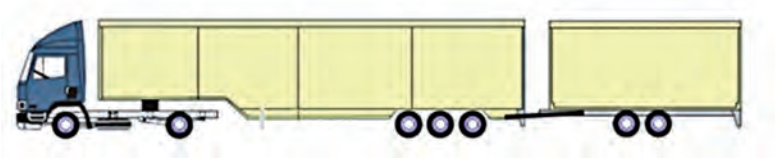
The Exemption Ordinance specifies the conditions that certain longer goods vehicles and vehicle combinations need to fulfil to participate in road traffic that deviate from the provisions in the German Road Traffic Regulations (Straßenverkehrs-Ordnung, StVO) and Road Traffic Registration Regulations (Straßenverkehrs-Zulassungs-Ordnung, StVZO).

All the types of longer goods vehicles depicted in the image may participate in road traffic. The actual number of axles

Elongated tractor-semitrailer combination with a total length of up to 17.80 metres



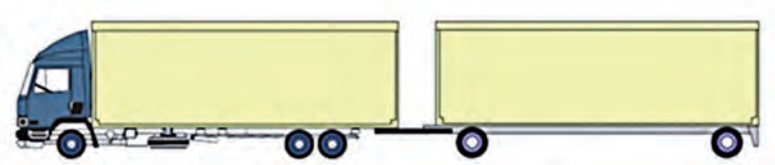
Tractor-semitrailer and additionally a central axis trailer with a total length of up to 25.25 metres



LHV with dolly axis and semitrailer with a total length of up to 25.25 metres

Tractor-semitrailer with another semitrailer with a total length of up to 25.25 metres

LHV with trailer with a total length of up to 24 metres



can differ from the examples shown in the image.

Conditions

The field trial does not involve increased axle loads or total weight. Previous BASt studies have shown that the infrastructure - bridges in particular - is not designed for vehicles or vehicle combinations with a permissible total weight of up to 60 tons. Such vehicles or vehicle combinations have a higher kinetic energy due to their weight and pose a higher traffic risk, making the consequences of an accident more severe. This is why the Federal Government decided to test only longer vehicles and not heavier vehicles. The total mass of a longer goods vehicle may amount to up to 40 tons, or 44 tons in pre- and post haulage for vehicle combinations, and does not differ from conventional lorries.

Road network

Longer goods vehicles must comply with Section 32d StVZO in terms of their cornering characteristics, but due to their excess length LHVs that are up to 25.25 metres long are not suitable anyway for all kinds of road elements, for instance small roundabouts. Longer goods vehicles up to a length of 25.25 metres are to be used only on roads that the Länder have deemed suitable and reported as such to the BMVBS. The Exemption Ordinance includes a road network outlining the only routes that can be used for the trial.

This network is a dynamic one and will be expanded at regular intervals. A number of new routes have already been added to this positive list of suitable routes in the scope of the first ordinance of 5 July 2012 to amend the original LKWÜberlStVAusnV of 19 December 2011. Additional amendments will follow depending on the reports from the Länder. The extended semi-trailer with a total length of 17.80 metres is not subject to this limitation. They are allowed to drive in the entire public road network of the Länder participating in the field trial.

Drivers and vehicles

The Exemption Ordinance also includes special requirements with which the drivers and vehicles need to comply before they can participate in the field trial. The requirements focus primarily on road safety. The vehicles need to be equipped with active and passive safety systems (e.g. electronic dynamic driving systems (ESP), lane departure warning systems, autonomous cruise control or emergency braking assistance). The drivers must have continuously held a driving license of the CE category for a minimum of five years, and have at least five years of work experience in commercial road freight transport or intra-company transport operations. Additionally, every driver must complete a two-hour instruction by the manufacturer or a body authorised by the manufacturer. The instruction focuses mainly on manoeuvring issues. Longer vehicles and vehicle combinations may participate only in road traffic provided they do not transport liquid bulk goods in large tanks, or live animals, or goods with partial fastening that may affect driving stability due to their mass. The drivers are not allowed to overtake other vehicles or vehicle combinations unless these can or must drive at a speed lower than 25 kilometres per hour.

Research focus

Scientific supervision by BASt is a key component of the field trial and this is why it is explicitly mentioned in the Exemption Ordinance. The researchers at BASt identified the research focuses in the run-up to the field trial and their scientific supervision. They aimed to compile a comprehensive a list as possible of all the issues to be covered. They studied relevant international publications to identify aspects mentioned in the various sources qualifying as potential opportunities or risks related to the use of longer goods vehicles – however insignificant or easy to answer they may be. This list was discussed during an expert colloquium in May 2011. The discussions resulted in an overview of the issues considered relevant that the research was to focus on.

In addition to the observations and interviews in the scope of the empirical part of the field trial, specific questions need to be evaluated experimentally or theoretically (e.g. impact tests on road restraint systems or fire behaviour in tunnels). As it is not possible to test every vehicle combination imaginable and every possible property, especially during the experimental test, all the vehicles to participate in the field trial first need to be categorised together with their properties so that the proper vehicle combination can be determined during the trials, e.g., for testing brake efficiency.

Given the size and complexity of the task BASt will involve external experts for support on selected issues. In these cases details and if necessary fundamental aspects of the study methodology will be defined in coordination with the experts.

The following tests, sometimes comprising more than one subject to be studied, were assigned to third-party experts or have become part of on-going research projects to which the aspect of longer goods vehicles were added:

- Effects on transport demand
- Impact on vehicle safety and the environment
- Psychological aspects
- Load on road infrastructure
- Manoeuvrability of LHVs at special road facilities such as at-grade junctions, rest areas or road works on motorways – effects on road safety and traffic flow
- Impact tests on road restraint systems
- Effects on road safety and traffic flow during overtaking (on rural roads) and at signalised junctions

- Effects on safety-relevant equipment and fire protection systems in road tunnels

Study phases

The scientific supervision of the field trial is subdivided into several phases.

The first study phase is scheduled for about a year. Comprehensive statistical surveys will be conducted with the help of drivers' logs and interviews to gather a multitude of information on the vehicles employed, the drivers, the goods transported, and the routes chosen. The interaction of the vehicles with the infrastructure and other road users will be analysed on the basis of interviews and observations. Cases in point are interviews with lorry drivers, their passengers in the vehicle, or observations of turning manoeuvres and driving behaviour at road works.

A series of experiments and theoretical modelling will be conducted at the same time. These include for instance studies on the impact on road restraint systems or fire protection in tunnels as mentioned above. The findings of the first study phase will be processed, evaluated, and documented in a first interim report.

At the same time, in case of accidents involving longer goods vehicles, accident report forms and other data relating to special incidents of different kinds in connection with the use of these LHVs will be collected (e.g. fire in a tunnel). For statistical purposes, this second study phase will cover the entire trial period.

In the summer of 2016, about six months after the Exemption Ordinance expires, the third study phase is scheduled to conduct follow-up surveys to verify the results of the first study phase.

A final report will be compiled at the end of the field trial to summarise the results of BASt's accompanying research. ■

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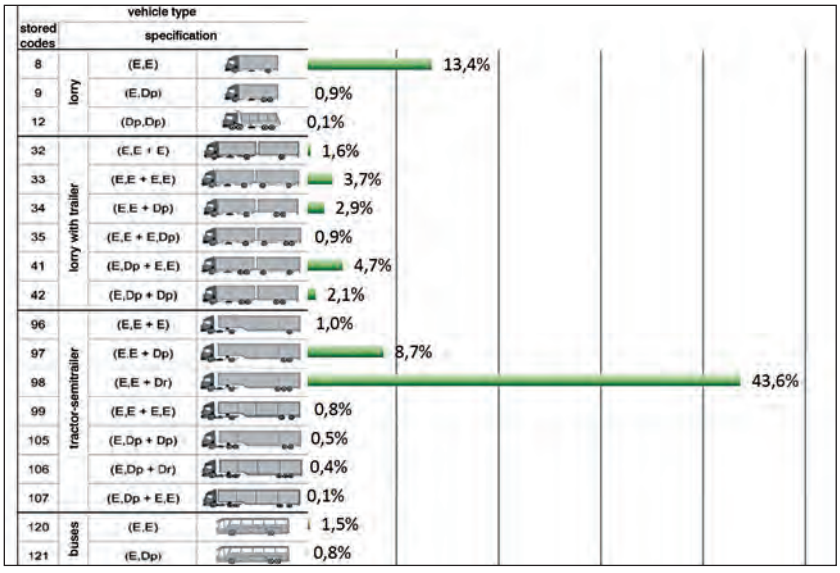
What is the actual weight of lorries?

Roads are affected many times more by the weight of heavy goods vehicles (lorries and buses heavier than 3.5 tonnes) than by passenger cars. BASt has set up a nation-wide WIM (weight-in-motion) network to study actual loads on roads and bridges. Vehicles are detected and weighed on the main lanes (and sometimes the first overtaking lane) at 22 cross-sections. Sensors have been installed beneath the road surface to record traffic flow. For each vehicle they record vehicle type, speed, distance between two vehicles, axle distance, dynamic axle weight, and total weight. Statistical evaluations of the information can be used to optimise road construction design and load models in bridge construction.

Detected vehicle types

Upon detecting a heavy goods vehicle, an axle load measuring point can differentiate among a tractor semi-trailer combination, a lorry with or without a trailer, and a bus. Each vehicle can be further identified due to varying axle configurations using 255 stored codes.



The 18 most common types of HGVs at the axle measuring points 2011/2012

The most frequently found type on German motorways is code number 98, a tractor with two single axles and a three-axle semitrailer. This vehicle is a 40-tonne lorry, i.e., it may not exceed a total weight of 40 tonnes. Type 8 is the most common lorry without trailer. It is designed for smaller loads and often used in transporting supplies.

Axle loads

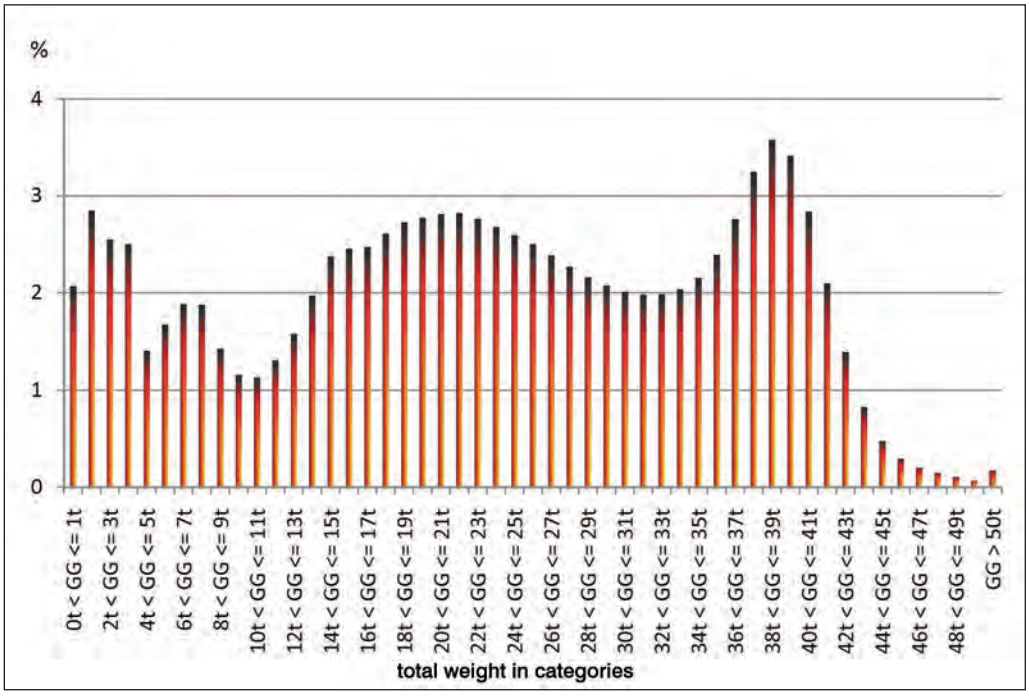
According to Section 34 of the Road Traffic Registration Regulations a single axle must not exceed an axle weight of 10 tonnes, and 11.5 tonnes in case of a drive axle. More than 80 per cent of all the axles show an actual axle weight of less than 8 tonnes and do not utilise the maximum permissible weight.

There are only minor seasonal differences as the axles are only slightly lighter during the first and the fourth quarters of the year than during the second and third quarters.

Determining the load

The total weight of a vehicle can be calculated by adding up all its axle weights. A graph of the vehicles sorted by 1-tonne categories would show clear peaks around the legally permissible maximum weights of 3.5 tonnes, 7.5 tonnes, and 40 tonnes or 44 tonnes for vehicle combinations. A majority of the vehicles falls into the 14 to 28-tonne category, including tractor-trailer combinations not fully loaded and lighter vehicle combinations.

The different axle measuring points can vary greatly in the data they record, depending on where logistics centres, gravel pits or industrial areas are located. The vehicle composition may vary, as well as whether the vehicles pass the



Frequency distribution of total weights 2011/12

measuring point loaded or empty. The weight distributions on the two opposite sides of a motorway cross section differ significantly although the volume of the heavy load traffic is the same.

The daily equivalent standard axle load is an important parameter for designing roads. As stipulated by the Guidelines for the standardisation of pavement constructions for traffic areas (Richtlinien für die Standardisierung des Oberbaues von Verkehrsflächen, RStO) each axle weight (Achsgewicht, AG) per day is put in relation to a 10-tonne axle, raised to the power of four, and added up: $\sum(AG/10)^4$. The higher the arithmetically calculated 10-tonne equivalent, the higher the load impact on the road.

A correlation between the volume of heavy load traffic and 10-tonne axle equivalents can be deduced with an $a \cdot x^b$ equation. However, different measuring points can show significant differences in the load impact on the road while the heavy load traffic volume is the same. A heavy load traffic of DTVSV, comprising 6,000 vehicles per 24 hours, can show about 4,500 10-tonne-axle equivalents per 24 hours, but a different measuring point may indicate twice as much due to heavier axles per vehicle.

The average weight of a lorry and the daily 10-tonne equivalent standard axle loads depend on the vehicle's composition and whether it is being used to its full freight capacity. Conditions specific to the road section in question play a decisive role. ■

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Increasing parking space capacity for lorries on German motorways

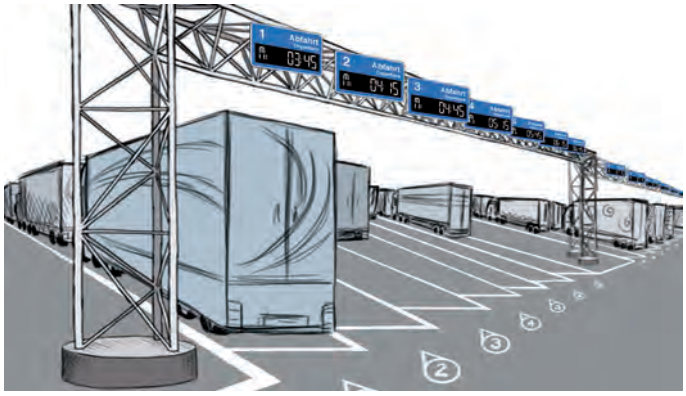
A survey commissioned by the Federal Ministry for Transport, Building and Urban Development (Bundesministerium für Verkehr, Bau und Stadtentwicklung, BMVBS) in March 2008 showed that about 14,000 parking spaces for lorries were lacking at motorway rest areas. In interviews drivers have repeatedly mentioned that trying to find a suitable parking space for their lorries for overnight stays is a significant stress factor. At the same time, lorries parked where they are not supposed to pose a danger to other road user's road safety.

Using intelligent traffic systems (ITS)

ITS is used to distribute the demand for available parking capacity on a motorway section. It aims to guide road users entering a road section to a suitable empty parking space. By means of intelligent parking space management, the existing parking capacity for lorries can be used more efficiently through more even and comprehensive capacity utilisation. The freight industry will be able to better plan the driving and resting times of its lorry drivers, improving road safety for all road users.

Solutions

An intelligent parking space management system per road section provides a great potential to support lorry drivers in finding appropriate parking spaces. The necessary capacities cannot be provided only by structural measures at a small number of large rest areas. All parking spaces in each section need to be used in their entirety. As demand is not always the same, an intelligent system is required to react to the needs as they arise and guide drivers looking for a parking space to the available ones within the road section they are on.



ITS can serve as such a system. Detectors automatically register how much space is already occupied at a rest area and how much is still available. This information can be transmitted to the vehicles directly or to the logistics companies, using a range of communication means. Dynamic displays have been in use since April 2008 in the scope of various pilot projects. They show the detected number of available parking spots.

Evaluation procedure

BASt has been commissioned to provide scientific supervision to the pilot projects and to evaluate them. A new evaluation procedure was developed to systematically evaluate ITS, in particular the detection systems that are at the beginning of the information chain.

The procedure is to enable a comparison of the different systems; it is also to be implemented cost-efficiently. Particular attention was paid to occupancy detection and to the understanding that more than one sensor is necessary. The actual quality of the information thus depends on the interaction between at least two sensors. The evaluation procedure was ultimately based on two criteria: accuracy of vehicle

classification and deviation between actual occupancy and the result of the (system) measurements over a longer period of time. Both criteria are used in evaluating the information's quality, ranked from A to E (A stands for best quality, E for worst). The ranking indicates how frequently undesired errors occurred in the detection.

Control procedure

BASt developed a new control approach to increase parking space capacity without structurally enlarging rest areas. The "ITS controlled compact parking" control procedure – compact parking for short – is characterised by the re-use of the middle aisle as additional parking space so that several lorries can compactly park directly behind and next to each other.

To prevent problems only vehicles scheduled to leave at the same time or later than the vehicles in front of them will be allowed to park in one row. ITS controlled compact parking is based on the dynamic allocation of virtual departure times on variable message signs (VMS) above each parwking row. Arriving drivers are to use this information to choose the row corresponding to their own scheduled departure time.

Compact parking is intended for drivers wishing to park for several hours or over night (long-term parking), but also for drivers who are staying at the rest areas for no longer than one hour (short-term parking). The benefits of the VMS are that parking capacity for lorries can be used flexibly.

The challenge for the new control procedure lies in the decision on when to update the VMS and what departure time is to replace the previous one. The quality of the decision will determine how efficiently the capacity can be used at the rest area.

Outlook

The newly developed evaluation procedure will be used to swiftly test the detection methods deployed by the pilot projects to check which has gathered the best information. Detection methods proved to achieve sufficiently good quality can be used to set up parking management systems in the future.

BASt is currently further developing the compact parking control procedure. Preliminary tests using simulations are to be completed by early 2013 and the new procedure is then to be tested at a rest area.

BASt is additionally responsible for developing a generic architecture from data collection to providing the information to the road user.

Necessary standardisations have already been started such as completing the DATEX II profile for parking information. The development of concepts for parking information is embedded into the framework of international developments; specifically the information concept for road users constitutes the focus of international discussions and is represented by BMVBS and BASt. ■

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Automotive engineering: alternative, innovative and beneficial for its users

Alternative power train technologies

Hydrogen in emissions modelling

Automatic emergency braking systems

Numerical crash simulations

Vehicle safety to protect cyclists

Advanced driver assistance systems for older drivers

euroFot: European Field Operation Test for advanced driver assistance systems

Alternative power train technologies

If we wish to remain mobile in the future, reduce our dependency on oil, and encourage climate and environmental friendliness, our vehicles need in the medium to long run to be retro-fitted with sustainable technologies. Alternatives such as hybrid, electric, and fuel cell vehicles are gaining more and more attention.

The Federal Government adopted the National Development Plan for Electric Mobility in August 2009 In the field of electric mobility as a major focus in alternative power train systems. It is part of implementing the "Shifting away from oil" strategy and aims to foster research and development as well as market preparation and market launch of battery-powered electric vehicles. The National Platform for Electric Mobility (Nationale Plattform Elektromobilität, NPE) was founded in 2010 to coordinate the implementation of the development plan. It is intended to play a decisive role in promoting electric mobility and accelerating its spread in Germany.

BASt initiated a long-term observation of the vehicle market and accidents involving vehicles with alternative power train technologies (hybrid, electric, fuel cell) in 2010 to be able to follow and analyse their future development and swiftly identify potentially adverse effects on road safety.

Reliable quantitative information on the development of vehicles with alternative power train technologies is a sine qua non for anticipatory measures in road safety.

The objectives are the following:

- Tracking the actual implementation of technological progress in products already available in the market,
- Early and detailed knowledge of market development resulting from technological development,
- Timely identification of possible undesired developments – particularly from the perspective of road safety.

The last point, in particular, provides the possibility to make suggestions for a more reasonable development.

