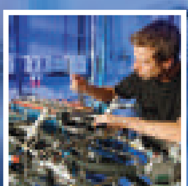
NACHRICHTEN

MAGAZIN DES DEUTSCHEN ZENTRUMS FÜR LUFT- UND RAUMFAHRT

118

November 2007 / G 12625

Special Edition TRANSPORT



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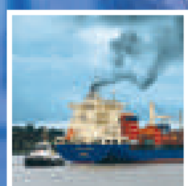

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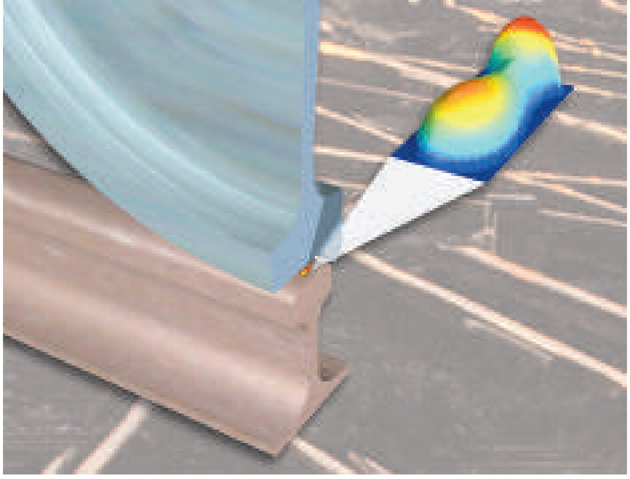

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Imprint · DLR NACHRICHTEN – Das Magazin des Deutschen Zentrums für Luft- und Raumfahrt - DLR (German Aerospace Center) · Publisher: Deutsches Zentrum für Luft und Raumfahrt e. V. in der Helmholtz-Gemeinschaft · Editorial Staff: Bernhard Fuhrmann (ViSdP), Cordula Tegen (Editorial Manager) DLR Corporate Communication · Phone: +49 2203 601-2116 · Fax: +49 2203 601-3249 · E-Mail: pressestelle@dlr.de · www.DLR.de/dlr-nachrichten · Address: Porz-Wahnheide, Linder Höhe, D-51147 Cologne · Printed by: Druckerei Thierbach, D-45478 Mülheim an der Ruhr · Layout/Design: CD Werbeagentur GmbH, Burgstraße 17, D-53842 Troisdorf, ISSN 0937-0420 · Reproduction only with the agreement of the publisher and reference to source. Note in accordance with Section 33 of the German Data Protection Act: The addresses of the postal recipients of DLR NACHRICHTEN are stored in an address file which is managed with the aid of automatic data processing. Printed on environmentally-friendly, chlorine-free bleached paper. · Pictures DLR, unless otherwise indicated.

Coordination English Translation: Annette Bona, DLR Program Directorate Transport.

Dear Readers,

The centenary year 2007 is now drawing to an end. At the beginning of the year, German Aerospace Center (DLR) celebrated 100 years of aerospace research in Göttingen, generating enthusiasm with interesting discussion topics and impressive exhibits. In late summer, over 80,000 visitors attended the Air and Space Day in Cologne-Porz. To mark the close of the year, we looked back over a very eventful year with excellent research results at our annual general meeting. In December, the commissioning of the space laboratory Columbus will have us holding our breath.

Milestones in aeronautics and spaceflight – that is what is expected from us. After all, it is these two fields which form our name. Concluding the aerospace year with a special edition on transport may cause people to sit up and take notice. And so it should.

Transport is our most recent field of research; it is not yet ten years old. For the DLR transport researchers, progress has been racing ahead in the fast lane. New institutes, unique large-scale facilities, a modern structure, and practice-based partnerships are what shape transport at DLR. DLR transport researchers use these competencies, picking up on synergies between aerospace and transport in order to make mobility as efficient, safe, and environmentally-friendly as possible. The use of satellite data and monitoring environmental parameters from flying platforms are just two of many examples.

Transport researchers at DLR are clearing the way for mobility in the 21st century – a factor which is of fundamental importance for the development of our country and, given the growing level of traffic, something that should not be taken for granted. At DLR, the way ahead has therefore been cleared for precautionary research for the mobility of tomorrow. At the same time, this demonstrates the innovative powers of our scientists and engineers. The Federal Ministry for Economics and Technology is supporting us on our way. I am therefore very pleased that Michael Glos, the Federal Minister for Economics and Technology, is providing the foreword to this issue of DLR Nachrichten.

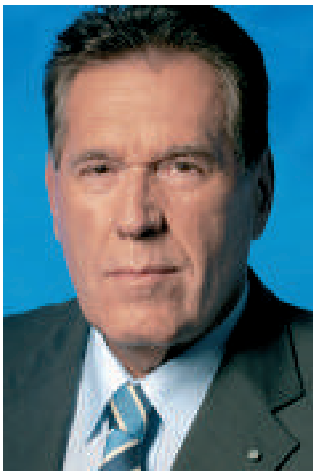
In this spirit, DLR can now also be taken to signify: the German Aerospace, Energy and Transport Center.

Prof. Dr.-Ing. Johann-Dietrich Wörner
Chairman of the Executive Board

MOBILITY

AS A RESPONSIBILITY OF SOCIETY

By Michael Glos, Federal Minister of Economics and Technology



It all began at a time when the stars still lay far beyond our reach. A hundred years ago, the "Modellversuchsanstalt für Motorluftschiffe" (Institute for the testing of aerodynamic models of powered airships) was founded in Göttingen, Germany. This marked the birth of aerospace research in Germany. It was this testing institute that was to become the germ cell for the German Aerospace Center (DLR).

Today, DLR has grown far beyond its original core aerospace mission and now includes the research fields of energy and transport. In these areas, DLR plays an important bridging role between basic research and applied industry research.

In future, networks between companies, universities and research institutes will become increasingly important. It is there that the technologies will be developed with which we will conquer the markets of the

future. Our goal is therefore the strategic promotion of research and technology with which ideas can be translated more quickly into marketable products. To achieve this, we need the right balance between basic research and application-focused research.

This notably applies to the transport sector. Transport creates mobility – and without mobility our economy cannot prosper. Mobility is thus an essential factor which secures our jobs.

Above all, mobility must be affordable as well as being guaranteed everywhere and at all times. Transport for goods and people must be designed to be efficient and safe while at the time as environmentally friendly as possible.

Noise and emissions are damaging to both people and the environment, traffic accidents result in injuries and deaths and the rapidly increasing level of road freight transport is associated with the threat of a significant increase in traffic jams. The result? A standstill with enormous consequences for our economy and society.

From this complex situation, the necessary research objectives are derived as well as clearly distributed tasks. The transport business segment of DLR primarily concentrates on key research-relevant issues that are indispensable for system competence and an interdisciplinary approach. Focal issues lie in the areas of road and rail vehicles and transport management as well as transport development and the environment.

In its bridging role, DLR contributes its expertise towards many projects of the Federal Government's transport research program. In this way, it is ensured that knowledge from basic research can reach industrial applications.

Politics act as a catalyzer in this process and set the framework conditions, ensuring a fair balance of opportunities and expenditure. This is an issue that concerns both jobs as well as Germany making a decisive contribution towards overcoming the challenges of the transport sector through its competencies in technology.

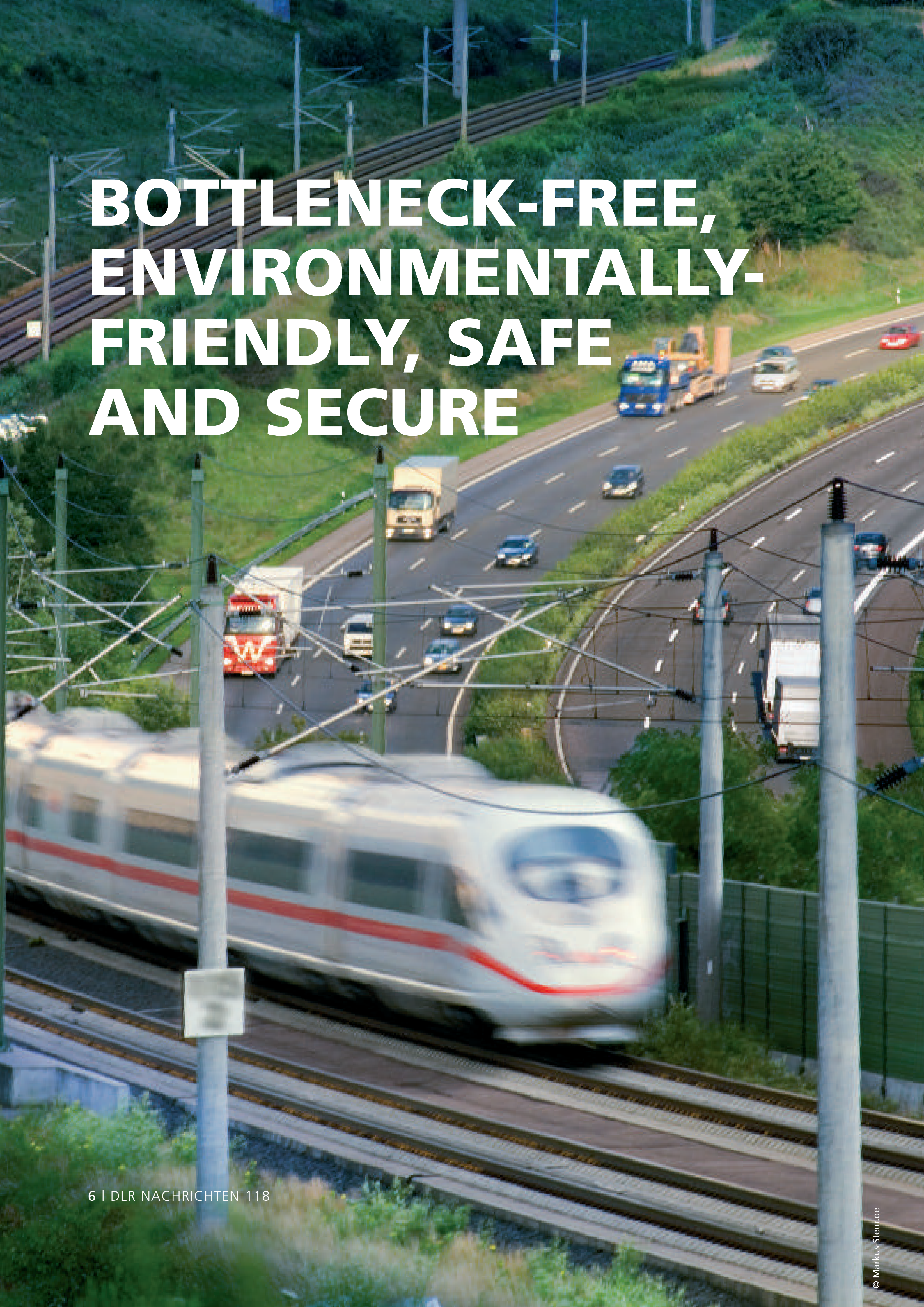
At the European level, there is even more at stake. Due to its favorable geographical location, Germany has the potential to be developed into Europe's most cutting-edge logistics hub. However, this will not be possible without intelligent solutions for future transport systems.

I am therefore pleased that DLR is using its abilities to find innovative solutions to meet the challenges in the transport sector, thus ensuring that affordable mobility will remain feasible at all times and everywhere in the future.

Yours

Federal Minister of Economics and Technology

BOTTLENECK-FREE, ENVIRONMENTALLY-FRIENDLY, SAFE AND SECURE



Transport in the 21st century is facing monumental challenges – the German Aerospace Center is tackling them

By Dr.-Ing. Christian Piehler, Program Director Transport at DLR

Every day, 7,500 kilometers of traffic jams obstruct the free flow of traffic on Europe's main roads. At the same time, European rail traffic reaches its limits on 16,000 kilometers of infrastructure. Capacity-related bottlenecks and delays are commonplace in air travel. But that's not all. Noise and exhaust emissions from motor-powered vehicles impair the quality of life in congested areas, and hardly anyone doubts the negative effects on the climate any more. And every year, more than 40,000 people are killed in road accidents alone in Europe.

These traffic problems are the result of a noticeable increase in passenger as well as freight transport over the last decades. Particularly Germany as a transit country sees itself confronted with significantly growing volumes of traffic due to its central location in the heart of Europe.

The problems that already exist for all modes of transport will increase with the onset of the predicted development, especially because an expansion of the transport network adequate to demand hardly appears possible due to economic and ecological reasons. However, fast, reliable, safe and secure traffic connections are a necessary prerequisite for facilitating economic growth. At approximately 1,000 billion Euros, the transport sector has a share of over 10 percent in the gross domestic product of the European Union and provides more than ten million jobs. Added to this is an overall economic importance of transport, which specifically applies to Germany as the worldwide leading export nation.

Mobility without bottlenecks has therefore become a real economic concern for industry. It also articulates the widely spread individual needs that are typical of the way of life in modern societies.

There is no sight of a radical trend reversal either regarding the development of demand for commercial transport or regarding individual mobility behaviour. According to the scientists from the DLR Transport Program, three central challenges arise from the tense relationship between the demands for mobility and the negative effects of mobility: securing mobility, protecting the environment and preserving resources, improving safety and security.

These challenges cannot be met simply by expanding existing infrastructures or liberalizing transport markets. In order to build a sustainable, viable transport system, economic, ecological and societal concerns must be brought into a stable balance.

The DLR Transport Program provides important contributions to this aim through researching and developing state-of-the-art transport technologies, concepts and strategies. We use our specific transport expertise to systematically access DLR internal know-how in the areas of aeronautics, space and energy for transport applications. This symbiosis, which is unique in Germany, ensures problem-oriented results using innovative and sophisticated technologies. We concentrate our efforts on the following three programmatic research topics: Terrestrial Vehicles, Traffic Management and Transport System.

Cars, commercial vehicles, trains, and locomotives of the next generation with a lower energy consumption, lighter structures, optimized aerodynamics, increased safety, better comfort and less noise are in the focus of our research. We improve the effectiveness and efficiency of infrastructure utilization with innovative approaches to managing road and rail traffic as well as airports. Our contributions to traffic management for public mass events and disasters support police and emergency services. We are breaking new ground in transport system evaluation by taking an integral view of transport development and environmental impact.

In our research, concrete applications are always kept firmly within our sights. We therefore form a bridge from basic research through future technologies to economically viable innovations. We are not acting in isolation but seek strategic cooperation and coordination with outstanding research groups and leading companies in Germany as well as in other European countries. We also incorporate our skills into national and European networks, contribute to developing technology platforms and represent the interests of research institutions in panels and associations. By working close together with our partners, we therefore contribute towards the success of the German and European economy and science in the face of global competition.

Why
Do People Drive from A to B?

If you want to design the transport of the future, you need to understand why people travel and transport their goods.

The DLR Nachrichten interviewed Professor Barbara Lenz, Head of the Institute of Transport Research at the German Aerospace Center (DLR) in Berlin.

Professor Lenz, you came from the University of Stuttgart to the DLR in Berlin five years ago – was this because of transport?
If you like, yes. Researching transport is a highly interesting and challenging task. Transport is an indicator for the complex interaction of very different processes, of objective and subjective needs and necessities, of causes and their effects. To investigate why transport is this way or that, to question the connections between economic development and the need for transport, to analyze human behavior, that is all very appealing to an economic and social geographer. And transport in Berlin, if that is what you are referring to, has many advantages …

… And they would be?
The public transport services are excellent. You can usually do your shopping close to where you live. The road and pathway network in Berlin is also very well laid out for pedestrians. I really like living in Berlin.

The great Berlin naturalist and globetrotter Alexander von Humboldt would have bequeathed many more discoveries if he had been able to get from A to B more quickly. Back then, there was a lack of well-designed roads and paths and there was no fast means of transport. 200 years later, we have both and we are increasingly spending our time in traffic jams. Is the path of the mobile society leading to a dead end?
It was only during the industrial revolution that peoples' traveling area fundamentally changed – naturally also that of goods – and not only for especially privileged individuals or those that were particularly thirsty for knowledge, but rather for a continually growing number of people. In other words, people are now traveling not only faster and further, but also more people are traveling. And they are not only doing this for special occasions but on a daily basis – be it going to work, to school, for leisure or other purposes. If we want to answer the question of future mobility, we need to investigate why people travel from place to place and how they get there. Only then are we able to think about how this can be planned. How can transport be controlled? I see this positively. Transport is certainly a variable that can be influenced. Other possibilities than the dead end are available, we just have to find them and make them accessible.

How, for example?
Car traffic jams can be countered with an attractive public transport system. Shopping facilities around the corner, which can be easily reached on foot, reduce traffic. A good infrastructure for bicycles – a continuous cycle path network, multi-story bicycle parking garages and other parking facilities, for example, like in the city of Münster – creates the possibility of making the city accessible by bicycle. I see various solutions here. There is no one model that effectively leads to the target everywhere to the same degree. You need to deal with the structure of the city, understand the system and reflect the use of space and traffic development in terms of the social and individual needs.

How is a comprehensive understanding of the transport system achieved?
First of all, through surveys and by analyzing data and traffic flow surveys. Secondly, through models that depict, for example, the movements of all sections of the population of Berlin on a typical working day – we call this "transport demand". By using empirically analyzed behavior with the aid of mathematical formulas to depict real life, we can find out how people behave and potentially change their behavior. To what extent do people allow themselves to be guided through traffic by a navigation device? How will the need for mobility and traffic behavior change when people get older? Here, at the Institute of Transport Research, we focus above all on what is known as "microscopic modeling". This focuses on individual people and therefore enables detailed statements about changes in transport demand and the reasons for this, be it through the targeted exertion of influence or through new general conditions. Such questions are: What traffic flows are created when people change their activities, for example, through the increase of job-related trips? What means of transport are used for this? What is the reaction to measures such as charging parking fees in the city center? And in general: How does transport demand change if new costs are created or if the costs are distributed differently?

The density of traffic flows is continuing to increase. Town planners, traffic control centers, legislators and other political decision-makers expect help from transport research for making decisions in order to be able to also guarantee mobility in the future. In your opinion, what are the most important questions that need to be answered?
In addition to an even better understanding of the way in which passenger and commercial traffic functions and the factors that influence this, there are currently two main questions when it comes to transport. First of all: How can transport be better designed, more fluid and more environmentally friendly? We are working very intensively on the question of what contribution both technology and politics can make towards reducing the impact of transport on people and the environment. We were therefore commissioned by the Deutsche Verkehrsforum (German Transport Forum) to draw up a "Transport energy and emissions balance". Here, we were able to show, among other things, that the technological potentials relating to cars in terms of energy requirement and CO_2 emissions at best lead to a form of compensation for the growing level of traffic. We worked on the basis of the traffic growth rates that have been calculated by other renowned institutes in modern trends and scenarios. Furthermore, we are cooperating on projects that are aimed at reducing the consumption of energy and emissions. A particularly interesting example is the "Driving Style Manager," which is aimed at reducing energy consumption in rail transport – it's not only car drivers that can conserve energy when driving, train drivers can also learn this! The second important question is: How can transport demand be appropriately met in a society which is getting older? In 20

Professor Barbara Lenz has been directing the Institute of Transport Research at the DLR in Berlin since the beginning of 2007.

years' time, nearly a third of road users will be older than 65. The number of elderly road users is increasing. At the same time, the number of young people is decreasing and there are less people that are gainfully employed. As a result, the requirements placed on commuter traffic, on the vehicles and assistance systems as well, and on the entire transport system are changing. In order to be able to react to this process in good time, forecasts are necessary that estimate the long-term developments and incorporate as many traffic development elements as possible.

Speaking of commercial transport, being able to transport goods as inexpensively as possible can decide the success of a company. This can lead to conflicts of interests with passenger transport or protecting the environment. What role does commercial transport play in the work of your institute?
It is one of the two profile lines of our research. Until now, freight transport has only been examined very generally. We still know too little about the conditions that induce a company to transport their goods using this method or that, with or without intermediate storage, with or without changing means of transport. That is why we are investigating what decision-making rules are used by companies when it comes to dispatching their goods. We are gathering data from companies surveyed in the producing sector and the service sector. By analyzing and evaluating this data and applying the data in microscopic modeling, we produce reliable statements and forecasts on commercial transport and its future development.

... To answer which questions?
What role do delivery criteria such as delivery time windows or delivery quantities play in the choice of transport mode? Or: Under what circumstances do companies shift their goods transport to the railways? What about service-related transport? There is hardly any data on this subject. In this field of research, we are working closely together with other research institutes, for

Clearing House for Transport Data

example, with the Institute of Applied Transport and Tourism Research in Heilbronn and the Research Institute for Telecommunications in Dortmund. Together with these partners, we create a solid data foundation and, at the same time, develop concepts suitable for the practice regarding the efficient handling of transport that is necessary for performing services.

In the car-dominated country of Germany, mobility is without doubt an issue that affects many people? but mobility is not only a national problem ...

No, not at all. Rapidly growing metropolises around the world, for example, in Latin America, have

entirely different problems. We are therefore cooperating as part of the joint megacity project "Risk Habitat Megacity," which is run by the Helmholtz Association. We are investigating what political transport decisions need to be made today in these megacities to develop alternatives to automotive growth or to counteract the critical air pollution conditions. In cooperation with scientists from two universities in Santiago de Chile, we are utilizing the TAPAS travel model developed at the Institute of Transport Research. TAPAS is the abbreviation for "Travel Activity PAttern Simulation". In the model, interactions within the complex megacity system can be depicted and analyzed. Measures such as the introduction of

Transport research requires a considerable amount of detailed information on traffic movements. Empirical studies and measurement campaigns are accordingly extensive and varied. Many relevant datasets are often only known to a small group of well-informed users or their application potential is limited because the survey methods are not documented well enough. The clearing house of the DLR closes these information gaps, qualifying itself as a central point of contact.

In the transport data archive of the DLR, detailed metadata is provided as well as notes on possible uses and sources. Furthermore, access to the data itself is facilitated. This includes, for example, the "MiD 2002" survey commissioned by the Federal Ministry of Transport, Building and Urban Affairs on the daily mobility of private households. Germany-wide, 25,000 households containing over 61,000 people were surveyed. The answers to around 40 questions provide an indicative picture of the socio-economic conditions of the people and their actual mobility behavior. For example, reports about 167,000 roads were compiled. The services offered by the clearing house are targeted at the entire transport research community, which includes both organizations who gather transport-relevant data and those who wish to use the results of this research. The above includes engineering firms and planning authorities as well as academic institutes. ■

Angelika Schulz

Questions about mobility? –
The DLR transport data archive has answers.
Contact:
http://www.clearingstelle-verkehr.de
info@clearingstelle-vekehr.de

city center road tolls are assessed in terms of their effect before they are even implemented. This provides support for the decision-makers at the megacity's urban and transport planning departments and, at the same time, reinforces acceptance of the use of tools for sustainability management.

Back to Germany now: What is the situation with the transport of the future? What is the outlook for mobility in 2020?
We will need to make use of our immediate environment again for daily life. We will have to learn that geographical flexibility has its value and that this value cannot be taken for granted. Mobility will in all likelihood become more expensive, for both the individual and society as a whole. Modern, environmentally friendly vehicles will certainly become more expensive, but bicycle paths or truly pedestrian-friendly sidewalks of course also have their price. And we need to consider all those involved in transport far more than we do now. Currently this is only just starting. We are quite rightly placing our trust in new technical solutions, but we should always bear in mind that the real development of individual wishes, needs and preferences will be shaped by both people and companies.

What does that mean for your institute?
That we will continue to follow the system research path on which we have started, we will create qualified analyses, improve modeling and focus on the transferability of our work right from the outset. We can make the added value which lies in complementary in-house DLR research even more fruitful.

DLR Transport Research also works intensively on new vehicle concepts, on driver assistance systems and investigates the environmental impact of transport. To do this, other institutes often use large-scale systems. The "large-scale systems" of the Institute of Transport Research are called analysis and modeling. To assess future requirements that will be placed on transport and to develop solution concepts? these

Mobile Seniors

The message from the demographers has finally been received loud and clear everywhere: Germany's population is decreasing. The population structure is changing. In future, there will be more elderly people among them an increasing share of "elderly seniors", i.e., people aged 80 and over. Therefore, the basic general condtions are changing in nearly all areas of society and thus also transport. What are the implications when an ever-increasing number of elderly people have an influence on traffic movements? What is the outlook for the mobility of the elderly in the future? These are questions to which scientists at the DLR Institute of Transport Research are seeking the answers.

Already today, senior citizens are more mobile than in any other generation before. This is thanks to generally better health, a rising life expectation and an increasing number of driver's license holders, in particular among elderly women. But the trips made by senior citizens are less and shorter. Once they enter retirement age, there is no more commuting to work and the distances that are covered decrease. Instead, elderly people go shopping more frequently and undertake more leisure trips – "getting out and about" is thus of increasing importance. It appears that they generally keep to the mobility they have "learned". If they often used to take the car, people will also barely leave the car in the garage when they are retired.

Nevertheless, the mobility of the elderly in the future is difficult to predict. It can be expected that in 20 years' time, senior citizens will be even more mobile than elderly people today. Key determinants for the number of kilometers that a person travels in a given period of are the challenges to which we are finding answers and with which we contribute both towards scientific progress and towards solving concrete problems. ■

The interview was conducted by Cordula Tegen, Editor at DLR Corporate Communication.

Pictures: © Markus-Steur.de

time are driver's license ownership and car availability. While in 2002, in the 60- to 65-year old group, 82 percent already had a driving license, in the group of over 80-year-olds only 42 percent were entitled to drive a car. When, in 20 years' time, the current group of 60- to 65-year-olds is over the age of 80, then 82 percent will have a driving license – which is almost twice as many as today. It is particularly striking that this so-called "catching-up motorization" is above all attributable to women. While large gender-specific differences exist in today's older birth year cohorts – the number of men with a driver's license is significantly higher than among women – these differences will be brought in line with each other.

But the elderly of the future will not only hold a higher percentage of driving licenses, they have also been more mobile all their lives than today's senior citizens. And they have clearly distinct habits, particularly with regard to overcoming distances. Changing family structures, such as the increase of single households in which over-proportionally many trips are made, are having an effect on transport demand.