Market penetration

In the 2010 period of review the market penetration of innovative vehicle concepts has not accelerated significantly. However, major manufacturers are about to launch vehicles with alternative power train technologies more broadly. Vehicles with a hybrid technology seem to be on the rise – although the quantitative level is still low at present. They currently represent the fastest market growth among alternative power train technologies.

Considering the development in vehicle population, in 2010 the number of hybrid vehicles at 35,996 doubled since 2007 (16,619). According to the future models announced by manufacturers, numerous new models can be expected in the full-hybrid, plug-in hybrid, and all-electric segments.

In 2010 only 212 electric passenger cars were type-approved. The real vehicle population of registered electric motor vehicles amounted to about 2,300

Passenger car population by fuel type (2007 to 2010, Source: Federal Motor Transport Authority)

	Petrol	Diesel	Electric	Gas	Hybrid-Petrol/ Electric	Petrol/ Ethanol	Total
2007	30.063.404	9.810.106	59	358.831	16.619		40.249.019
2008	29.960.754	10.057.074	57	357.123	21.452	8	40.396.468
2009	29.872.527	10.580.915	78	349.312	27.870	1.082	40.831.784
2010	30.082.247	10.939.078	212	344.114	35.996	2.492	41.404.175
2010/09	0,7 %	3,4%	171,8%	-1,5%	29,2%	130,3%	1,4%

	2007	2008	2009	2010	Change 2010/09	Distribution 2010
Petrol	271.154	254.185	244.841	227.537	-7%	71%
Diesel	95.113	93.540	93.045	91.408	-2%	28%
Electric	0	0	0	0	-	-
Hybrid Petrol/ Electric	113	151	204	220	8%	0.07%
Petrol/Ethanol	0	0	1	12	-	0%
Gas	3.198	3.159	3.162	3.087	-3%	1%
No information	43.388	36.739	36.459	32.664	-10%	-
Total	412.966	387.774	377.712	354.919	-6%	100%

Passenger cars involved in personal injury-causing accidents by fuel type

passenger cars in 2010 according to the Federal Motor Transport Authority (Kraftfahrt-Bundesamt). However, only passenger cars with a type approval are eligible for the purposes of an accident analysis.

Accidents

In 2010, a total number of 354,919 passenger cars were involved in accidents causing personal injury. No information was available for the fuel type of 32,664 passenger cars. With a share of 71 per cent, petrol-fuelled vehicles dominated among the passenger cars with known fuel types. Of all the passenger cars involved in accidents 220 were hybrid ones, making their share 0.07 per cent. In the given time frame no type-approved battery-powered vehicle was involved in a personal injury-causing accident. Any further analysis of this data should take into account that electric vehicles, for example, can only be covered in official road accident statistics if they have an EC type approval. At the end of 2010, however, only 212 of roughly 2,300 registered electric passenger cars had such a type approval. With increasing serial production, the share of vehicles with a type-approval will grow enabling conclusions to be drawn from accident statistics.

While the total number of passenger cars involved in accidents decreased in 2010 (minus six per cent compared to the previous year), the number of hybrid passenger cars involved in accident increased by eight per cent – with still a very low number of cases in general. The increase is significantly lower than the 30 per cent increase in hybrids among the vehicle population. The increased involvement of hybrid passenger cars is largely due to the rise in accidents on rural roads.

On average, 65 per cent of the personal injury-causing accidents were recorded on roads in built-up areas. At 75 per cent (n=164) the share of hybrid passenger cars was slightly higher. The question whether this above-average share is based on the different ways a hybrid passenger car is used cannot be answered here. This does seem to be the case, however, because the system-inherent benefits of a hybrid vehicle are most apparent in traffic in built-up areas.

Injury-causing accidents involving one passenger car and another more vulnerable road user (pedestrian or cyclist) were another focus of the study. The accidents may have been caused by either road user, not necessarily by the passenger car. Of the almost 60,000 accidents in total, 94 per cent occurred within built-up areas: hybrid vehicles were involved in 60 accidents in built-up areas out of their total number of 62 accidents (97 per cent).

The overall number of passenger cars involved in accidents with pedestrians or

cyclists decreased by eleven per cent in 2010 while the number of hybrid vehicles involved dropped by nine per cent (to n=60).

Conclusion

Against the backdrop of the latest market developments, an accident analysis naturally has limited significance. The considerable increase of hybrid vehicles involved in accidents by 95 per cent from 2007 to 2010 can be placed in relative terms considering their increase of 117 per cent in the vehicle population during the same time frame. This indicates that the risk may be below average. However, this interpretation does not include the average mileage. The relatively high number of accidents in built-up areas can be explained by how these vehicles are used for the most part.

According to the latest information from the Federal Motor Transport Authority, the vehicle population of electric passenger cars has nearly doubled in late 2011 compared to 2010 (amounting to 4,541 passenger cars). The number of type approvals has also increased significantly, from 212 to 1,180 type-approved passenger cars. ■

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Hydrogen in emissions modelling

Together with the topics “electric mobility” and “biofuels” hydrogen as an energy source is part of an entire package of possible actions the Federal Government is relying on during Germany’s transition to climate-neutral and sustainable mobility. The Federal Ministry for Transport, Housing and Urban Development (Bundesministerium für Verkehr, Bau und Stadtentwicklung, BMVBS) has recently launched a project on a “Mobility and Fuel Strategy” (Mobilitäts- und Kraftstoffstrategie, MKS) to prevent various energy options and action areas from existing side by side without any differentiation made between them.

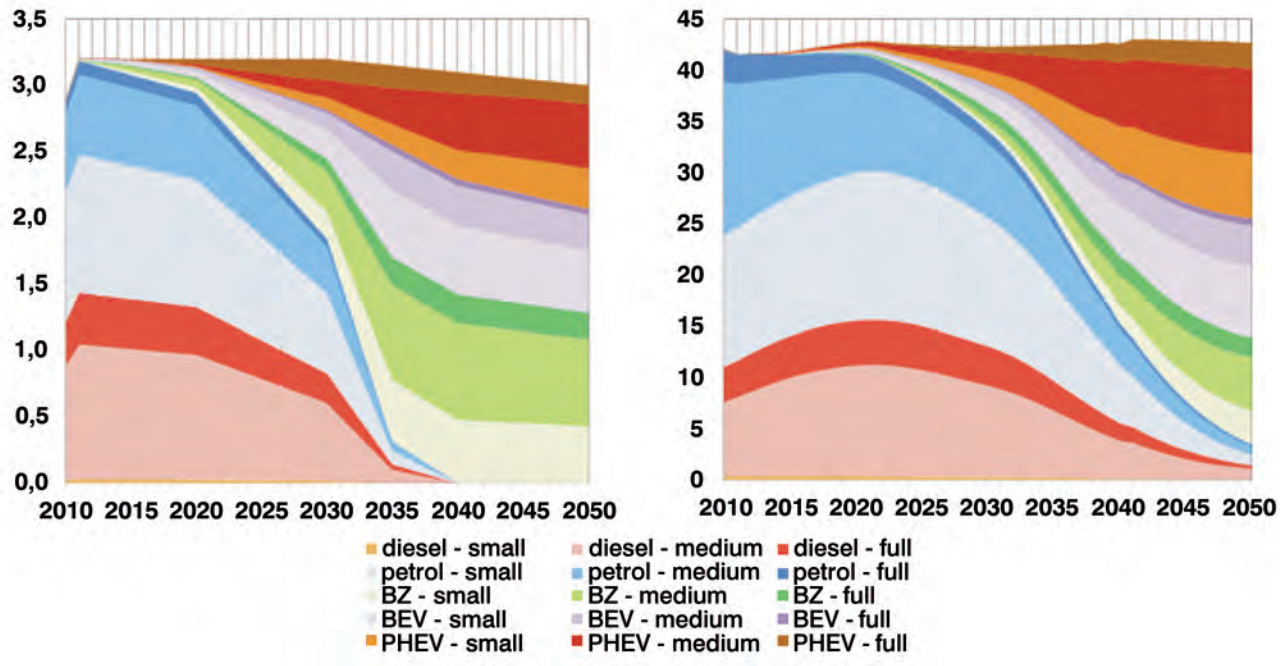
The project aims to compile a comprehensive collection of expert opinions, to bundle different activities, and to integrate partners in a target-based approach to ultimately develop a consistent and sustainable strategy for future mobility. Hydrogen as an alternative fuel is explored in the context of the Transport Development Plan (“Entwicklungsplan Verkehr”) and is part of the National Innovation Programme (NIP) on Hydrogen and Fuel Cells (“Wasserstoff und Brennstoffzelle”). The programme focuses on technical developments that will contribute significantly to securing power supply, to increased efficiency, and to CO_2 reduction once they have been successfully introduced into the market.

Targets for CO_2 reduction

The question is, however, where will the hydrogen for the transport infrastructure come from? How will it be produced and distributed? And finally, is it possible to quantify the reduction in CO_2 emissions to be expected already today? In other words, is there a real chance that Germany will succeed in reaching its ambitious climate target of an 80 per cent reduction in greenhouse gas emissions by 2050 compared to 1990 levels?

A study carried out by TREMOD-GermanHy an independent research institute tries to help find answers to all these exciting questions on a technically and scientifically grounded basis (www.tremod-germanhy.de). The project is coordinated by BASt; the Heidelberg Institute for Energy and Environmental Research, the Fraunhofer

New passenger car registrations according to the results of the TREMOD-GermanHY (left) study and changes in the vehicle population (right) differentiated by vehicle concept (diesel, petrol, fuel cell (BZ), Battery Electric Vehicle (BEV) or Plug-in hybrid Electric Vehicle (PHEV)) and segments (“full size”, “medium size”, “small” vehicle classes) in millions of vehicles

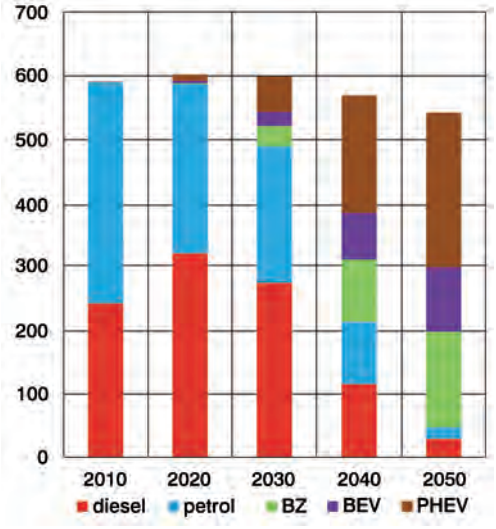


Institute for Systems and Innovation Research, Ludwig Bölkow Systemtechnik GmbH, and the Wuppertal Institute for Climate, Environment and Energy are cooperating partners.

Where will hydrogen come from?

A previous study on hydrogen as an energy source "GermanHy – where will Germany's hydrogen come from?" provides the basis for the current project. Fundamental aspects such as industrial production and transport routes, including their energy consumption and emissions, have already been collected, quantified, and evaluated. As a conclusion, the study offers projections up to the year 2050 and shows how the market for hydrogen as an energy source is likely to develop, and how different political and economic constraints may influence the pace of the development. GermanHy, however, was able to describe the scenario for entering the hydrogen era only in general terms by outlining the total energy need of the transport sector based mainly on projected mileages from the 2010 pilot study.

But questions remain about what specific scenarios are necessary for introducing fuel cell vehicles in the near future, how fast the vehicle population would develop, and what the vehicle fleet would consist of to fulfil the 2050 projections?



TREMOD-GermanHY scenario for annual mileage of passenger cars, differentiated by power train systems in billions of kilometres

Electrification of private transport by 2050

The technical preconditions for simulating a hydrogen scenario on the basis of a differentiated quantity structure for fuel cell vehicles is provided by TREMOD (transport emission model) (www.tremod.de). Though it may not provide exhaustive answers to the questions raised here, TREMOD is nonetheless able to produce a view of the future development of vehicles that is much more graphic and closer to reality than was previously possible.

The origins of TREMOD go back to a programme developed by the Heidelberg Ifeu Institute which was commissioned by the Federal Environment Agency (Umweltbundesamt, UBA). It is regularly updated and serves as the basis for Germany's official emissions reporting (national emissions inventory by UBA). Its database comprises information from the data bases of the Federal Motor Transport Authority (Kraftfahrtbundesamt), the "Energy balances" Working Group, surveys on Mobility in Germany ("Mobilität in Deutschland", MID), Transport in Figures ("Verkehr in Zahlen", VIZ), and the traffic census and mileage surveys regularly carried out by BASt. For more than 15 years, TREMOD has been the benchmark for expert data base systems in the field of modelling total transport emissions in Germany. Its data is updated at regular intervals by BASt and UBA in alternation.

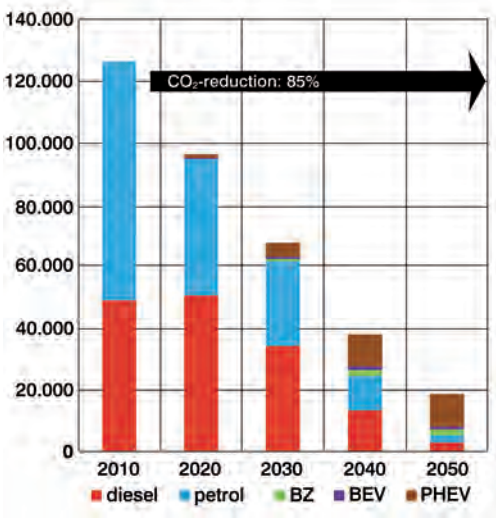
TREMOD not only covers the vehicle population in Germany broken down by vehicle segment and class on annual discs, but also specific vehicle mileage and emissions, including emissions upstream in the chain emitted during the fuel production. The calculation of vehicle mileage takes into account empirical knowledge, for example, that new passenger cars have a higher mileage per

year than older ones, that the mileage of full size cars is higher than that to compact models, and that diesel-fuelled cars have a higher mileage than petrol cars. The model identifies emissions and energy consumption by differentiating the mileage of each vehicle segment according to traffic situations, road categories and gradients, and then aggregates the results.

Trend scenarios can be used to extrapolate the vehicle population and mileage as they are likely to change year by year. This draft scenario makes it possible to introduce new vehicles into the fleet and replace parts of a previous vehicle population.

The TREMOD-GermanHy project's prime task was to apply the hydrogen transport scenario of the previous GermanHy study onto a still fictitious but specific vehicle population providing detailed mileage and consumption data. In the future, three car segments are planned to be equipped as fuel cell cars: "small", "medium size", "full size". A number of assumptions needed to be made with respect to their technical characteristics – consumption, survival curve – and their introduction into the vehicle population. Nonetheless, the scenarios were always consistent with parameters such as interaction with alternative power train types, the availability of primary energy, and basic assumptions about the economic situation.

The graphs show an overview of the key findings of the study. One particular consequence of converting passenger cars to run on fuel cells, plug-in hybrids, or electric batteries by 2050, shows the reduction of CO_2 emissions by more than 100 million tonnes compared to present



TREMOD-GermanHy scenario for the CO_2 reduction potential from passenger cars by 2050 on the basis of the assumed vehicle population and mileage scenarios (CO_2 in kilotonnes)

day levels, corresponding to a reduction of more than 80 per cent of the greenhouse gases produced by passenger cars. ■

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Automatic emergency braking systems

Automatic systems providing active safety have the potential to significantly reduce the number of accidents involving passenger cars. They can also contribute to mitigating the effects of collisions that cannot be avoided. Since the middle of the last decade braking systems have been available that prevent collisions in traffic flowing in the same direction. These systems make use of ambient sensors to alert a vehicle's driver, supporting an emergency braking if necessary. In the meantime, automatic collision-preventing systems have become available for use at low speeds – also for smaller car categories. At higher speeds, modern systems succeed in lowering the car's speed. If the driver reacts in time – even weakly – accidents can be prevented even at high speeds if systems are in place that alert the driver or help in an emergency. A large number of these systems activate the brakes automatically (automatic emergency braking) if a collision is unavoidable. Every system consists of alerting the driver and subsequently activating braking assistance (driver-initiated emergency braking).

Technical potential

These systems, however, are currently not taken into consideration for vehicle safety evaluations in the context of ratings – for example in the field of consumer protection by Euro NCAP (European New Car Assessment Programme). For customers wishing to buy a car it is difficult to compare automatic emergency braking systems. A universal testing procedure would be required (one that is, for example, independent of sensor configuration), but to date no such standardised procedure exists. It

ASSESSOR target object, tail end of vehicle

"MARVIN" cart and test vehicle driving in a row

is expected that they could be launched onto the market much more quickly were they covered in conventional tests.

Several initiatives and research projects are currently in the process of coordinating a testing procedure for emergency braking systems in vehicle-vehicle collisions. The procedure is planned to be used in vehicle tests for Euro NCAP assessments as of 2014.

All the testing procedures suggested in these initiatives have in common that their tests include full vehicles that (could) collide physically with a target object. They differ mainly in how the tests are evaluated and performed, what target objects are used, and how these are moved. BASt has been active in one of these initiatives, the ASSESS (Assessment of Integrated Vehicle Safety Systems for improved vehicle safety) EU project (www.assess-project.eu). In a first step, scenarios were tested in which the target vehicle and the ego-vehicle, i.e., the vehicle equipped with an emergency baking system to be tested, moved forward constantly and other scenarios in which the target vehicle was not moving. Additional tests will follow in the near future and will cover scenarios with braking target vehicles.

For the driving tests, the vehicles were equipped with measurement devices to accurately determine their position and speed. Where necessary, the measured data from several vehicles was synchronised using GPS time signals.

BASt uses the "MARVIN" (Motorized Autonomous Research Vehicle for Innovations) cart as its motion system. It was developed independently by BASt itself. The ASSESSOR target object is recognised as a passenger car by conventional sensor systems and can be attached to the cart. It was developed by a project partner in the scope of the ASSESS project.

Depending on driver response, a test vehicle driven at 50 km per hour was able to either avoid a collision altogether (early driver response) or reduce the impact speed by about 16 kilometres per hour (no driver response » automatic braking).

Benefits of emergency braking systems

Another element of the EU's ASSESS project was to develop an effective method for identifying the potential benefits of emergency braking systems. Tried and tested dose-response models and feasibility studies were used to determine the safety benefits of the emergency braking systems tested in the project, and the benefits were assessed in monetary terms.

Using different scenarios the number of people injured or killed in road accidents was forecast for 2010 to 2030 and the future vehicle population was estimated to be able to determine the benefits emergency braking systems would provide at the European level. The scenarios took into account the different types of future improvement in traffic safety the individual Member States would achieve in other fields even without using emergency braking systems. The safety benefits of the systems, however, depend not only on the number of vehicles equipped with them, but also on the vehicle mileage. This is why additionally the correlation between market penetration and vehicle kilometres driven was calculated on the basis of German data on vehicle age, mileage and service life.

Finally, a sophisticated dose-response model was applied to translate the results from testing various variants of emergency braking systems into accident reduction potentials, in relation to their effect on impact speed: automatic braking versus alerting the driver combined with automatic braking. In a last step, typical speed-related frequent courses and graphs for various injury risks in rear-end collisions were developed to identify the reduction potential in percentages in categories of slightly injured or seriously injured casualties or deaths. According to the test results, the risk of being killed in a rear-end collision can be reduced by almost 55 per cent under defined conditions. The risk of being seriously injured (minus 29 per cent) or slightly injured (minus 20 per cent) can also be reduced significantly.

Adding the reduction potentials of the various system variants to the forecast numbers of victims and cars involved in accidents, the conclusion for the median scenario assuming a market penetration rate of five per cent in 2020 and 15 per cent in 2030 leads to 31-35 fewer deaths in the EU in 2020 and 51-54 fewer deaths in 2030. In this scenario, the maximum safety benefit in monetary terms amounts to about 124 million euros in 2020 and 278 million euros in 2030. If all vehicles were equipped with emergency braking systems, their benefits would increase to about 1.2 billion euros respectively for both years.

Legal aspects

Automatic emergency systems involve a range of legal aspects. They are systems intervening in the driving task attributed to a vehicle's driver according to the Road Traffic Regulations. As long as the systems operate safely as intended and the driver is well informed about their function and boundaries, they provide a valuable contribution to increasing road

ASSESSOR target object in driving experiment

safety. At the same time, however, it is not possible to prevent these systems from having an adverse effect on the traffic situation, in cases, for example, in which a sensor's malfunction could induce an automatic intervention and on occasion be responsible for damages. Conversely, a driver may not solely rely on the system to intervene. Road traffic laws does not allow the driver to abdicate responsibility.

In the context of the ASSESS project BASt was heavily involved in investigating liability issues in four major automotive markets (Germany, France, Japan, U.S.) from a legal perspective. Various scenarios were taken into consideration to examine the impact of malfunctions of the "false positive" (objectively unnecessary intervention) and "false negative" (omitted intervention) types.

The most significant findings can be summarised as follows: the product should comply with state-of-the-art science and technology as much as possible, and users should be instructed fully and comprehensively by the car manufacturer about what the product is capable of and what it cannot do, in particular about the system's purpose, its boundaries, and possible malfunctions. Such instruction is essential because the system's design can vary greatly from manufacturer to manufacturer. The differences may include the defined point in time and intensity of the intervention, oversteer options, and the objects the system can detect. The users should be warned against trusting the system blindly, and no exaggerated expectations should be raised.

If a malfunctioning emergency braking intervention causes damage, the claimant may hold various parties liable for the damage. These include the driver, the vehicle's registered keeper, the vehicle owner, the insurance company, the sales agent (dealer), or the vehicle's manufacturer. This question ultimately depends on the details of the individual case and the underlying facts.

The internationally applicable Vienna Convention on Road Traffic, dating from 1968, is based on the understanding that a driver must always be able to control his or her vehicle. This idea is also reflected in national road traffic codes. The concept of controllability has been incorporated in the Code of Practice for the Design and Evaluation of Advanced Driver Assistance Systems developed in the RESPONSE3 project. This makes controllability a significant element in behavioural law as well as in product liability law.

In the context of controllability it is important to design automatic emergency braking systems to include an oversteer option in case of an erroneous intervention. At the same time, this is advantageous from a manufacturer's perspective in terms of product liability because it leaves the ultimate decision with the driver. However, this aspect is a difficult one as it raises questions about how good a driver's individual capability to react is in practice. Furthermore, interventions in areas beyond human capabilities should not be a problem from the perspectives of behavioural or product liability laws. Likewise, from the same perspectives, adequate driver instruction and warning should precede the use of any automatic emergency braking, so that the driver is given the opportunity to override a potentially wrong intervention if necessary.

Conclusion

Emergency braking systems for vehicle-vehicle collisions can contribute to

improving road safety. A calculation of the socio-economic benefits of emergency braking systems was possible under the framework conditions of the ASSESS project. Taking into consideration the legal aspects outlined above, the issues raised by automatic emergency braking systems from the perspective of behavioural or product liability law can be resolved.

The introduction of a suitable testing method is currently pending, and is planned for 2014. Such a testing procedure in the Euro NCAP framework will help to compare various emergency braking systems. ■

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Numerical crash simulations

Numerous experimental impact tests are currently being carried out for the purposes of type approval procedures for motor vehicles and vehicle components, as well as for compliance assessment procedures (CE marking) for road restraint systems. These tests have been harmonised within the EU over the past few years and aim to maintain the high safety level as reflected in the declining number of deaths and seriously injured casualties in accidents on German roads.

Although vehicles and road restraint systems represent very different products, their assessment procedures are nonetheless in principle comparable. Representative scenarios are selected from the total accident history and translated into test configurations. The vehicle and the road restraint system are subjected to impact loads representative of the corresponding impact in an accident situation. The impact tests can also be described as experimental simulations. To assess a vehicle's safety in a head-on collision, the on-coming vehicle can, for example, be simulated by a standardised barrier, and the impact of the crash on the occupants can be examined by means of a biomechanically representative model of a human being, a crash-test dummy. The real crash tests and limit values to be used as criteria in certifying vehicles and road restraint systems are described and made legally binding in the European EN 1317 standard. The crash tests are the basis on which the performance data of a road restraint system is specified on its compliance certificate: containment level, working width, and impact severity.

The road safety of the vehicles and road restraint systems in question can be assessed objectively and repeatably when established test configurations, measurements, and safety-relevant criteria are used. If the product exceeds the limit values stipulated by regulations and standards, it is banned from being sold in the European market. As the tests are destructive in nature and require sophisticated technical handling, experimental simulations incur high costs, most especially the costs of producing prototypes and those of delays in product development due to negative test results.

Virtual tests

For many years, numerical simulations have been successfully employed in developing motor vehicles. They aim to limit to a minimum the number of prototypes during the development phase, to reduce development costs, and to reduce the time needed for developing a new product.

Increasingly, there have also been considerations about whether and how to replace or complement experimental testing procedures by numerical (computer-aided) simulations in type approval and compliance procedures.

A numerical simulation of a given test configuration is based on simulation models containing relevant parameters for real-life application in simplified terms. By approximation, the differential equations underlying the physical phenomenon are transferred into systems of equations, which in turn are solved by high-performance computers and simulation programmes.

Model verification and validation

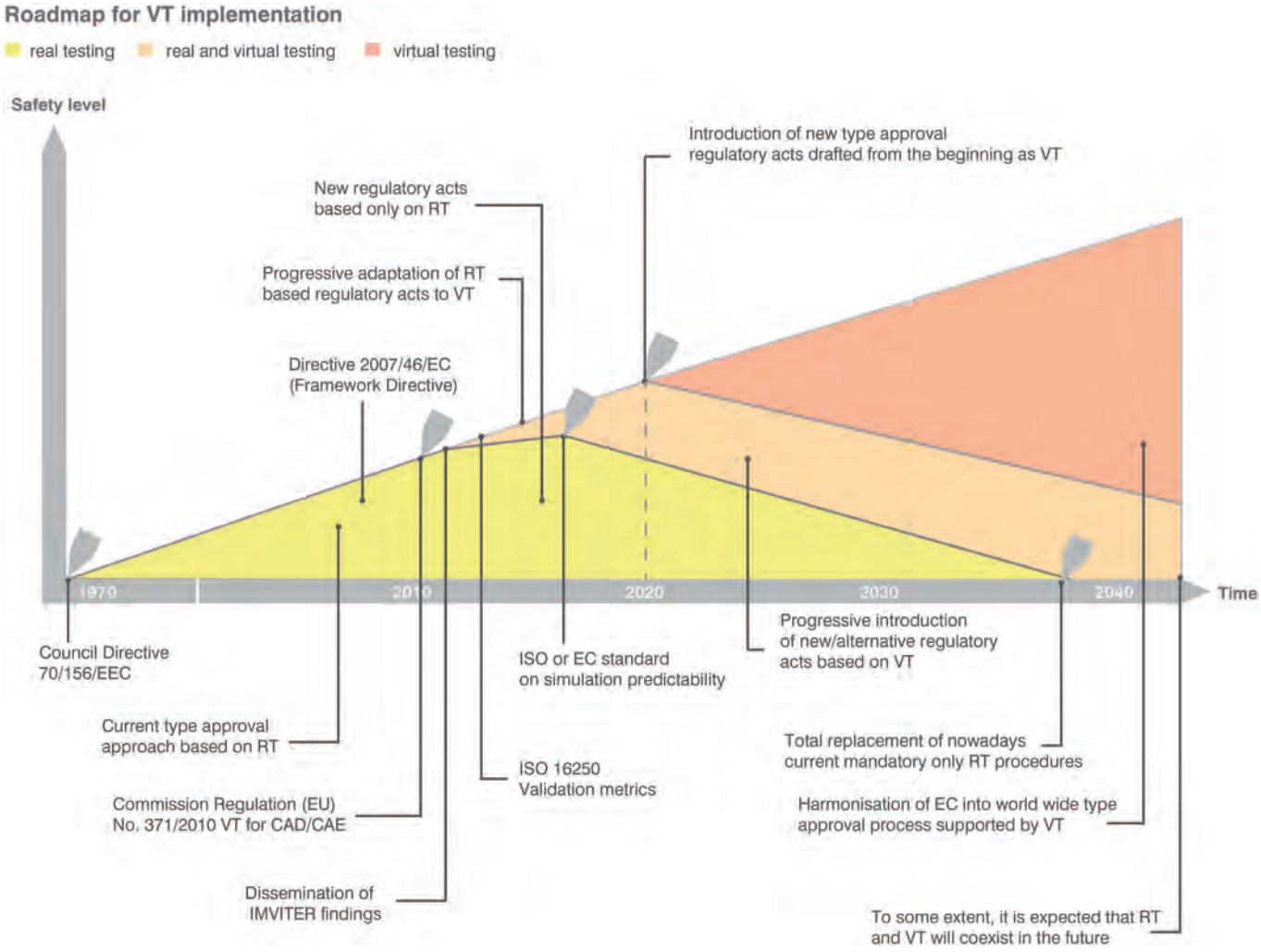
In contrast to experimental tests, numerical simulations require a computer-based (numerical) model of the product to be tested. To make sure that the model provides reliable results for testing or assessing the system in question, a validation of the simulation model is essential. A model verification and validation needs to ensure that the numerical model maps all the relevant properties of the real system.

Virtual methods have been allowed for selected regulations in motor vehicle type approval on the basis of EU Regulation 371/2010 since 2010. In its annex, it calls for the computer models to be validated as a necessary prerequisite, but precise implementation instructions are lacking. Detailed validation procedures were developed in the context of the IMVITER (IMplementation of VIrtual TEsting in safety Regulations) project which was funded by the EU. BASt was involved in this process; together with private sector and research project partners and testing institutes, they were evaluated using the example of type approval provisions for head-on collisions in pedestrian protection. Under the guidance of BASt, additional procedures were produced as possibilities for virtual type tests in vehicle safety-related regulations.

These procedures have already been implemented by testing institutes.

According to EN 1317-5:2007 + A2:2012, modified road restraint systems may be certified on the basis of a reduced number of impact tests, or calculations, computer simulations, or simple stress tests. A verified and validated simulation model is required for this procedure. The model should correspond well to impact tests already conducted and be confirmed by an independent third party. A working group of the European Committee for Standardization (CEN) TC226/WG1 is currently preparing a uniform method for verifying and validating simulation models. Along the lines of the results of the IMVITER project, this method will consist of testing the simulation model developed; it includes specifications for the validation procedure as well as the requirements that the verification and validation processes be documented. BASt is intensely involved in this Committee's work and accompanies it with several external research projects. These research projects explore the possibilities and limits of numerical solutions and analyse parameters inter alia.

Comparison of test results to simulation results for developing validation procedures for head-on collision tests in the IMVITER EU project



IMVITER projection for the future implementation of virtual tests in type approval procedures for motor vehicles (Source: IMVITER EU project)

Future potential

Due to increasing computing capacities, numerical simulations have a great potential in product development, type approval, and CE marking.

The projections portrayed in the graph assume that with increasing safety levels more and more real tests will be replaced by virtual ones. Once virtual testing procedures are introduced, they will probably not be restricted only to replacing previous systems. They offer the possibility to change the boundary conditions at no additional cost and to expand the test configurations so that real-life accident situations can be simulated much more comprehensively. Simulations can also be useful for developing resilient testing conditions. The influence of parameters such as impact angle, speed, and vehicle type, in a crash with road restraint systems can be tested with the help of sensitivity analysis.

Using numerical human models also has potential for the future. The crash-test dummies used in experimental test configurations mentioned above are limited in their ability to represent occupants' biomechanical reactions in a crash in any realistic or detailed way. Computer-based human models enable a much more detailed representation of human biomechanical properties. Future models can, in particular, simulate specific muscle activities which may be relevant in certain test configurations. Many open questions will have to be answered,

THUMS numerical human model for an improved assessment of vehicle safety in the future

however, before such models can be used in virtual tests as part of standardised testing procedures. As a prerequisite these models themselves will have to be standardised. In the future BASt will continue to actively participate in finding answers to this question and others with regard to using virtual tests for products of relevance for road safety. ■

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Vehicle safety to protect cyclists

In 2011 one in ten persons killed in road accidents in Germany were cyclists (399 persons). 76,351 cyclists were injured; 14,437 of them sustained serious injuries. Nonetheless, the average rate of cyclists wearing helmets totals just six per cent. This includes the above-average 53 per cent rate of under 10-year-olds and the low rate of only two to four per cent of over 17-year-olds wearing helmets. However, the severity of head injuries can be significantly reduced by wearing a bicycle helmet. According to analyses of the GIDAS (German In-Depth Accident Study) database, serious head injuries are reduced by 33 per cent when a helmet is used.

Active and passive safety

Taking into consideration the consumer research and testing programme Euro NCAP (European New Car Assessment Programme) and their assessments of vehicle front ends for pedestrian protection, a study of all the accidents in GIDAS involving cyclists leads to the conclusion that the potential for serious head injuries in cyclists can be significantly reduced if the tests are expanded to include pertinent measures.

Measures for passive pedestrian safety (injury mitigation) as well as active pedestrian safety (accident avoidance) have been taken into consideration. Systems providing active safety usually consist of automatic braking systems.

Based on existing specifications for passive pedestrian protection, modified vehicle tests and assessment procedures can contribute to improving cyclist safety. In parallel, accident analyses, human model simulations, and real-vehicle tests have indicated that an extended test area may result in improving the safety of cyclists because the impact of a collision between a bicycle and a passenger car hits the cyclist's head, especially an adult one, further back on the vehicle's front-end compared to a passenger.

At the same time, additional tests on the safety potential bicycle helmets offer may provide information about whether and in what situations bicycle helmets can mitigate the severity of an injury, be it in collisions with another motor vehicle or single-bicycle accidents. In addition to established test methods, such as the ones described in the European EN 1078 standard, BASt's newly developed full-vehicle and component test configurations reproduce several typical accident scenarios: lateral upset, handlebar overturn, and lateral vehicle-cyclist collision followed by secondary impact on the road.

Both approaches for passive vehicle safety can be used to demonstrate the protection offered by bicycle helmets. The tests performed to date have shown that the protection potential of the helmet has a tendency to increase with increasing impact severity.

Anticipatory safety systems can help reduce a vehicle's speed prior to a collision and thus on average mitigate injury severity. Tests have also shown that a reduced speed has a significant influence on cyclist kinematics and head trajectories. Ultimately, this may lead to the head impact being shifted onto different structures.

Boundary conditions

The potential of future active safety systems is mainly determined by overall legal conditions, by physical limitations to

the braking process, and by the systems' capability to interpret different situations.

With regard to legal conditions, a balance needs to be struck between maximising the effects and minimising misguided wrongful automatic responses.

The maximum in physically decelerating a vehicle is determined by the properties of the road, tyres, and the intermediary. At good road conditions, it amounts to merely 10 m/s^2.

However, in view of the sometimes short braking times available, the system's ability to initiate a deceleration quickly is much more important than the highest deceleration that is physically possible. Present-day actuators still fall short of the brake pressure gradient reached by a driver hitting the brake pedal purposefully.

The following points are essential for an automatic braking system with regard to interpreting different situations: detection time, i.e., the time needed by the system to identify a cyclist and classify the situation as risky ("critical"), but also sensor failures, caused for example by adverse weather, play an important role.

The requirement to guarantee low probability of faulty activation is most likely to decide how much these systems can contribute to avoiding accidents.

First systems in the market

Some initial systems are already available for pedestrian protection. The systems as well as tests and requirements related to them are currently being busily developed for a broad range application. Some vital factors need to be taken into consideration for a vehicle to be able to brake for cyclists.

While pedestrians can often stop in front of a car at a distance of up to one meter or change direction if necessary, cyclists are much more restricted in their freedom of movement and dynamics. Conversely, cyclists move faster than pedestrians and the detection time as well as the field of vision of the sensors both need to fulfil higher requirements.

Head impact often occurs beyond current test areas (yellow mark)

Cyclist-passenger car collision

BASt is currently participating in research on the requirements of active cyclist protection conducted in the context of the "AsPeCSS" research project. Initial findings indicate that conventional sensor and actuator concepts can indeed be used to influence accident situations involving cyclists.

Active vehicle safety systems will be integrated into the assessments carried out by Euro NCAP as of 2014. Active pedestrian safety is planned to be explicitly covered as of 2016. Since active cyclist protection is also planned to be integrated into the assessment eventually, Euro NCAP has decided to currently refrain from assessments of passive protection potential by means of modified tests. ■

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Advanced driver assistance systems for older drivers

Given the demographic shift taking place, keeping mobile and driving safely in old age have become increasingly important. Accident statistics and scientific studies have shown that specific driving mistakes are committed by older drivers. These become apparent in unforeseen situations requiring quick decisions, when driving under time pressure, or in complex traffic situations. Older people are apparently less and less able to compensate with their driving experience in the situations mentioned above. Given their greater driving experience compared to younger drivers, the questions remains why senior citizens find it increasingly difficult to cope with these situations.

Experimental study

This question was the subject of a project during which the neurophysiological aspects of cognitive information processing in younger and older drivers were studied. They were asked to perform a dual task (tracking and peripheral detection). The results of this experiment were intended to be used to outline how suitable advanced driving assistance systems can help senior citizens maintain their mobility.

The experiment was conducted in BASt's ergonomics laboratory and involved 63 people. The average age of the 30 younger participants was 30.5, and the average age of the older ones was 72.9 years. All participants had to fulfil certain criteria, including having a driving licence, sufficient visual acuity, and an intact visual field.

The experiment used a dual activity paradigm, as a dual task is a good simulation of the demands in an actual driving situation.

Dual task experiment

The main task was a tracking task to simulate driving along a winding road. The participants were asked to keep a reticle in the centre of a grid on a moving lane as best they could using their steering wheel. The secondary task consisted of a peripheral detection task. A light stimulus was presented simultaneously on their right and their left visual fields at angles of 20 and 60 degrees. The participants had to respond to the light stimulus as quickly as possible by pressing a button at their steering wheel. The light stimulus was to represent other road users and objects which may call for the driver's attention while driving.

The trial participants were told they should consider the tracking task analogous to staying in one lane while driving and that the peripheral detection task was their secondary task.

During the entire trial, the participants were connected to an EEG to generate event-related potentials (ERP). Based on the international 10-20 system (Jasper, 1958) 32 electrodes (BioSemi "pin-type"

active electrodes) were attached to the participants' heads for the EEG.

The following ERP components are important to interpret visuo-spatial attention processes:

- P1: activity (positive) within 100-150 milliseconds after stimulus; the earliest detection potential after presenting the light stimulus.
- N2: activity (negative) within 150-280 milliseconds after stimulus; characterised by the control process of disengaging and shift attention.
- P3a: activity (positive) within 300-600 milliseconds after stimulus; correlates with refocusing on new stimuli
- P3b: activity (positive) within 300-700 milliseconds after stimulus; associated with allocating processing resources to accomplish a task.

A sketch of the brain was used to show the ERPs and how they map topographically.

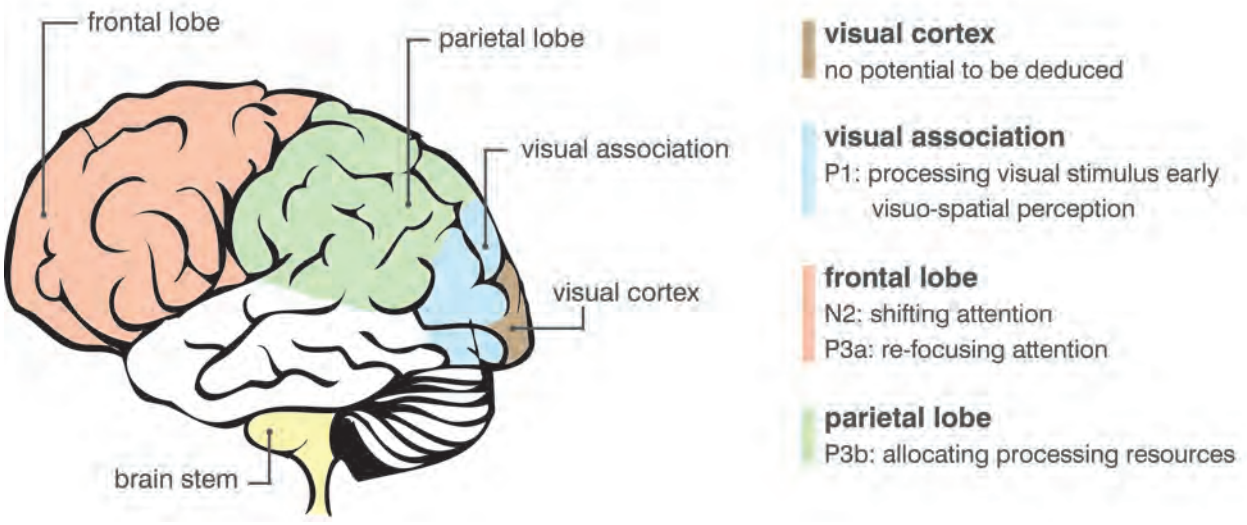
Results

The behavioural data revealed, as expected, that the older participants detected fewer stimuli and took longer to respond.

Since the behavioural data does not allow any conclusion on the reasons for the performance deficits among the group of older drivers, the ERP data was instrumental in studying sensory cognitive and attentional processes. This method made it possible to explore in more detail the reasons for age-related driving errors.