The general development of car mobility has lead to the coining of the term "Society on Wheels". Transport and social scientists are unanimous that the "Society on Wheels" will become a "Graying Society on Wheels". By analyzing already identifiable behavioral changes and their implementation in microscopic transport demand models, the Institute of Transport Research has developed scenarios that illustrate the influence of demographic change on transport development, making an important contribution towards transport forecasting and especially towards ensuring the mobility of elderly people. ■

Anne Klein-Hitpaß

More and more elderly citizens are becoming road users – either with motorized means or on foot – this is something which city and transport planners need to take into account.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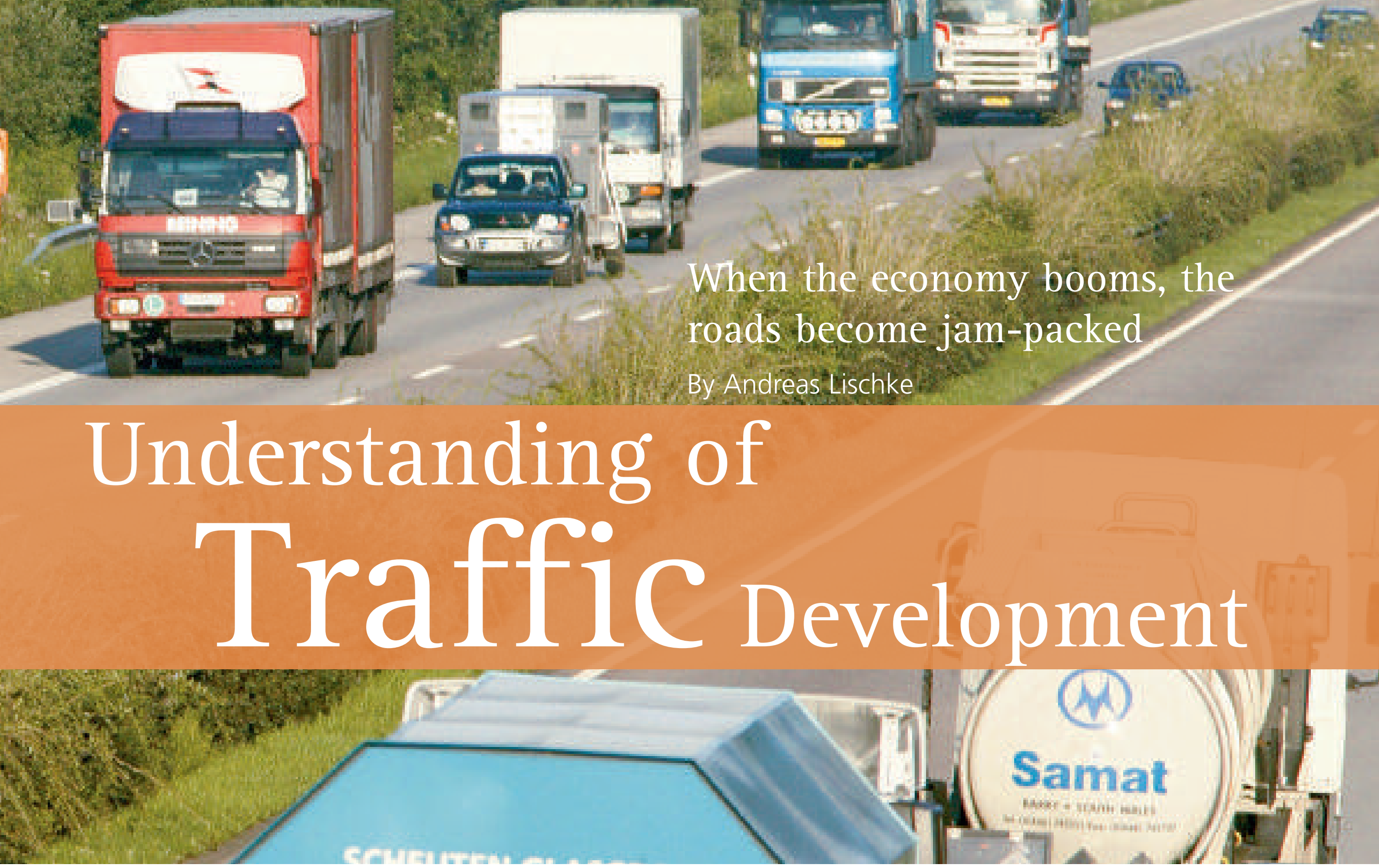
Germany's economy is experiencing an upswing – and so is freight traffic. For 2007, growth is expected in rail traffic of 8.2 percent, with 8.1 percent on the roads and 3.3 for inland waterway transportation. The forecasts are also predicting long-term growth for freight transport. Above all, road transport is set to increase. However, it is also clear that commercial traffic, as important as it is for the functioning of the German economy, is a major emitter of pollutants, carbon dioxide and noise. In order to better understand the reasons for the demand in freight traffic, the DLR Institute of Transport Research has developed the commercial transport model WiVSim.

The WiVSim model depicts the "actors" as the shippers, i.e. the producing companies and commerce, and the transport and logistic service providers together with their respective behavior. This approach describes the freight traffic caused by industry as well as service traffic. Only once the behavior of individual sectors is better understood, there can be estimated what effects future technological and regulatory measures will have on commercial traffic. The main idea is that traffic, which is caused by delivery vehicles and heavy goods vehicles as well as locomotives and rail wagons, can be designed to be more environmentally friendly through new technologies. Furthermore, the impact on people and nature can be reduced by appropriate regulatory measures. An example of a conceivable regulatory measure is the allowance of so-called "gigaliners", i.e., heavy goods vehicles with a permitted total weight of 60 tones and a vehicle length of 25.25 meters. This issue is currently being discussed at length at European level by politicians and affected lobby groups. However, there is a lack of precise knowledge on the impact of these gigaliners. The Institute of Transport Research is investigating how the vehicle-kilometers i.e., the total number of kilometers driven by road freight traffic, would change if gigaliners were permitted. It can basically be expected that the number of necessary HGV journeys would be reduced by the deployment of gigaliners, efficiency would increase, and transport costs



When the economy booms, the roads become jam-packed

By Andreas Lischke

Understanding of Traffic Development

and thus transport prices would be lowered. However, it is feared that rail transport, in particular from combined rail/road transport, would partially be re-shifted to the road-haulage.

Using the modeling tool WiVSim that was developed at the Institute of Transport Research, the expected effects can be quantified with regard to individual relations (routes between origin and destination) and projected for the entire volume of freight traffic. The model simulation calculates suitable journeys for the gigaliners; the modified consignment volumes and the relevant route patterns and transport distances are especially taken into account. Restrictions can also be taken into consideration in a 2^{nd} step, e.g. if it is prohibited to use these vehicles on certain roads. At the end it can be forecast how many shipments are suitable for transportation with gigaliners and how many HGV journeys can be saved.

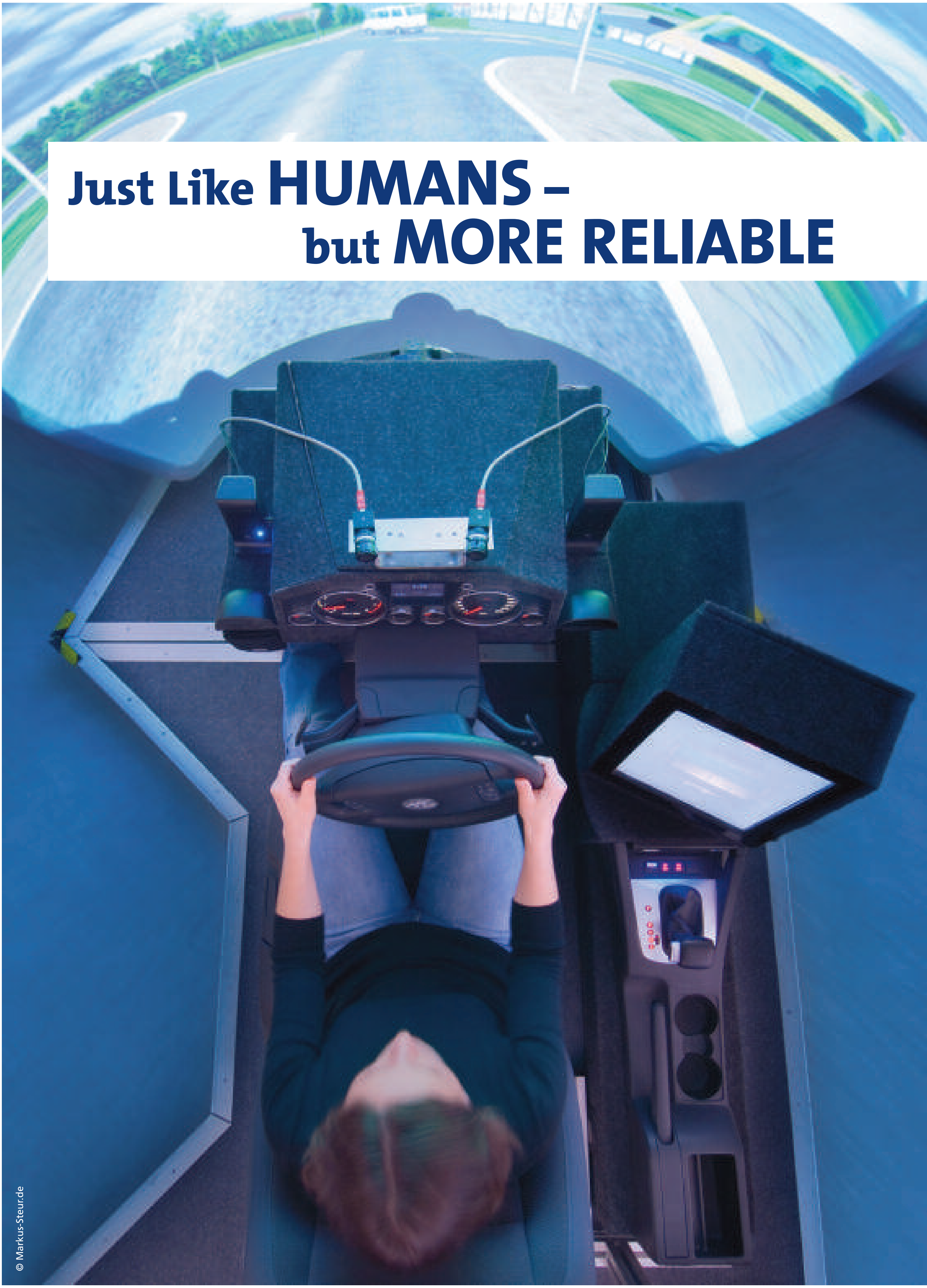
Further questions that are investigated, some of which in cooperation with other research institutes, concern the impact on traffic which results from new logistics concepts as well as the effects of measures expected from the "Freight traffic and logistics" master plan that is announced by the German Federal Government. The aim is also to use the model to investigate and calculate the changes in transport that can be expected. Also new vehicle technologies, for example like the ones that are going to develop at DLR in Stuttgart, can be investigated with the model in terms of their overall impact on freight transport.

With the expertise of different DLR institutes can be realised a link between the models for forecasting the demand in freight and passenger transport with models analyzing and monitor the road traffic related effects (e.g. emissions) Thus, much more accurate forecast can be made on the development of the demand for transport and on the impact of traffic on the environment at a local, regional and global level in the future.

Author:

Andreas Lischke is the acting Head of the Department for the topic of Commercial Traffic Modeling at the DLR Institute of Transport Research in Berlin.

Just Like HUMANS – but MORE RELIABLE



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Technology to Assist Drivers – Safe, Reliable, Ergonomic

By Jürgen Rataj

If you want to drive a car today, you will be confronted with an array of demands and influences. The driver has to navigate, maneuver and stabilize the vehicle as well as master the modern operating elements of his vehicle. Assistance systems provide support and can help to make transport safer, more efficient and environmentally friendlier. They prevent accidents by informing or warning the driver or even intervening. Assistance systems can also reduce traffic jams by optimizing driving behaviour and coordinating the different road users. This also has a significant effect on conserving resources and reducing pollution. The DLR Institute of Transportation Systems in Brunswick researches and develops technical systems for driver assistance.

Driver assistance technology has high demands to satisfy: the system must always provide correct information and actions. The driver must be able to trust his assistance system at all times. And last of all, the driver assistance system must be ergonomically designed so that people can operate and understand the technology. Only in this way can assistance and automation become a trusted companion for mobile people.

Technical driver assistance systems essentially fulfill four tasks: They acquire information, interpret it, ascertain the appropriate form of assistance for the driver and communicate this in a comprehensible manner. In order to really support the driver with his tasks – navigating, maneuvering and stabilizing – assistance systems require information about the driver, the vehicle, the surrounding traffic and the available transport infrastructure. Sensors, communication, positioning, database and information processing technologies are necessary for this. Depending on the assistance function, movements in the driver's line of sight or his blinking frequency can be detected. Information about the behaviour and condition of the vehicle for stabilization (ESP – electronic stability program) is gained with the aid of vehicle sensors, for example on the wheels. To assist maneuvering, the surrounding traffic and transport infrastructure is assessed (e.g., with cameras, radar or infrared sensors).

To detect the same information, dependent on the maneuver different sensors are required. The distance to a car in front is measured by radar or lidar on highways and with an ultrasonic system for parking. To assist with navigation, the position of the vehicle is determined using satellite positioning and matched with a digital road map

The sensor information that is gathered in the car is also important for other drivers in the vicinity. Beyond purely visual means, i.e., via turn signals and brake lights, information can also be directly exchanged between vehicles (Car2Car) and between vehicles and the transport infrastructure (Car2Infrastructure).

The information basis for driver assistance is thereby extended to include data outside of the range of the vehicle's own sensors. The vehicle in front can, for example, pass on a measured slip on the front wheel as information and provide a warning against slippery roads.

From the infrastructure system, a vehicle can receive information about current speed limits and use this to directly set the ACC system (Adaptive Cruise Control). In order to fully exploit the potential of this technology field, infrastructure operators, auto-

In a simple simulation environment, new approaches can be quickly and flexibly tested with regard to their technical functioning and their effect on people.

motive manufacturers, suppliers and research institutions such as the DLR are working together in the globally organized Car2Car Communication Consortium.

A picture of the situation is created from the information that is gathered with the sensors. Future assistance systems will be able to ascertain from this what maneuvers are possible in the situation – just like a driver does from their sensory perceptions.

Future complex assistance systems furthermore require a system architecture that collects and processes the information independently from a specific hardware. In this way, the information can be used by several assistance functions that are linked together via defined vocabulary and communication channels.

One of the aims of driver assistance is to prevent errors that are made by the driver. It is therefore especially important that the assistance systems function without errors and can be operated without mistakes. Otherwise, danger can arise due to the assistance itself or through its potential failure.

Many sensors and their reliable deployment for road traffic still form the focus of research today. Among other things, DLR is currently working on improved image processing systems.

Camera images are essentially only a representation of color intensities of reality – the interpretation, which is easy for humans at a glance, must still be added. Patterns need to be recognized and classified (car, bus, cyclist, etc.) and their behaviors need to be interpreted (speed, direction, etc.).

Redundant systems ensure reliability

At the virtual institute DESCAS (short for Design of Safety Critical Automotive Systems), DLR is working together with the University of Oldenburg and the Technical University at Brunswick on a safety-focused development process. This takes into consideration what would happen if a system failed just once. What would happen, for example, if a laser failed to recognize the vehicle ahead?

Redundant elements could help here to analyze the situation, for example, to determine the position in the lane. The corresponding module can either be the driver himself or another sensor.

And what would happen if the electronics failed? Hardware errors or failures should not have a critical impact on the assistance functions. Diagnostic algorithms or redundant structures can provide a remedy. In the analytic redundancy approach, a system used in aviation, the correct behavior of the systems is simulated and compared with the measured behavior, for example. Software in contrast must not fail. However, it is possible that it contains hidden program errors that lead to problems.

Extensive component and system tests must therefore be carried out in the development process. If an assistance system does fail once, it must be possible for the driver to take over the affected function.

Once the assistance systems are working without technical glitches, it must be ensured that the driver can operate and understand the assistance systems to guarantee error-free use. This is where system ergonomics comes in, for which intensive exchange is required between engineering science, computer science and psychology. Visual, acoustic and haptic displays and control elements are being developed that enable intuitive operation and reliable interpretation of the system's actions. If the driver understands what the function is capable of based on the information provided, the driver can also predict this function's behavior and use and monitor the function in an accordingly targeted manner to his benefit.

In order to ascertain the expectations that drivers have with regard to assistance functions, in addition to theoretical examinations, experimental investigations with test subjects were carried out in simulators. The various configurations of the human-machine interface are investigated with increasingly realistic simulations, ranging from theater simulation, in which a test subject is provided with system behavior simulations by a hidden scientist, through to tests in the driving simulator, which contains the function as well as a complete vehicle. In the test vehicle FASCar, different assistance systems can be installed and tested on real roads.

People are not just drivers – they participate in traffic in a variety of ways, but the tasks are always the same. If the road user is the driver of a vehicle, he has to carry out the tasks of navigating, maneuvering and stabilizing. Stabilizing encompasses keeping the vehicle in the lane, maneuvering means, among other things, all interactions with other road users. If the road user is only a passenger, the tasks of maneuvering and stabilizing do not apply. It is only the task of navigating that is shared by all road users.

In the test vehicle FASCar, nearly any assistance system can be installed and tested during a real journey.

Future assistance systems can assist in navigation throughout the entire trip planning and guidance process, independent of the selected means of transport. In addition to road information, the future intermodal navigation devices will thus additionally contain information about public transport, such as transfer times and locations. This increases the attractiveness of public transport and thereby reduces traffic on the roads. This improves mobility on the roads, conserves resources and allows trips to be planned more efficiently.

For the future, a ubiquitous mobile network of information, assistance and automation encompassing the different fields of application is just as conceivable as hybrid vehicle forms that act as a bridge between individual and public transport. Such new types of vehicle could, for example, automatically drive to the user and then continue their journey controlled by the user.

Author:
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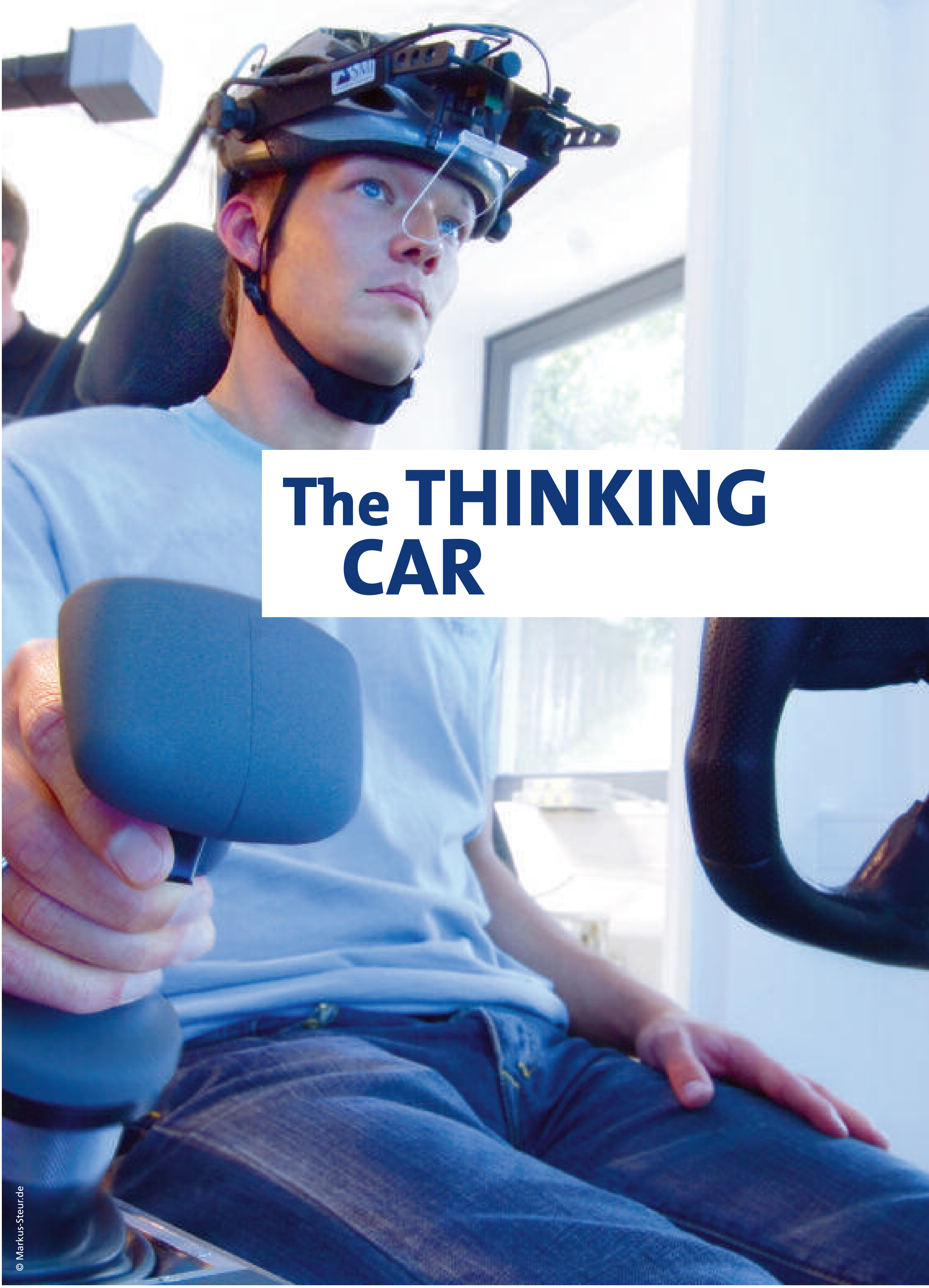
The THINKING CAR



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Assistance System Developers Have Set their Sights on Drivers

By Prof. Dr. Mark Vollrath

"... a massive pile-up occurred on the A2 late Sunday evening ... According to information from the police dealing with the incident, the accident was caused by the driver of a car who did not see an approaching vehicle when pulling out into the outside lane, causing the approaching car to brake. Twelve cars behind collided with each other due to high speeds and the lack of a safe distance between the vehicles."

We read accidents reports of this kind all too often. Although the number of accidents is continually declining, in particular those with injury to persons, this is mainly due to technological developments that increase "passive safety", such as airbags. The protection they offer to vehicle occupants is becoming better and better. However, a greater degree of active safety, which prevents accidents in the first place, could reduce both material damage and injury. DLR scientists are looking for ways to assist drivers.

The demands that are placed on these systems are high: In certain situations, they need to be more intelligent and reliable than people. To achieve this, the technological system of the car needs to be completely re-designed. However, the first step is to analyze what errors are made by drivers and how they can safely deal with the respective situation.

In over 90 percent of accidents, it is the driver who contributes at least in part towards the cause. But what exactly are the causes of accidents? An analysis of around 5,000 accident reports filed by the Brunswick police has revealed two main causes to DLR scientists: Drivers "overlook" important information, which means that they are unable to react in the correct way. There are many reasons for this. Drivers are often not concentrating, distracted, tired or overtaxed. The second cause is wrong decisions. Drivers consciously take risky actions but decide to accept these risks, often overestimating their own abilities. A typical example is rear end collisions in icy and slippery conditions caused by driving too fast. Driver assistance systems can prevent such mistakes. With radar technology, for example, obstacles can be identified and then be avoided. It is more difficult to calculate a speed that is suitable for the respective situation.

Information about weather conditions, road conditions, speed restrictions and the course and layout of the road must be combined with information from sensors (e.g., grip of the tires to the road), with highly accurate position information and constantly updated databases containing route information (e.g., traffic jams, detours).

It is even more difficult when it comes to intersections: The situation must be correctly analyzed, all relevant road users need to be identified and their behavior correctly interpreted. With better sensor technology, new data fusion possibilities and increasingly intelligent vehicle systems, these problems will be solved in the next few years. With its experience in aerospace, DLR provides important stimulus for these developments.

But how can drivers be induced to adopting the correct behavior? The apparently simplest solution would be the automatic corrective intervention of the assistance system: The driver cannot exceed the permitted maximum speed; the car brakes at

The driver-focused approach to developing driver assistance systems allows room for new forms of interaction. Here, a test subject is driving with a sidestick in the SMP-Lab.

The Test Person is Virtual.

OFFIS and DLR are Jointly Developing Driver Models.

Von Andreas Lüdtke

IMOST is a project that integrates the "human factor" into the development process of electronic control devices to prevent risks caused by misunderstandings or incorrect operation. The abbreviation stands for Integrated Modeling for Safe Transportation. In the project, which is funded by the Federal State of Lower Saxony, DLR is cooperating, among others, with the associate institute OFFIS.

In the IMOST project, the model-based approach, which is already being used today for the development of driver assistance systems, is being extended to include cognitive models regarding the behavior of the driver. This involves more than just incorporating human behavior. All components ? driver assistance system, vehicle, environment and humans ? are integrated into a common semantic model. This allows assistance systems to be fully tested in the virtual world in order to predict the impact on safety – entirely without the involvement of real test drivers.

An interdisciplinary working approach is followed within the project. The University of Oldenburg, DLR and OFFIS have consolidated their expertise. DLR's empirical approach, which includes the investigation of driver behavior in test vehicles and simulators, provides important information for the runtime capable driver models which OFFIS develops.

With its Safety Critical Systems (OFFIS SC) area, OFFIS concentrates on the development process of electronic components for safety-critical transport systems. This includes developing methods, processes and tools for people-friendly system design. At the center of it all are virtual test operators in the form of cognitive models which imitate key aspects of human behavior as "cognitive crash test dummies" and enable error predictions in realistic application scenarios. Fields of applications for this are pilot assistance systems and driver assistance systems.

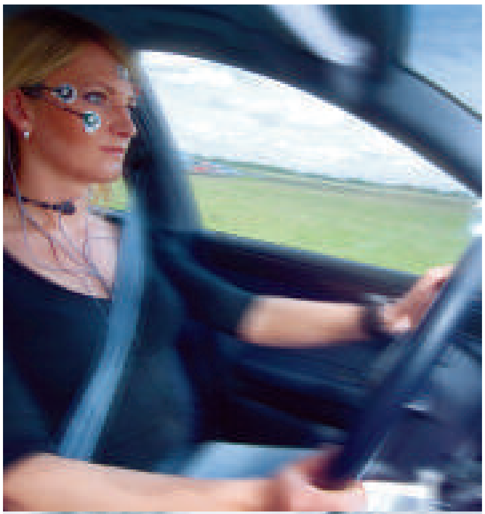
OFFIS was founded in 1991 as the "Oldenburg Research and Development Institute of Computer Science Tools and Systems" by the Federal State of Lower Saxony, the University of Oldenburg and professors of the Department of Computer Science. As an associated institute of the university, OFFIS researches new forms of computer-aided information processing in hardware and software systems and implements the results in application-oriented developments.

the intersection to ensure that the right of way is given. This example indicates just how problematic this type of assistance would be. The manufacturer would have to be able to guarantee that these interventions are one hundred percent safe. Otherwise, the driver would be unnerved if the car did not react the way he wants it to. Another problem would be the danger of becoming too used to the system, which would result in a lack of drivers' own action in the event of a system failure. This type of intervention system is therefore only to be considered for extreme situations.