The results indicate that older drivers' driving errors were caused less by visual impairments than by constraints in performance in the subsequent cognitive processes such as disengaging and shifting their focus of attention. They were also caused by the older drivers' refocusing on the new peripheral stimulus and allocating additional attention to be able to see difficult light stimuli. This became apparent in delayed latency and reduced amplitudes in the N2, P3a and P3b results when the light stimuli were presented at a 60-degree angle.

For driving this means that senior citizens are particularly at a disadvantage in situations that require a change in attention (going through the steps of disengaging, shifting, refocusing, and allocating processing resources). Responding too late to relevant stimuli or even failing to see them altogether is one of the main reasons for senior citizens

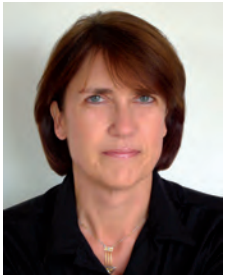


Schematic depiction of the brain with event-related potentials and their topographical mapping

Experiment with older trial participants

to commit driving mistakes or cause accidents.

On the basis of the results of this study and in the light of driving being a multi-task activity, one possible option would be to influence the field of vision in a car. Peripheral road users such as cyclists or pedestrians could be shown in a head-up display for example, or "visual field assistance" systems such as a camera-monitor-system could be installed where they can best be seen by the driver (at a 20-degree angle). This would make peripheral road users visible and improve drivers' recognition of them. ■



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euroFOT: European Field Operation Test for advanced driver assistance systems

euroFOT was the first large-scale project for assessing advanced driver assistance systems at the European level. Its purpose was to conduct field tests in real road conditions and to study advanced driver systems and their effects on driver behaviour, user acceptance, road safety, traffic flow, and energy efficiency.

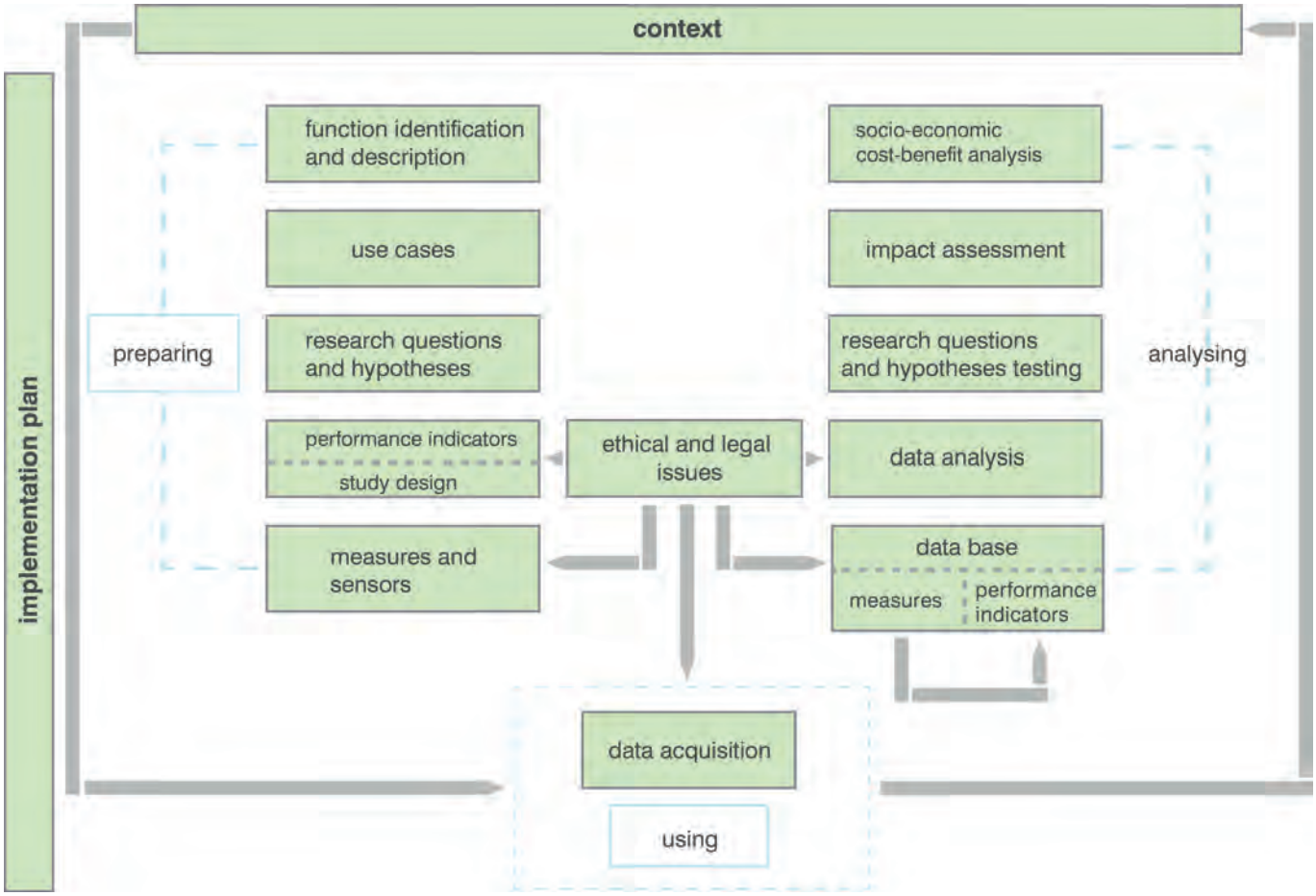
Autonomous in-vehicle (on-board) advanced driver assistance and information systems (ADAS/DIS) have been developed on the basis of new information and communications technologies for some time now. These systems are intended to help the driver in the driving process and thereby contribute to improving road safety and traffic flow, and to help prevent adverse effects road traffic has on the environment. The ADAS/DIS's functions have been studied in numerous experiments and research projects, but to date little data has been available for evaluating practical operating experience and long-term tests in real traffic conditions. This information gap has now been closed with the help of the euroFOT project funded by the European Commission. However, the systems need to be widely used to fully develop their potential. The test results can be used to better understand future users' decision-making processes and to support the systems' more targeted launch into the market.

As a project partner in euroFOT, BASt has been involved in defining test hypotheses and evaluation criteria, in preparing the tests' experimental design, in analysing data and discussing the effects the systems have on driver behaviour, and in the final socio-economic impact assessment.

Advanced driver assistance systems tested

The test covered about 1,000 vehicles (passenger cars and lorries) equipped with ADAS/DIS that were either already available in the market or about to be released. Eight different assistance

Vehicle with night vision assistance (Picture: Deutscher Verkehrssicherheitsrat e.V.)



Flowchart for large-scale field tests (graph: FESTA)

functions were tested, in particular assistance for longitudinal and lateral control. Cases in point are adaptive cruise control in combination with the forward collision warning, lane departure warning and blind spot detection.

Procedure

The framework strategy and recommendations for field tests in road traffic developed in the scope of the European FESTA (field operational test support action) project provided the basis for euroFOT's method. The FESTA strategy stipulates three different stages:

- Preparing: planning and preparing the test
- Driving: collecting data during test drives
- Analysing: analysing and evaluating the data

The test methodology used in euroFOT included elements of so-called "natural" driving in the experiments. A large number of private individuals and professional drivers were asked to participate as test drivers. The data was collected during real traffic situations while the vehicles and systems were being used on an ordinary day-to-day basis. The data was therefore influenced only a little by experimental conditions.

Five test management centres in Germany, France, Italy and Sweden supervised the vehicles and the drivers throughout the test. They were in charge not only of recruiting the more than 1,000 drivers, but also of equipping the vehicles with the necessary measuring systems, and of collecting and storing the data.

Data was collected over a period of 12 months and divided into two phases:

during the first three months the ADAS/DIS to be tested was disabled during driving (baseline phase). In the nine months that followed the drivers were free to use the system according to their own habits (application phase). In addition to a continuous collection of objective data via a data logger, questionnaires were used to collect the subjective opinions of the drivers participating in the trial, concerning, for example, user acceptance and driver workload.

Data evaluation

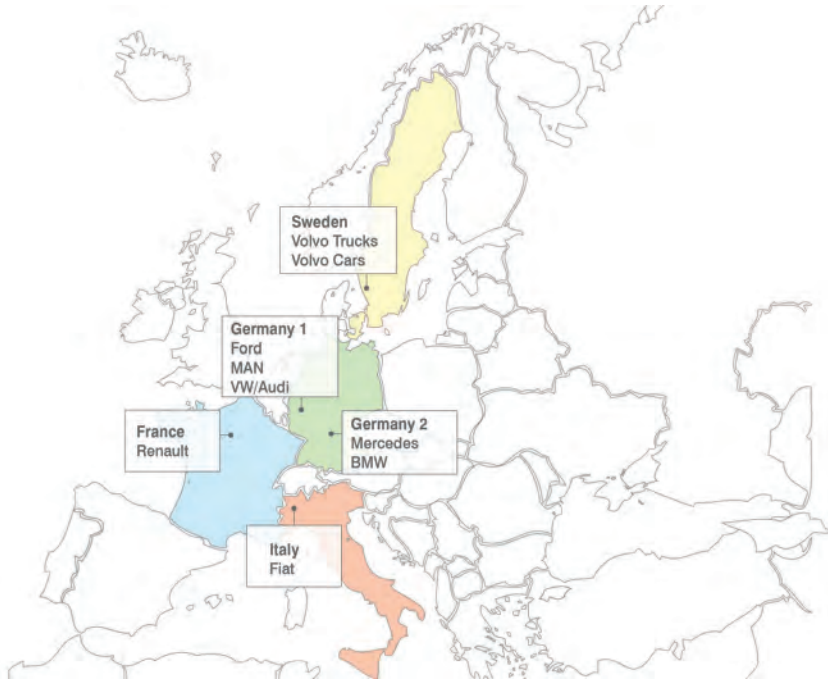
The trial vehicles were driven over a total distance of 35 million kilometres during the data collection phase. The raw data was processed, augmented with additional attributes from a digital map, and reduced to relevant data sets, so that in the end it was possible to use data material from 16.5 million kilometres for a statistical data analysis. Relevant parameters were deduced from the initial test hypotheses at the beginning of the project. The parameter values were calculated and compared for the baseline phase (system off) and the application phase (system on) to evaluate the effects of the ADAS/DIS tested. In several successive steps the results were then extrapolated for a larger user populations and geographical areas. This made it possible to put together an estimate of the systems' potential effects at EU level assuming a high market penetration.

User-related effects were assessed on the basis of parameters describing driver behaviour (e.g. speed, own vehicle's distance to vehicle in front, delayed braking), driver workload, acceptance and use of the function and the drivers' trust in it. The safety-related analysis aimed to estimate the effect the systems were likely to have on accident situations (collisions, injuries, deaths). It was clear from the beginning that the number of accidents would be low during the one-year trial phase and would not provide enough data for directly measuring collision and injury risks, which is why proxy indicators were defined. They were derived from results of changed driver behaviour, but also included safety-critical incidents, for example heavy braking or leaving less than a safe distance to the vehicle in front. Effects on traffic efficiency and on the environment were quantified based on changes in journey times, frequency of congestions caused by accidents, homogenising traffic flow, fuel consumption, and CO_2 emissions.

Bundling the ACC with the FCW function

On the basis of the two bundled "adaptive cruise control" (ACC) and "forward collision warning" (FCW) functions, the selected trial results below were achieved:

- There was a significant increase in the use of the function. During the last month of the application phase, the frequency and length of time the function was in use was higher than the first month by 30 per cent. This measured result was in line with the results from the questionnaires in which more than 75 per cent of the interviewees found driving with ACC + FCW switched on safer and more comfortable than driving with the system switched off.
- When the ACC + FCW function was switched on, the average distance to the vehicle in front was increased significantly compared to driving switching it on. This effect was measured in passenger cars on motorways and city streets (increase by about 16 per cent), and in lorries



Test management centres (graph: euroFOT)

on motorways (increase by about 5 per cent). The number of incidents that measured a critical distance or required heavy braking decreased by 30 to 80 per cent depending on the situation.

- During the application phase a slightly increased average speed was measured when the system was switched on compared to when it was switched off. The drivers' higher speed was closely linked to situations in which they were driving with the system switched on, which indicates that the drivers used the systems mainly in non-critical situations at low traffic densities.
- Drivers of passenger cars more often engaged in secondary activities which had nothing to do with the driving task and shifted their attention off the road when they had their system switched on compared to driving with the system switched-off. This did not happen, however, in critical traffic situations. The result was interpreted to show that the drivers were capable of controlling their secondary activities depending on the situation. This distraction effect was not found to affect lorry drivers (professional drivers).
- By projecting the results at the EU level while assuming a high market penetration, positive safety effects were identified for passenger cars on all road types (motorways, rural roads, city streets). For lorries the positive effects could be forecast only for motorways. Traffic efficiency was also found to be positively affected. An estimate for EU-27 showed that the hours drivers lose in congestions caused by accidents could be reduced by more than three million hours. Fuel economy was found to increase on the basis of changed driver behaviour by about three per cent in passenger cars and two per cent in lorries. The positive effects on consumption due to improved traffic efficiency were not included in these figures.
- The effects on traffic safety, efficiency in traffic flow, fuel consumption and environmental pollution were incorporated into a socio-economic impact assessment. An estimate for the benefits at the EU-27 level, assuming high market penetration, shows a total amount of about one billion euros per passenger car and up to 150 million euros per lorry in benefits. The increase in traffic safety has proved to be a dominating factor in terms of economic benefit. Increased fuel efficiency and lower environmental protection as well as a reduction in the number of congestions caused by accidents lead to additional vital benefits.

Outlook

All in all, the results indicate positive effects with regard to road safety, traffic safety, fuel consumption, and user acceptance. The euroFOT project was

thus able to provide information to foster public awareness of the systems and their wider use. The results are highly useful for further optimising existing advanced driver assistance systems, and will be taken into consideration for the specifications of future systems. With respect to the methodology of field operational tests (FOT) euroFOT was instrumental in proving at the European level for the first time that large-scale FOTs can contribute considerably to assessing advanced driver assistance systems and driver information systems. However, the euroFOT experiences have also provided a more realistic understanding of the FOT method, for example in showing the amount of effort required for data collection and data processing. On the basis of euroFOT, recommendations were deduced which will influence further development of the FOT methodology. ■

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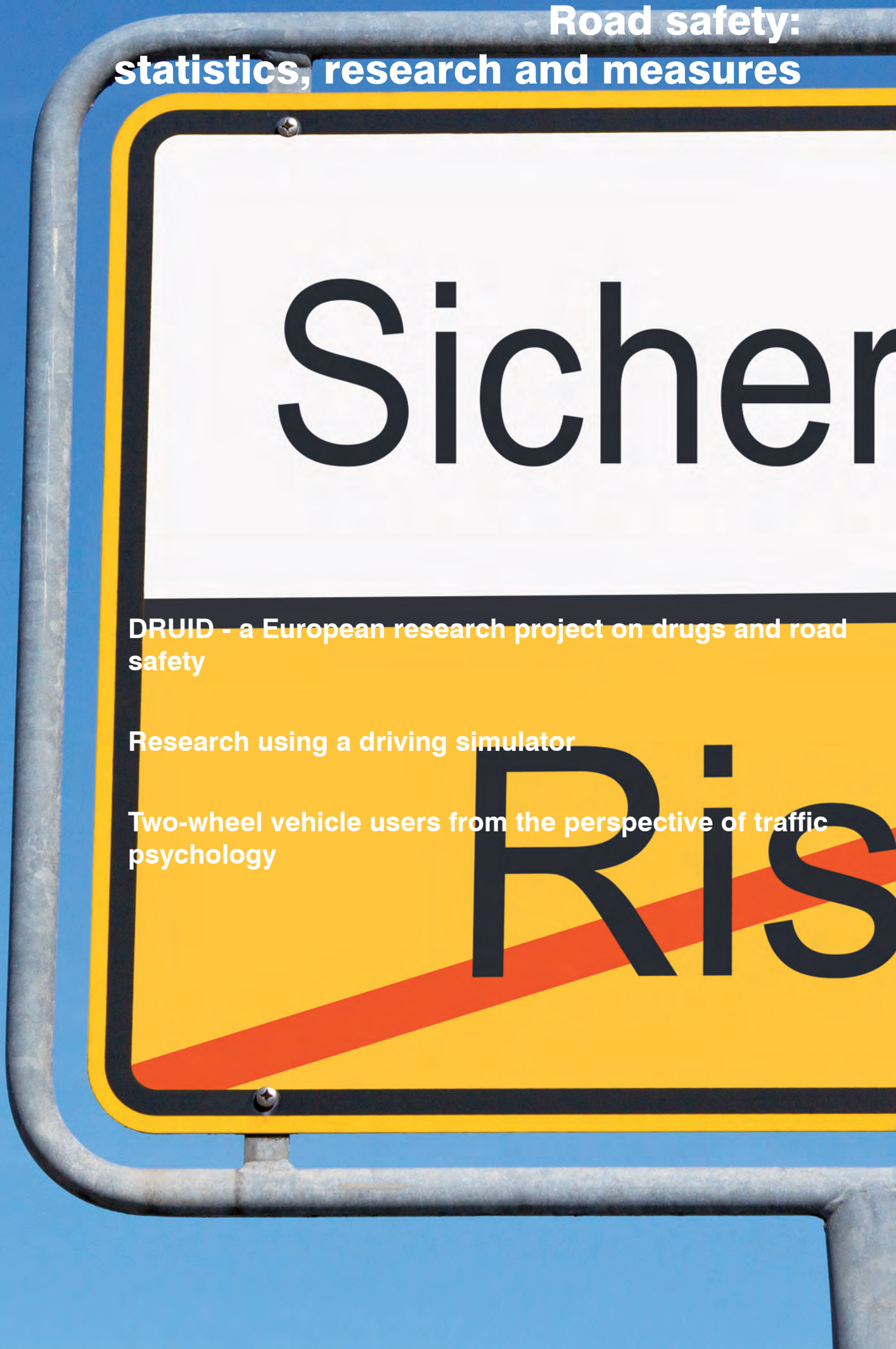
Road safety: statistics, research and measures



DRUID - a European research project on drugs and road safety

Research using a driving simulator

Two-wheel vehicle users from the perspective of traffic psychology

How to plan school route maps easily

Pre-test driving training in Germany

Motor caravans' involvement in accidents from 2000 to 2010

DRUID – a European research project on drugs and road safety

Driving under the influence of alcohol or drugs is one of the main reasons for fatal accidents on Europe's roads. It thus constitutes a major risk for road safety. The European Commission commissioned the DRUID (Driving Under the Influence of Drugs, Alcohol and Medicines) research project to assess the magnitude of the risk and to develop suitable counter measures. With its total budget of 23.5 million euros it is the largest research project to date awarded by the European Commission on improving road safety. Over a period of five years renowned institutes from 18 European countries conducted research on road safety risks related to the consumption of psychoactive substances. BASt was the project coordinator.

Data collection

In an attempt to find out how many drivers were actually driving under the influence of alcohol, drugs and medicines on Europe's roads, about 50,000 drivers in 13 countries were stopped at random, without showing erratic behaviour, and asked to provide blood or saliva samples. The samples were tested for alcohol, drugs, and specific medicines.

The results showed that alcohol is still the most common substance people consume when they drive. The percentage of drivers consuming illegal drugs has turned out to be lower than originally assumed. The rates in the 13 countries participating in the survey reveal that 3.5 per cent were driving under the influence of alcohol, the highest percentage. Only 1.9 per cent of the drivers were driving under the influence of illegal drugs such as cannabis, amphetamines, or cocaine, while 1.4 per cent of them were driving under the influence of medicines with an impairing effect on their response capabilities. The percentage of people driving under the influence of more than one illegal drug was about 0.4 per cent, which corresponded to the percentage of drivers under the influence of alcohol in combination with illegal drugs.

The fact that a substance is found in a driver's blood does not mean that the substance presents a risk. Additional factors need to be taken into consideration before such an assessment can be made, e.g., how many accidents have been caused by people driving under the influence of the substance in question. DRUID analysed data of 3,600 drivers involved in accidents. Drivers with a blood alcohol level of more than 1.2 permille and those driving after consuming alcohol together with illegal drugs showed the highest likelihood of becoming involved in an accident. Although only few drivers use

Countries participating in DRUID

their cars under these conditions, they are a major risk, because they are involved in accidents most frequently.

Cannabis, the most frequent illegal drug for which drivers tested positive, led to a moderate increase in accident risks, comparable more or less to drivers with a blood alcohol content of 0.5 permille. However, epidemiological studies alone are not a sufficient basis for recommending clear limit values for cannabis or for stimulants comparable to the limit values for alcohol. Additional experimental studies showed that a concentration of 3.8 ng/ml THC in serum (effective substance of cannabis) leads to impairments comparable to a concentration of 0.5 permille of alcohol in a driver's blood. The values in tests for stimulants were ambiguous, so that the "zero-tolerance" approach should be continued. DRUID experts advised against introducing limit values for legal prescription medicines with possible impairing effects. They recommended providing more targeted information for patients.

DRUID conducted driving tests under experimental conditions in both road traffic and driving simulators: volunteers were placed under the influence of drugs and medicines in a targeted and controlled manner. In the Netherlands, for example, a study researched the effects of driving under the influence of stimulating drugs, sometimes in combination with alcohol, or after sleep deprivation. The result showed that the effect of stimulating drugs does not suffice to compensate for the impairment from sleep deprivation or alcohol. Instead, the drivers are more likely to underestimate their impairments. Drivers who drive home after a night of drinking alcohol excessively and consuming stimulating drugs are particularly likely to become involved in an accident.

Measures

What countermeasures can be taken to further reduce the number of accidents? DRUID reviewed the existing measures and developed specific recommendations. A cost-benefit analysis revealed that in

countries such as Germany, where the police are already active in relatively intense drug monitoring, stricter controls would not yield a significant economic benefit. In countries where monitoring is not sufficient, however, stricter controls do make sense As driving under the influence of alcohol is still the biggest safety risk on Europe's roads, drug-drive tests should not be enhanced at the expense of drink-drive tests.

Rapid tests were reviewed to determine how suitable they are, and evaluated with regard to their operational usability (such as handling and duration) and their scientific viability. The results of this critical analysis provide substantial information for improving rapid tests, and they will be

taken into account in developing future products.

Physicians can contribute to improving the safety on Europe's road by prescribing medicines that impair their patients' fitness to drive less. An extensive database developed in the scope of DRUID classifies medicines according to four different categories with respect to their impairing effects on driving, thus providing physicians and pharmacists with necessary information. A pictogram was designed to further foster communication among physicians, pharmacists, and patients, and to better inform patients about their fitness to drive after taking medication. The pictogram is a good graphic illustration of the severity of the impairments to be expected, and at the same time suggests appropriate behaviour.

In a pilot project for physicians' surgeries and pharmacies a classification and labelling system was successfully integrated into the software systems used when prescribing and dispensing medicines. It ensures that sufficient information can be provided about impairing side effects each time a medicine it prescribed or dispensed.

Driving license

In addition to preventing alcohol- or drug-related accidents, rehabilitation of repeat traffic offenders is important. DRUID was the first project to comprehensively compare the measures for repeat traffic offender rehabilitation across Europe and review them for their optimisation potential. The results showed that in some cases the measures vary greatly from one country to another. DRUID compiled recommendations for improving the

Category	Label	Warning advice
0	no label	no warning
I	Fitness to drive 	**Be careful!** Read the patient information leaflet before driving.
II	Fitness to drive 	**Be very careful!** Do not drive without the advice of your GP or pharmacist.
III	Fitness to drive 	**Attention: danger!** Do not drive! Seek medical advice before driving again.

DRUID labelling for medicines

current systems to reduce the number of repeat offenders. At the same time, recommendations were made for Europe-wide harmonisations and quality control standards.

European regulations for withdrawing or re-instating driving licenses were compared as well. This led to specific guidelines for improving legal provisions, e.g., in the fields of suspension periods, conditioned suspension, combination with rehabilitation measures.

DRUID delivered the first comprehensive analysis of all the aspects related to driving under the influence of alcohol, drugs and medicines. Its findings and recommendations are the basis for future decisions in transport policies within the European Union and in the individual Member States. They provide a good basis for initiating target group-specific measures to improve road safety.

All 46 reports of the DRUID findings are available in English for download from the DRUID home page: www.druid-project.com. ■

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Research using a driving simulator

Road tests have a long tradition at BASt. Initial studies were conducted already in the late 1970s using a standard vehicle especially equipped with measuring devices, with two video cameras capturing the driver and his view of the road. Visual information, measured data about the driver's actions (steering, using pedals) and the vehicle's movements were recorded on videotapes. Technology progressed and other vehicles followed this first one, each equipped with state-of-the-art measuring and video technologies.

Conducting tests on public roads is still the best method to study driver behaviour. However, this method has its limits: it is time-consuming and cost-intensive and involves risks. Road tests are difficult to standardise as the behaviour of other road users and weather conditions can hardly be influenced. It is nearly impossible to study driver behaviour in dangerous or even rare traffic situations, although this type of behaviour is of particular significance for the research on road safety.

In these cases a driving simulator offers a suitable alternative because driver behaviour can be studied even in critical traffic situations without endangering anyone. Specific traffic situations can be simulated and reproduced repeatedly. The effects of driving under the influence of alcohol, drugs, and medication, for example, can be examined with the help of a driving simulator. Other cases in point are driving while the driver is distracted or tired. Driver assistance and warning systems can be studied before they are ready for use in real road traffic.

Due to technical restrictions, driving in a driving simulator can never be an exact representation of driving in real road traffic. However, for most of the issues under investigation this is not necessarily

BASt driving simulator

required. If pertinent methodological conditions are complied with and the simulators correspond to state-of-the-art technology, the results of a simulation are considered transferable to reality.

The driving simulator at BASt

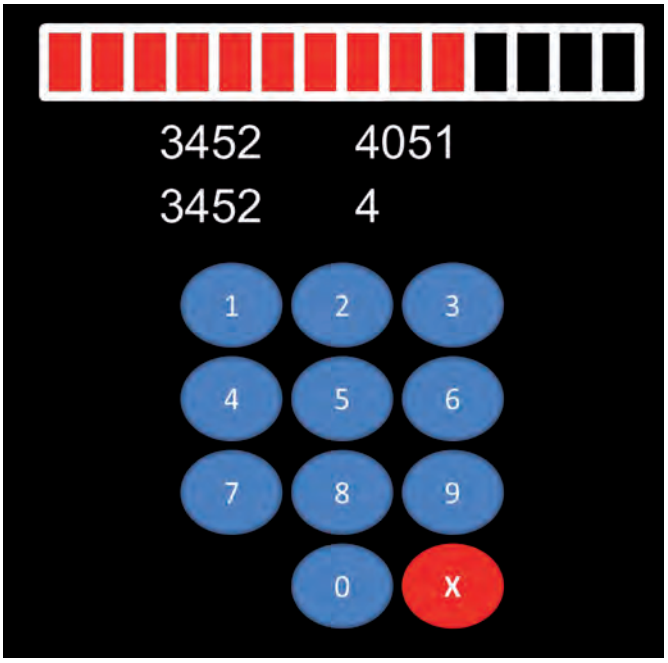
Three high-definition beamers can be used to project a traffic situation onto three screens of 2.80 metres x 2.10 metres size each, enabling a 180-degree field of vision that shows what is in front of the driver and to the sides. The inside rear view mirror and both wing mirrors are simulated by LCD displays.

The design of the driver's cab is based on a medium-sized passenger car. It is equipped with an accelerator and a gas pedal, direction indicators, a light switch, and an instrument panel, just like an ordinary vehicle. A motor is integrated into the steering column giving the steering wheel a resistance that needs to be overcome each time the driver turns the wheel, just as in a real car. As an additional element, the centre console contains a touch display screen showing navigation advice or tasks to be fulfilled.

Eleven interconnected computers operate the driving simulator. A 5.1 sound system is used to produce the sounds normally emitted by the car itself and by other road users.

The driving simulator is operated with the SILAB software, which was especially developed by WIVW GmbH to fulfil the requirements of experimental studies. With its help the roads and surrounding landscapes can be freely designed. It also allows detailed control over the behaviour of other road users, so that complex interactions with other vehicles or pedestrians can be represented.

The entire data is recorded for later analysis, including data on all the driver's actions as well as the movement and position of the vehicle. The positions and behaviour of any other road users are recorded as well. The simulator can be controlled and the data recording monitored from an observation desk using a graphical user interface. Two infrared cameras can be used to record the driver's eye movements in real time. The driver's brain waves can be recorded by means of an EEG system.



Secondary task: The drivers are requested to enter the figures they see on the display into a keypad. The bar indicates how much time they have left to complete keying in a specific number sequence

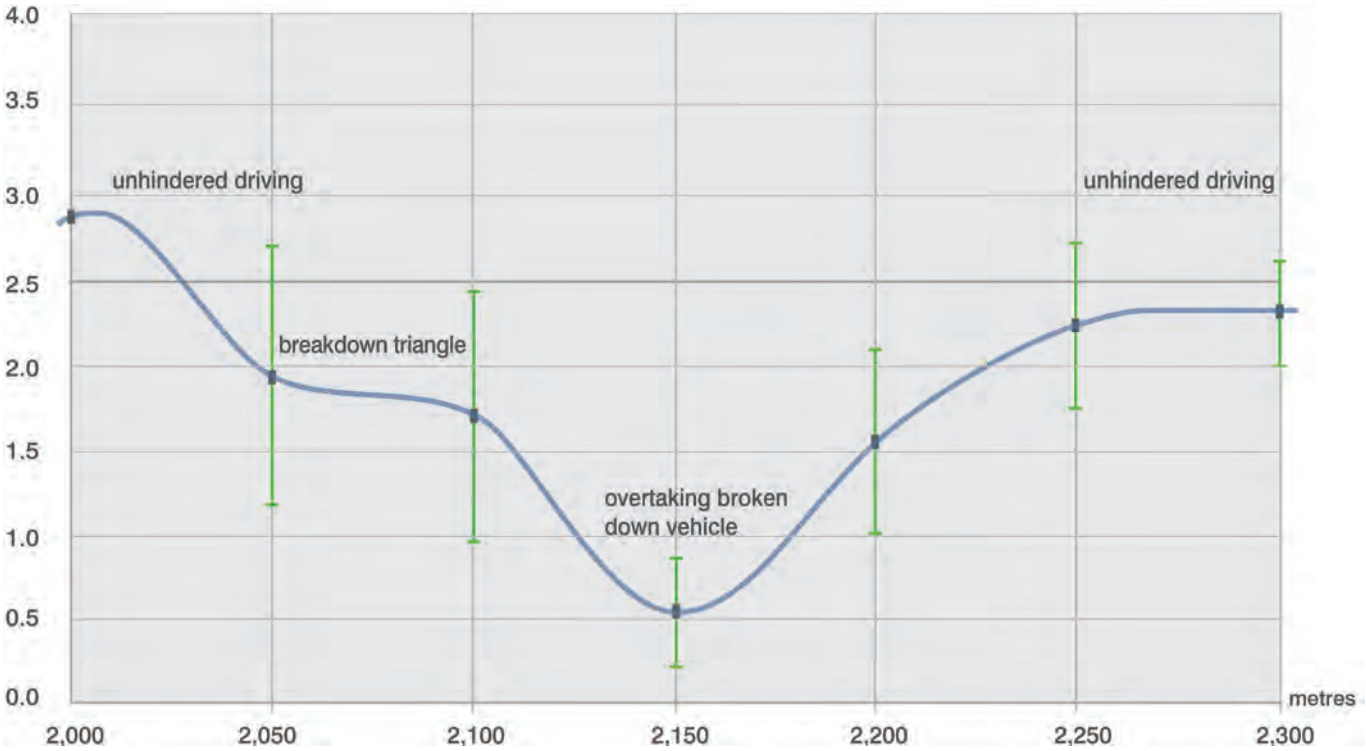
Secondary tasks while driving

For safety reasons and for the purposes of reproducibility, a driving simulator is usually better suited to research how secondary tasks are fulfilled while driving than real traffic situations are. These studies often aim to assess how dangerous a certain activity is. The trial participants are usually asked to complete a defined task while driving at the same time. Only very rarely do the tests take into account that in reality the driver can decide to pursue a secondary activity depending on the traffic situation or even to interrupt it if necessary. When the test driver in the simulator is requested to complete a secondary task at a certain time, this can lead to a distortion with regard to how dangerous the task in fact is. A method study conducted in the scope of a thesis attempted to determine whether drivers are capable of self-regulation if necessary and what effect this has on road safety (Wandtner, 2012).

In order to vary the testing self-regulation aspect, some of the 39 trial participants were asked to complete a secondary task which demanded the use of their visual and motor skills under time pressure during a specific stretch of their route (block condition) while others were free to complete the task in their own time (allowing self-regulation). The secondary task consisted of entering several number sequences into the touch display.

The route the trial participants had to drive along included built-up areas as well as non-built-up areas. Changes in continuous operations (lane keeping, driving speed) were studied, but in order to be able to discern how quick the participants' reactions were in critical situations, several incidents were added to the programme requiring fast reactions, e.g., braking when a pedestrian unexpectedly walks onto the road.

As the driver's behaviour is recorded in real time, simultaneously with the traffic situation and the completion of the secondary task, it is possible to gain precise information on how many operations the driver carried out during



Recording how many times the keys were pressed: mean number per 50 m in the broken-down-vehicle situation. They enter fewer number when they are driving closer to the broken down car they need to get past while watching on-coming traffic

a specific section of the road or traffic situation. This recording enables an evaluation of the driver's control over the vehicle.

One of the main results of the study was that it showed that the likelihood that drivers would make mistakes in critical traffic situations to be significantly higher in block conditions when they were distracted. This heavily affected their lane keeping in particular. Those trial participants, who were allowed self-regulation, hardly made any more mistakes than drivers focusing exclusively on driving. However, in critical situations they completed relatively few tasks.

The study has indicated that research on the influence of secondary tasks needs to consider the aspect of self-regulation, because some drivers may regulate the execution of various tasks better than others.

These findings have found their way into another on-going comprehensive research project using the driving simulator that aims to reliably assess and compare the influence of the most relevant non-driving related activities. ■

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Two-wheel vehicle users from the perspective of traffic psychology

Motorcyclists and cyclists have not benefitted from road safety measures to the same extent as other groups of road users, such as drivers and pedestrians. In 2011 76,750 cyclists and their passengers were involved in accidents on Germany's roads, as well as 30,680 motorcyclists and their passengers. The accidents caused the deaths of 398 cyclists; 14,381 cyclists sustained serious injuries, and 61,602 were slightly injured. Among the motorcyclists involved in accidents, 708 were killed, 9,889 seriously injured, and 20,083 slightly injured. Compared to 2001 the number of motorcyclists involved in accidents dropped by 21 per cent. The number of cyclists, however, increased by seven per cent since 2001. For purposes of comparison: over the same period the number of victims of car accidents decreased by 30 per cent.

Picture: Deutscher Verkehrs-sicherheitsrat e.V. Bonn

The high percentage of motorcyclists and their passengers killed or seriously injured is particularly striking in the statistics for accidents involving motorcyclists. In all the accidents 2.3 per cent of the motorcyclists were killed and 32 per cent seriously injured, whereas among passenger car drivers the percentage of deaths was roughly one per cent and of seriously injured casualties 13.5 per cent. For cyclists, the most striking aspect is that the figure for the seriously injured has practically remained stagnant over the past ten years.

The increased number of cyclists involved in accidents can be explained to some extent by the increased number of cyclists overall. The Federal Government has recommended that people of all generations increasingly use bicycles as an environmentally compatible and cost-efficient means of transport with the additional effect of improving physical fitness. Unlike previous generations, especially senior citizens above 65 choose to use a bicycle to stay fit. However, the use of motorcycles is also increasingly popular with this age group. This is reflected in the rise in average age of motorcyclists. However, the disproportionate increase in the number of older two-wheel vehicle users involved in accidents is a cause for concern. Over the past ten years, the number of accidents involving cyclists over the age of 65 rose by 45 per cent; among motorcyclists aged 65 and older it even increased by 136 per cent.

Research on weaker road users has mainly focused on improving passive safety and infrastructure. The latest developments indicating that motorcyclists and cyclists have enjoyed fewer safety benefits compared to other road users,

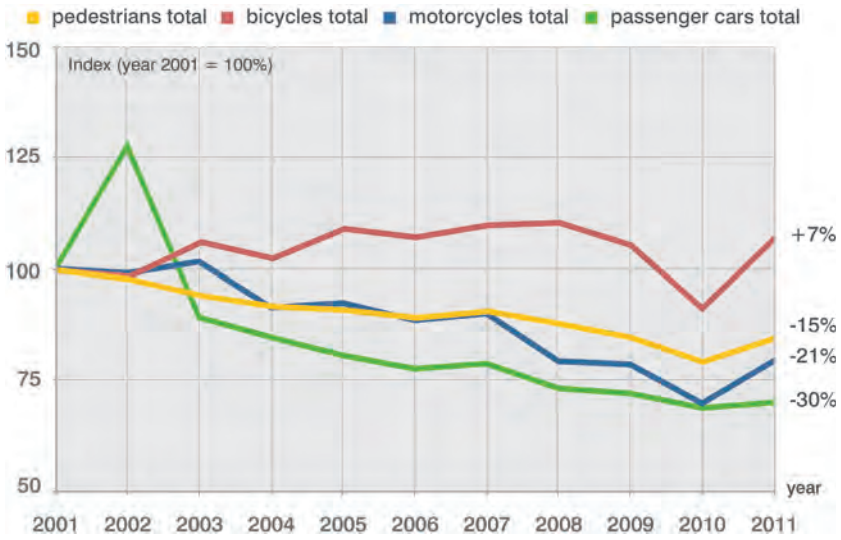
the demographic shift, and the increasing use of Pedelecs are all reasons to conduct more in-depth research on behavioural aspects among the motorcyclists and cyclists group.

Road safety measures designed for motorcyclists or cyclists usually address the entire group respectively. However, both these groups are very heterogeneous in their composition. This is why it does not seem appropriate to gear the measures to all users within each group without distinction. BASt has several on-going research projects focusing on the road safety of two-wheel vehicle users to arrive at an understanding of the current situation concerning motorcyclists and cyclists, and then to develop target group-specific road safety measures.

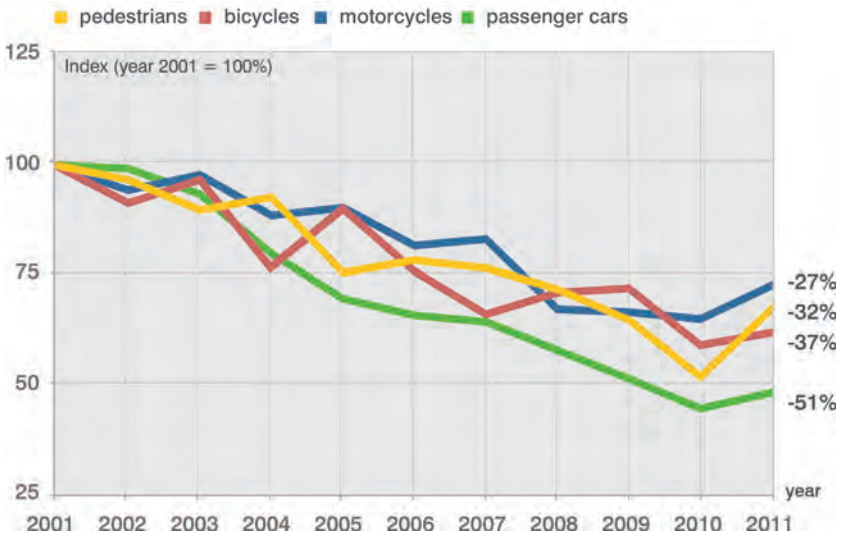
Motorcyclists

During a representative survey, a market research and polling institute interviewed 1,039 motorcyclists aged 16 to 76. The interviews covered different issues related to motorcycling.

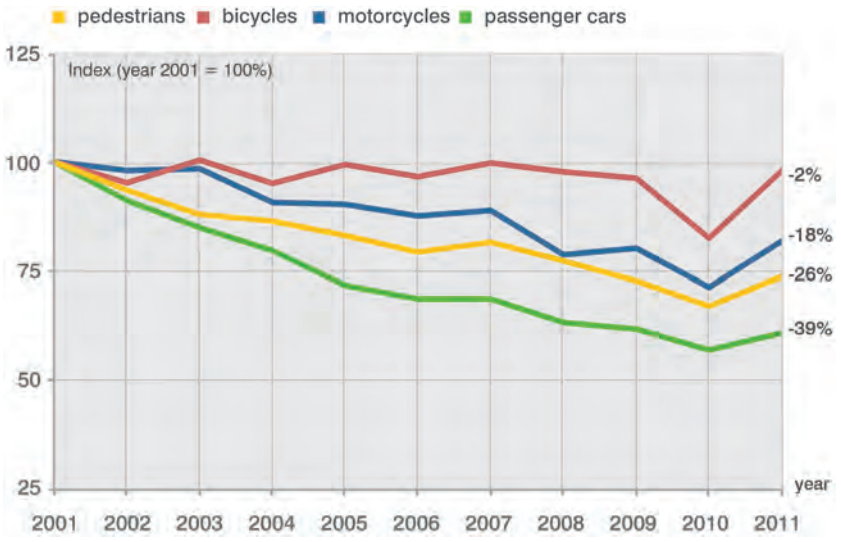
The interviewees were asked questions about their habits in using their motorcycle, what they thought of safety-relevant aspects of motorcycling, e.g., using their motorcycle under the influence of alcohol, risky behaviour on the road, assessing their own motorcycling skills, how many times they were involved in an accident with their motorcycle, and how many times they had been issued a warning by the police for traffic offences. The questionnaire also includes questions on aspects of the interviewees' character, e.g., how fearful or short-tempered they were. Other questions focus on life style (leisure time activities, favourite style of music, affinity to social groups, favourite TV genre). The project aims to collect



Number of victims of road accidents from 2001 to 2011



Number of deaths in road accidents from 2001 to 2011



Number of seriously injured casualties from 2001 to 2011

up-to-date information, including socio-demographic data and information on motorcyclists' attitudes and behaviour. It also intends to identify sub-groups among motorcyclists on the basis of their lifestyles, so that recommendations for road safety measures can be tailored to their needs.