Information systems, which, for example, display the current speed limit, are different. Here, the driver has control and the responsibility. But what is the benefit of such systems? It is a well-known fact that in the case of ice and snow the speed of the car has to be adjusted to the weather; additional information is of little help here. If a driver is already overtaxed at an intersection, he will oversee additional information about other road users just as much as the problem with the other road user.

Consequently, the support that is provided by information is only helpful in preventing accidents in certain cases. A balance between these two approaches is warnings. The driver's attention is specifically drawn to the dangerous aspects of the situation and it is made clear to him how he needs to react. For example, a warning about a cyclist is triggered at an intersection with an alarm signal from the right-hand speaker and a light signal in the right-hand exterior mirror as soon as the driver begins to turn right. It is important that

Picture above and center: On the road in the ViewCar – the measuring vehicle is used to analyze driving behavior. Different sensors monitor the driver, the vehicle and the surrounding area.
Picture below: The dynamic driving simulator provides a realistic driving feel. This allows unusual or dangerous situations to be investigated with or without driver assistance.



Pictures: Markus-Steur.de

a warning is only given when the situation really is dangerous and the driver has failed to react as required. Otherwise, the risk arises that the driver may become used to the warnings and would then start to ignore them.

A multitude of possibilities exists for assisting drivers. But when do drivers need which particular form of support? How do you provide the driver with the right degree of assistance? – In order to tackle these questions, DLR is inviting different types of drivers to drive the measuring vehicle ViewCar in different traffic situations. The driver behavior (how does the driver react?), the visual behavior (what information does the driver take in?), the strain on the driver (how high is the strain?), the behavior of the vehicle and events in the vicinity are measured.

From this, it can be derived in which situations the psychological strain increases particularly for certain drivers. If the driver is overtaxed, this can result in mistakes. Important information will be overlooked or the awareness of risk declines. Using the ViewCar, the scientists observe driving in day-to-day situations which could become critical due to their complexity (intersections, highway onramps ...). For investigating more unusual or dangerous situations, DLR uses various driving simulators.

In the virtual environment, an accident has no consequences for the test driver. Under controlled conditions, it can thus be identified why errors are made and how drivers react to them. In the next step, driver assistance systems can be developed and tested for their ability to prevent accidents. These systems can eventually be tested in reality in the test vehicle FASCar, which DLR has been operating since 2006. The FASCar is able to drive certain routes automatically. However, automatic driving is not the aim but rather a prerequisite for an adequate degree of driver assistance.

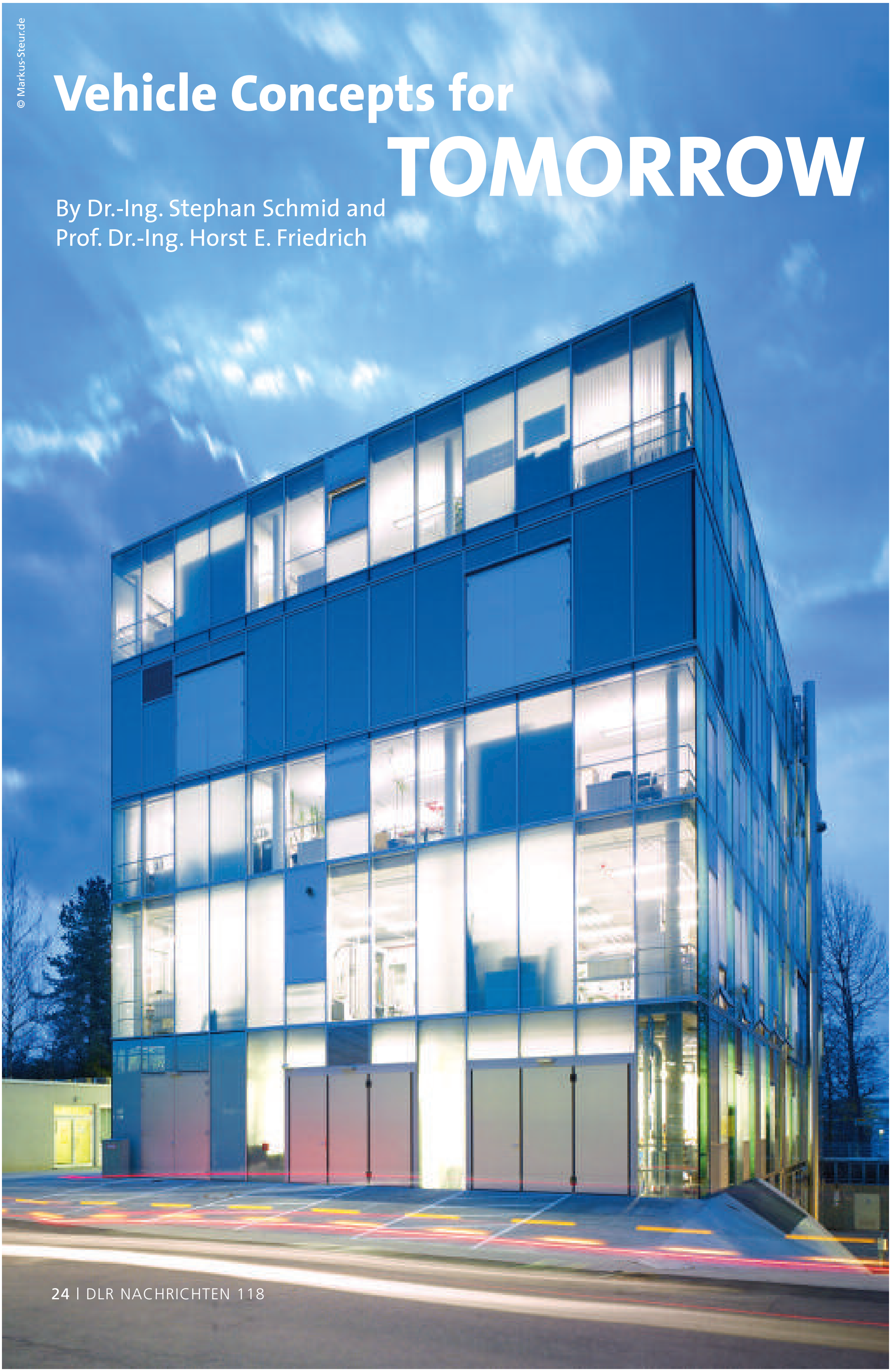
With driver assistance, the scenario described at the start of this article could have turned out as follows: During the journey, radar and infrared sensors recognize vehicles in the neighboring lanes. By means of a driver model, the probability of a lane change is constantly calculated.

If the driver initiates a lane change and another vehicle is located in the dangerous area of the next lane, a warning will be issued and steering wheel resistance will be activated. The driver does not change lanes and the dangerous chain reaction is prevented.

Author:
Prof. Dr. Mark Vollrath followed a job offer at the Technical University at Brunswick to the newly established Chair of Engineering Psychology in October 2007. Prior to this, he managed the Department of "Human Factors" at the DLR Institute of Transportation Systems in Brunswick.

Vehicle Concepts for TOMORROW

By Dr.-Ing. Stephan Schmid and
Prof. Dr.-Ing. Horst E. Friedrich



Traffic causes almost a quarter of the world's carbon dioxide emissions (CO_2). It is true that CO_2 emissions of newly sold cars have decreased by 40 percent within the last 30 years. However, the expenditure required to reduce CO_2 emissions is still estimated to cost approximately 100 to 500 Euros per ton of carbon dioxide. By now, this is much more expensive than in other sectors such as, e.g., electricity generation (5 Euros per ton of CO_2) or construction (10 Euros per ton of CO_2). Therefore, creativity is required to align new environmentally friendly technologies with economic constraints.

DLR is developing complex evaluation models to calculate the energy efficiency of future technologies, to account for their emissions from manufacturing to operation and up until disposal, and estimate the corresponding costs in advance to implementation. Very often, many different technical solutions compete with one another and the following questions arise: Which has the greatest potential to develop or reduce costs? What technical solutions deserve an investment? Therefore, models that are able to depict the decisive contexts and provide conclusions about potential market success are also in the focus of research.

THE OTTO ENGINE IS NOT YET PAST ITS SELL-BY DATE

The main areas in which vehicle technology acts today are the drive train, the overall energy efficiency, the reduction of all drive resistances and the utilization of alternative fuels. Is there life in the old dog yet? Yes, the internal combustion engine will still be around successfully for a long time – not in the way we know it today, but technologically advanced. The Otto engine can be enhanced to become 25% more efficient; in combination with an electric engine even a lot more so. Hybrid vehicles are already on the market and offer a path for developing electrified vehicles in the medium-term. Replacing conventional combustion engines/generator concepts with alternative electricity generation units – such as the free-piston linear generator, which is a flexible fuel combustion engine that transforms chemical into electrical energy in a compact format (patents at DLR) – and in the long-term with the fuel cell, is conceivable.

LESS RESISTANCE, LESS CO_2

Manipulating drive resistances also harbors great potential. This especially concerns lightweight vehicle construction. If the vehicle weighs less, it will gain a more agile driving behavior as well as consume less energy. These effects can be achieved by using lighter materials, saving material and conceptually enhancing components and joints. The path here leads from conventional lightweight construction to the more advanced concept lightweight construction. 100 kilogram of weight loss in a vehicle reduces its CO_2 emissions up to 10 grams per kilometer. There is a lot to be achieved with current cars of an average weight of 1,300 kilograms.

Additionally, better tires enable a car to run smoother and easier. Through innovations in tire production, tire resistance could be reduced by as much as 50% in the next 25 years, which translates into a saving of 10 grams of CO_2 per kilometer. Last but not least, aerodynamic drag hinders energy-free floating. The relevant measure here is the product of frontal area and aerodynamic drag coefficient. A 0.1 square meter reduction saves 3.5 grams of CO_2 per kilometer in the driving cycle, even more at higher speeds.

Today, a car engine in everyday use only converts 25% to 35% of the chemical energy stored in the fuel into mechanical energy. The rest is lost to the environment through engine cooling and exhaust. This is why DLR is working on waste energy recovery. The following article in this edition focuses in this aspect.

LOW CARBON FUELS

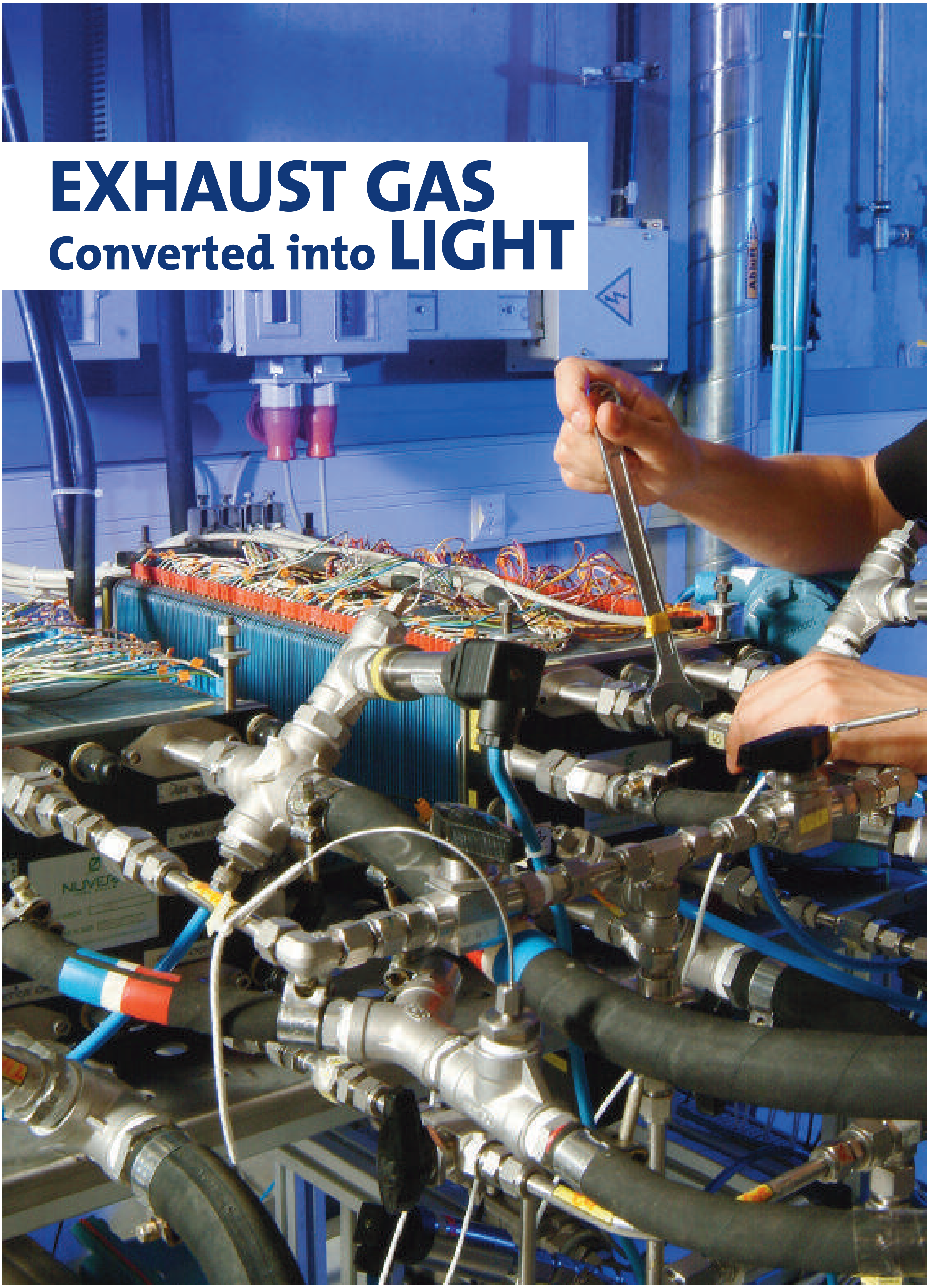
Which fuel will power our vehicles in 50 years time? Oil and gas will no longer be an option to the extent that we use them today. Climate change, however, will force us much earlier to emit less carbon to the atmosphere than we do today. A greater diversity of fuels is on our doorstep: natural gas and bio fuels will be added, hydrogen, electricity and others are being discussed. DLR provides solutions such as innovative production concepts for gas tanks and modular and robust architectures for fuel cell drive trains.

It remains to be seen whether a single energy carrier or a mixture will lead the way. DLR is actively engaged in analyzing scenarios with renewable energy sources, in technical feasibility evaluations, process chain analyses and in cost evaluations at the interface of energy system and vehicle.

NEW VEHICLE CONCEPTS

The key to the car of the future, however, lies in the symbiosis of new drive technologies and new construction concepts. Using this approach, new differentiated, lightweight and cost-effective vehicle generations will be created. Cost effective options for making these a reality need to be found. DLR's researchers engage in vehicle concepts and technologies that create a new type of mobility that is environmentally friendly, affordable and free of compromises.

EXHAUST GAS Converted into LIGHT



Two polymer electrolyte membrane fuel cell stacks on the test stand at DLR in Stuttgart. Identical fuel cell stacks are incorporated (installed) into the HyLite prototype of the Institute of Vehicle Concepts.

Innovations in the Energy Management of Future Vehicle Generations

By Dr. Peter Treffinger, Jörg Ungethüm and Julia Förster

The energy balance of a car looks fairly sad: not even a third of the fuel's energy is really being used. The rest simply goes up in smoke – part of it quite literally. Vehicles are clearly in serious need of improved energy management. At the end of the day, it is not only a question of costs but also of the climate and valuable resources. DLR engineers at the Institute of Vehicle Concepts in Stuttgart are therefore scrutinizing the energy balance of vehicles and are developing ideas that make better use of waste heat, for example, electricity.

The goal is to reduce CO_2 emissions and the primary principle is therefore to use fuel in the most effective way possible. The higher the degree of fuel utilization, the lower the CO_2 emissions of the vehicle and the greater is the range of fossil and renewable fuels. In order to drastically increase the degree of fuel utilization, the engineers must fully know and understand every path, transformation and type of energy flow within the vehicle. Once this has been achieved, the second step is to embrace even those ideas that may at first glance appear strange and to evaluate whether or not they may help gain a few percent more energy efficiency. If we take this another step further, we find that as soon as such a small idea is considered at series vehicle production level, it may in fact hold a great deal of overall potential.

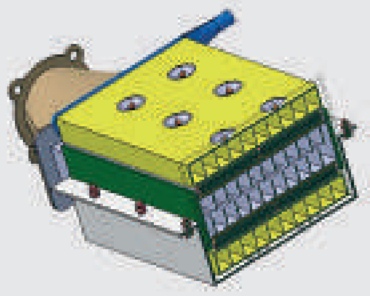
The research is thus very promising – and it begins with the engine because it is the first energy converter in the process. Today, it is almost exclusively internal combustion reciprocating piston engines that produce mechanical torque. The first area of potential for optimization thus already lies with the vehicle manufacturers and engine developers who are seeking the highest possible degree of efficiency from this primary energy converter. The present buzzwords are "new combustion methods," "downsizing" and "adapted turbocharger technologies."

All these methods focus on a single goal: achieving maximal output with small engines designed for minimum friction loss and low pollutant emissions in order to increase the degree of efficiency in the combustion process.

DLR is tackling this issue with the "free-piston linear generator" (FPLG) project. This combines the advantages of a combustion engine with those of a linear electric generator. The electricity generating part of the engine has lost its crank shaft. This setup allows for a variable adjustment of the stroke and compression. In this manner, the fuel can be combusted highly efficiently with low emissions both with a full and partial load. Additionally, several different fuels can be used. The FPLG has the potential of lowering costs through the use of a modular method of construction that can easily combine several modules to increase the performance.

The next options for improvement already concern the car as a system. The car is a highly dynamic system, very different to a power plant that is switched on once and then works virtually continually. A car only seldom runs under a full load and is supposed to warm up quickly when it is started. Already these two aspects illustrate that energy management involves a highly complex interplay between numerous requirements and functions.

What can be done if a car typically seldom travels at top speed on highways or with a heavy load on steep mountainous roads but rather much more frequently under highly dynamic partial loads? – Research is currently seeking to enable the engine to operate at a high degree of efficiency and to recuperate braking energy. This can be achieved through the hybridization of the drive train which allows the vehicle to be driven with either an electric or combustion engine as well as through adapted torque converters, such as CVT transmissions (Continuous Variable Transmission), which means gearless transmissions. And what about the warming-up period of the vehicle? Everything needs to be done quickly – defrosting the windscreens, heating up the interior for the passengers and warming up the engine to reach optimal consumption and emission values. In order to optimize these and other components of the vehicle's energy system, such as thermal, electrical and mechanical components, one must understand them and their energy flows as well as their interaction. This is most easily achieved with a simulation.



Layout of a thermoelectric generator: The hot exhaust gas flows through the channels (light blue) and transfer heat to the cooling water, which also flows through channels (yellow). The heat then flows through the thermoelectric material which is located between the channels (green). Part of the heat is converted into electrical energy.

For the purposes of modeling the "Vehicle" system, over the last few years DLR has created software libraries based on the newly developed object-oriented simulation language MODELICA, which can depict various vehicle energy systems. This means that this library contains data about the presently examined vehicle details such as chassis, tires and other components. These are then "assembled" into a comprehensive vehicle model, which can simulate, e.g., how quickly the exhaust of the vehicle heats up. A potential observation could be that the exhaust heats up so quickly that its warmth could be used to heat up the still-cold transmission more quickly.

What is still a dream of the future is the utilization of such models in the vehicle's control unit to guarantee optimal operation at all times through constant analysis of the state of the system. This requires real-time simulation since the simulated system must also work exactly as the real-world system with regard to the timeline. DLR is currently researching into such models. Synergies with the field of space research can be exploited here since the energy management issues related to aircraft are similar to those of vehicles.

Back to the present and to a simulation of a reference vehicle with a

[1] www.modelica.org

diesel engine to represent the compact car segment. In the simulation, the reference vehicle drives the so-called NEDC, which is the New European Driving Cycle – a standardized velocity profile which forms the basis for emission and consumption measurements. The result is not very impressive. Of the total energy quantity of the fuel, only 30 percent is utilized to overcome the drive resistances or to power auxiliary units in the vehicle. The greatest proportion of the fuel's energy is already transformed into waste heat in the engine. The amount of energy required to heat up the units from their cold state alone is already 27 percent of the fuel energy, which is even more than is rejected by the cooler. Approximately 23 percent of the fuel's energy is emitted via the exhaust gas. For vehicles with a gas engine, the outcome is even worse. Their share of the energy utilized is even lower and the proportion of energy that is emitted via exhaust gas is even higher.

The obvious question is therefore: How can the amounts of energy that are emitted to the environment as heat be utilized? This is where really innovative ideas are called for. Nevertheless, even the most creative ideas cannot bypass certain basic requirements: The lost energy must be stored and converted into a form that is usable within the vehicle and it must be transported to the area in the vehicle where it can be used.

Using heat is obviously easiest if it is directly used as thermal energy. It would be imaginable, for example, to create a passenger compartment heating system which draws its energy from a heat accumulator at the start of the journey. Once the engine is at operating temperature, it re-charges

New Energy Management for Future Vehicles

By Dr. Johannes Liebl,
Head of Energy Management at BMW

The automotive industry has achieved substantial reductions in vehicle consumption and carbon dioxide (CO_2) emissions. Classical developments, especially with Otto and diesel engines, have considerably contributed to this.

Climate change, a globally increasing energy demand, the finiteness of fossil energy resources and increases in individual transport are forcing us to further reduce CO_2 emissions.

Reducing a vehicle's CO_2 emissions alone does not promise the required customer acceptance and or market success. Customers' wishes are extremely diverse. Some need big cars, others are satisfied with small city cars, some mainly want to get from A to B and stay dry, others additionally demand safety, comfort and luxury. The BMW Group has chosen an integrative and function-oriented holistic vehicle approach in order to bridge this conflict between customers' wishes and environmental demands.

All physical levers must be taken into account and evaluated in their cause-effect context. What is new about this approach is only creating energy flows in the vehicle (mechanical, electric, hydraulic, pneumatic and thermal flows) when they are actually needed. If this is not possible, we need try to recapture this lost energy. In order to understand these complex relationships and be able to derive the correct decisions, simulations of the energy flows in a vehicle play a vital role.

Over the last few years, DLR has developed software libraries based on the newly created simulation language MODELICA, which serve to model the highly interacting system of a car. These allow a depiction of various vehicle energy systems. Such software will be used in future for optimization and control purposes in vehicle control units in order to optimize these systems in operation. DLR is focusing its research on developing such real-time capable models. For the BMW Group, these applications are a development tool for EfficientDynamics™.

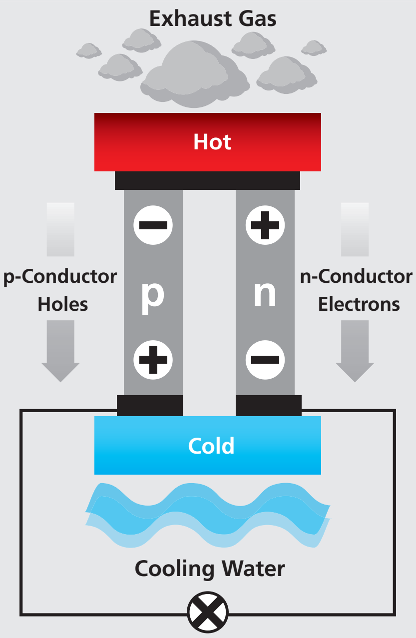
Furthermore, heat management is constantly increasing in importance. Even today, approximately two thirds of the chemical energy used in a combustion engine is still transformed into waste heat. This heat is generally released to the environment and is consequently lost. A solution for using the waste heat is to transform it into electric energy.

The BMW Group is cooperating with DLR on a basic principle project regarding thermoelectric generators. Our cooperation ranges from research into the fundamentals of energy transformation through to verification on test benches and in the vehicle. This prepares a further step in the expansion of the EfficientDynamics™ program.

Free-piston linear generator and the respective measurement data at DLR: Variable compression and variable adjustment of stroke enable entirely new perspectives for combustion technology.

the heat accumulator. Another very interesting idea in principle is to use the heat to power a cooling machine for the air conditioning in the vehicle. This means to basically use the heat to create cold air. Using a power conversion process, the heat can also be transformed into mechanical energy.

A thermoelectric generator could directly generate electricity from heat. The fuel could lastly be upgraded in terms of energy via a fuel reforming process that uses the heat of the exhaust gas to enhance the fuel's energy content.



Principle of a thermoelectric generator: A positively doped and a negatively doped semiconductor leg are located between a heat source and a heat sink. A current is created through thermal diffusion of the electrons and holes (Seebeck effect), which can be tapped from the outer circuit.

And already we arrive at the actual main field of activities of vehicle energy optimizers. All around the world, researchers are especially working on the utilization of power processes and their conversion into electrical energy. DLR is primarily working on designing thermoelectric generators, a field in which DLR already has substantial experience from space engineering. In space engineering, thermoelectric generators provide space probes with energy on their discovery trips which take several years.

In thermoelectric generators, the areas of different temperature lead to the so-called thermal diffusion of the electrons (a.k.a. the Seebeck effect) and a voltage is generated which can supply an external circuit.

If one was to presumptuously formulate this idea, one could now prophesize that such a thermoelectric generator will one day replace the alternator. Expressed in more modest terms, it is conceivable that such generators can cover the continually increasing demand for electric energy in cars. Either way, there are quite a few tasks to be solved yet before this principle can be utilized in vehicles. Thermoelectric materials that provide high degrees of efficiency in the temperature range relevant for cars are needed. DLR is working on just such materials.

Furthermore, the properties of these materials must satisfy the requirements of a thermoelectric generator within a vehicle in terms of design. For example, the generator must not strongly retroact on the engine if it is integrated into the exhaust system. It must operate stably even when the temperatures vary strongly and it must fit into the exhaust system, the cooling system and the electrical system of a vehicle in terms of both geometry and function. DLR researchers and engineers are therefore working on solutions in cooperation with suppliers and the automotive industry.

The first self-designed prototypes of such thermoelectric generators are already being tested at the hot gas test bench at DLR. The best electric performance achieved so far is approx. 200 Watts, but concepts suitable for vehicles are already being realized that promise an electric performance of more than 300 W under a partial load.