Cyclists

One comprehensive project dedicated to cyclists' road safety of consists of two different sub-projects. A representative survey makes up the first sub-project, which is an equivalent of the survey among motorcyclists. It focuses on the cyclists' habits in using their bicycle, and their attitude towards various bicycle-related topics, such as risky driving, accident involvement, and character traits of cyclists. During this survey 2,158 people aged 14 to 84 were interviewed. All of them owned a bicycle and had used it at least once in a year. The study aims to shed a light on the current cyclist population and to identify sub-groups for developing target group-specific measures.

Commissioned by BASt, the University Hospital Münster is in charge of the second sub-project. This project analyses bicycle accidents in order to provide a detailed overview of accidents involving cyclists. A total of 22 clinics within the TraumaNetwork NorthWest are participating in the study. Cyclists arriving at any of the clinics after an accident are asked to fill in a questionnaire covering socio-demographic aspects, their bicycle use, and the accident sequence of events. The hospital complements their data by adding information on the severity and type of their injuries. All the data is anonymised and entered into a database. The data will be evaluated with a view to drawing conclusions about the correlation between the accident sequence of events and the injury type and severity. Ultimately, the study will also provide information about bicycle accidents not reflected in the official accident statistics, as the official data only covers accidents recorded by the police on the site of the accident. Accidents with only minor consequences and accidents not involving motor vehicles are rarely reported to the police.

Pedelecs

Another project focuses on the potential influence of Pefelecs on road safety. Pedelecs offer cyclists, including inexperienced ones, the possibility to reach high speeds easily and climb hills with little effort. Their disadvantage is that they impose higher requirements on the cyclists because of their heavy weight, stronger brakes, shifted centre compared to conventional bicycles, and more rapid acceleration from zero. Planungsgesellschaft Verkehr Hannover is the company contracted to carry out the project. By analysing relevant publications, behavioural studies, and surveys among users, they will identify who the actual users of these bicycles are, how they are used, and what specific problems there are in using Pedelecs. In addition to handling issues, the study will also cover the question of whether the existing cycle path infrastructure is suitable for the increasing number of Pedelecs.

Conclusion

The project results aim to increase knowledge about two-wheel vehicle users and their habits. They will make it possible to identify sub-groups with a high likelihood of becoming involved

in an accident or showing risky driving behaviour. On the basis of detailed findings, recommendations can be developed for specific road safety measures tailored to the needs of each target group. ■

Poster for the "Analysis of bicycle accidents" project

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How to plan school route maps easily

The idea behind school route maps is to use a map to show where children can safely cross streets when walking to school, to identify problem areas and how to solve them, and to outline the fastest route from a child's home to school. These maps help children walk to their schools safely and on their own.

For decades, school route maps have been considered a useful measure to improve children's safety on their way to school. Many road safety organisations and Ministries of Education and Cultural Affairs and Ministries of the Interior of the Länder recommend developing them.

BASt conducted a research project to find out if school route maps are comprehensible and deployed by parents and children at all, whether the recommendations they contain are accurate, and how they are developed. The results show that three-quarters of the parents of children at elementary schools and also as many of children at secondary schools find school route maps an important instrument for their children's road safety and ask for them. Parents who are familiar with their school's route maps often use them to practice safe behaviour with their children along their walk to school. However, an exemplary examination of existing school route maps revealed that a significant number of them contained errors, sometimes even severe ones. Some plans recommend that the children cross roads that allow speed limits of 60, 70, or even 100 km per hour without using crossing facilities. Others recommend as a safe option for elementary school children crossing at spots with an obstructed view of the road. There are also examples of recommended routes along roads without a pavement.

A school route mapping guide was developed to prevent wrong or even dangerous information from being given to parents and children, and at the same time to help create accurate school route map. It provides guidance for non-specialists on how to use simple means to assess various traffic situations, to make technically accurate recommendations, and how to prevent mistakes.

The guide, which has been subjected to an applicability check, describes the entire process of developing a school route map. It provides important information and lists useful sources for creating a map within reasonable effort.

Its addressees are schools, municipalities, the police, parents and every one else intending to prepare school route maps and every one who should logically be involved in the preparation process.

The guide outlines five steps for developing a map.

Basics

The chapter on “Basics” starts by providing examples of different school route maps for elementary and secondary schools describing the basic requirements and the variety of possibilities that exist. The maps can, for example, be based on varied cartographic material ranging from cadastral plans to hand-drawn maps. The maps for secondary schools usually cover a wider catchment area around the school and focus not only on pedestrian issues, but also on cyclists and public transport.

Initial phase

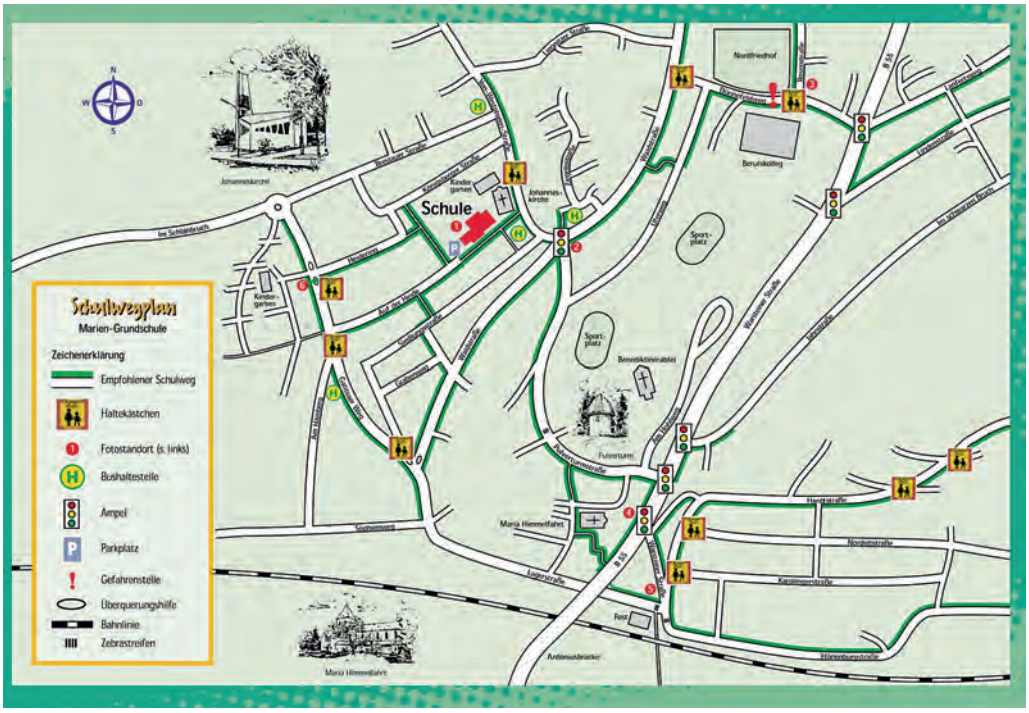
The “Initial phase” usually sees the set-up of a working group, ideally including representatives from the school, the municipality, the police, and parents. Each of these representatives has valuable information and possibilities to be taken into consideration and utilised when preparing a school route map. Further representatives, e.g., from road safety associations are always welcome. The guide includes samples that can be used for sending out invitations to the first meeting, for agendas indicating the issues to be addressed, and for a list of participants. They are intended to reduce the workload for every one involved, and to ensure no important step is left out.

Taking stock and analyses

This chapter describes what is necessary in terms of “Taking stock and conducting analyses”. These include surveys among the parents of primary or secondary school children, as they are vital for gathering information on

- specific problems on the children’s ways to school
- the relevant school catchment area
- the school routes
- the means of transport available along school routes.

Sample questionnaires can be found in the guide: only the school’s logo and the section from the respective city map need to be inserted. The guide also includes advice, tips, and templates for evaluating the questionnaires to quickly deduce consolidated findings.



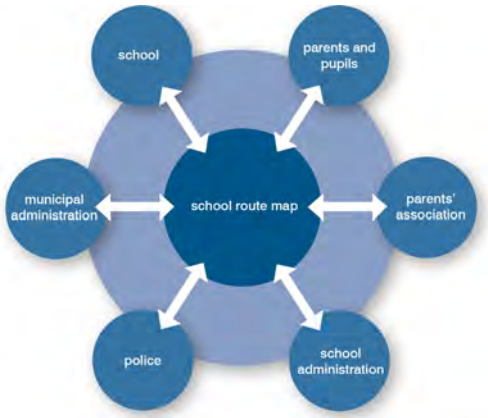
Excerpts from a school route map for an elementary school in Meschede

The results are incorporated into a basic plan with an additional note on possible accident hot spots near the school known to the police. Upon identifying the problem areas in the school surroundings and marking the routes used most frequently, a priority list of problem situations can be prepared. These spots need to be inspected jointly, so that the sources of potential risks can be discussed and, where possible, solutions found to deal with them.

Because the factors influencing road safety can vary greatly, the guide includes several checklists for different kinds of typical situations. They are intended to help non-specialists identify what is causing a specific problem.

At traffic lights, for example, certain aspects need to be taken into account: do the children have to wait too long for the lights to change; can pedestrians see how the traffic flows on the road; is the waiting area large enough; are the traffic lights used at all; do motor vehicles often exceed the permissible speed limit. The guide describes simple methods to scrutinise each aspect separately so that the problems can be analysed in depth. The guide suggests short-, medium-, and long-term solutions for dealing with the shortcomings identified.

There are checklists on zebra crossings, traffic islands, school bus use, parents drop-off and pick-up (parent taxi services), so that safety deficits can be reviewed on site. They can also be used for recommending specific routes or crossings on the map.



School route map working group

The guide includes technical background information and checklists as well as recommendations for short-, medium-, and long-term solutions to certain problems:

- lack of eye contact between drivers and pedestrians while crossing the road,
- incorrect use of cycle paths,
- motor vehicles exceed the speed limit,
- pavements are lacking or too narrow,
- pavements are lacking in non-built areas,
- problems with lorries turning left or right (blind spot),
- unprotected level crossings.

The above include most of the problems that can arise in the field of road safety near school.

Map development and dissemination

After analysing the school surroundings and discussing solutions to problem situations, the map itself can be developed. The guide lists the different methods for doing so – such as using the "school route planner". It describes step by step how freeware can be used to prepare school route maps.

The guide additionally contains:

- advice on how to use and obtain appropriate cartographic material,
- the template of a sample school route map,
- all essential graphic elements,
- software recommendations, including where to find it and
- rough instructions for drawing maps.

The finished school route map should not be made available solely online. Experience has shown that parents accept it more easily if it is presented and explained on their children's first day of school. This is the final step in creating a school route map.

Effectiveness control

Regular checks of the following aspects should be conducted in order to ensure an optimum effectiveness in the long run:

- Are school route maps issued in time?
- Have the children accepted the recommended routes?
- Are the recommendations still up-to-date?

These questions can be answered through occasional surveys or by talking to parents. Watching the children on the school routes can complement the information provided by the parents on whether the recommended routes have been accepted.

The bibliography and links listed at the end of the guide provide information for more in-depth and alternative methods.

The brochure can be obtained from BASt at no charge.

More information, the guide in digital format, and aids for developing school route maps are available at www.bast.de/Schulwegplan. ■

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Pre-test driving training in Germany

Despite improved safety measures such as “accompanied driving from 17” and “zero alcohol limit for novice drivers and young drivers”, novice drivers continue to have an above-average likelihood of becoming involved in an accident. Against this backdrop, the Federal Ministry of Transport, Building and Urban Development (Bundesministerium für Verkehr, Bauwesen und Stadtentwicklung, BMVBS) commissioned BASt to develop a conceptual framework to further improve novice drivers’ road safety.

The conceptual framework was developed by a group consisting of BASt experts and independent third-party researchers. It was comprehensively coordinated with representatives from transport policy authorities at the federal and Länder levels, as well as with practitioners such as driving instructors, test organisations, and road safety associations. In an initial step, key requirements for preparing novice drivers in a safety-effective way were identified. Suitable approaches were defined corresponding to the six key requirements for improving the safety of novice drivers. The entire range of possible interventions was analysed and functional equivalences among the measures were taken into consideration.

Requirements

The main aspects of the requirements and recommended measures defined in the conceptual framework are outlined below. They include issues such as combating the main causes for the heightened likelihood of novice drivers of becoming involved in an accident (tasks 1 and 2), optimising existing methods for teaching and testing driving and traffic skills (tasks 3 and 4), and integrating more technical and scientific learning methods, and a system of measures to support acquiring safe driving skills (tasks 5 and 6).

1: Extended periods of driving practice under low-risk conditions

The conceptual framework suggests extending the concept of accompanied

Picture: Deutscher Verkehrssicherheitsrat e.V. Bonn

driving to newly-qualifying drivers from 18 and establishing additional novice driver-related special regulations targeted towards reducing the exposure to risks at the beginning of independent driving, in addition to measures to optimise the concept of accompanied driving from 17.

2: Fostering the idea of road safety in the minds of novice drivers
The suggested measures for fostering the idea of road safety focus on a broad approach to influence young people throughout their socialisation process encompassing every measure available (traffic education for school children, driving instruction and safety communication / extracurricular road safety training).

3: Providing novice drivers with solid basic skills for motorised road use
The recommendations for conveying fundamental skills to drive a motor vehicle are geared towards improving the performance of instruction at driving schools, e.g., by developing a research-based reference curriculum. They also involve developing other sources of driving instruction in addition to driving schools, e.g., independent courses using innovative learning media as well as road safety education for school children.

4: Improving the instruments for assessing the acquired driving skills
The recommended measures focus on improving the efficiency of theoretical and practical tests in terms of their basic functions, selecting sufficiently qualified novice drivers (selection function) and teaching standards in preparing for road safety (control function). Additional recommendations aim at improving instruments for adequately assessing the skills learnt at driving schools and for novice drivers to assess their own driving skills and traffic competence.

5: Using innovative technology to support learning and driving
The recommendations concerning this requirement focus on a more extensive use of electronic communication and learning media for learning how to drive, and the use of in-car information and feedback systems tailored to the needs of novice drivers. They also support vehicles for novice drivers to being equipped with state-of-the-art safety technology.

6: Using research options for optimising the system of measures to prepare novice drivers for road safety
Scientific methods have been used before to find answers to important questions relating to novice drivers and road safety. They have provided essential information for substantially improving road safety. In the light of this experience the framework strategy recommends strengthening and sustaining research and development not yet conducted systematically. Extended research and development activities are intended to contribute to continuously optimising relevant measures to prepare novice drivers. They consist of in-depth and fundamental studies on finding new and improved approaches to solve the problem of the likelihood of novice drivers becoming involved in accidents.

Measures

The measures recommended in the conceptual framework are based on experience with previous measures in Germany. They are in line with the recommendations resulting from international discussions on extending practical driving training under low-risk conditions (OECD, 2006), and make use of the entire range of targeted approaches

in an integrated system of basic driver training (BASIC EU project, 2003). ■

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Motor caravans' involvement in accidents from 2000 to 2010

This study follows up on BASt's last study on accidents involving motor caravans conducted in 1999. It focuses on the structure of accidents, in addition to how the number of accidents evolved between 2000 and 2010. The analysis includes the characteristics of drivers of motor caravans involved in accidents and technical features of their vehicles, such as motorisation and permissible total weight. The small group of passenger cars towing trailer caravans involved in accidents has been taken into account to as great an extent as possible. These two groups are compared to the entire group of passenger cars involved in accidents.

Official accident statistics do not have an explicit code for motor caravans, which means that no information about accidents involving them can be found in the regular publications of the Federal Statistical Office. However, with the help of complementary information from the Federal Motor Transport Authority (Kraftfahrt-Bundesamt) on the vehicles, it is possible to identify German motor caravans and evaluate them on the basis of the full range of characteristic features available in official data material.

Accident figures

In 2010, 743 accidents causing personal injury had motor caravans involved. Compared to 2000 their number dropped by 36 per cent. This shows a more favourable balance than the development of accidents involving passenger cars (minus 28 per cent). The total share of motor caravan involvement in personal-injury causing accidents amounts to less than 0.3 per cent and does not play any significant role. However, a study of the

accident consequences, especially for passengers in the vehicles, shows there is still potential to improve safety aspects.

In 2010, a total of 19 people were killed and 202 people sustained serious injuries in accidents involving motor caravans. Four of the deaths and 62 of the seriously injured people were passengers of a motor caravan; the remaining victims were recorded with the other party involved in the respective accident.

This low number of serious accident consequences is linked, inter alia, to motor caravans' rare involvement in accidents. An analysis of the relative "serious personal injuries (Schwere Personenschäden, SP) correlated to the number of passengers" parameter shows that in 2010 the ratio for motor caravans was 45 SP per 1,000 passengers, which is similar to the ratio of passenger cars (43 SP per 1,000 passenger).

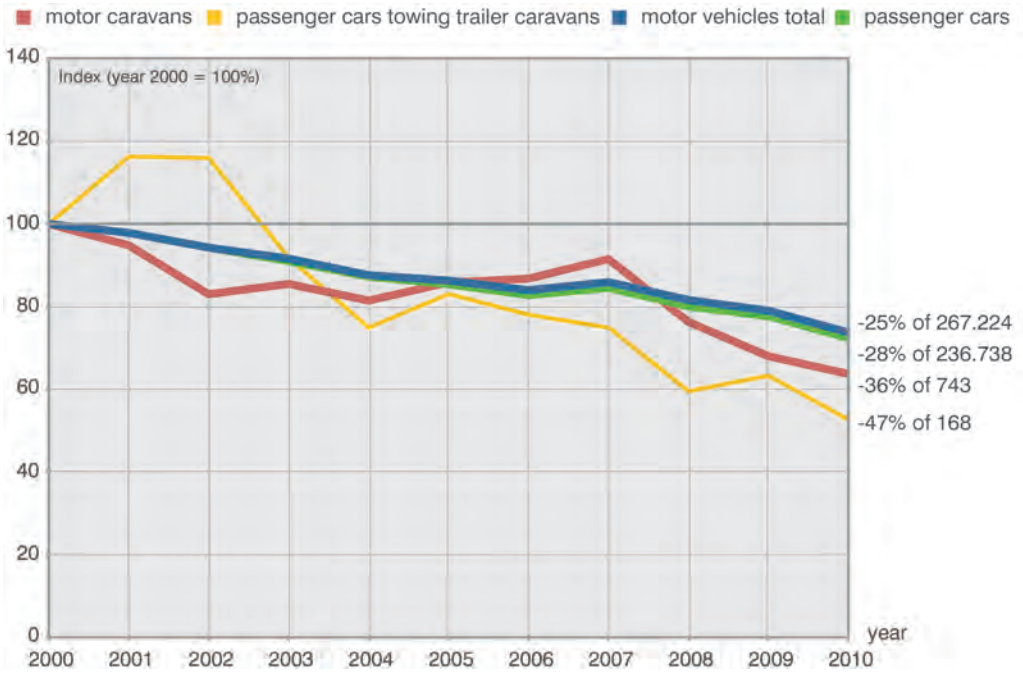
The ratio for drivers of motor caravans (37 SP per 1,000 drivers) is even lower than that for drivers of passenger cars (43 SP per 1,000 drivers). Motor caravans benefit from having a lower collision speed and a larger vehicle weight. Passengers in motor caravans are at a much greater risk (64 SP per 1,000 passengers).

The development of the relative parameters over time for the period 2000-2010 shows no reduction in the number of serious injuries in accidents involving motor caravans. The share of motor caravan passengers sustaining serious injuries from 2000 and 2010 swings between 32 and 50 SP per 1,000 passengers. Conversely, the corresponding value for passengers in passenger cars dropped continuously from 59 to 43 SP per 1,000 passengers.