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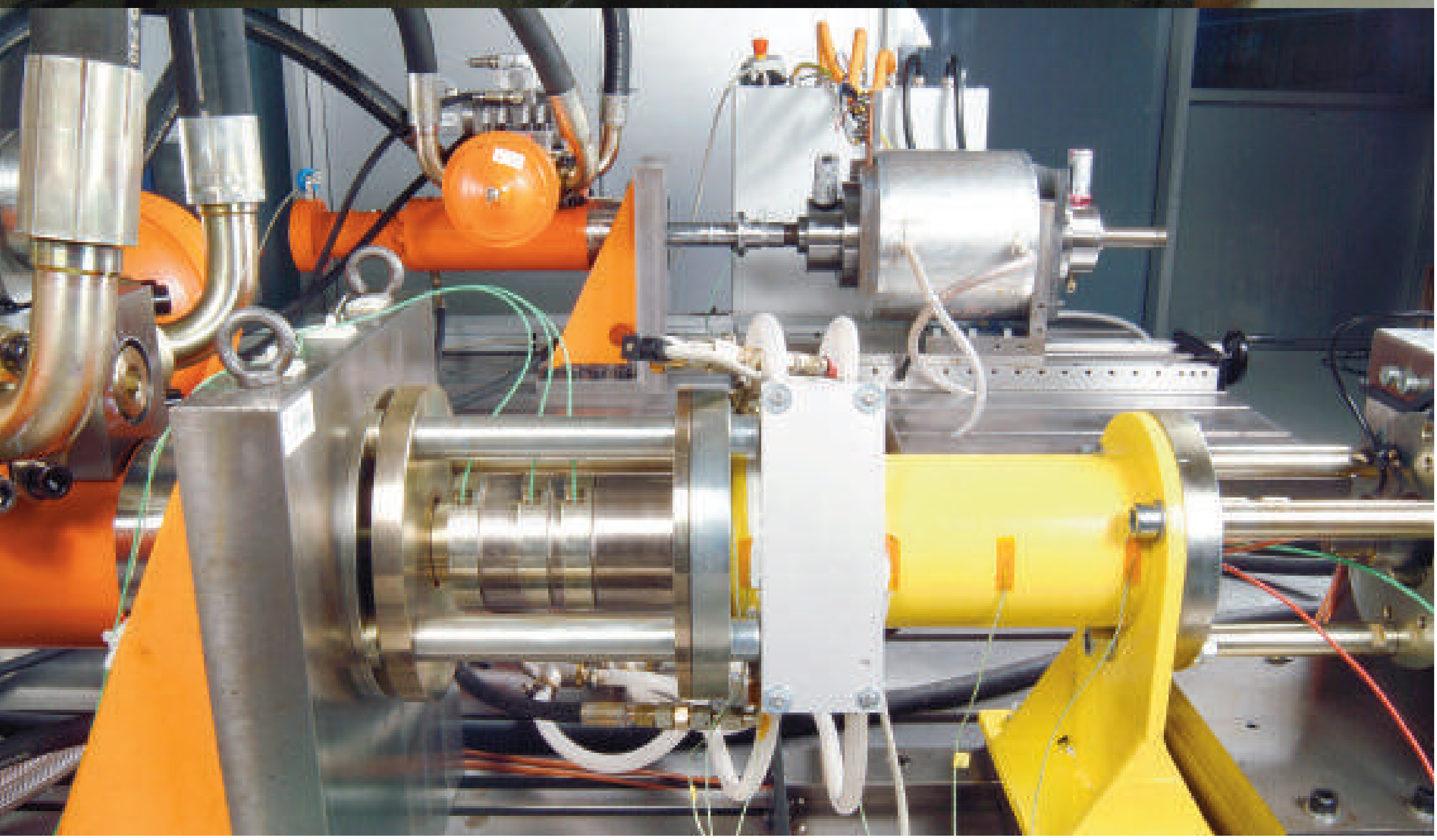


200 BAR in a Lightweight Construction Tank

New Production Practices are Geared Towards Making Natural Gas Vehicles More Competitive

By Gundolf Kopp, Roland Schöll and Julia Förster

Why is there still only a small number of environmentally friendly natural gas vehicles? The answer is simple: Natural gas vehicles are more expensive than conventional vehicles. It costs manufacturers between 1,000 and 2,500 Euros to integrate the high-pressure tanks designed for natural gas compressed at 200 bar into vehicles. Engineers at the DLR Institute of Vehicle Concepts' Department for Lightweight and Hybrid Design Methods are working with new materials, production methods and many partners from the industry in order to create a cheaper and lighter solution.

Using natural gas as a fuel for combustion engines is not a new idea at all. The first combustion engines in the 19th century were already based on the principle of stationary gas engines. This principle is still used today in block heating stations. The advantages of gas combustion engines? Low CO_2 emissions and lower sulfur dioxide, soot and other particulate emissions compared to combustion engines that burn liquid fuels.

If we were already able to use natural gas to a greater degree in transport today, the advantages would be plentiful. Not only would it reduce CO_2 emissions, but it would also prolong the availability of fossil fuels and additionally be a pacemaker technology that could advance the utilization of renewable energies. This last aspect is owed to the fact that the properties of compressed natural gas (CNG) are very similar to those of alternative energies such as biogas or hydrogen.

Natural gas could basically replace conventional fossil fuels such as petrol or diesel. According to a study conducted by the consulting firm Roland Berger, the total fleet of natural gas vehicles in Germany will increase to 360,000 by the year 2010. However, in spite of the potential for development that the study predicts for natural gas vehicles and despite the obvious advantages for the environment, only very few natural gas vehicles have been produced and sold to date. This is just as much true for Germany as for the rest of the world.

It is partly a monetary issue which is causing only such a small amount of natural gas vehicles to be on the road today. Many people are deterred from buying a natural gas vehicle because of its higher price. The more difficult storage of compressed gaseous fuels in high-pressure tanks causes an increase in production costs of 1,000 to 2,500 Euros per vehicle compared to conventional cars.

The core issue can be easily described: If the gas is left at ambient pressure, it will fill a volume which is approximately one thousand times larger than the volume of a liquid fuel that delivers the same amount of energy. There are thus no alternatives to liquefying or compressing the gases at a high pressure. Since our entire gas supply is based upon gaseous natural gas, the high-pressure approach is much more promising in practice and is already a reality at gas stations that store and offer gas at a pressure of 200 bar. But still, the volume requirement of natural gas is two to three times higher when compared to liquid fuels with the same energy content.

This relationship characterizes the starting point or even the starting line of the DLR project "DLR-Gas-Tank." The goal is to reduce the disadvantages of the increased volume requirement: Compared to the conventional steel gas tank, the mass of the tank is to be reduced by 30 percent and the space requirements for packaging are to be reduced by 35% in relation to the same filling volume. The production costs should be reduced by up to 25 percent. A total of nine project partners, of which six

Driving lighter for less CO_2

Since the year 2005, the German Aerospace Center (DLR), the Fraunhofer Gesellschaft and the University of Karlsruhe have been closely cooperating in the area of lightweight vehicle construction within the research alliance "Competence Center for Lightweight Vehicle Construction" with a focus on fiber compound materials. The research alliance has set itself the goal of significantly reducing the energy consumption of a vehicle and the associated CO_2 emissions by reducing drive resistances. This also represents an obligatory research theme for Volkswagen.

The Institute of Vehicle Concepts is therefore coordinating the DLR's activities in the field of transport in Stuttgart and is also involved in the Volkswagen coordinated EU project "Super Light Car." This project researches into and evaluates innovative construction methods and vehicle concepts, for example, vehicles with highly integrated and cost-effective magnesium constructions.

DLR scientists are working as development partner on strategies that enable the employment of the right material in the right place – multi-material design is the buzzword here. In this project, the depth of the research, which ranges from conceptual design through to simulation and the demonstration of concepts in suitable test environments, is a core competence feature.

Technically, multi-material design enables a 30 to 40 percent reduction of vehicle chassis weight with the same level of safety and comfort. When calculated in terms of a mid-sized vehicle, this weight reduction equates to a saving of 10 valuable grams of CO_2 emissions in the European driving cycle. In the customers' eyes, these advantages are even more appealing!

Dr. Martin Goede, Volkswagen head of the project "Super Light Car"

are from the industry and three from science, are working on the project which is funded as a lead project by the Ministry of Economic Affairs of the State of Baden-Württemberg. Its full name is "Innovative technologies for the creation of load-bearing lightweight construction elements made from short fiber enhanced thermoplastic with continuous filament strengthening using the example of a CNG tank (LLBT)."

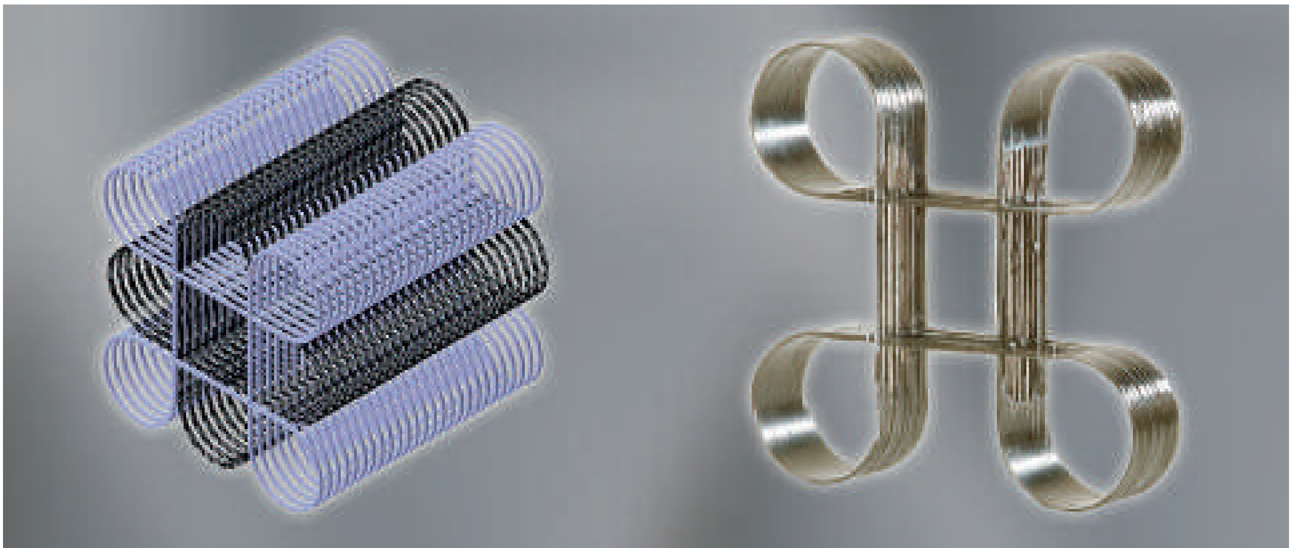
The basic body of current CNG tanks is made from steel. They are consequently heavier and can only be integrated with difficulty into the package of existing series production vehicles due to their classic gas-bottle resembling cylindrical shape. The weight problem can be solved using fiber-reinforced materials that are produced using the so-called wet winding method for fiber-reinforced thermosetting plastics. However, this production method leads to long cycle times and thus high manufacturing costs and does not solve the packaging problem.

The project partners are thus approaching the new tank structure in very different ways. They have drawn up a system that is based upon individual honeycombs which can vary in length and diameter and can thus be integrated more easily into the existing vehicle package. Vehicle developers hence have more liberty in creating new chassis concepts, the packaging can be more easily optimized and the weight of the car can be reduced. This is an important step toward considerably reducing energy consumption and CO_2 emissions from cars.

However, this system cannot be realized using either the currently employed winding techniques or any other conventional method of compound material technology. Instead, the engineers want to produce the tanks from short fiber strengthened plastics using a die-casting production method. This can achieve lighter components and thus more cost-effective series production. There is one catch, however: So far, no sufficient failure criterion exists for a short fiber strengthened plastic, especially not for multi-axle loads like the ones exerted in a high pressure tank. In other words, there is no reliable knowledge that describes in what way this new plastic needs to be created in order for it to fulfill all requirements safely.

The engineers are provided with this knowledge from a test unit which is being tested under a double-axis load and different temperatures at the Fraunhofer Institute for Mechanics of Materials (FhG-IWM) in Freiburg.

An important issue is optimizing the orientation of the short fibers in the plastic. Their orientation depends on the die-casting production process, which needs to be controlled accordingly. The tank also requires a further



A continuous filament structure is designed to enable the lightweight tank to withstand radial tensions.

component. For gas pressure tanks, the tensions in the circumferential direction are much stronger than in the longitudinal direction and the short fiber strengthened thermoplastics cannot withstand these tensions on their own. They are to receive help from carbon fibers that are manufactured as continuous filaments in a loop shape and that are integrated into the honeycomb structure of the tank.

The continuous filament structure will be able to withstand the exerted circumferential tensions. Using the test subjects, the DLR engineers participating in the project and their partners have already been able to prove that this continuous filament structure can in principle be manufactured.

The conditions for a "new" tank are thus not that bad at all. The project partners are now using the test items to analyze how the honeycombs can be created using the die-casting method and how continuous filaments and short fiber reinforced thermoplastics connect to each other. This is an essential issue because of the requirements with regard to load transmissions between the two components. Several simulations and experimental analyses are still required with regard to the issue of how the short fiber orientation and the continuous filament strengthened elements can be optimally adjusted towards each other.

The road to success in finding the solutions is, obviously, rather long and slippery. In today's day and age, however, it is only such roads which lead to the development of true innovations. At the finishing line, we will be rewarded with new possibilities and new vehicle concepts, DLR technologies for alternative fuels and the vehicle of the future.

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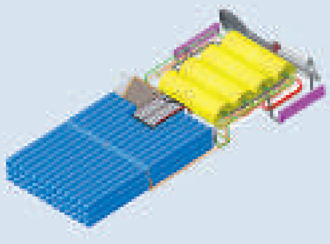
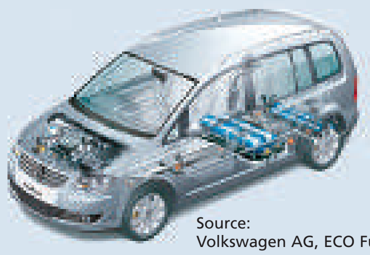


Package-optimized drive train module with DLR gas tank structure (blue) and free-piston linear generators (yellow)

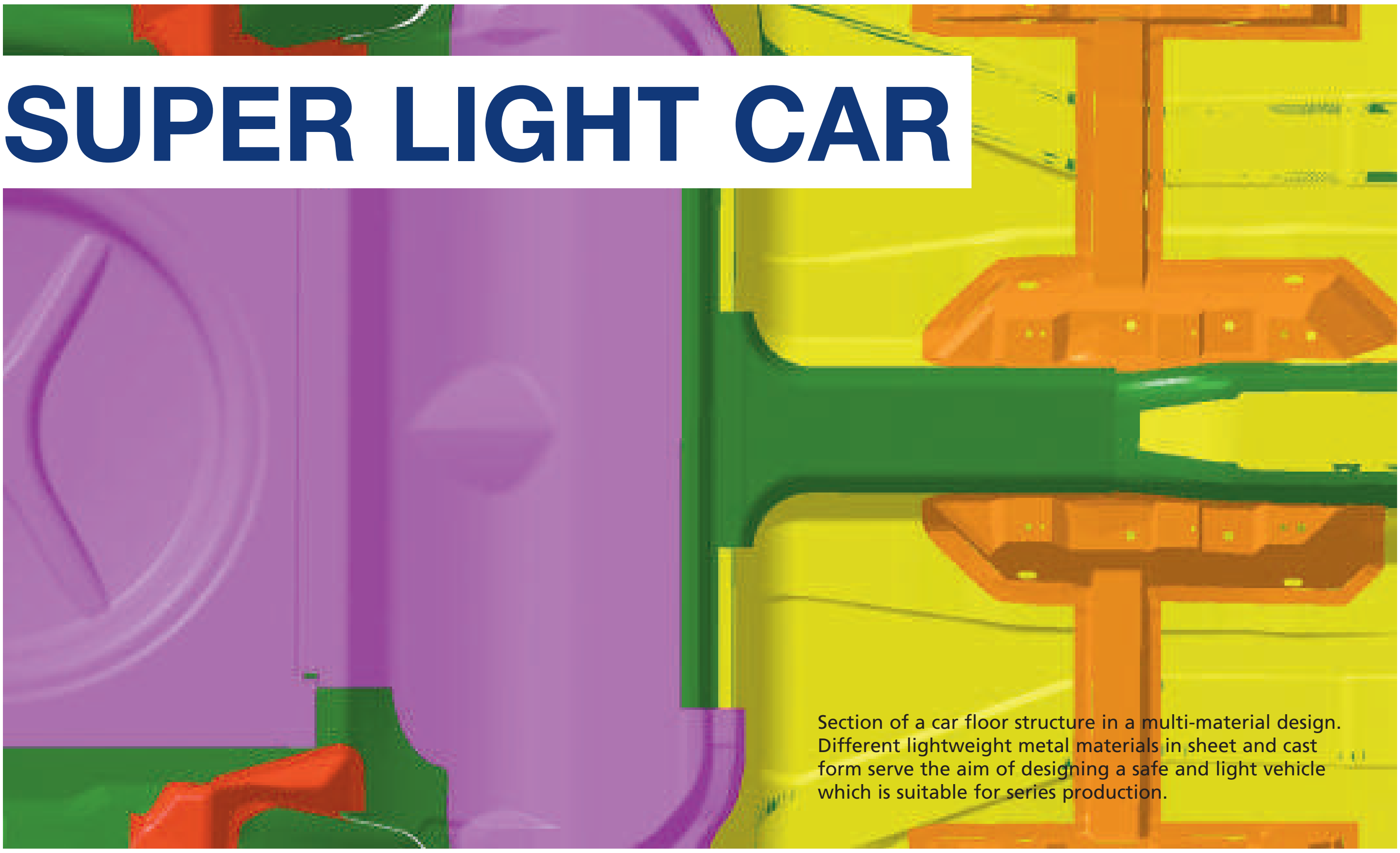
Integrated drive train module with a safety bottom structure and lateral fiber compound crash elements (black)



Source:
Volkswagen AG, ECO Fuel

Contemporary series production car by Volkswagen with conventional steel bottles for storing CNG (Compressed Natural Gas)

SUPER LIGHT CAR



Section of a car floor structure in a multi-material design. Different lightweight metal materials in sheet and cast form serve the aim of designing a safe and light vehicle which is suitable for series production.

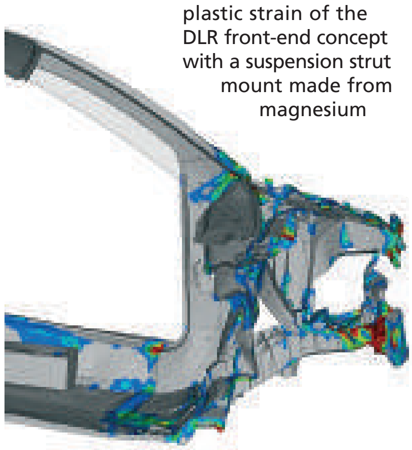
A lightweight, economical car is the goal. The 38 renowned partners from the automotive industry, the automotive supply industry and research are unanimous on this point, which is why they are working together on a project funded by the European Union. The DLR Institute of Vehicle Concepts in Stuttgart is also one of the partners involved. All of the partners are united by the idea of a Super Light Car. New types of lightweight construction and material solutions in the vehicle structure should enable the concept to become reality.

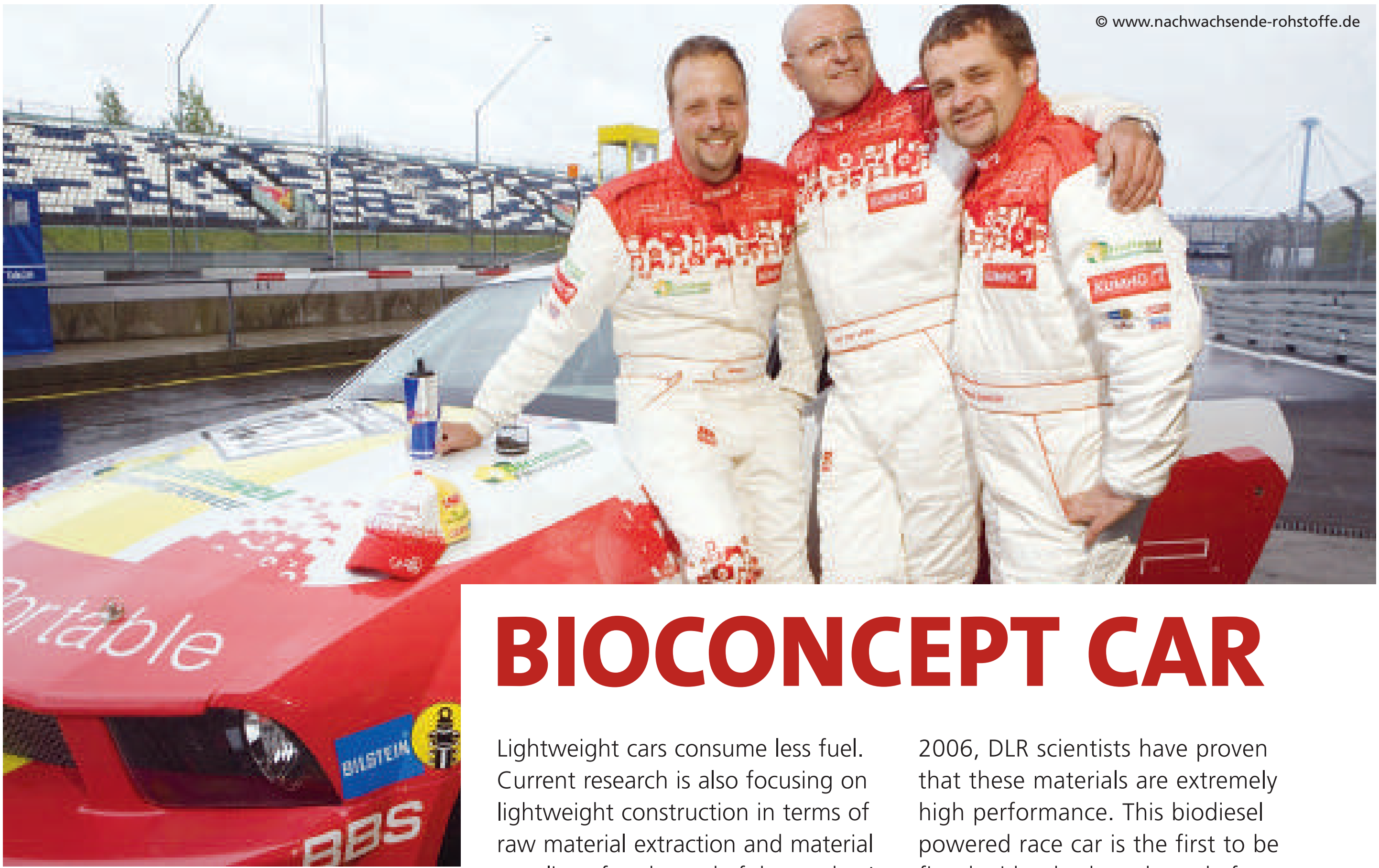
At the end of this major four-year long project, multi-material lightweight constructions for vehicle structures suitable for large-scale series production will have been developed. With this development, a car from the so-called C-class segment (reference VW Golf V) should be able to save 30 percent weight on the vehicle structure. As a result, up to ten grams of carbon dioxide emissions could be saved for a medium-sized vehicle. As the weight saving needs to be achieved with guaranteed production figures of 1,000 vehicles per day as well as high crash safety and rigidity, the requirements placed on the available technologies for materials, assembly, joining and production are extremely high. Environmentally-specific aspects such as recycling are being considered and evaluated parallel to the conceptual design of the new lightweight constructions. It is the ambition of those involved in the project to present and validate these lightweight construction concepts with a front-end vehicle construction.

DLR is working in the area of vehicle concepts and design. It is researching structures for the front-end vehicle in a lightweight metal construction design made from materials such as magnesium and aluminum. This includes a suspension strut mount made from magnesium which is combined with an aluminum side rail structure. The first results are structures with a weight saving of up to 56 percent. The crash simulations show cowl intrusion reduced by up to 20 millimeters compared with the reference structure. With regard to the aluminum side rail, the scientists and engineers are currently working on replacing the expensive aluminum casting process with more cost-effective aluminum sheet solutions.

Author:
Gundolf Kopp, Head of the Research Field of Lightweight and Hybrid Construction at the Institute of Vehicle Concepts, is responsible for the research components of DLR in the EU Project Super Light Car (SLC).

Crash simulation and illustration of the plastic strain of the DLR front-end concept with a suspension strut mount made from magnesium





Smudo (left), lead singer of the German hip-hop band Fanta4, advertises a “clean cause” at the Nürburgring and the IAA. The bio-concept car not only fills up on biodiesel – its body is also made from bio-composite materials, developed by DLR.

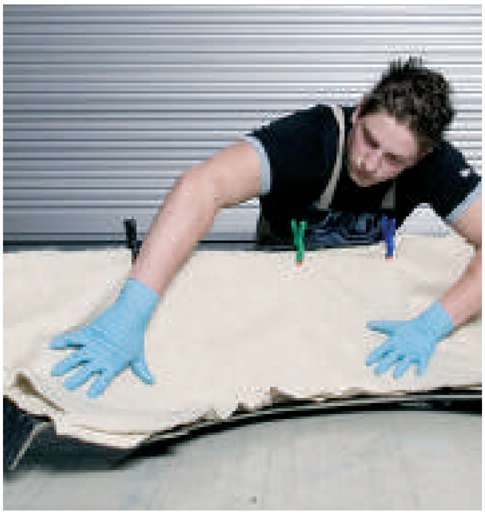
BIOCONCEPT CAR

Lightweight cars consume less fuel. Current research is also focusing on lightweight construction in terms of raw material extraction and material recycling after the end of the product’s lifetime. However, conventional plastics and fiber composites are not always environmentally friendly and are particularly complex when it comes to production, use and disposal.

DLR researchers have found a solution: biopolymers reinforced with natural fiber, bio-composites for short. By embedding plant fibers such as flax, hemp or ramie in biopolymer matrixes, fiber composites can be produced that are environmentally friendly through raw material recycling or thermal utilization in the carbon cycle. From a technical point of view, the natural fibers stand up to critical tests: They exhibit specific properties that are comparable with those of glass fibers. Given the current price trend in crude oil, it is also logical from an economic point of view to make greater use of renewable raw materials. Technical viability has, of course, to be taken into account from case to case.