Accident occurrence

Motor caravans show the following characteristic features in the occurrence of accidents:

- Drivers of motor caravans cause a considerably lower number of single-vehicle accidents: six per cent of motor caravans compared to eleven per cent of passenger cars towing trailer caravans and 13 per cent of passenger cars in total.
- The majority of the accidents involving motor caravans occurs in built-up



Accidents with personal injury

areas, namely 55 per cent of all the personal injury-causing accidents (passenger cars in total: 67 per cent). The share of motor caravans involved in accidents on motorways is, at 16 per cent, double the share of passenger cars (seven per cent).

- The reason for 24 per cent of the accidents involving motor caravans is “rear-end collisions with moving vehicles”: in built-up areas the motor caravan is usually the impacting vehicle (61 per cent). On motorways, 70 per cent of the accidents are caused by other road users colliding with the motor caravan’s rear end.
- Most of the accidents involving motor caravans occur between May and October: 65 per cent of all the accidents occur during these six months. Looking at the days of the week, and including all types of road users, a slight above-average accident concentration can be seen on Fridays.

Causes of accidents

Among the motor caravan drivers responsible for accidents, the 45 – 54-year olds are the largest group in terms of percentage, increasing from 15 per cent in 2000 to 21 per cent in 2010. Generally speaking, this has to do with the rise in the overall age of road users involved in accidents. The average age of motor caravan drivers increased from 44 to 50 years between 2000 and 2010. The average age of drivers of passenger cars involved in accidents increased as well, but at 41 years it is significantly lower.

Among the drivers of motor caravans 51 per cent were categorised as having caused the accident (n = 380). This rate has remained relatively stable since 2000. In comparison, 56 per cent of the passenger cars involved in accidents were responsible for the accident.

The main reason why mobile caravan drivers were responsible for the accidents they were involved in fell into the category “not enough safety distance” (19 per cent). The next most significant categories (18 per cent) had to do with errors with respect to “giving way or having priority” and with errors with respect to “ turning left or right, turning round, reversing” (17 per cent). The category “not complying with the speed limit” was mentioned only in fourth place, covering 14 per cent of the cases.

Conclusion

With the 0.3 per cent share that motor caravans have in all personal-injury causing road accidents, they do not play a major role in accident occurrence. However, an analysis of accident consequences for the passengers sitting in them shows there is potential for improving their safety. ■

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Mechanical engineer
Working at BASt since 1992
Responsible for the analysis of road network, region specific, and key issue data at the “Accident Statistics, Accident Analysis” section

Figures, data and facts

Personnel, Awards/Appointments/PhDs/Teaching assignments

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International cooperation

Press and public relations

Personnel

The personnel situation at BASt is characterised by continuous manpower reduction due to budgetary restrictions. BASt still employs about 400 members of staff, but the number of permanent contracts has fallen significantly over the past few years. At the same time, the number of temporary contracts has increased considerably: about one third of BASt's employees have temporary work contracts. Despite the reductions in human resources BASt's workload still covers a broad range of tasks. The workload has become more complex due to additional cross-disciplinary and international tasks. The reduction in manpower can only be compensated by hiring temporary workers to fulfil the ambitious technical requirements. About one third of the research assistants work at BASt on temporary contracts.

Career page

In the summer of 2012, a "career page" was established on the BASt website to better inform potential candidates about career opportunities and working conditions at BASt.

Age structure

More than 50 per cent of BASt staff is aged between 31 and 50; their average age is 45. The average age of BASt's permanent staff with a high workload will increase over the next few years, which is one of the reasons why BASt has intensified its in-company health promotion measures since 2011.

A concept for in-company health management was developed in 2011. The measures include lectures and seminars on topics such as "work-life balance" and "stress management". Some have already been implemented and others will follow.

BASt promotes a healthy work-life balance by offering, for example, flexible working hours. Additionally, a parent-child room was set up in 2012. It includes a fully equipped office desk as well as playing, sleeping, and diaper changing facilities. This parent-child room provides parents with the possibility to bring children of various ages to work in case of bottlenecks in child care.

BASt's "career page" on the Internet

Vocational training

On average, 19 apprentices are receiving vocational training at BASt and thus preparing for future careers. The training profile includes building materials testers, physics laboratory technicians, chemical laboratory technicians, architectural draughtspersons, specialists in media and information services as well as metalworkers and computer scientists specialising in systems integration. In 2011 and 2012 six trainees were able to finish their training early or take their final exams early. Upon completion of their courses trainees are usually given temporary work contracts to enable them to gain initial work experience.

In addition to their technical tasks, seven trainers committed themselves to providing the young people with a qualified and sound training. Another 20 BASt staff members supported and accompanied the training schemes.

In Berlin in December 2011, Professor Klaus-Dieter Scheurle, retired State Secretary at the BMVBS, honoured four former trainees: Amelie Bosbach, Jessica Faber, Tina Heimes, and Kristina Steinbrecher for their outstanding performance and Anika Kropf as a trainer.

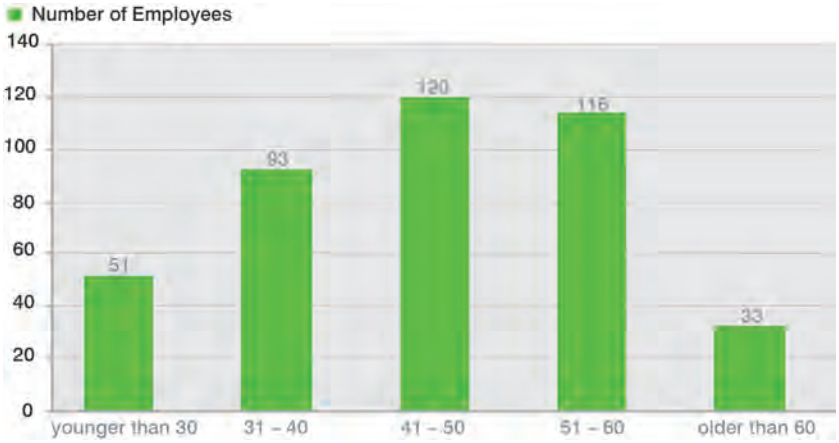
Retired State Secretary Professor Klaus-Dieter Scheurle from BMVBS honoured Jessica Faber, Kristina Steinbrecher, Anika Kropf, Amelie Bosbach, and Tina Heimes from BASt (from left to right) (Picture: Sven Augstein, BMVBS)

Training and development

Training and development are essential to maintain and expand the current knowledge base among BASt staff, especially its academic staff. Participation in training and development courses improves the staff's technical performance and provides improved career opportunities. More than half of BASt's staff attends training and development seminars per year. BASt offers needs-based qualification measures, in particular for executive and junior staff. These seminars are organised either by third parties or as in-house seminars.

BASt also attaches priority to tertiary education. In 2012 ten scientists were guest lecturers at universities in addition to their full-time jobs at BASt. In 2011 and 2012 five members of BASt staff received their PhDs. ■

Age structure of BASt staff



Awards/Appointments/PhDs/Teaching assignments

Several awards, appointments, and PhDs received by BASt staff and a list of selected teaching assignments at a variety of universities and departments show how successful BASt employees were in 2011 and 2012.

Dr Thorsten Adolph has been a guest lecturer at the Institute for Automotive Systems and Production at the University of Applied Sciences in Cologne since the 2012 summer term.

Since 2001 Dr Torsten Geißler has been a guest lecturer for macroeconomics and media economy at the Academy of Business Administration and Public Management in Düsseldorf and the Fresenius University of Applied Sciences in Cologne.

In June 2012 Dr Hardy Holte received his PhD in Philosophy from the Institute of Philosophy at the University of Bonn.

Since the winter term of 2009 Dr Birgit Kocher has been a guest lecturer in environmental chemistry at the University of Koblenz.

Beata Krieger and her co-authors were acknowledged at the XXIVth World Road Congress in Mexico for their article “The Forever Road - Defining the Next Generation Road”.

Since the winter term of 2012-13, Dr Jan-André Bühne has been a guest lecturer at the Faculty of Management, Economics and Social Studies at the University of Cologne.

Dr Karl-Josef Höhnscheid has been BASt Research Commissioner since September 2012.

In August 2012 Dr Thomas Jährig received his PhD in Engineering from the TU Dresden.

Dr. Thomas Kranz was appointed BASt EU Auditor in October 2012.

Anita Künkel-Henker has been a guest lecturer on “Management Systems for Road Maintenance” at the Ruhr University of Bochum since 2007.

During the 2012 summer term Janina Daniela Küter was a guest lecturer at the Business Administration course of the University of Applied Sciences for Economics and Management in Essen.

Dr. Sebastian Lipke received his PhD in Engineering from the TU Dresden in 2012.

Since the winter term of 2010, Dr Eike A. Schmidt has been a guest lecturer at the Institute for General Psychology and Occupational Psychology of the Heinrich Heine University Düsseldorf.

In 2012 the Board of Directors re-elected Andre Seeck as president of EURO NCAP (European New Car Assessment Programme) for another two years.

Tobias Teichner has been a guest lecturer on controlling traffic signals at the University of Wuppertal since 2012.

Stefan Zirngibl was a guest lecturer at the Institute for Transport Systems and Spatial Planning at the Universität der Bundeswehr München in 2011.

Sabine Lilgert has been BASt Quality Management Commissioner since October 2012.

Dr Jan Ritter received his PhD in Engineering from the Ruhr University Bochum in January 2012.

Dr. Horst Schulze was appointed president of FERSI (Forum of European Road Safety Research Institute) in 2011.

Hans-Jörg Seifert was accredited by Colonel Holger Voß as the sole external auditor for driving tests to the Federal Armed Forces.

Dr Marko Wieland has been a guest lecturer for road construction at the Magdeburg-Stendal University of Applied Sciences since 2006. In December 2011 he received his PhD in Engineering from the TU Dresden. He received the Kirchhoff Foundation Award for his doctoral thesis.

Budget and finances

Because of funds earmarked for various construction projects, BASt's budget was increased over several years. The financial volume returned to its average level in 2011 and 2012.

However, these years saw changes in the budgets for external research in the fields of road safety, road construction, and transport technology (see table on page 135) for many years. BASt has been awarding research contracts to third-party contractors such as universities or private sector companies. BASt had additional funds of 500,000 euros per year for the years 2011 and 2012 to have research conducted on the fields of alternative power train technology, electric mobility, and the reduction of traffic emissions.

Innovation programme

In the years 2011 and 2012 a separate budget enabled grants for innovative research on improving the road infrastructure. Projects of a striking magnitude have already been awarded. This is a new instrument for BASt to subsidise innovative research; the keen interest of the expert community in submitting tenders on several subjects has been quite apparent.

Personnel costs

Expenditure on personnel has remained the biggest budgetary item for BASt, covering about 55 per cent of the total expenditure in 2011 and 53 of the total expenditure in 2012. Administrative expenditure (such as external research, maintenance of premises and experimental facilities, operating costs and public relations) made up 38 per cent in both years. Allocations and grants as well as investments follow at a considerably lower volume.

Cost and results accounting

The cost and results accounting that was introduced in 2007 for BASt as a supplement to governmental accounting has become well-established. The regular analysis of management costs and cost and results accounting have aimed to include a breakdown of the costs by origin. This has already resulted in appropriate modifications to the benefit of all those functions for which cost and results accounting provided the basis. The process is a continuous one. ■

Budget estimates (in thousands of euros)	**2011**	**2012**
BASt budget	**36.824**	**36.929**
Personal costs	20.148	19.969
Administrative expenditure	13.970	13.968
Allocations/Grants	652	1.144
Construction projects	200	200
Other investments	1.854	1.648

Research at BASt

Research planning

The annual programme budget is a short-term/operational planning instrument and was completed and published in July 2012. It describes BASt's projects for a two-year period, specifying their contents, share of the overall budget, and other relevant structural aspects. It is used for general controlling purposes within the federal administration. It also serves as a basis for annual discussions between BASt and BMVBS to determine future key areas of activity.

The programme budget documents the tasks and objectives of BASt, explains research activities, and in a summarised overview illustrates the most important parameters by department, expected development, and significant research projects. The programme budget shows the planning of the structure for research topics, including human resources besides those already tied up: memberships in administrative bodies, permanent functions such as approval and certification tasks and quality assessments for third parties, on-going projects, and opinions at short notice for BMVBS on significant topical issues. The programme budget also includes an outline and case-by-case differentiation of BASt's entire human and financial resources for the coming year and previous years.

BASt's second strategic planning instrument is the "strategic research plan". This instrument was introduced in 2011 and has 19 research titles covering five cross-disciplinary topics. It is BASt's generic strategic research plan. The planning spans five years and was continued during the 2011-12 period. In 2012 an interim revision was started and, where necessary, updates and adaptations of individual research titles were initiated. The adaptations will be coordinated with BASt's Scientific Advisory Board during its first session in 2013. The research titles will be revised in their entirety in 2013 as a starting point for developing the "strategic research plan for 2016-20".

In addition to its own research planning BASt follows the long-term planning of the Federal Ministry for Transport, Building and Urban Development.

Research titles managed by BASt	**2011**	**2012**
BASt funded (in thousands of euros)		
Road safety, road construction, traffic technology	4.166	3.966
Grants for innovative research to improve road infrastructure	300	700
In-depth survey of accidents and their causes	760	760
Road traffic census at federal trunk roads	220	220
Revenues from funded projects	840	380
BMVBS funded (in thousands of euros)		
Road construction research	5.000	12.120
Inventory of federal trunk roads	1.200	700
Research programme on urban transport	400	380
Meta data platform initiative for traffic information	1.500	3.000

Research details

BASt conducts its own research and also awards research contracts to third parties. The research is financed by BASt's own budget and BMVBS funds. When designing its research concepts BASt works closely together with BMVBS and other institutions such as the Road and Transport Research Association (Forschungsgesellschaft für Straßen- und Verkehrswesen, FGSV).

BASt conducts about 300 research projects of its own and is in charge of 500 external research projects.

During the period under review two programmes that are essential for BASt's research activities were published; BASt was instrumental in their development.

Roads in the 21st century

The "Roads in the 21st Century – Innovative Road Construction in Germany" research programme was presented in 2012. The programme provides the framework for research activities in the road sector and is intended to give a boost to innovation in road construction. It aims to further develop the functions of roads as safe and reliable traffic routes. It consistently pursues the idea of sustainable construction using intelligent technologies and materials. Roads as part of our living space are intended to cause lower emissions in future and consume less energy, thus paving the way to attract the general public's attention to roads as sources of innovations. Research projects are funded as part of the framework research programme with a special focus on developing new concepts and technologies.

Road safety programme

A new road safety programme was presented in 2011 to accommodate changes in general conditions and new challenges in road transport. These include social changes such as the demographic shift and revolutionary technological developments. The demographic shift will profoundly change Germany. The older generation will have a larger share in the total population,

"Roads in the 21st Century" research programme (Picture: Miredi/Fotolia.com)

The protection of children is a key area of the "road safety programme" (Picture: Deutscher Verkehrssicherheitsrat e. V.)

and more senior citizens will use the public road environment with their own cars, bicycles, public transport, or as pedestrians into advanced age. Furthermore, electric vehicles, hybrid and fuel cell vehicles will become a widespread feature of road transport in Germany, posing new requirements for road safety. Changing communication and information behaviour among the population need to be taken into account increasingly in road safety measures. Traffic policies are intended to focus more on the most serious injuries in accidents. The protection of more vulnerable road users, including children and senior citizens, is another key area of the programme.

EU research

BASt has been involved in 93 EU projects since 1999. It was the coordinator for four completed projects. All 15 projects in the scope of the 6th Framework Programme in which BASt participated were concluded by 2011.

BASt was involved in a total of 26 projects under the 7th Framework Programme: 16 of them were concluded by 31 December 2012.

In 2012 BASt was working on 24 EU projects. Additional projects are currently in the application or negotiation phase. ■

Construction projects at BASt

Refurbishing the metal facade and roofs of the hall complex

Between October 2010 and March 2012 BASt carried out the last of three major construction projects on its premises. A total of about five million euros was used to improve the energy efficiency of the facades and roofs of its experimental halls. The measure was financed by funds from the Economic Stimulus Package II, Federal Government funds for improving energy efficiency, and BASt's own contribution.

The hall complexes needed to be refurbished because many spots on the metal facade and roofs had corroded and the underlying insulation no longer adequately fulfilled its function. In addition to the outer shell, windows, gates, and doors had to be renewed for the building complex to achieve the required energy balance and thus become eligible for pertinent official funds.

The pure construction costs of about five million euros increased by 200,000 euros when additional fire protection measures became unavoidable. Upon completion the construction measures had a significantly positive effect on in-door climate control, resulting in considerably lower energy costs. ■

Pictures:
Ulof Rückert

Road infrastructure asset

One key function of every authority responsible for construction and maintenance is to ensure that road transport systems are of a high quality and available on a continuous basis. The fixed assets need to be maintained. One of BASt's key tasks lies in providing the scientific basis for decisions concerning technical issues and transport policy issues. The quality of such support depends in many cases on how BASt's technical and scientific competence can be interwoven with overall administrative and economic conditions.

BASt founded the "Asset Management for Roads" expert centre in 2009. It focuses on issues of network analyses, procedures for supporting decisions, management systems, assessing road infrastructure assets, and asset management concepts. A macroeconomic analysis of the road infrastructure in particular was identified as a key area which can be explored and will bring about additional useful benefits to BASt's existing competences. The expert centre was integrated into the "Research Controlling, Road Infrastructure Assets" office in 2012 in order to pursue this special generic macroeconomic approach.

This office will focus on developing and evaluating decision-making procedures, but also on financing and controlling instruments in road infrastructure, and the closely linked subject of assessing road infrastructure assets and developing its value. ■

Picture: Jomare/Fotolia.com

Quality management

The “Research Controlling, Road Infrastructure Assets” office is in charge of coordinating BASt’s quality management (QM) activities by a quality management commissioner.

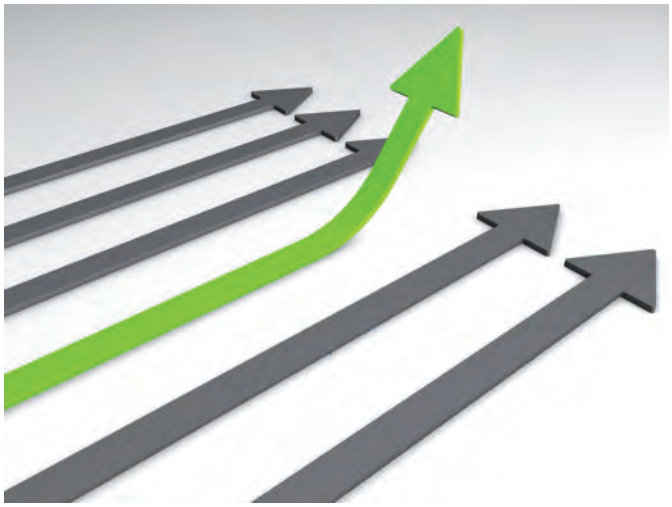
All activities are aligned to current overall conditions such as:

- reduction in manpower; human resources are becoming scarce while the number of tasks is increasing
- demographic shift: experienced staff is retiring yet knowledge needs to be maintained
- harmonising the requirements of EU Regulations and resulting changes in working conditions, basic parameters
- increase in client requests (bodies of rules and regulations)

An economical handling of resources requires that mistakes be avoided. Internal audits review, analyse and, if necessary, improve processes and procedures.

All activities strive to result in safe, error-free, reliable and standardised products (processes, projects and procedures) as well as a continuously high quality despite increasingly strict overall conditions.

Picture: vege/Fotolia.com



A key function of quality management is to expand and further develop a targeted quality management system that is appropriately interlinked with BASt’s framework manual. It has a special focus on requirements originating from the Ministry and external clients (political decision makers and society).

BASt’s testing and calibrating activities, for instance, need to fulfil special requirements. These led to the “Passive Vehicle Safety, Biomechanics” section being appointed by the Federal Motor Transport Authority as a “Technical Category A Service”, notified as such to the Commission of the European Union and the UN-ECE Secretariat.

In legal issues an accreditation according to DIN EN ISO/EC 17025 through the German Accreditation Agency (Deutsche Akkreditierungsstelle, DAkkS) is a prerequisite for a notification (since 2011 also in the construction product sector). In-house QM supports and accompanies the implementation of the rules and regulations mentioned above and the resulting requirements the “Highway Equipment” section needs to fulfil as the notified body for highway equipment.