With the example of the Mustang GT RTD, the first bio-concept car in 2006, DLR scientists have proven that these materials are extremely high performance. This biodiesel powered race car is the first to be fitted with a bodywork made from bio-composites. It was created on the basis of a Mustang bodywork that team leader Thomas von Löwis then further developed into a bio-concept car in cooperation with DLR and INVENT GmbH.

The doors, fenders, bumpers, hood, hatch and spoiler of the Mustang were made from natural fibers, which were placed in pre-cast moulds and soaked in liquid bio-plastic. After hardening, the formed parts are stable enough to withstand even the most extreme stresses and strains in motor sports.



Placing the composite fibers in the body-work component moulds requires prudence.

Author:
Dr.-Ing. Ulrich Riedel, Institute of Composite Structures and Adaptive Systems of the DLR in Brunswick.

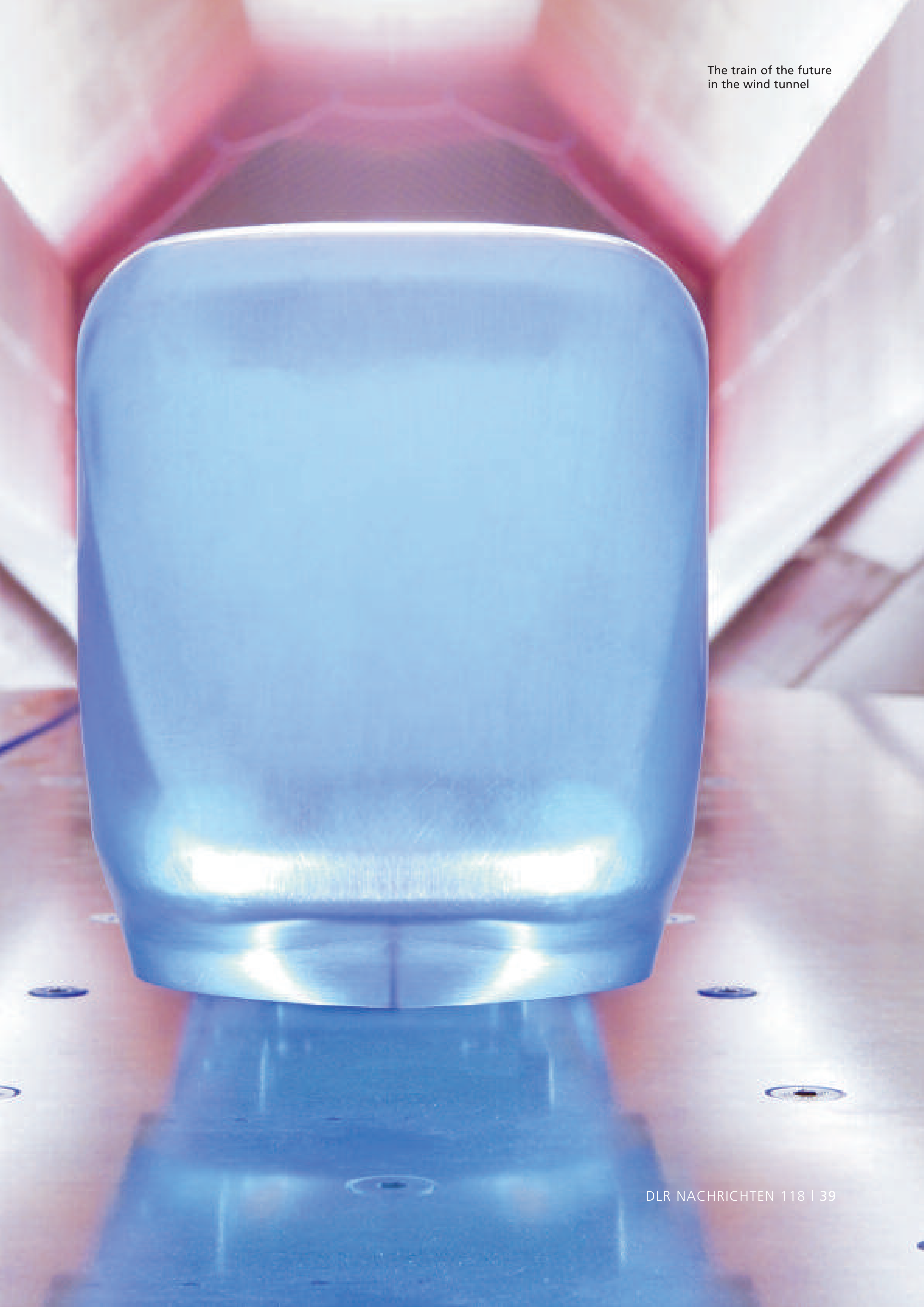
Information:
www.fourmotors.com

WITHOUT MUCH OF A STIR

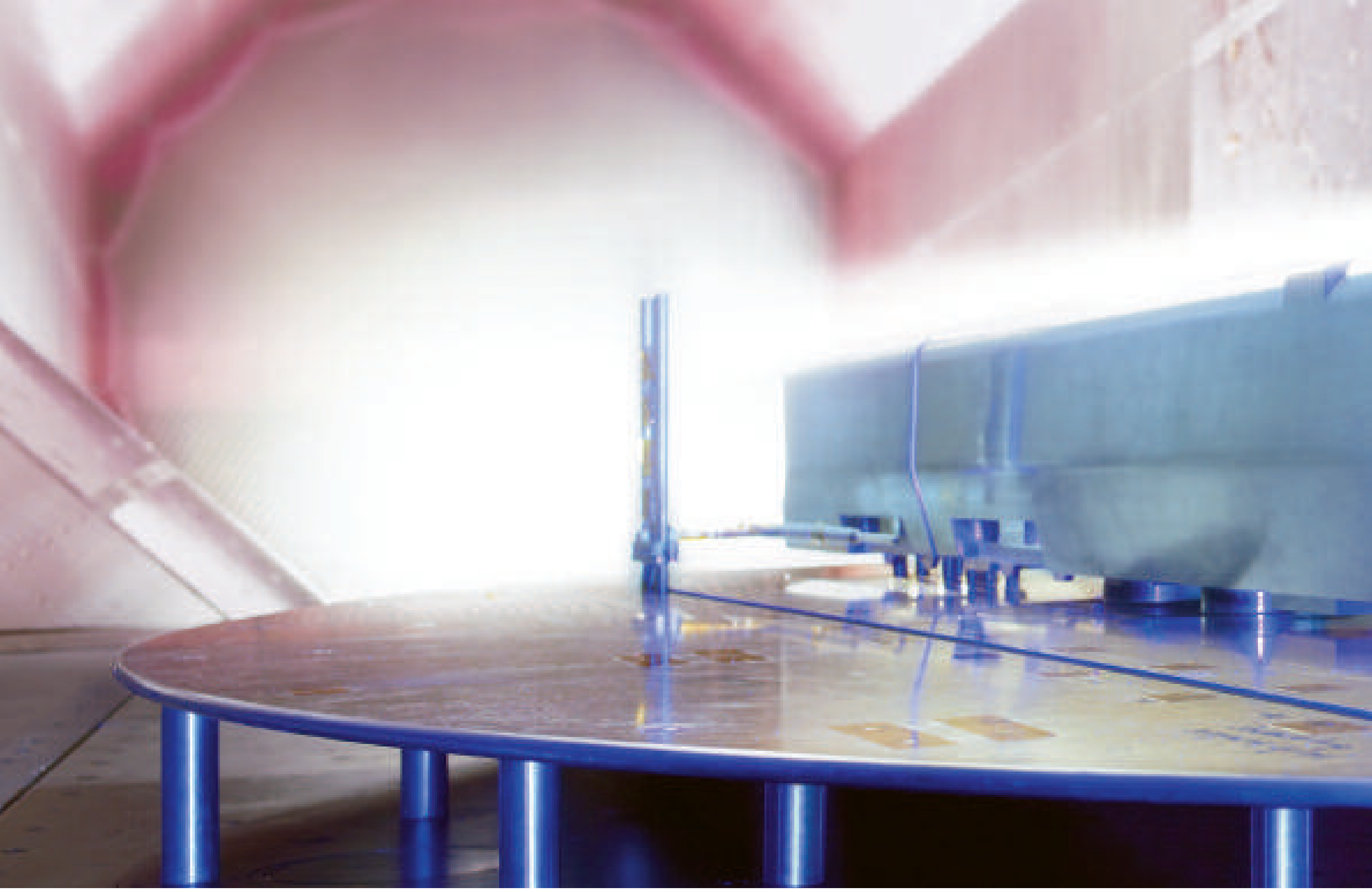
The Train of the Future is Light and Fast – and, Above All, Safe

By Sigfried Loose

Safely operating rail vehicles means taking numerous components into consideration. The vehicle is naturally the first aspect. However, there are also the passengers, staff, residents, other vehicles, and, last but not least, the infrastructure to take into account if new materials and production techniques are to be introduced. Contemporary means of transport have to satisfy both economical and ecological requirements. These invariably require the use of lightweight materials. At the same time, the demand for short traveling times is also to be taken into account. For the next generation of rail vehicles, this means that the vehicles need to be lighter and be operated at higher speeds with greater acceleration. With the project "Next Generation Train," DLR scientists are tackling this challenge while making sure that safety is not left along the wayside.



The train of the future
in the wind tunnel



THE LATERAL FORCE ON THE VEHICLE AND LIFT COULD RESULT IN AN UNWANTED CHANGE IN THE LOAD BALANCE

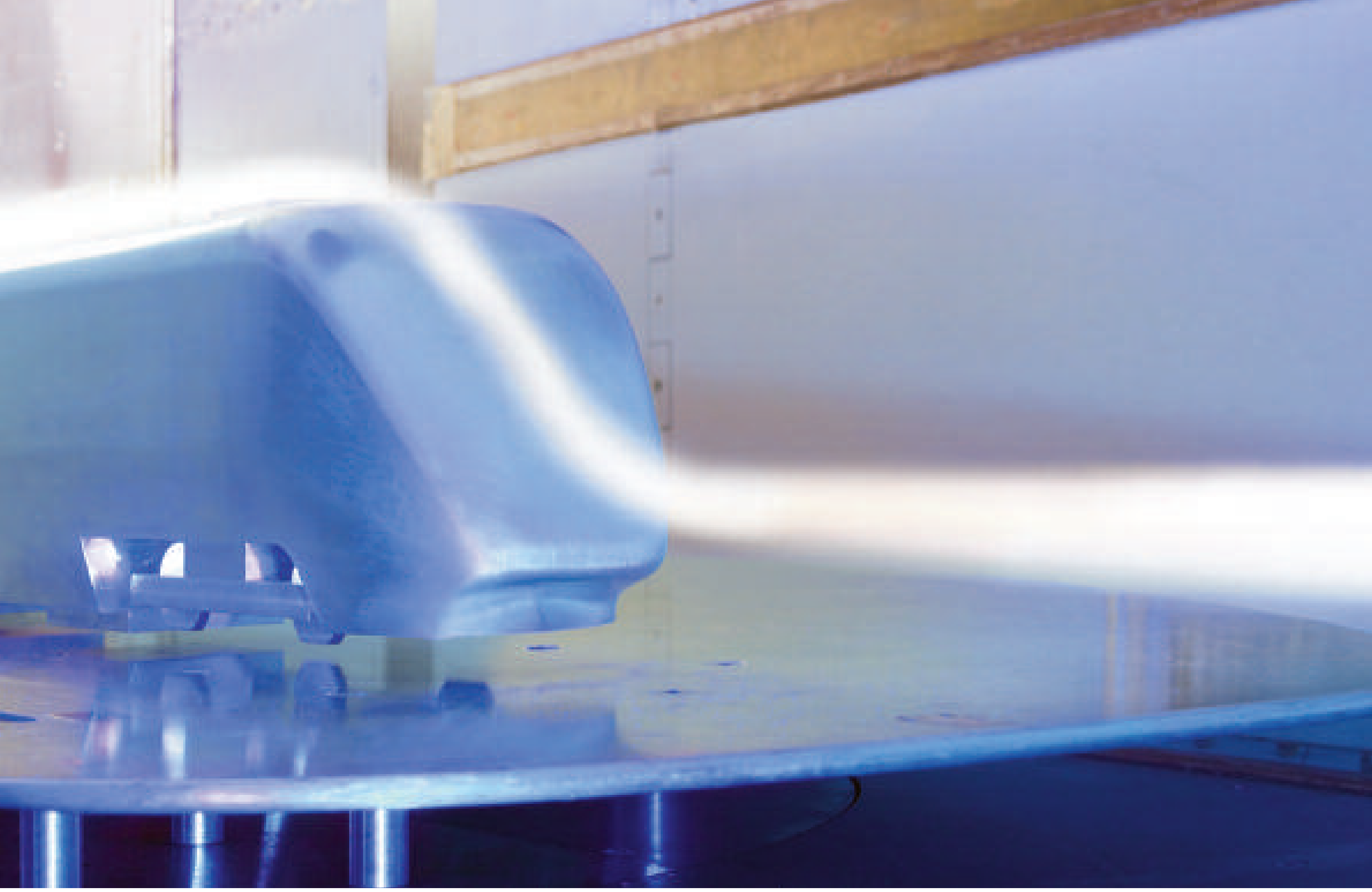
For a new lighter and faster train, above all stability against crosswinds needs to be examined from the point of view of safety. The higher the speed and the lower the weight of the train (in particular the traction unit), the more problematic is the susceptibility towards crosswind. The developers and, in particular, the aerodynamic engineers working on the use of a control car (without drive) for the transition from the first to the generation of high speed trains in Germany (ICE 1 to ICE 2) especially had to deal with this problem. The change that was made from the classical locomotive drive train to the rail car concept (distributed drive system) for the transition to the last generation of high speed trains, the ICE 3, further intensified these issues.

The crosswind that impacts on the vehicle and the lift it experiences from the diagonal airstream force resulting from the crosswind can, in particular, lead to an unwanted change in the load balance of the leading pivoted bogie. That is unless these forces and the resulting momentum are compensated by more weight or through forces that are induced by aerodynamic control surfaces.

Due to their weight, existing fast trains manage with relatively small passive (immovable) spoilers. If the weight of the trains is significantly reduced through lightweight construction (30 percent would be conceivable here), this would no longer be enough. Forces and momentum will also have to be controlled by active control elements in order to be able to safely operate the vehicle at all times and all circumstances.

In order to design and draft these control elements and processes you need to be precisely familiar with the transient flow field surrounding the train. In principal, the experimental and numerical tools that exist today enable a precise analysis of these time-dependent and partly time-limited occurrences. However, the use of special experimental facilities is necessary in order to gain an as realistic as possible simulation of the actual flow field. Highly precise simulations of the driving dynamics need to expand this procedure in order to arrive at reliable statements about the expected real behavior of the vehicle.

At DLR, extensive experimental investigations are being carried out

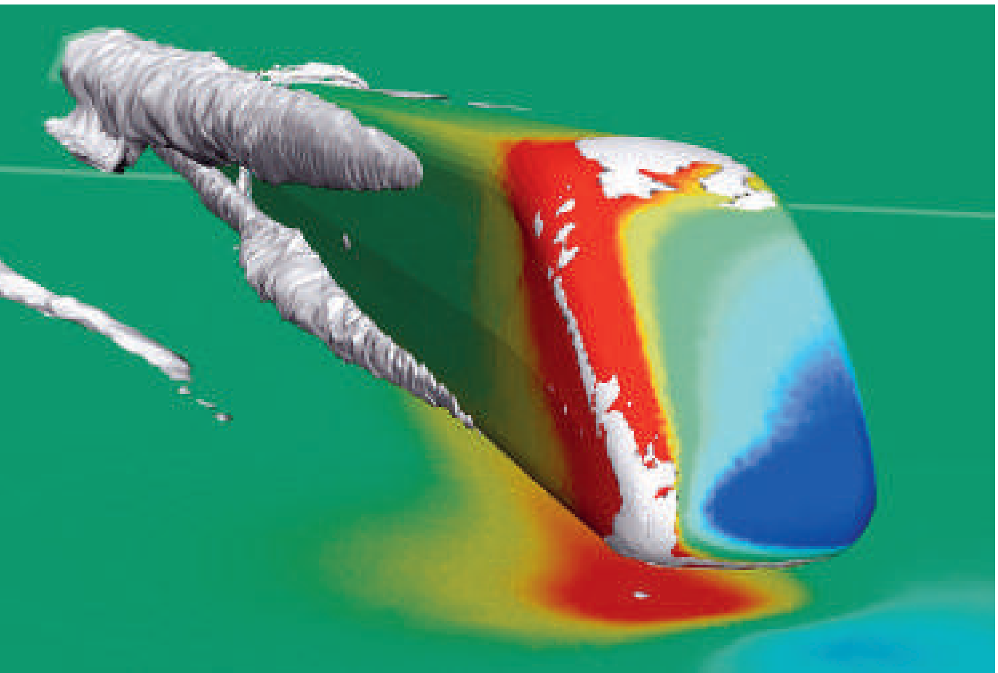


in various experimental facilities. Detailed numerical calculations are also being carried out. The turbulence structures of a generic train model subjected to incoming streams of strong crosswind force were studied in the cryogenic wind tunnel of the German-Dutch wind tunnel (DNW) in Cologne-Porz.

It was examined how the turbulence structure resulting from the surrounding airflow impacted on the time-related development of the forces and momentum. This turbulence structure can then be reduced by influencing the flow field in a targeted manner.

Another important issue is the impact of the vehicle on its environment. The issues that are being researched here include tunnel transits (pressure waves), the slip stream that is dragged along with the train, the head wave, and vehicle-track system interactions. When passing through tunnels, an increase in traveling speed causes the pressure wave amplitudes induced by the train to significantly increase.

This increases the mechanical strain on the components and structural elements of the vehicle and on the tunnel system. It also means a vital problem for the maintenance personnel of tunnel systems. The amount of the pressure amplitude which can be expected mainly scales with the train speed, the head shape and head length (design parameters), the tunnel cross-section, the tunnel length, and the composition/geometry of the tunnel (gravel, surfaces, etc.).

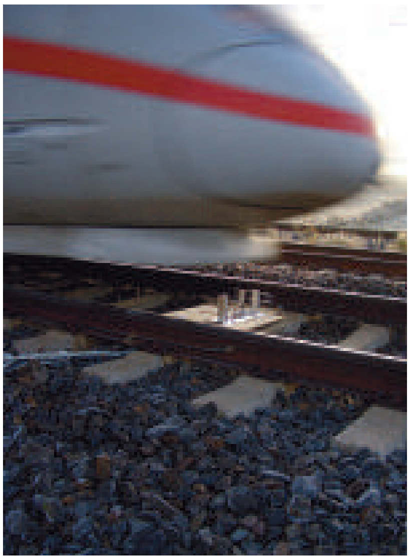


Numerical flow field calculation of a generic high-speed train with crosswind influence; the pressure is colored coded. Clearly identifiable: the leeward turbulence structure.

With the design, in other words the shape of the rail vehicle, it is possible to influence the behavior of the train when passing through tunnels and the pressure waves that are caused. Another possible method of influence is to change the geometry of the tunnel.

However, this second option is quickly reduced as infrastructural requirements determine these parameters to a large degree. With regard to the environment, the impact of the pressure waves consists of highly varying mechanical loads. These can result in damage to or even destruction of the tunnel infrastructure. A phenomenon which is equally to be taken into account is the so-called slip stream, a boundary layer dragged along by the train. Through the movement of the rail vehicle, air is displaced which, in combination with the boundary layer that forms around the vehicle, is manifested in a complex three dimensional flow induced by the vehicle. You are exposed to this flow when you are in the proximity of a passing train. When trains drive through train stations, the slip stream can be felt as a sudden gust of wind. The forces exerted by the flow field of the vehicle on the people are scaled with the flow speed, which is in turn dependent on the distances of the people to the train. The flow field that is induced by the train is determined by the length and speed of the train, the composition of the surface and the shape of the train, the type of train (passenger train; freight train; double-deck train, etc.), the local wind, and the environmental conditions.

ANOTHER IMPORTANT ISSUE IS THE IMPACT OF THE VEHICLE ON ITS ENVIRONMENT



Transit of a high-speed ICE 3 type train over a sensor-equipped panel for determining the speed and pressure field in the undercarriage area of the train.

In combination with the so-called head wave – the pressure wave caused by the train – this flow which is induced by the train harbors a latent potential for danger. If the traveling speed is increased or if double-deck trains are used, this potential danger increases. This critical problem must be taken into account when designing the vehicle. A surface which is as smooth as possible and has no gaps will have a positive effect on the development of the induced speeds. Particular value must be placed on analyzing the wake of the vehicle. With the existing vehicles, this is what causes the highest speeds.

Further vital questions for both the vehicle and for the infrastructure and other vehicles concern vehicle-track system interactions. Depending on the composition of the track and the configuration of the train, "whirlwinds" of gravel stones may result from the gravel bed.

These stones can cause serious damage to the vehicle, the infrastructure, and to other vehicles. The decisive influential parameters here are the composition of the undercarriage, the clearance height, the speed, as well as the condition of the infrastructure and/or the track bed.

The same applies for dealing with this problem as mentioned above: Without being familiar with the time-dependent flow field, it is difficult to find solutions. To this end, DLR is developing a measuring system in the track bed for the transit of a French "Thalys" -type high-speed train. The work is being carried out in cooperation with the company Bombardier on various European high-speed sections in Germany, Spain, and Italy. The ground clearance and speed of the train are generally fixed parameters; the infrastructure can only be altered on a wide-scale in the very long-term.

The composition of the vehicle's undercarriage is also subject to numerous requirement profiles. A dynamic design requires that certain components must be affixed due to the required weight distribution in the undercarriage area. However, this can potentially lead to the ground beneath the train becoming highly fissured, which in turn creates conditions which will cause gravel to be sprayed into the air.

As part of the DLR project "Next Generation Train," solutions will also

In the control room of the cryogenic wind tunnel of the German-Dutch Wind Tunnels (DNW) at the DLR in Cologne-Porz: The behavior of generic train models under the influence of airflows is analyzed.

be found for this problem over the next few years. It will be a long time before all the questions have been answered for the lighter and, at the same time, fast train of the future. However, with the results of the DLR researchers there is one thing it will certainly be – aerodynamically safe. Without too much of a stir.

Author:
Sigfried Loose is a researcher at the Institute of Aerodynamics and Flow Technology in Göttingen. For many years he has been investigating the special problems posed by aerodynamic rail questions and is in charge of the project "Next Generation Train," which was launched in January 2007.

STRATEGIC PARTNERSHIP WITH BOMBARDIER TRANSPORTATION

By **Dr. Tjark Siefkes**, Senior Director Product Development, Centers of Competence and Knowledge Management of Bombardier Transportation GmbH

Rail is by far the safest form of transport and ensures environmentally friendly transport from A to B. However, we should not be complacent with what we have achieved today if we want to ensure sustainable mobility in Germany. We therefore need to firstly improve the performance and attractiveness of rail transport and secondly improve energy efficiency and resource conversation.

Bombardier Transportation chose DLR as its strategic research partner because it brings with it ideal requirements: proven competencies, many years of experience, interdisciplinary working approach and the necessary scale to be able to successfully overcome the enormous challenges in the rail transport sector. Our experiences so far through our cooperation with DLR are extremely positive and provide a fruitful basis upon which we can jointly build on, for example, with the project "Next Generation Train."

STOPPING SAFELY

Doors and Brakes as Objects of Scientific Analysis

By Dr.-Ing. Michael Meyer zu Hörste and Matthias Grimm

Whenever you undertake a journey, you always have a story to tell. If you travel by train, you might talk about the new comfortable train or, occasionally, about delays. But that is not all that happens during a train trip. We barely notice brakes and door movements, which is why we never talk about them. This is not the case for the engineers at DLR who are researching into safe rail travel.

Nowadays, when we travel by train we rely on the fact that all technical systems on the train are entirely reliable. We assume that the doors will function even when there is ice, snow, or extreme heat.

What is more, we presume that the systems will react according to the respective situation. If the door did not open during a fire, our escape route would be blocked. If the doors are suddenly closing during a standstill of the train, this could injure the passengers who are entering and exiting the train.

The brakes are also a critical component of the train. They must be able to stop the train in all situations and this faultless function is assumed in the Train Control System. Systems, such as the European Train Control System (ETCS), which control the speed of the train, can only do this if the brakes are working.

However, most passengers are unaware that the brake system on modern rail vehicles is highly complex. Up to ten different systems can trigger the brakes. Numerous brake components then carry out the process of braking. Each of these "sub-brakes" is able to slow down the train and bring it to a safe standstill. "A safe condition is when the train has stopped," describe the train experts, indicating that they always have a final way of reacting to a malfunction. Unlike aviation where the safety requirements are similarly high, bringing the train to a standstill is a safe alternative in rail travel.

For a passenger train carrying around 400 passengers and a braking distance of, for example, four kilometers at a speed of 300 kilometers per hour, the consequences of an insufficiently functioning brake would be devastating. As a result, new systems and components are intensively tested for approval and checked for safety-critical points.

DLR contributes towards this with its train laboratory "RailSiTe." The rail laboratory provides the facility to analyze systems, sub-systems, and

components of railway control and safety systems as well as operating concepts. At the same time, it helps to introduce new technologies more quickly by developing methods and tools for testing safety. One of the methods is safety analysis. Their results must confirm that the system safely fulfills its task under all conditions. The procedure developed by DLR is comprised of a series of consecutive modules that are to be worked through. In the first step, it is investigated what functions the system – in this case the brake – fulfills.

This sounds easier than it is as the brakes can carry out various forms of braking: routine operational braking, emergency braking, fast braking and braking in the event of danger. A self-test and starting interlock also form part of the repertoire. In the next step is then analyzed how these functions are carried out. The procedure used by DLR fulfills the conditions of the current standards for such analysis. In addition, a Failure Mode and Effects Analysis (FMEA) can be performed for a specific part or the entire system. This is a standardized procedure for analyzing in detail what technical errors and failures lead to what effects and consequences. RailSiTe can also help here.

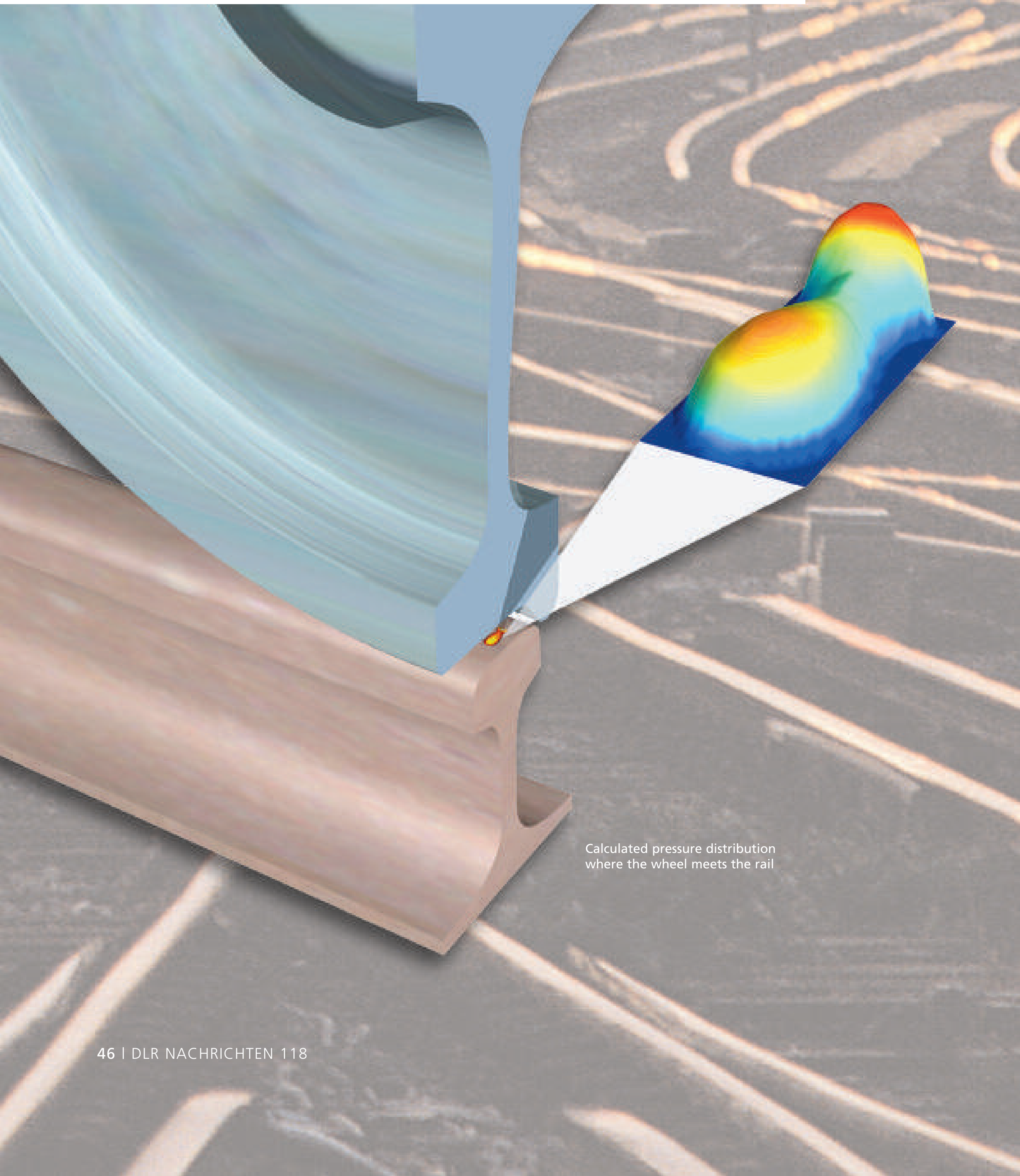
For certain components, the effects of errors and failures can be evaluated using simulations. As an independent, neutral institution, DLR also acts as a partner for the approval of rail vehicles. Once all of the documents have been filled out and checked again, they are passed on to the approval authority. In Germany, this is the Federal Railway Authority (Eisenbahnbundesamt – EBA). At the Federal Railway Authority, the start of operation of the vehicles is approved. This also certifies that the doors and brakes meet safety requirements. And that's something we can rely on.

Authors:
Dr.-Ing. Michael Meyer zu Hörste and Matthias Grimm are researchers at the DLR Institute of Transportation Systems in Brunswick.

SMALL SURFACE, BIG EFFECT

Better Performance for Wheels and Rails

By Dr.-Ing. Andreas Heckmann



Calculated pressure distribution where the wheel meets the rail

It's hard to believe it but the forces that keep a rail vehicle on track are transmitted between the wheel and track over a contact surface of approximately one square centimeter in size. Figuratively speaking, the surface area of a thumbnail per wheel is enough to resist the aerodynamic drag or crosswinds and simultaneously support up to ten tons of vehicle weight! A traction force of only 100 Newton per wheel is enough to overcome friction and move a rail vehicle.

Form, position and force distribution of the contact surface are of course not at all constant in operation but are influenced by the complex interaction of a multitude of factors and components. This context is comprehensively described as the wheel-rail system. It comprises cargo loads and superstructures, the undercarriage, the drive train and brakes of the rail vehicle, track system and line, aerodynamic drag and side forces and many other factors. Analyzing such complex systems with regard to derailing safety, stability in the high-speed area and exposure to the influence of crosswinds is no longer imaginable without computer simulation. For this purpose, a special calculation technique, the multi-body simulation, was adapted and advanced at the Institute of Robotics and Mechatronics at DLR in Oberpfaffenhofen. Since the early 1990s, this technique has been implemented in a simulation tool which is used by the majority of rail vehicle manufacturers today.

HERE, A LOAD OF 8,000 KILOGRAMS PRESSES ON AN AREA THE SIZE OF A THUMBNAIL

However, as is often the case in technology, a standstill means taking a step backwards. The requirements demanded of modern rail vehicles are growing. Goals, such as CO_2 reduction, energy efficiency, high speeds, improved relation of cargo load to total weight, improved comfort, and reductions in noise and wear, are all increasing in importance.

The paramount task of guaranteeing passenger, crew and resident health and safety only becomes more difficult in the light of these new requirements. Higher speeds mean higher loads on the drive train, undercarriage and brakes. Lightweight structures tend to be affected by vibrations which increase due to higher dynamic loads in the entire wheel-rail system. The result is more wear of the wheels and rails, which again increases vibrations. This reveals that a complex system can only be analyzed and optimized in its entirety.

The key to driving safety, however, lies precisely in the forces that directly keep the rail vehicle on track. These are the forces of the wheel-rail contact. This is also where wear and tear is created. The diameter of a rail vehicle's wheel diminishes by between 1 and 10 millimeters per 500,000 kilometers of distance covered. The costs entailed by maintaining the vehicles and track infrastructure form the biggest part of the expenditure for any rail operator. Additionally, the wheel-rail contact is the cause of rolling noise which defines the noise emissions of rail vehicles. DLR thus develops methods that enable a more precise depiction of wheel-rail forces in computer-aided driving dynamics simulation for the next generation of trains. The central approach is the description of the elastic properties of the wheel set and the track, which lead to the fact that these individual bodies in themselves already are vibration-capable partial systems.

The realistic computer simulation of wheel-rail forces creates a technology which is close to practice and which will pave the way for the optimized construction of the overall system and its monitoring in operation. This will ultimately lead to safer, more wear-resistant and quieter rail vehicles.

We can thus ensure that the wheel-track technology, which was already used in 16th century mining for transporting goods more safely and more efficiently, remains on the right track with regard to the demands of the 21st century.

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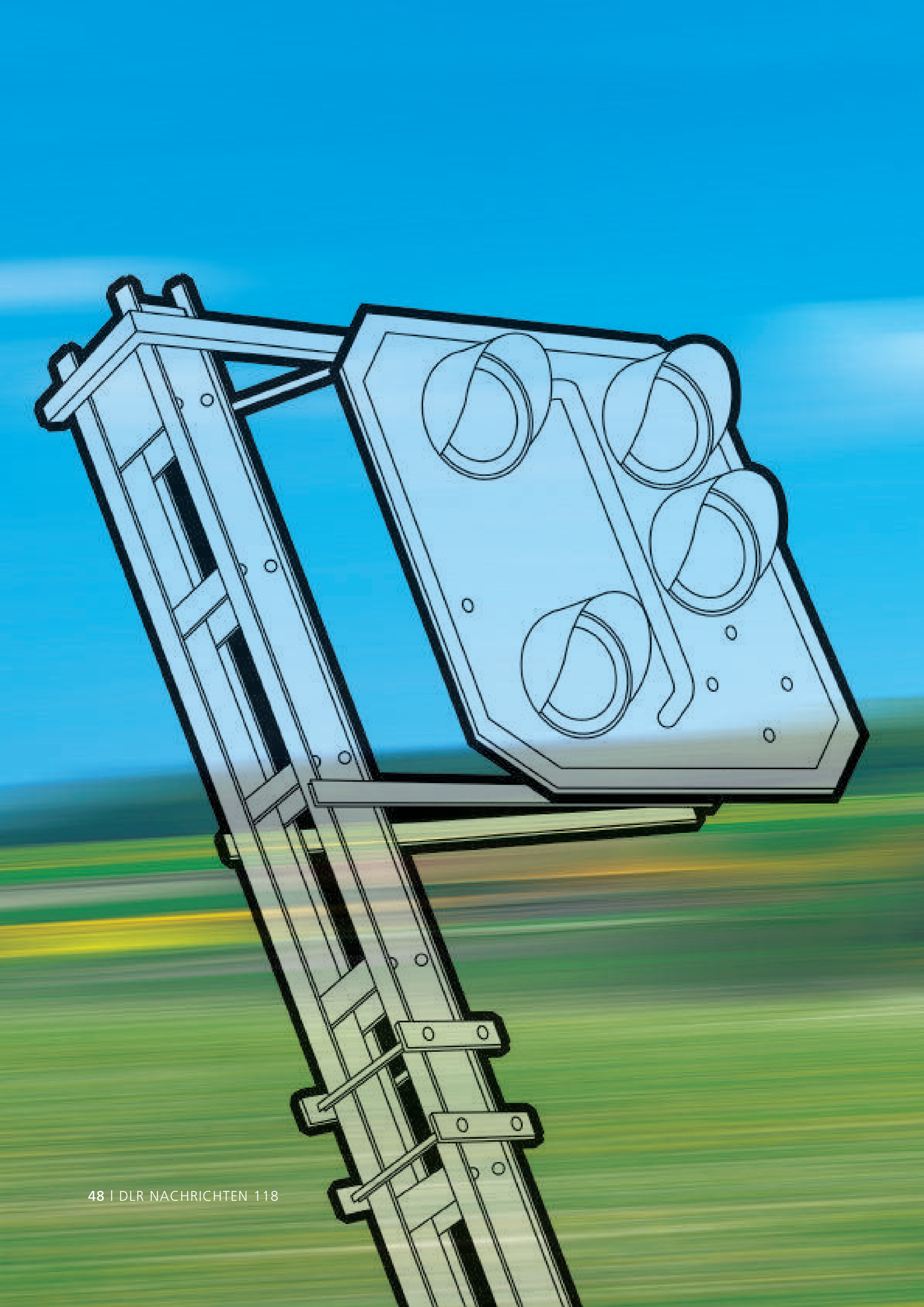
Dr.-Ing. Andreas Heckmann is a research associate at the Institute of Robotics and Mechatronics of the DLR in Oberpfaffenhofen and is jointly responsible for the project "Next Generation Train."



RAIL TRAVEL WITHOUT BORDERS

The harmonized European Train Control System ETCS simplifies traveling around Europe

By Dr.-Ing. Michael Meyer zu Hörste

Sometimes traveling by train is like flying. In high-speed trains we rush from one European metropolis to the next, gliding along without jerking or jolting, practically floating – until braking suddenly interrupts the journey shortly before reaching the bordering country. Time to stop at the border. While we are looking out of the window, perhaps already feeling impatient because of the obligatory stop, the on-board computer and the sending and receiving components of the traction unit are at the peak of their performance. The place where coal and water once had to be refilled in the past has now been replaced by a small data processing center. Sometimes even several of them are necessary if the bordering country has developed other processes and technologies when modernizing its railway system, requiring cross-border traffic to carry systems from both countries. The alternative would be to exchange the complete traction unit. – Or a standardized safety system needs to be established – an issue that DLR scientists are currently working on. And this is far more complicated than we would like to think.

RailSiTe Railway Laboratory

In the RailSiTe laboratory in Brunswick, the entire range of railway system operations can be simulated. The complete chain from the interlocking to control and safety technology right through to the traction unit is represented. This simulation system can be used to analyze new technical systems and components as well as new operational concepts.

Test facilities for ETCS onboard computers constitute the core of RailSiTe. This core is supplemented by the simulation of an electronic interlocking, track-side and on-board train control systems and a driver control console. The operating context is thus emulated from the signaler right through to the driver. Trackside and on-board train control devices can be connected virtually to RailSiTe or as an actual original system. Its interoperability (interaction with other systems, even from different manufacturers) and conformity (compliance with current standards) is predominantly tested. As a sub-contractor of the "Interoperability" notified body by Railway-Cert (EBC), DLR also supports industrial partners with its RailSiTe in the approval process for new systems.

RailSiTe features a mobile laboratory – the Rail Driving Validation Environment, "RailDriVE" for short. This road-rail vehicle, which is capable of driving on both roads and rail, serves the purpose of practically testing sensors for distance measurement and the positioning of trains. It is examined, for example, how GPS and radar can be deployed for railway control and safety systems. By means of a common computer concept, the data obtained with RailDriVE can be used directly in RailSiTe.

Oliver Gantz, DLR Institute of Transportation Systems, Brunswick

Train control systems have been used in Europe since the 1930s. Different approaches were adopted in the various European countries, making the continent resemble a patchwork blanket as far as train systems are concerned.

ETCS MAKES IT POSSIBLE TO TRAVEL IN OTHER COUNTRIES WITHOUT ANY ADDITIONAL TECHNICAL EQUIPMENT.

In Germany, non-continuous and continuous train control systems (PZB and LZB) are used. Typically every nation deploys one to two systems throughout the country. For cross-border travel, this means either exchanging locomotives at the border or using special traction units which are equipped with the two respective country systems on both sides of the border. The consequences? A stop at the border and increased costs for vehicle equipment.

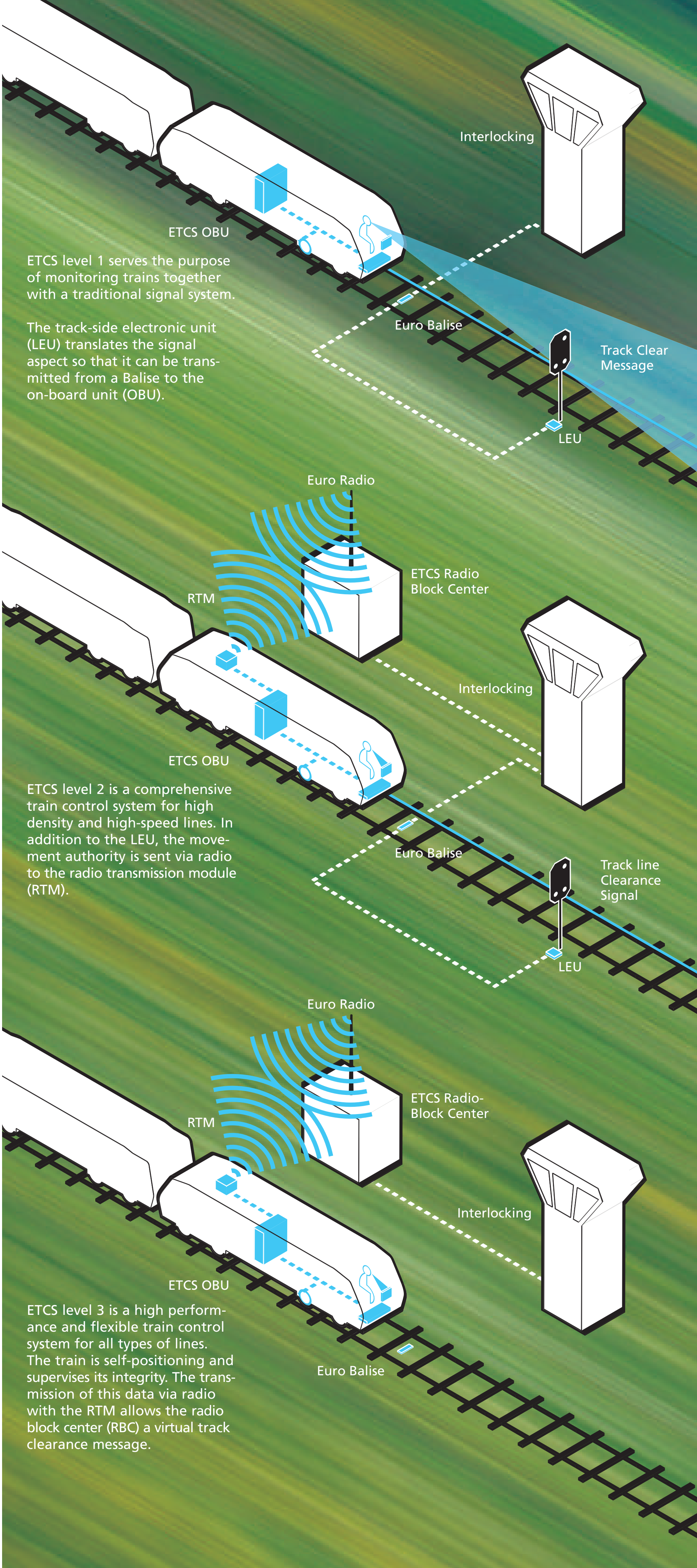
It is now nearly twenty years that signal engineers have been working on the European Train Control System (ETCS) project. With ETCS, it is possible to use trains from one country in other countries without any additional technical equipment. This feature is called interoperability. As a first step, technical compatibility – also referred to as technical interoperability – will be introduced. A common body of rules and regulations encompassing the so-called operational interoperability will then be agreed.

The basic idea of the common system is that an on-board computer receives information about how fast the train is allowed to travel at a certain section of its route and how far it may travel. Combined with other relevant data, for instance gradients or tunnels, this authorizes a passage approval.

Transponders built into the track – so-called Balises – serve as “electronic milestones.” With their help, the train can determine its position. ETCS is being implemented in three stages: In stage 1, traditional signals indicate to the train driver whether he needs to brake or can continue his way. In stage 2, passage approvals and all related data is visualized on a display in the locomotive. In stage 3, the train reports its position and integrity via radio, rendering superfluous the traditional systems for reporting “track clearance.”

One of the first routes where ETCS has to prove its worth in an operational test is the freight traffic corridor from Rotterdam to Genoa. The ETCS equipment will be installed all the way from the Netherlands, passing through Germany and Switzerland, right through to Italy. This will form a practical test for the systems from different manufacturers – they need to prove that they are actually compatible both on the route and on the trains.

The European Commission is promoting the introduction of ETCS with two directives: Directive 96/48 requires the deployment of ETCS on high-speed tracks while Directive 2001/16 demands this for conventional tracks. The technical specifications of interoperability (TSI) put the requirements into precise terms and bindingly define the extent of the system specifications. The development and production of ETCS has been taken on by six signal technology suppliers who write these system specifications under the name of UNISIG.



Within the framework of approval for new ETCS components it has to be proved that both the system specifications and the implementation correspond with the TSI. This correspondence is defined as conformity and serves as proof of technical interoperability. More than 70 test sequences are used for this, which are composed of numerous test cases. They have been published by a European working committee and by the European Rail Agency (ERA).

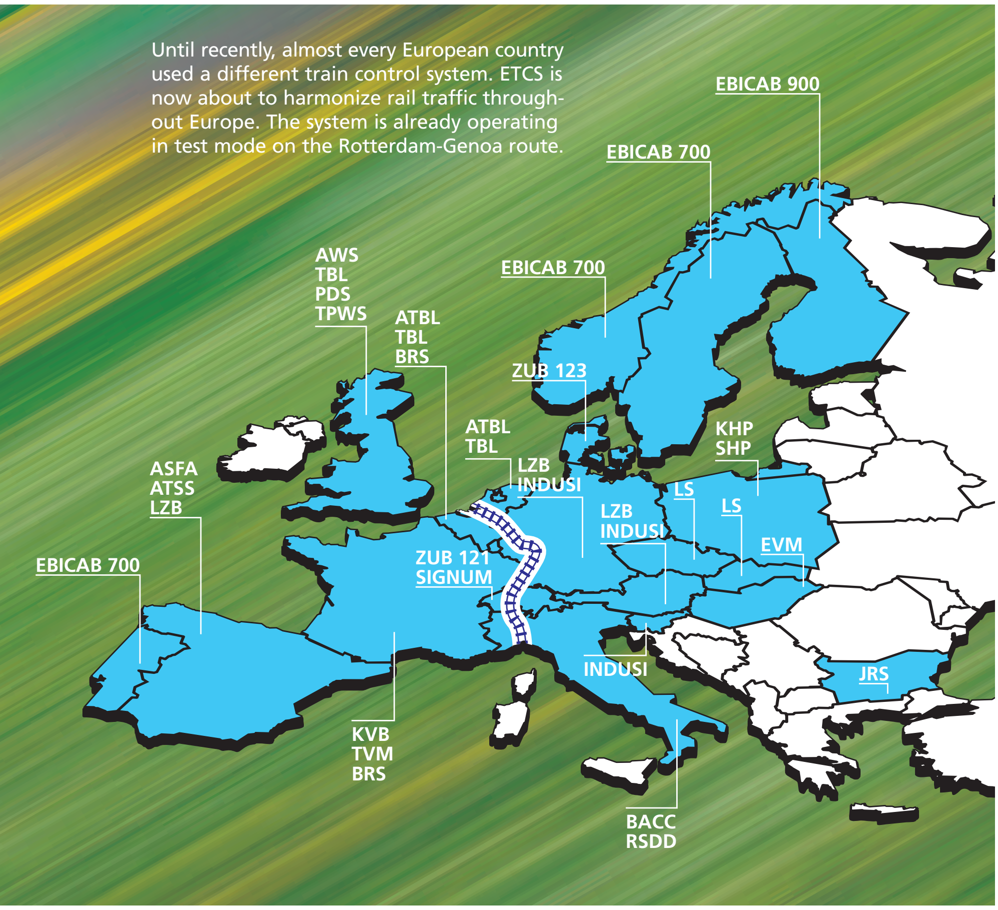
DLR scientists and engineers are working on developing and controlling these laboratory tests. DLR is the only German research institute assigned with defining the test cases and sequences. The methods used by all partners for developing these results also come from DLR. Apart from test sequences for the on-board unit, the laboratory test environment was also specified with the substantial involvement of DLR.

DLR IS THE ONLY GERMAN RESEARCH INSTITUTE ASSIGNED WITH DEFINING THE TEST CASES.

Such a laboratory was subsequently implemented at the DLR institute in Brunswick. The RailSiTe (Railway Simulation and Testing) is an ETCS reference laboratory based on currently valid specification. The RailSiTe and the "Laboratorio de Interoperabilitad Ferroviaria – LIF" (Laboratory for Railway Interoperability) at the CEDEX research institute in Madrid are the only laboratories of this kind in the world. In Germany, Eisenbahn-Cert (EBC) is the "notified body for interoperability" and is responsible for the approval of ETCS equipment. Since 17 September 2004, as a subcontractor of the "notified body," the Institute of Transportation Systems, including the railway laboratory RailSiTe, has been certified for the analysis of conformity and interoperability for ETCS – a worldwide first accolade.

Before a device for technical safety, e.g., an ETCS vehicle device, can be put into operation, approval is required from the authority responsible for safety. The ETCS certification consists of two parts: It must be demonstrated that the device complies with the safety regulations of the railway system. The device also has to be compatible with other ETCS systems from all other manufacturers. It therefore needs to correspond with the European specifications and be technically interoperable. This is ascertained by a conformity test with the aid of defined test sequences in a recognized, neutral laboratory such as RailSiTe.

In the test, the ETCS vehicle device is mounted on to a rack together with all the necessary components. An entire vehicle equipment system is thus assembled in the smallest of spaces, complete with an ETCS vital computer, GSM-R receiving unit, Balise antenna, juridical recording



Until recently, almost every European country used a different train control system. ETCS is now about to harmonize rail traffic throughout Europe. The system is already operating in test mode on the Rotterdam-Genoa route.

unit and display. In Brunswick, it is connected to the RailSiTe simulation environment using standardized European interfaces. Here, the device has to pass more than 70 defined test rides without errors in order to obtain ETCS conformity.

A simulated test ride of this nature involves a list of messages that the device receives via GSM-R or Balise together with entries that the driver has to enter on the visual display unit.

Test sequence no. 22, for example, is composed of the following steps:
- Starting situation: Traction unit and ETCS-on-board unit are switched off.
- The ETCS on-board unit is switched on, performs a self-test and switches into stand-by mode.
- The driver enters his identification number and the train data.
- The on-board unit receives a passage approval with full monitoring via radio from the radio block center.
- The train starts and travels approx. 900 meters at a speed of 30 kilometers per hour.
- At this position, the train movement ends and will be continued as shunting movement. The train requests the necessary permission and receives it via radio.
- The train will then drive approximately one kilometer in shunting mode.
- At the end of the shunting mode phase, the train stops and the ETCS on-board unit is deactivated.

The test run defines in 163 single steps and 26 messages when, at which kilometer of the route, what message is to be transmitted to the ETCS on-board unit and how the device is required to react. The RailSiTe generates this message and transmits it to the test subject. The subject generates a reaction and transmits it to the RailSiTe. This reaction is compared with the required reaction. Only if the correct reaction is performed at the right time can the device be used in operation – it then "conforms with specifications". A test report finally confirms that all tests have been passed successfully for this device. The EBC issues a certificate. Only then it may be used for cross-border operation.

The ETCS unit can then be used on trains running, e.g., from France to Italy via Germany and Switzerland. ETCS continuously guarantees safety, even though the signals look different. In this way, DLR is contributing to the fact that just like plane passengers today, train passengers will not notice when they cross a border.

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Information:
www.ERTMS.com

NEW FRONTIERS FOR TRAINS

DLR is a partner to railway vehicle supplier of Alstom

To be mobile in the city and region – Alstom LHB GmbH responds to this need by supplying modern railway vehicles which efficiently integrate into the concepts of railway traffic services. Regional city railways from the Regio Citadis product line, for example, are equally suitable for the urban or regional railway network. It sounds simple, but this is far from being the case. And this is where DLR's competence comes into play. If regional city railway vehicles are to use the present infrastructure and save costs, then the technical implementation and operational concept for these vehicles have to meet the requirements of both the regulations for city railways and those for standard railways. The rules and regulations of these usually entirely separated railway networks are partially based on contradictory safety philosophies. Safety analyses therefore need to venture into unknown territory.