The quality of the research projects is ensured by project controlling on the basis of standardised reporting (cost and results accounting with SAP). The data is processed, analysed, and evaluated. Additional quality assurance measures can be found in BASt’s framework manual. ■

BASt's Scientific Advisory Board

BASt has received advice on fundamental scientific matters from a Scientific Advisory Board since 2008 that is chaired by Professor Wolfram Ressel, Stuttgart University, and consists of German and foreign scholars from the private sector, academic institutions, universities and federal ministries. BASt's Scientific Advisory Board was instrumental, for instance, in developing the strategic research plan for the 2011-15 period.

During the period under review the Scientific Advisory Board has convened twice a year: the meetings took place at the BASt on 20 March 2011 and 22 March 2012, at the Boxberg Bosch-Test Centre on 6 October 2011, and at the Belgian Road Research Centre BRRC on 2 October 2012. The implementation of the strategic research plan, current state of affairs and future prospects of selected research titles were the core of the discussions during these meetings.

The number of members in BASt's Scientific Advisory Board has risen to 14 through the appointment of Professor Beate Jessel, President of the Federal Agency of Nature Conservation in Bonn. Professor Jessel has headed the Federal Agency for Nature Conservation since 2007. Previously, she worked as professor for landscape planning and landscape development at Potsdam University and TU Munich.

On 22 March 2012 the Advisory Board convened at BASt, e-bikes could be tested and "experienced" during the break

Professor Hans-Peter Krüger, university professor for methodology and traffic psychology at Würzburg University, passed away on 24 October 2012. Professor Krüger was known and appreciated as a scientist and campaigner in attempts to improve road safety. He was a founding member of BASt's Scientific Advisory Board. His passing deprives traffic psychology of an outstanding and renowned scholar. ■

Professor Beate Jessel

Professor Hans-Peter Krüger †

International cooperation

An international exchange of experience and participation in international organisations are key tasks of BASt.

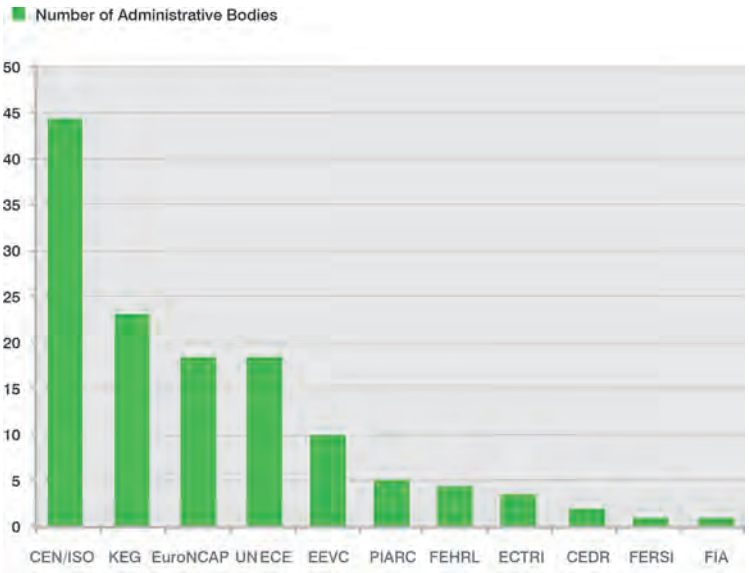
International organisations

In 2011 and 2012 more than 70 staff of the scientific service represented BASt in about 180 bodies of 38 international and supranational organisations. In terms of volume the cooperation in EU bodies was the most significant. About 30 per cent of BASt's activities in international bodies and committees focused on participating in developing European and world-wide standards. Creating a common European Research Area targets strengthening Europe's competitiveness and using its resources more efficiently. BASt supports this objective with close to 50 per cent of its committee activities.

BASt dedicates more than 20 per cent of its total participation in international bodies to the global exchange of experience in organisations such as PIARC (World Road Association), JTRC (Joint Transport Research Centre), the OECD (Organisation for Economic Co-operation and Development) and ITF (International Transport Forum).

Additionally, BASt is a member of FEHRL (Forum of European National Highway Research Laboratories). It is represented in its General Assembly, Executive Committee and is one of its Research Coordinators. BASt is also a member of ECTRI (European Conference of Transport Research Institutes) and FERSI (Forum of European Road Safety Research Institutes). In 2011 Dr Horst Schulze, head of the BASt "Behaviour and Safety" department, was elected president of FERSI. In this post he was involved in founding ETRA (European Transport Research Alliance), which came into existence on 20 September 2012.

BASt participation in selected organisations



CEDR	*Conference of European Directors of Roads*
CEN	*Comité Européen de Normalisation*
ECTRI	European Conference of Transport Research Institutes
EEVC	*European Enhanced Vehicle-Safety Committee*
Euro NCAP	*European New Car Assessment Programme*
FEHRL	*Forum of European National Highway Research Laboratories*
FERSI	*Forum of European Road Safety Research*
FIA	*Fédération Internationale de l'Automobile*
ISO	*International Organization for Standardization*
KEG	*Kommission der Europäischen Gemeinschaften*
PIARC	*World Road Association*
UN ECE	*United Nations Economic Commission for Europe*

Visitors and guest scholars

In 2011 and 2012 about 1,000 national and international guests were received at BASt. They were provided with information on research findings, on-going studies and new projects, or attended meetings of international organisations.

80 delegations often consisting of high-ranking officials and comprising 371 experts from 29 countries participated in usually one-day information workshops to discuss technical and administrative issues in the road sector: On 16 May 2011 a delegation from CATARC (China Automotive Technology and Research Center) visited BASt to learn about the German showcase project GIDAS (German In-Depth Accident Survey). In November 2011 a delegation headed by representatives of FHWA (Federal Highway Administration) and AASHTO (American Association of State Highway and Transportation Officials) was BASt's guest.

An additional 598 visitors from abroad took part in 40 meetings of European bodies that were held at BASt. 19 guest scholars spent several weeks at BASt working on issues of road construction technology, automotive engineering, and traffic psychology.

International cooperation agreements

Over the past two years 14 international cooperation agreements were signed. The cooperation partners were three research institutes from Russia, two institutes each from the People's Republic of China, Israel and Japan, and one research institute each from Australia, Korea, the Czech Republic, Poland, and the USA. The agreements aim to foster the exchange of scientific experience on defined road sector-related research topics.

Dr Horst Schulze, BASt Head of Department and FERSI President (left), together with four counterparts as presidents of large European associations and bodies on road traffic research, signed the agreement on the ETRA alliance (Picture: FEHRL)

Andre Seeck, BASt Head of Department, and Zhang Jianwei, Vice-President of China Automotive and Research Center (CATARC) concluded a cooperation agreement during the 5th China Road Traffic Safety Forum in Bejing

Events

Traffic science conference in Sochi, Russia

On 23 and 24 June 2011 a joint conference titled "Traffic safety and management in Olympic Sochi" was held in Russia. The conference aimed to develop proposals to solve road safety issues during the Winter Olympics 2014 and provide an optimal and environmentally compatible traffic

German-Russian Conference on Road Safety 2012

infrastructure, safe traffic routes, and best possible traffic management. The German delegation headed by the President of BASt comprised experts from universities, the German Road Safety Council, the German Aerospace Centre, the Police, the private sector, and BASt.

German-Polish seminar on road construction and road traffic technology

On the occasion of the signing of a Memorandum of Understanding between GDDKiA, the Polish Directorate General for national roads and motorways, and BASt, a German-Polish seminar took place in Zielona Góra, Poland on 18 and 19 April 2012. In addition to representatives from BASt and BMVBS, Germany was represented by experts from FGSV and Brandenburg. The participants of this conference comprised not only scientists from GDDKiA but also experts from regional branches and voivodeships. Polish and German scientists exchanged ideas on issues of asphalt and concrete road construction and maintenance and operational services. The discussions also focused on traffic survey methods and issues of environmental protection and nature conservation. The seminar also included a visit of a road construction project, the construction of the S3 national road, an important north-south link.

BASt Head of Department Michael Rohloff (left) und Andrzej Maciejewski (GDDKiA) signed an agreement on future German-Polish cooperation in the many different areas of the road sector

German-Russian road safety conference

BMVBS and BASt hosted the 6th German-Russian conference on road safety. The German Road Safety Council (Deutscher Verkehrssicherheitsrat, DVR) and German Statutory Accident Insurance (Deutsche Gesetzliche Unfallversicherung, DGUV) supported the conference as co-hosts. More than 40 Russian and German scientists were received by the Bavarian Highway Authority of the Bavarian State Ministry of the Interior on the Zugspitze on 14 May 2012. They exchanged ideas on road safety, accident

forecasting models, measures to reduce the number of accidents, rural road safety, safety analyses of road networks, the EU Safety Directive, road safety management, and highway geometric design.

Since 2002 a road safety conference has been taking place at two-year intervals, alternately in Germany or Russia.

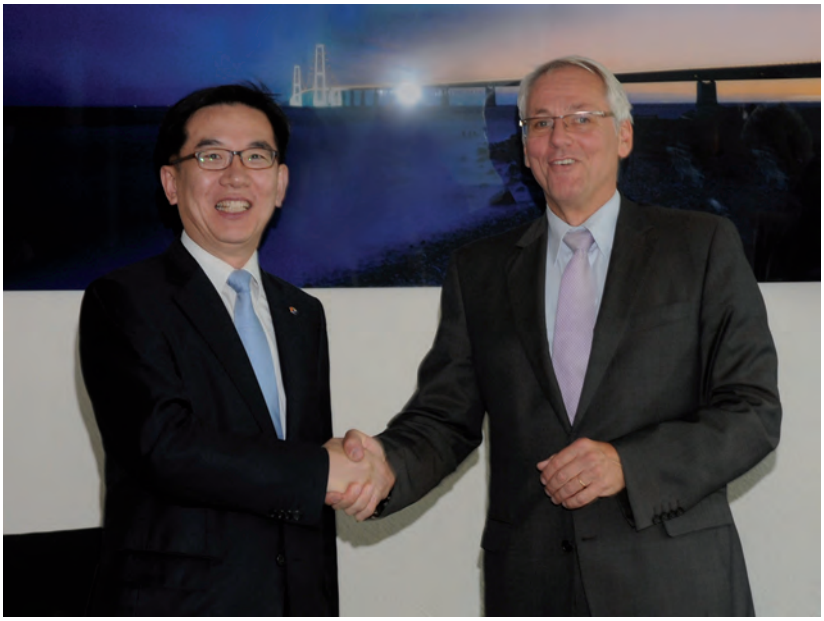
BASt/KOTSA Joint Symposium

On 29 August 2012 the 5th BASt/KOTSA Joint Symposium took place. Experts from the two institutes exchanged views in two sessions during the symposium. The key topics were: "Safe roads for more vulnerable road users" and "Safe freight transport" and included discussions on the protection of pedestrians, accidents involving cyclists and pedestrians, safe roads for motorised two-wheel vehicle users, impacts on occupational stress among lorry drivers, and safety of light commercial vehicles.

At the same time Dr. Il-Young Chung, President of the Korean Transportation Safety Authority (KOTSA) and the President of BASt, Stefan Strick, used the occasion of the symposium to discuss continued cooperation between the two research institutes.

ECTRI General Assembly

On 22 and 23 November 2012 BASt hosted the general assembly of ECTRI (European Conference of Transport Research Institutes). ■



Dr Il-Young Cung and BASt President Stefan Strick during the 5th BASt/KOTSA Joint Symposium

Press and public relations

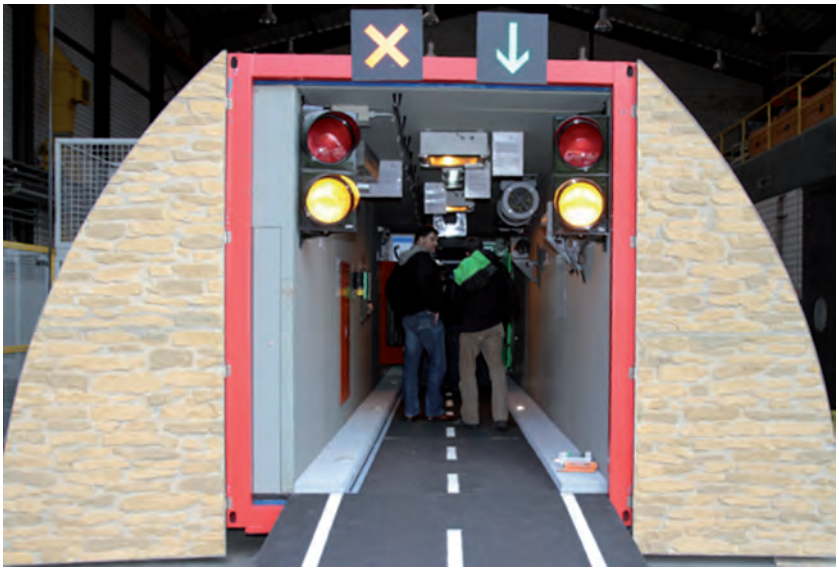
Open House and congresses

BASt celebrated its 60th anniversary in 2011. The ceremony took place on the BASt premises on 18 June 2011, Road Safety Day. Together with the Cologne police headquarters BASt organised a theme day with 23 partners. This colourful ceremony had more than 60 items on its agenda and was attended by almost 5,000 visitors.

Just as in previous years, BASt was represented with its own booth at the Federal Ministry for Transport, Building and Urban Development during the Open House of the Federal Government in Berlin in August. BASt's tunnel model (see page 11) drew a lot of visitors in 2011.

In 2011 and 2012 BASt was represented together with the BMVBS at three congresses: the 24th World Road Congress in Mexico from 26 to 30 September 2011, the 4th TRA (Transport Research Arena) from 23 to 26 April 2012 in Athens, and the German Road and Traffic Convention in Leipzig in October 2012.

A lot to see and "experience" on Road Safety Day



Events

On 21 Oktober 2011 Stefan Strick was ushered in to his office as the new president of BASt by State Secretary Rainer Bomba. At the same time the retirement of his predecessor Dr Peter Reichelt was celebrated.

From left to right: Dr Peter Reichelt, Rainer Bomba and Stefan Strick

Stefan Strick (born in 1960) began his professional career at the Federal Traffic and Transport Administration at the Waterways and Shipping Directorate in Hannover in 1990. In 1991 he switched to the Road Construction directorate-general of the Federal Transport Ministry. Stefan Strick, a lawyer, became the deputy head of the "Road law; road administration" section, and one year later he was appointed the Private Secretary to the then Parliamentary State Secretary. In 2000 he became the deputy head of the "Road traffic law" section. His appointment as the head of the "Environmental technology in road construction" section followed in 2002. Three years later he became the head of the "Private financing, special programmes, and road construction investments" section. In 2008 he became the head of the "Road construction policy,

The 2012 Road Safety Prize was awarded to eleven young scientists

road planning, road law" directorate at the BMVBS.

In 2011 and 2012 numerous national and international expert meetings such as symposia took place at BASt. A few of them are listed below as examples.

On 30 and 31 March 2011 a colloquium on ambient air quality at roads was held at BASt, during which experts were informed about current research activities and discussed additional measures in the field of preventing air pollution at roads.

A central information event on vehicle retention systems in Germany, including an exchange of experiences, was held on 30 August 2011.

New developments in the field of tunnel safety were the subject of a BASt symposium on 22 November 2011. During this event the film on how to behave properly in road tunnels was screened for the first time. It is available on DVD and on BASt's YouTube channel at: www.youtube.com/user/BASt20111.

On 5 October 2012 the 8th ADAC/BASt Symposium took place in Baden-Baden. National and international road safety experts discussed risk groups and aspects of safe road use. The 2012 Road Safety Prize of 30,000 euros was awarded during the symposium; a jury selected five projects by young scientists.

During the research colloquium on "Innovations in bridge and civil engineering" on 31 October 2012 the results of the initial projects of the "Roads in the 21st century" research programme were presented. State Secretary Rainer Bomba was among the participants.

The mobility data market square (MDM) is a landmark project for the introduction of intelligent traffic systems. It aims to create a network of as many suppliers and users of road traffic information as possible, thus setting up a platform for them to exchange their data. MDM was implemented by BASt as an Internet portal. Its official launch was celebrated at the user conference that took place at BASt on 14 and 15 November 2012.

Visitors

On 10 June 2011 Dr Matthias Ruete, Director-General for Mobility and Transport at the European Commission, visited BASt to learn about the focus of current research. The challenges of the "Roads in the 21st Century" system were one key point.

The then Transport Minister of North Rhine-Westphalia, Harry K. Voigtsberger, visited BASt on 23 February 2012.

On 31 August 2012 Dr Paul Becker, Vice President of the German Meteorological

BASt's newly designed foyer

Service (Deutscher Wetterdienst, DWD), and BASt President Stefan Strick signed a cooperation agreement in the field of the environment focusing on environmental monitoring, climate change and the impacts of climate change.

BASt took part again in Girls' Day in 2012: on 26 April 2012 a group of female pupils used the opportunity to get to know technical jobs at BASt.

Foyer and films

In 2011 BASt redecorated its lobby area: monitors display current BASt events. BASt's functions are presented on six additional screens with alternating text information and images. A lounge area with a large monitor invites visitors to watch films illustrating BASt's various activities.

The latest BASt image video can be watched there as of late 2012. It is a twelve-minute film produced in German, English, French, and Russian and is available on DVD and on the Internet.

New furniture complements the new lobby design. Since the summer of 2011 the lobby area has had a new exhibit: the base of a strand cable rope – an innovation in German cable-stayed bridge construction. The exhibit is a copy of the anchorage of the Rügen bridge, the first bridge in Germany to use strand cables.

Press

BASt invited media representatives on the occasion of special events: During the "Opportunities (!) and risks (?) of electric mobility" event which took place on 23 February 2011 in cooperation with the Association of Motor Journalists, research findings and current Euro NCAP test results were presented, including the first electric vehicle.

The pilot project on reducing pollutants on the A 1 motorway near Osnabrück

was launched on 7 October 2011 by the BMVBS Parliamentary State Secretary, Enak Ferlemann, and the State Secretary of the Ministry of Economics, Labour and Transport of Lower Saxony, Dr Oliver Liersch. The project aims to investigate the pollutant-reducing effect of titanium dioxide on noise barriers.

On 5 November 2012 a pre-fabricated concrete component was installed on the A 9 motorway in the presence of State Secretary Rainer Bomba as a modular quick repair system for damaged concrete road pavements. The basic idea is to use prefabricated concrete parts as quick fixes of diverse sizes.

Installation of prefabricated concrete part on the A 9 motorway

BASt's press centre answered a total of 1,600 media enquiries in 2011 and 2012.

The media showed particular interest in the atlas of accidents involving children. It illustrates the road accidents involving children of all 412 counties and urban districts as well as of about 11,000 cities and municipalities in Germany. The atlas enables a comparison of the traffic situation of children in one's own districts to those of other communities of a similar size. BASt published a second edition of the atlas at the end of 2012. Nearly every major media and online service reported about it. Numerous daily newspapers and radio stations requested the individual results for their town or municipality.

Numerous reports appeared in the media about the field trial with longer goods vehicles (see page 68).

BASt publishes the current number of participating of haulage companies and vehicle combinations on its webpage on a daily basis. BASt repeatedly receives enquiries about traffic load figures for German motorways, medical-psychological tests, safety belt and helmet quota, and the annual accident projections BASt publishes at the end of each year. The good news: after the number of accidents and those injured in accidents rose in 2011, the development of the road accident situation in Germany returned to its long-term positive trend in 2012. According to preliminary findings, 3,606 people died in road accidents in 2012, i.e., 403 fewer deaths or 10 per cent less than in 2011.

BASt's Internet presence: www.bast.de

Publications

The first edition of the new "BASt aktuell" information service was published in February 2011. There are four editions per year, informing about new and interesting developments at BASt.

In the past two years 69 reports were published as part of the BASt reports series. Since the series began in 1993 a total of 737 reports have been published.

The BASt reports are available as printouts to be ordered for a fee, but can also be downloaded from the Internet free of charge. BASt is striving for a fast and broad distribution by offering parallel publishing types, resulting in a swift implementation of its research findings: http://bast.opus.hbz-nrw.de. The BASt reports series as well as other BASt publications can be found at this address.

Reports of special interest are presented as summaries in the "Research compact" series. There were a total of 38 editions of these reports in 2011 and 2012.

BASt is also responsible for the BMVBS series on research on road construction and road traffic technology, in which 31 reports were published in the past two years.

The brochure on how to design school route maps easily (see page 118) was completed in late 2012. The brochure was published with mass circulation and made available free of charge. Some Länder and ADAC have had special editions printed. In addition to printouts, the brochure is also available as a download. Various templates, presentations, checklists and graphs can be found on the Internet.

Additional reports, conference proceedings, flyers, and regulations were added to the Internet presence in the past two years: www.bast.de.

BASt's publications are usually available in German only. ■

December 2012