The order volume for DLR consisted of complex analyses of errors, potential and influences according to DIN 25448 standards for safety-critical vehicle functions. A safety concept that complies with VDV Regulation 161 also had to be developed for the vehicle. This needed to be accompanied by an elaborate analysis of all electronic vehicle functions. DLR performed studies on specific areas which represent important elements for the verification of safety technical aspects. The success of the cooperation provided the impetus to continue the partnership between Alstom and DLR with regard to the regional trains from the Coradia Lirex product line for Deutsche Bahn AG.

FROM TRAIN TO TRAIN

Distributed Situation Awareness for Safe Rail Transport

By Prof. Dr. Thomas Strang

Evening news, 8.00 pm. Following the news on political developments in the world, a serious collision of a train with a construction vehicle is reported. A few days ago, there was an almost identical report: A regional train collided with a car at a railroad crossing. Why can collisions of this nature still happen today, especially given that the Europeans proudly refer to the high investments in the safety of their technology? Scientists at three different DLR institutes are investigating this question.

The cause of train collisions is frequently attributed to a "chain of unfortunate circumstances" or "human error." And this is exactly the crux of the matter: Serious accidents often have a highly complex pattern of faults. Simple cause-effect scenarios are covered by infrastructural or operative measures. They guarantee to a large degree that dangerous situations are identified and avoided.

It is impossible to entirely avoid situations that nobody has ever thought of, but which could develop into catastrophes. Humans continue to be the greatest element of uncertainty.

How can accidents be avoided? This is one of the questions to which transport research is dedicated at DLR. In the area of trains, an entirely new approach is being investigated. At the core the basic assumption is made that there will always be situations where even the most sophisticated safety functions will not be effective.

The scientists are thus not concentrating on further improving the infrastructure or operative processes. Instead they are investigating how collisions can be avoided through additional "awareness," or, more specifically, awareness-creating measures. At the end of the day, it is once again humans who are last in the chain of events in the form of the driver.

It actually sounds quite simple: As soon as the driver knows what awaits him on his route, he can react. For the driver of a train this generally means braking. There are no other options in situations such as a construction vehicle in the middle of the track section which had in fact been exclusively cleared for the train.

Broadcasting and analyzing traffic situation information in a distributed manner in trains is therefore the way to a solution. For this, a robust and reliable radio communication proce-

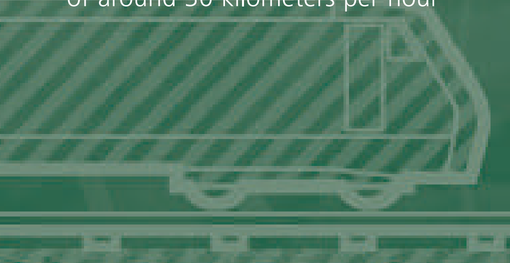
Ad-Hoc Properties, Vehicular Ad-Hoc Network
A Vehicular Ad-Hoc Network (VANet) is a mobile ad-hoc network whose nodes are vehicles. Important properties are the self-organization (no special configuration required before a connection is established) and decentrality (there are no central control nodes). A VANet must fulfill special requirements that are derived from its field of use. The nodes of a VANet move at different but potentially extremely high speeds.

Connection-Oriented Communication
Before data can be exchanged with aid of a communication connection, the connection first needs to be established and then disconnected after successful transmission. The advantage of connection-oriented communication is the direct addressability of the recipient and the possibility of deploying error-correcting measures. The main disadvantage is the additional time for establishing a connection and disconnecting.

High-Speed Train Network
Almost continuous double-track railroad network with typical speeds of over 160 kilometers per hour

Regional Train Lines
Mostly single tracks with typical speeds within a range of 80 to 160 kilometers per hour

Shunting Yards
10 to 40 parallel tracks, typical speed of around 30 kilometers per hour



dure is necessary with what are referred to as "ad-hoc properties." They are particularly important because neither can a central control component take over the coordination of all communication connections nor is there enough time in practice for connection-oriented processes. For other means of transport (aviation, shipping), similar concepts for avoiding collisions are already daily practice.

This communication principle also has the big advantage that no investments need to be made in the infrastructure, as for example for the introduction of the rail-specific variant of the mobile network GSM-R. A migration scenario, in other words, a scaled, step-by-step introduction of the system, also already exists. All trains that are equipped with the necessary technology can analyze the received traffic situation information and cross-reference it with information about the train's own route in order to provide a warning of any potential danger situation. All trains that have not (yet) been equipped with this technology can proceed in accordance with the present (infrastructure-based) safety standards.

By following this so-called "Safety Overlay" concept, none of the present safety systems is replaced. Instead a complementary system is being added. This can also become the primary safety technology due to economic considerations if other, infrastructure safety technologies are too expensive, for example, in less frequented parts of a regional rail network.

By looking at the deployment scenarios of such a radio-supported infrastructure-less collision avoidance system,

GREATEST BENEFIT ON REGIONAL ROUTES AND IN SHUNTING YARDS

it is clear that the benefits do not lie primarily with the high-speed rail networks. With these networks, thanks to largely crossroad-free routes, ultra modern, ETCS-equipped traction units, and other measures, the probability of collisions is far lower than with regional routes or in shunting yards. While the collision impact energy may not be so great in shunting yards due to lower speeds, the overall probability of collisions is higher. As a result, the communication system primarily needs to be designed according to the reaction times of this speed profile.

An analysis suggests that the whole application does not require any connection-oriented communication from train to train. Instead, each train, or even appropriately equipped stationary objects such as the above-mentioned construction vehicle, could transmit their current position, their planned routing, and other data to all receivers in the region (broadcast/geocast). Calculations have shown that the system needs to be designed for at least 500 potentially simultaneously transmitting stations, i.e., trains and other objects, in an area with a diameter of around ten kilometers.

As with any radio transmission system, the dimensioning is closely linked with the issue of the usable frequency range. In addition to the general technical conditions (the propagation conditions of radio signals are, for example, are frequency-dependent), regulatory aspects are equally important here. There are frequency ranges that are already intended for rail operations use (e.g., 460 MHz). Unfortunately, they vary according to global regions and are also dependent on their purpose of use.

INFORMATION EXCHANGE WITH ROAD VEHICLES

DLR researchers and engineers see potential for further solutions in the communication with road vehicles. If, for example, the collision avoidance system for trains could be linked with the standardization of Car2Car communication, which is also be driven forward by DLR, collisions between trains and road vehicles at railroad crossings could be significantly reduced. On average, such small collisions occur in Germany on two out of three days (according to statistics of Deutsche Bahn in 2004).

However, this plan is currently being thwarted by the frequencies that are already being used – Car2Car communication is just being standardized for the frequency range around 5.9 GHz. As part of the European Conference of Transport Research Institutes (ECTRI), DLR has committed itself to the holistic consideration of collision avoidance systems of both means of transport as part of an intelligent transport infrastructure.

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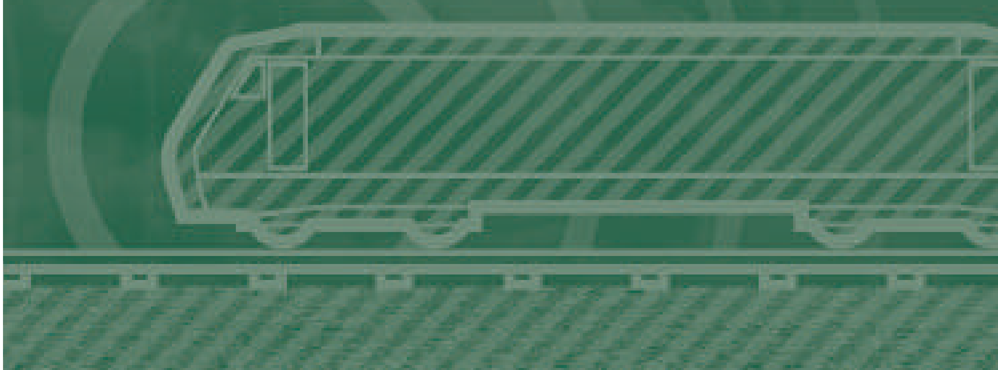
DLR DEVELOPMENT AS PART OF THE RAILWAY COLLISION AVOIDANCE SYSTEM PROJECT

The German Aerospace Center (DLR) is developing a Railway Collision Avoidance System (RCAS), a “safety overlay” system which can be deployed on top of any existing safety infrastructure in train networks. The core idea of RCAS is to broadcast the position and intended track of trains as well as additional data like vehicle dimensions to all other trains in the area using ad-hoc train-to-train communications. This enables train drivers to have an up-to-date accurate knowledge of the traffic situation in the vicinity, and act in consequence. Computer analysis of the received information, the own position and movement vector and an electronic track map detects possible collisions, displaying an alert signal, and advising the driver of the most convenient strategy to follow in order to avoid the danger. The system is adaptive to a variety of situations like advancing trains or road vehicles or obstacles.

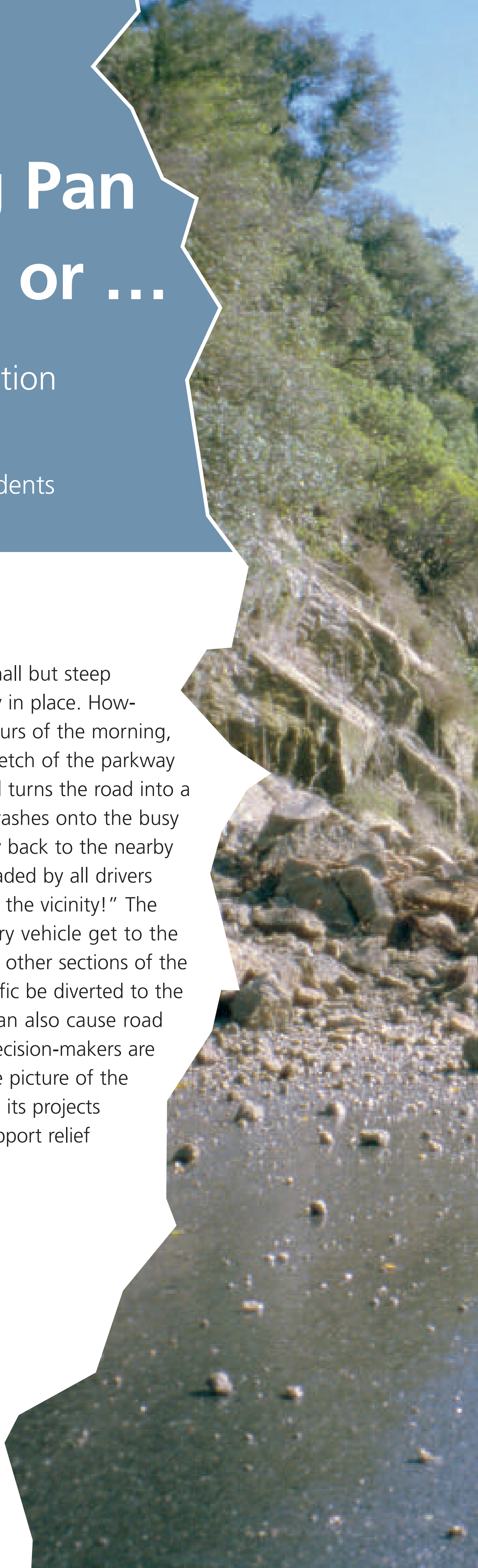
With the scientists at the Institute of Communications and Navigation who are developing the actual communication procedure under rail-specific conditions, scientists and engineers from two further DLR institutes are working on the RCAS project:
The Institute of Transporation Systems in Brunswick answers operational rail questions. It adjusts the jointly developed concept to the general conditions and the operational railway properties and further develops it to the stage of integrating the components in a test vehicle. The team at the Institute of Robotics and Mechatronics adds optical sub-systems to the RCAS system, for example, for monitoring that there are no obstacles on the track.



Out of the Frying Pan and into the Fire, or ...

... the Quickest Way to Your Destination

Keeping an Overview in the Event of Road Incidents Thanks to DELPHI and ARGOS



Overnight, strong autumn rain has badly affected the small but steep slope. The roots of trees have so far kept the soil firmly in place. However, the water keeps washing the soil away. In the early hours of the morning, the roots finally lose their grip. The normally picturesque stretch of the parkway suddenly turns into a perilous area as the washed down soil turns the road into a slippery slide. In the end, one of the trees loses hold and crashes onto the busy road. The morning rush hour traffic quickly jams all the way back to the nearby highway. The radio soon broadcasts the traffic warning dreaded by all drivers "Drivers who are familiar with the area are advised to avoid the vicinity!" The control offices are working frantically. How will the recovery vehicle get to the incident site as quickly as possible? What is the situation on other sections of the road? Can the bridge across the river still be used? Can traffic be diverted to the other riverbank given the bad weather conditions which can also cause road closures on that bank if there is flooding? In such a case, decision-makers are faced with a double problem: They only have an incomplete picture of the current traffic situation and they are under time pressure. In its projects DELPHI and ARGOS, DLR is developing solutions that can support relief units in making their decisions.

By Michael Bonert,
Daniel Hinkeldein,
Dr.-Ing. Peter Reinartz
and Dr.-Ing. Franz Kurz

Major emergency incidents as well as large-scale events place high demands on traffic managers and emergency services. They need to make decisions immediately and manage the organization of the respective event both safely and efficiently. In such situations, there is a danger that "critical infrastructure" such as roads, public transport, and emergency services can no longer fulfill its functions. In the worst-case scenario, public life comes to a standstill.

Over the past years, the Cologne police and DLR have cooperated on several projects, for example, during the World Youth Day 2005 and the FIFA Soccer World Cup 2006. In the course of this cooperation, a monitoring system for large-scale events was developed. It utilizes data from several different sources to depict and forecast the traffic situation.

Section of an aerial image taken from an altitude of 2 kilometers with DLR's own 3K camera system: Highway A96 with the exit north of the DLR branch in Oberpfaffenhofen

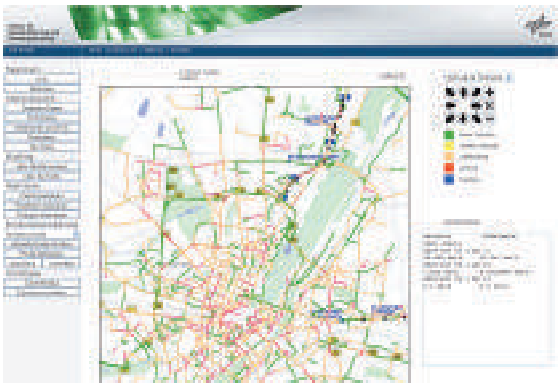
Closing information gaps

This system is now being further developed in the projects DELPHI and ARGOS. The DELPHI project is aimed at creating a decision support portal for traffic and crisis managers. Emergency services, such as the police or the fire department, instigate measures that influence the traffic situation. Traffic managers carry out measures which in turn affect emergency service activities. The DELPHI portal will allow these measures to be coordinated in future. It effectively provides (the presently missing or insufficient) information on the current traffic situation, which can then be used to develop a traffic forecast, as well as information about the effects of particular measures on traffic.

A typical problem is, for example, the lack of up-to-date data for a specific incident area. The ARGOS project therefore aims to create an airborne monitoring system. It transmits pictures of the situation and traffic parameters from a particular target area to a ground station without delays. In the case of an incident, this system can be immediately deployed. At night-time or during poor visual conditions, an active radar sensor (SAR) is utilized. The capability of the ARGOS and DELPHI system will be demonstrated in the regions of Cologne and Munich. Currently, researchers at the Institute of Traffic Control and Vehicle Guidance are surveying the requirements of the users. For this purpose, a user group comprised of emergency service staff was formed to define and assess requirements and to evaluate the capabilities of the system.

A first prototype of the DELPHI portal, which integrates situational functions and forecasting functions, is currently being developed. Traffic analysis and transport management functions will be subsequently developed. The DELPHI portal depicts the traffic situation in an integrated and holistic manner. Alternative approaches have so far only concentrated on partial networks such as the Federal highway system. Traffic flows, however, do not stop at the end of one sphere of responsibility or at a particular road type. Staff at the traffic computer centers can use the portal to take into account, e.g., the traffic situation in the city, when they divert traffic or provide detour recommendations. The public can thus be better informed, which reduces the danger of consequential traffic jams.

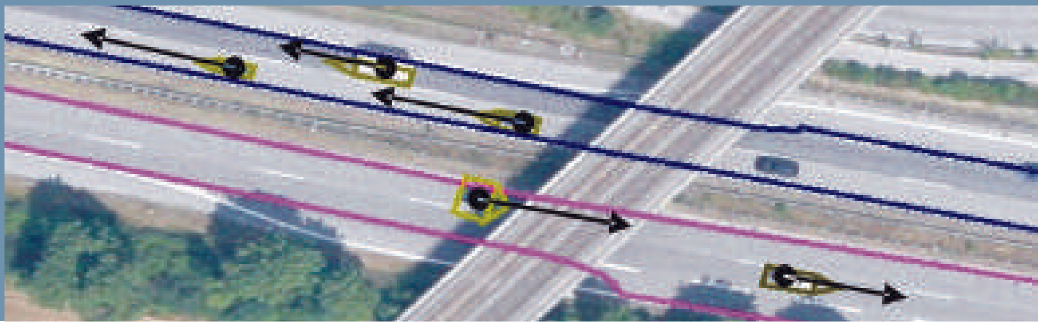
To this end, the portal integrates different data sources for a comprehensive and uniform depiction and aggregates the data for a common analysis. Data from local sensors of Federal highways and city roads is integrated and combined with Floating Car Data (so-called FCD) and traffic parameters provided by aerial images from ARGOS. Sensors carried by the plane provide images of highly sensitive road sections or roadway systems with a resolution of up to 15 centimeters. They fill up the data gaps for routes without other detectors, for example, by collecting traffic-relevant parameters such as the number, location and speed of vehicles. Based on these high resolution images, emergency services receive an overview of the current road situation and the area surrounding an incident in the DELPHI portal. This enables decision-makers to better manage operations.



DELPHI combines traffic and crisis management. A web portal supports networked decision-making between the various responsible parties.

Image details with automatically detected lane boundaries and vehicles

Detected vehicles with speed vectors, which are automatically derived from the serial images. The time interval between the images is 1/3 second



The automatic detection of vehicles and their speeds from a sequence of images is one of the challenges in the ARGOS project. Two consecutive images have a time interval here of less than a second. Only this frame rate enables vehicles to be automatically tracked. If a vehicle moves, it will be captured at two different positions on two consecutive images. The speed of the vehicle is calculated from the difference in location and the respective time difference of the images.

These calculations are highly complicated in particular for larger road networks since they must be performed very often and in a very short time span.

The associated system processes, such as image processing, must be extremely high performance. If decision-makers are confronted with questions such as: "Where is the traffic jamming up?" "Where is the nearest usable bridge?" "Which areas are flooded?" "Where shall we send drivers so that they will not end up in a traffic jam?" – the answers can be found in this image data.

This way, traffic controllers can prevent road users from jumping from the proverbial frying pan into the fire while trying to find a way through the traffic.

Transparency of depiction

The current traffic situation depiction is supported by details about the quality of the data. In conventional traffic situation depictions, missing or implausible information is usually replaced without the user having the facility to recognize whether the presented traffic situation is based on historic data or on current data. The depiction on the DELPHI portal carries out this task more transparently. If, for example, in a major incident situation the police are interested in the traffic situation along a particular route, which is to be used by particularly endangered persons, DELPHI can provide details about the usual traveling time or the current traveling time along the intended route. The transparent presentation of the data quality depiction provides planning certainty and can avert dangerous situations or even prevent them entirely.

Apart from providing a depiction of the current situation, the DELPHI portal can also develop a traffic forecast while taking into account the effects of planned measures. This improves the basis for decision-making in the pre-planning stage and when making ad-hoc decisions. Additionally, alternative modes of action can be evaluated with the help of the quantitative data provided, thus enabling the selection of more effective measures. The resulting disruptions for the public can consequently be minimized. DELPHI thus enables a directly citizen-oriented work approach to traffic.

The two projects DELPHI and ARGOS contribute in this way towards traffic safety in the event of an incident. They support decision-making for traffic managers and managers of emergency services. If measures are simulated in real time and if up-to-date aerial images are provided, emergency services operations can be optimized – and the consequences for other road users will be minimized.

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High Tech as Collaps Prevention

Traffic Monitoring with Radar

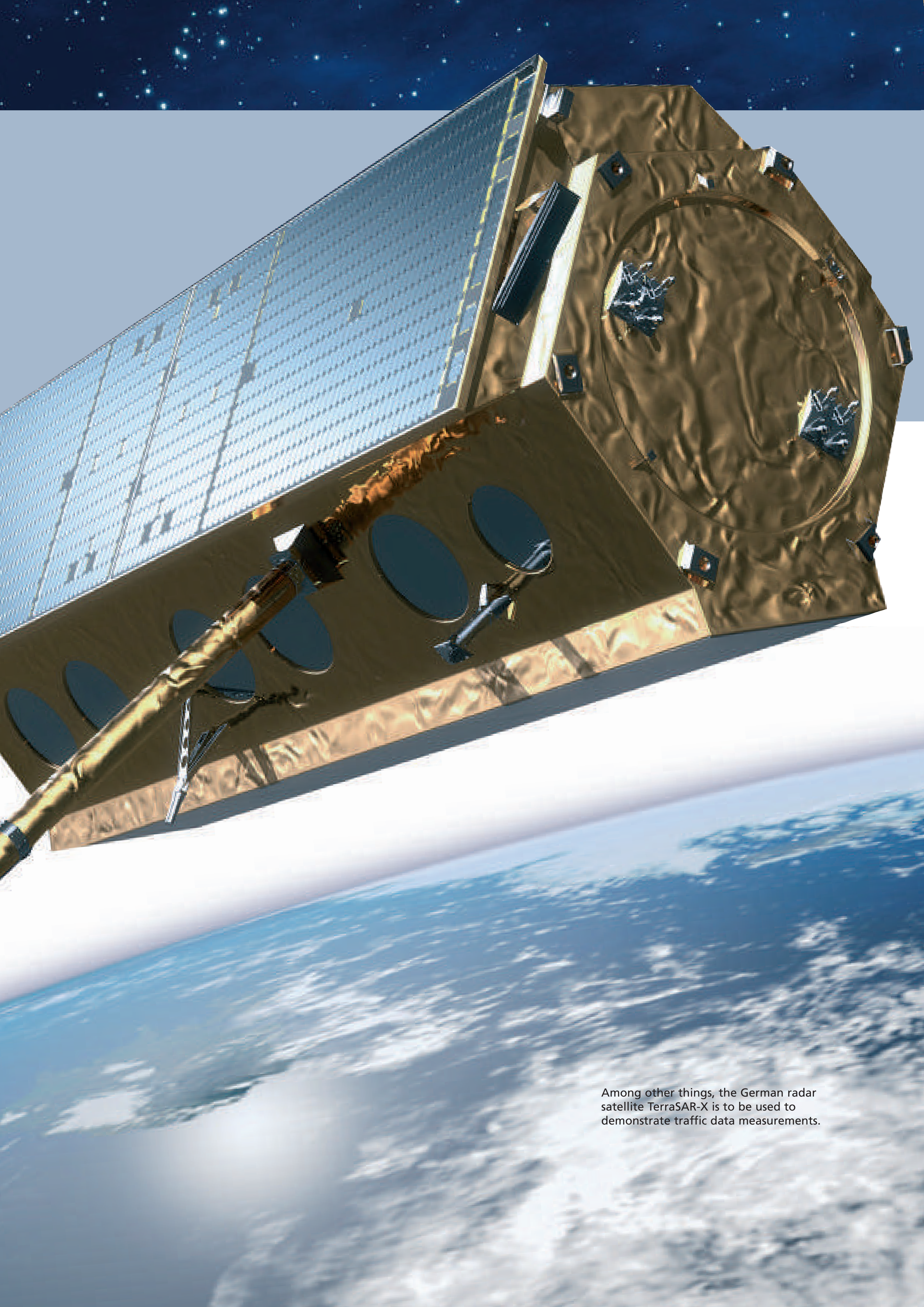
By Dr.-Ing. Karl-Heinz Bethke and Hartmut Runge

The word "infarct" is increasingly making the headlines and it is often not related to a medical diagnosis. Traffic, and primarily road traffic, is the issue at heart. While this may be a somewhat clumsy comparison, as is the case with all comparisons, the two references nevertheless have one factor in common: In order to be able to counter an impending infarct, the warning signs must be recognized in good time: bottlenecks, weaknesses in the overall system, capacity overloads. Monitoring the heart region in isolation will not suffice.

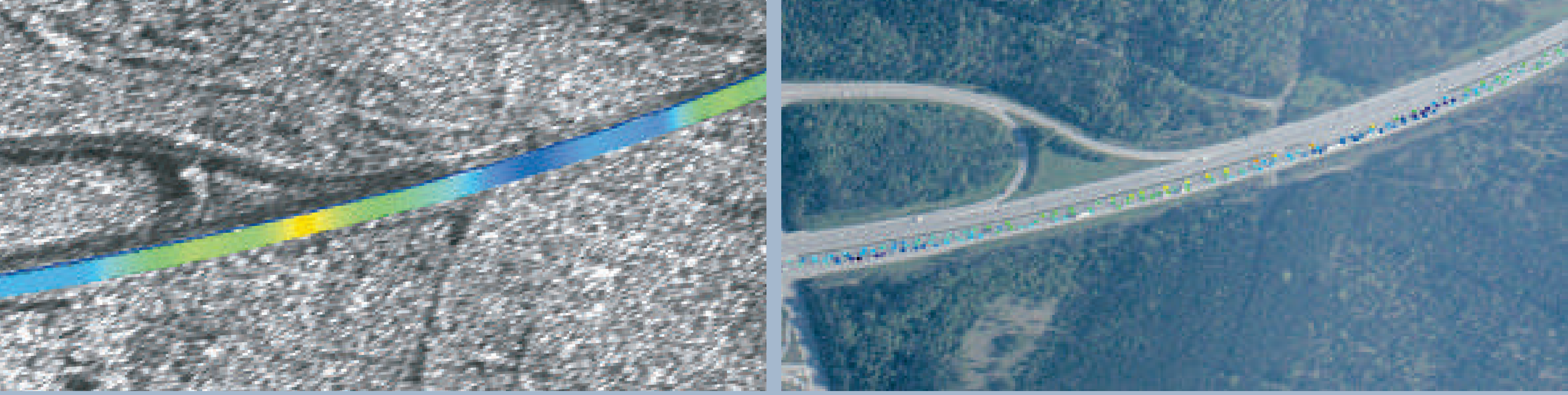
Information about traffic is generally obtained using permanently installed sensors (induction loops in the road surface) and cameras on bridges. However, wide-scale and seamless coverage of the road network is not possible using this approach. The picture of the actual traffic situation thus remains fuzzy, with signs of developing traffic jams failing to be identified. Things start getting dangerous when there is insufficient information for emergency rescue services regarding the navigability of the roads and when emergency services have problems in reaching the emergency site. Not to mention the unnecessary costs, loss of time, and carbon dioxide emissions that are created by traffic jams.

A promising solution exists in the use of "Floating-Car-Data," which, however, is not available everywhere. But a complete overview of traffic developments can only be obtained from high altitudes, in other words, with aircraft or satellites. DLR has access to both.

The catch is that as the height increases, the visual quality deteriorates. There is also the issue of traffic during the hours of darkness. Sensors that function in the visual optical field are dependent on sunlight. Infrared systems cease to work when it rains. Only radar technology can guarantee functionality in all environmental conditions, regardless of whether during the daytime or nighttime, with precipitation or heavy clouding. Radars work as active sensors and illuminate the scene with microwaves. The so-called Synthetic Aperture Radar (SAR) has established itself for large-scale and high-resolution images. This type of sensor is fitted on the DLR research aircraft Do 228 and on the German remote sensing satellite TerraSAR-X. Moving objects can be detected with a radar sensor and their direction and speed can be ascertained.



Among other things, the German radar satellite TerraSAR-X is to be used to demonstrate traffic data measurements.



Aircraft-supported traffic data measurements on the A96 near Munich using a radar (left) and camera (right)

The simultaneously recorded E-SAR radar data and series images of a digital camera reveal a traffic jam in front of a construction area during the morning rush hour. With the two systems, the exact length of the traffic jam was able to be ascertained at 1.3 kilometers and the traffic jam speed was recorded from the air. Although the radar and camera image exhibit different mapping geometries, it can be easily verified that the measurements tally with each other. The currently required time to pass through the traffic jam was able to be calculated from the radar data as 3 minutes and 53 seconds. In the image, an "accordion effect," which is typical of a traffic jam, can be identified: The speed of the vehicles, which can be read from the color coding, varies in a wave-like pattern.

By comparing with an earlier image ("Change Detection" process), it is even possible to map changes in the traffic infrastructure, for example, roads that have become impassable due to land slides or floods.

In addition to TerraSAR-X, DLR has the aircraft radar system E-SAR at its disposal and will soon have the new development F-SAR for demonstrating new technologies and applications for road traffic.

In both systems, the radar transmits laterally to the flight direction via its antenna. Depending on the flight altitude, the ground area covered measures several kilometers in width from the aircraft and up to several hundred kilometers in width from the satellite. The radiation which is reflected from the ground and from traffic vehicles is received by two to up to four antennae. They are located behind each other in the direction of flight and assigned to separate receiver chains. From the radar data, a two-dimensional image is created of a locally covered scene for each reception channel. The static image background can be eliminated by taking the difference between the different channels. This ensures that only the moving object is detected.

If there are more than two channels available, as is the case with F-SAR, the exact location of the vehicle can be ascertained in addition to the speed and the traffic on entire road networks can be depicted.

The newly developed radar F-SAR flies on a Dornier Do 228 and is an experimental SAR. The diverse settings options require a radar operator that operates the radar devices. The collected measurement data then need to be read and processed on the ground before it is made available for traffic analysis. As part of the DLR project ARGOS, the further development of hardware and software is being driven ahead so that fast data processing will be already enabled on-board and data can be transmitted from the aircraft to a ground station.

The Dornier Do 228 as a carrier platform for the F-SAR: The antenna system is attached in a radome under the tail of the aircraft.

The experiences here will then be used to develop a concept for a compact, lightweight and cost-effective radar sensor, which will be implemented in the medium-term in an operational system. The measurement data will then be able to be processed in real-time and transmitted to a control center. The system would then also be able to be used on small aircraft independent of the Do 228 or even on high-flying unmanned platforms such as so-called HALE aircraft (High Altitude Long Endurance) at an altitude of 20 kilometers.

New, high performance analysis processes are currently being developed. They will be designed to use the diverse technical possibilities that the F-SAR offers in order to achieve more precise results than have so far been possible. F-SAR will demonstrate what potential aircraft-carried SAR has for applications in transport and here, in particular, in crisis and catastrophe scenarios. On 15 June 2007, the German radar satellite TerraSAR-X was successfully launched. Just a few days later, the first high-resolution radar images were able to be analyzed.

F-SAR radar and operator in action on the Dornier Do 228

All results to date confirm the outstanding quality of the satellite and the ground segment developed at DLR. Although the satellite is still in the test phase for the standard modes, the first images have already been able to be made in a special mode for along-track interferometry (ATI). In this, moving objects, such as vehicles, can be detected and their speed measured. Unlike location-bound sensors on the ground, large-scale speed measurements are possible with the satellite procedure with a scene area of typically 1500 square kilometers. Through the high flight speed of the satellite, this area can be covered in just seven seconds.

As soon as the ATI imaging methods for traffic data collection with TerraSAR-X have been authorized for operation, the achievable precision and the detection rate will be investigated in detail through further experiments. The aim is to generate traffic parameters in virtually real-time for traffic information systems, for transport research, and emergency management. In addition to precise traffic jam lengths, travel times in congested traffic will also be ascertained on selected road sections. The system can cover the entire surface of the earth, making worldwide measurements possible. In central Europe, every area can be recorded almost daily, in Northern Europe even several times a day. Through a cooperation partnership with the Canadian space agency CSA the Radarsat-2 satellite can also be used, more than doubling the time coverage rate. Thanks to the installation of a traffic computer directly in the TerraSAR-X ground station in Neustrelitz, North of Berlin, it can be guaranteed that traffic information is available a short time after the satellite has flown over the area.

TerraSAR-X has been designed as a remote sensing satellite for a multitude of applications and was not specially developed for measuring traffic. It serves to demonstrate this new application. With the aid of the experiences gained, future radar satellites will be able to fulfill this task even better.

A large-scale overview of traffic developments will then be provided. State of the art radar technology, which is currently finding its way into traffic data collection, makes this possible. With the F-SAR, DLR has at its disposal a platform for developing entirely new radar concepts. With the TerraSAR-X satellite, traffic data can be gathered around the world for the first time in all weather conditions. The challenge for the future lies in developing lighter radar devices for high-flying stratospheric aircraft, which continually monitor traffic and road conditions over conurbations or catastrophe areas.

This would provide up-to-date, precise, and reliable traffic information that would make it easier for road users to decide whether to wait in the traffic jam, circumnavigate the traffic jam, change to public transport, or rather postpone the journey. Regardless of what course of preventative action is chosen, the risk of a traffic infarct can certainly be reduced.

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Dr.-Ing. Karl-Heinz Bethke is ARGOS Subproject Manager at the DLR Microwaves and Radar Institute in Oberpfaffenhofen; Hartmut Runge is a researcher at the DLR Remote Sensing Technology Institute in Oberpfaffenhofen and Head of the TerraSAR-X traffic project.

Position Information from Moving Traffic

DLR Research Cooperation with TomTom

Since October 2006, DLR and navigation device manufacturer TomTom have had a research contract regarding their strategic cooperation. TomTom is a licensee of the FCD technology (FCD = Floating Car Data) which has been developed at DLR over the last five years. This technology uses the position information of vehicle fleets gathered with GPS (Global Positioning System) which are controlled by a logistics planning system. This information is also used for a second purpose: From the movements of all vehicles of such a fleet, the traffic situation of a large area can be determined and depicted by reconstructing the driven route and, above all, the speeds achieved. For the people on the road, this has the advantage of significantly improved route recommendations with which current traffic jams can be avoided. Demonstration projects (Berlin, Hamburg, Stuttgart and Nuremberg) can be seen at www.cityrouter.de.

The cooperation with TomTom has the aim of further developing the usability of FCD technologies. TomTom's experiences from practical implementation and usage are complemented by the technological expertise of DLR.

The Dutch company, which was founded in 1991 and has been operating under the name TomTom since 2001, is the largest provider of navigation products in the world. With navigator software, navigation devices and solutions for cell phone navigation, TomTom has customers in 30 countries. The company is listed on the AEX stock exchange, Amsterdam. An employer of 1,400 staff, the globally active company's name is derived from the tom-tom drums of Native Americans which were able to transmit messages over distances of many kilometers.

Dr. Peter Wagner

Information:
www.tomtom.com

Green Light Ahead with ORINOKO

Cooperation for Improved Traffic Flows

The situation is all too familiar: Instead of a green wave, you are met with a wave of annoyance which immediately spreads through your body. You sit and stare at the red traffic light, which is clearly pointlessly preventing you from continuing on your journey as the intersecting road is empty and behind you the cars are increasingly lining up. This is just one of many situations that show that traffic flows can certainly be improved.

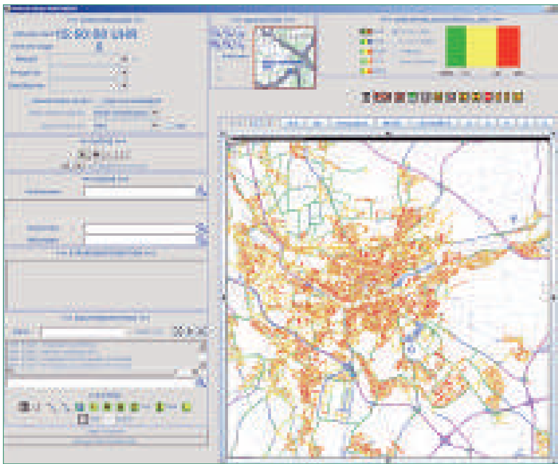
However, this is more difficult than we would generally like to think. Better traffic flows require more efficient and intelligent transport management. And good management requires up-to-date, precise information about the traffic situation.

This is where ORINOKO comes in – a project funded by the Federal Ministry for Economics and Technology. The German abbreviation stands for "Operative Regional Integrated and Optimized Corridor Control." Six partners are currently working together with DLR under the management of the City of Nuremburg. The work of DLR relates to traffic data collection using Floating Car Data (FCD) technology and software development. This technology supports the traffic engineers on location with traffic quality management in their city. The acceptance and degrees of adherence and thus the effects of such traffic information services, which are developed as part of the project, also form the subject of their investigations.

The procedure for improved traffic light signal control (LSA) that has been developed within the ORINOKO project is to be tested in the city of Nuremberg in spring 2008. This testing includes an evaluation of the quality differences between the current traffic light control system and the new one. The evaluation will include the integrated data basis from FCD, video and counting loop data, which is developed in ORINOKO, as well as the results from the DLR traffic flow simulation.

However, new processes for optimized traffic flows are having difficulty in revealing their full effect. This is partly due to the fact that light signal systems are generally in operation for many years and their modernization is a slow process. Step by step, the old systems have to be connected to new network traffic computers. The new technical and scientific developments must therefore also be followed by an adaptation of the infrastructure. Smooth traffic flows thus require the interplay of entirely different actors in research, technology and management. With the know-how from the ORINOKO project, the signs are positive for smooth traffic flows in the long-term which spare the nerves of drivers as well as economize on time and fuel.

Jürgen Mikat



Screenshot of the quality assurance tool that has been developed by DLR as part of the ORINOKO project and which is currently being tested by the Nuremberg city administration. Based on the integrated data basis of ORINOKO, the quality of the traffic flows can especially be recorded at traffic lights. This enables a fast reaction to changes in the flow of traffic.

MANY ROADS

Author

Prof. Dr.-Ing. Uwe Clausen, Head of the Fraunhofer Institute for Material Flow and Logistics (IML), Chairman of the Fraunhofer Network on Traffic (FVV)

LEAD TO NEXT DOOR

Researchers and Technicians are Building Bridges Across Institute Borders to Ensure that the World Stays in Motion

By Prof. Dr.-Ing. Uwe Clausen

Increased traffic, negative traffic impacts, traffic jams, traffic infarct – these are the buzzwords which form talking points in the media just as much as in current academic discussions. The reasons for the increase in traffic are manifold. Freight haulage has increased due to the continuing positive economic development, which has increased the volume of goods that require transportation. Heavy goods vehicles, which are still the most important cargo carriers, have increased traffic but even more so have rail traffic, aviation, and marine cargo. For passenger transport, the need for mobility is on the increase. As a result, the traffic load per transport user continually rises. All of these trends are, of course, accompanied by challenges. Researchers are tackling these challenges and are overcoming institutional frontiers, as demonstrated by the cooperation partnership between the Fraunhofer Institute and the German Aerospace Center (DLR).

Researchers and engineers have found a number of topics in the area of traffic research on which DLR institutes and Fraunhofer institutes are now collaborating. This cooperation is being conducted in diverse ways and forms, ranging from joint activities in European scientific organizations, such as ECTRI (European Conference of Transport Research Institutes), through to joint cooperation projects covering topics such as traffic control and monitoring as well as aviation cargo, and planning cooperation in applications of the European satellite navigation system Galileo.

Pedestrian navigation with mobile devices can take into account all available means of transport.

Tests for Galileo system applications

Galileo applications are especially predestined for joint projects. With its 20 associated institutes for traffic research alone, the Fraunhofer Gesellschaft, which has committed itself to application-oriented research, offers ideal conditions for developing new traffic applications for the satellite navigation system Galileo.

A demonstration of these applications in freight and passenger transport and in the area of safety within the Galileo test and development environment (GATE) enables the presentation of Galileo's usefulness for transport before reaching full operational status. This has led many Fraunhofer institutes, especially the Fraunhofer Institute for Production Systems and Design Technology (IPK) in Berlin, to cooperate with DLR. Their common goal: to develop satellite applications with demonstrations in GATE.

The right traffic perspective

Transport management is another common research interest: Practicable and financeable solutions for comprehensive monitoring of the traffic situation city-wide and traffic light control optimization are being developed in the research project ORINOKO (Operative Regional Integrated and Optimized Corridor control). The goal of this project is to prove that adding relatively affordable but effective traffic technologies such as video detection (for the monitoring of the traffic situation with cameras) increases the benefits of transport management with the simplest possible operational conditions.

An integrated database and a concept for data management are being created as part of the cooperation between the Fraunhofer Institute for Transportation and Infrastructure Systems (IVI) and the DLR Institute of Transport Research. The scientists have already cooperated closely during the conceptual design stage and the concepts are currently being put into practice.

Image and video detection is also a joint research topic. Existing expertise in this area will be aggregated in order to develop a high-performance and robust algorithm for traffic situation monitoring on camera-monitored stretches of road. Both institutes have a wide experience in developing video detection algorithms.

Passing a serious test: Balls and buses were rolling

The cooperation in the research project TRANSIT, which is funded by the Federal Ministry of Economics and Technology, was of direct use for traffic participants during the FIFA Worldcup 2006. The TRANSIT system provides traffic-related services for visitors, participants, and organizers of large-scale events in real time on mobile devices.

The difference over conventional systems is that TRANSIT evaluates information about transport means available at a particular location. Apart from up-to-date schedules for local public transport, the driving times of taxis or private cars, regional rail networks, and bicycles were also taken into account in the analysis.

For this purpose, the transport specialists at DLR developed a special aggregation of transport data. The Fraunhofer Institute for Software and System Engineering (ISST) and the Fraunhofer Institute for Material Flow and Logistics (IML) created software modules which build on the DLR system and enable this data to be further used in the TRANSIT system and be provided to the visitors.

Safe aviation thanks to new detectors

Aviation is also included in the research cooperation. The joint efforts here are concentrating on increasing air traffic safety. The Fraunhofer IML project center "Airport" is working together with the DLR Air Transport and Airport Resarch as well as the Institute of Planetary Research to improve safety in airfreight transport. Lufthansa Cargo AG was won as a project partner for a new venture with the German title "Sichere Fracht" (SiFra – literally "safe freight").

The factors which led to this joint project are the rising safety concerns in aviation which, so far, only concentrated on passengers and their luggage. The technologies and processes employed in passenger aviation cannot be transferred to airfreight because of the different dimensions and strongly differing particularities of air cargo. The x-ray technology employed in luggage monitoring cannot be used for freight due to its low resolution.

The aim of the research project is to create a new detector concept for identifying illegal objects. The technological development is supported by a comprehensive analysis of the processes for the optimal positioning of security controls in the airfreight transport chain as well as for determining supporting safety measures. National and international legislation requirements also have to be considered.

The project team is planning to develop a detector based on Terahertz technology. This detector will then prove its practicality at a German airport in the form of a demonstrator. The prognosis and the concept will then be integrated into a simulation model in order to assess the requirements for implementation at German airports. The results gathered by the demonstrator will also be incorporated into the simulation.

Lightweight construction vehicles to decrease emissions

The car of the future is another topic where Fraunhofer and DLR scientists are combining their innovative powers. In their many cooperation projects, they are working towards reducing the weight of vehicle components and, thus, vehicles overall by developing new types of materials and structures. The goals are high stability, safety, and reliability while maintaining optimal costs and consumption rates of the vehicles in both production and operation.

These research efforts are represented by the Fraunhofer initiative "Intelligent Lightweight Construction Systems" and the competence center "Lightweight Vehicle Construction," which was jointly founded by DLR, the University of Karlsruhe, and the Fraunhofer Institute for Chemical Technology (ICT). Their research activities range from developing fundamentally new ideas to material and process development and prototype construction.

The partners have set themselves the goal of reducing a vehicle's energy consumption and, thus, the resulting CO_2 emissions by reducing driving resistances.

All these activities and cooperation partnerships as well as the results they have produced demonstrate that combining competences and bundling abilities makes tremendous sense in the area of traffic research. – A reliable way of ensuring that, even in the light of growing knowledge and new issues, in the future, the perspective for a holistic consideration of the world in motion is not lost.

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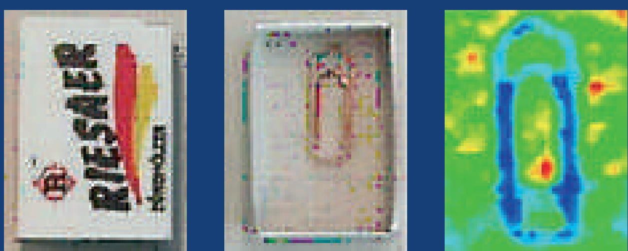


High-resolution images produced by a detector based on Terahertz technology for identifying illegal objects in airfreight

Test facility for the checking of airfreight units

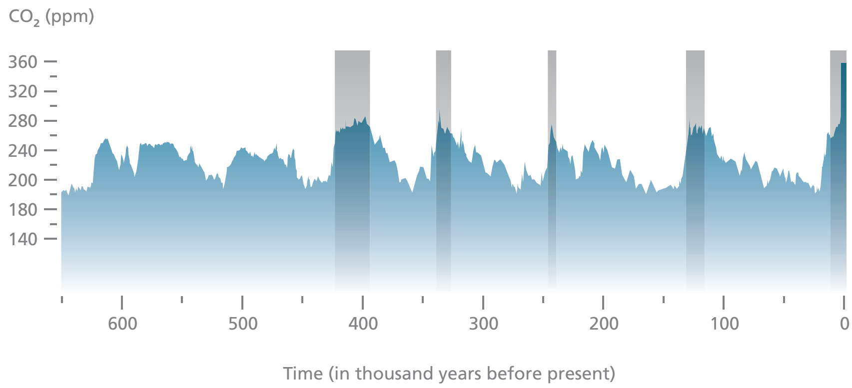
The Impact of Transport on the Environment

By
Prof. Dr. Robert Sausen

Since the middle of the 18th century, humans have been using increasing amounts of fossil fuels, beginning with coal and then later moving on to crude oil and natural gas. This enabled industrial production to develop to such a tremendous rate. The wealth of the people increased in many parts of the world. However, burning coal, oil, and gas has a number of adverse effects. The Earth's atmosphere is changing. Never before has man interfered so much with the planet's climate system. We are continuing to do so at increasing rate, in particular via our transport system. What are the consequences? This is what climate researchers at DLR in Oberpfaffenhofen are investigating.

The greenhouse gas carbon dioxide (CO_2) is generated when fossil fuels are burned. Due to their optical properties, greenhouse gases lead to an increased temperature at soil level and in the troposphere, which is the lowest atmospheric layer. The greenhouse effect also exists without human interference. It is primarily caused by water vapor, CO_2, ozone (O_3), methane (CH_4), and nitrous oxide (N_2O). Without this natural greenhouse effect, the temperature on earth would be some 30 degrees centigrade lower.

Man has considerably interfered with this natural system by emitting additional greenhouse gases. This can be proven by analyzing air which was trapped in the Antarctic ice several hundred thousand years ago and was "archived" this way. According to the findings in this air, during the last 650,000 years the CO_2 concentration in the atmosphere was always below 300 parts per million (ppm), which means below 300 CO_2 molecules per 1 million air molecules. This CO_2 concentration rose quickly from approximately 280 ppm in the



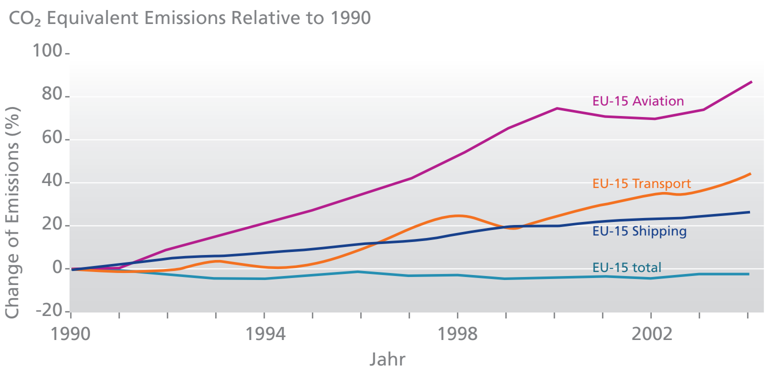
Timeline of the development of atmospheric CO_2 concentration during the last 650,000 years; data from ice core. The last 50 years tally with measurements in the Antarctic air. The vertical gray bars mark the warm interglacial periods.

According to IPCC (2007)

middle of the 18th century to 379 ppm in the year 2005. Other greenhouse gases are revealing similar developments. The methane concentration, for example, had a pre-industrial level of 715 parts per billion (ppb), i.e., 715 CH_4 molecules per 1 billion air molecules, and has risen to more than twice its original value: 1774 ppb in the year 2005. Apart from the naturally existing greenhouse gases, man has also emitted some which only exist due to human activity. These include, e.g., chlorofluorocarbons (CFC) and sulfur hexafluoride (SF_6), also called heavy gas.

These (anthropogenic) greenhouse gases that have been additionally emitted by mankind into the atmosphere are leading to a further temperature increase in the troposphere. This warming effect is further amplified by feedbacks in the climate system. The atmosphere absorbs more water vapor when temperatures are higher. This water vapor in turn also functions as an additional greenhouse gas, causing the troposphere to heat up even more. The ground level air temperature has increased by a global average of 0.75 degrees centigrade over the past 100 years.

Eleven of the twelve years between 1995 and 2006 are among the hottest years since the beginning of regular instrumental ground level temperature measurements in 1850. Paleoclimatic analyses have revealed that at least within the last 1,300 years it has never been as hot in the Northern hemisphere as it has been in the past 50 years. The Arctic has never seen temperatures as high as today within the past 130,000 years. There is a high probability that a large proportion of the temperature increases of the last 100 years have been caused by man.



Changes in CO_2 equivalent emissions of the EU-15 relative to the emissions in 1990. All anthropogenic emissions are depicted in turquoise, transport emissions in orange, emissions from international aviation in magenta and from international shipping in blue.

Source: UNFCCC

The Intergovernmental Panel on Climate Change (IPCC) has analyzed several potential developments in society and the resulting greenhouse gas emissions during the next 100 years. Depending on the choice of scenario, the forecast for the temperature increase by the end of this century, i.e., the year 2100, lies between 1.1 and 6.4 degrees centigrade. The lowest values can only be achieved, however, if drastic cuts in greenhouse gas emissions are made. The increase in global temperature is simultaneously reflected in changes in the weather: The melting of the arctic sea ice, more frequent and intense rainfall, more frequent severe storms – the consequences cannot be overlooked.

Transport contributes significantly to the greenhouse gas emissions: Road traffic, aviation, and shipping contributed 13.8 percent, 2.2 percent, and 2.7 percent respectively to the anthropogenic CO_2 emissions in the year 2000. In order to reduce greenhouse gas emissions, the United Nations passed the Kyoto Protocol in 1997. By 2012, the EU and its member states (before the enlargement to include the Eastern and South-Eastern European states) are accordingly required to reduce their CO_2 emissions equivalents by 8 percent relative to the value in 1990.

When calculating equivalent CO_2 emissions, the other Kyoto Protocol gases (methane, nitrogen dioxide, sulfur hexafluoride, chlorofluorocarbons, perfluorocarbons) are converted into the amount of CO_2 which has the same radiative effect over a time horizon of 100 years.

By the year 2004, the respective 15 EU member states achieved a reduction in their anthropogenic CO_2 emission equivalents of 2.6 per cent.

However, transport emissions (including those from national aviation and national shipping) increased by 26 percent in the same time period. The emissions from international aviation and shipping ("bunker fuels") originating in the EU have even increased by 87 percent and 43 percent respectively. The relatively strong increase of transport emissions occurred because the growth in transport volume was so fast that it has outstripped the effect of substantial reductions in specific emissions from technological progress.

However, making transportation a scapegoat in the current climate debate would mean ignoring the fact that it signifies an essential component within our globally linked economic

Complex Task – Far-reaching Cooperations

In order to analyze the effect of transportation on noise emissions, air quality, and climate change, DLR is cooperating with partners in Germany, Europe, America, and Asia. DLR cooperatse with the Research Center Karlsruhe (Forschungszentrum Karlsruhe – FZK) in the area of harmonizing forecasts of noise and local air quality, taking into account meteorological influences. Joint indicators will help to avoid competing measures for noise reduction or improving air quality.

A similar situation is found in the area of studying the effects of transport on the composition of the global atmosphere and climate. Here, DLR is coordinating the EU Integrated Project QUANTIFY (Quantifying the Climate Impact of Global and European Transport Systems). More than 100 scientists from 41 institutions from 19 countries (Europe, Asia, and America) are involved. This way, not only experts from a diverse range of disciplines come together but also uncertainties resulting from incomplete scientific knowledge can be better evaluated through the combination of independent tools (measurement devices, models, etc.). The EU project ATTICA was derived from the QUANTIFY project. ATTICA's core aim is to create a European assessment report of the effects that transportat has on the atmosphere and climate.

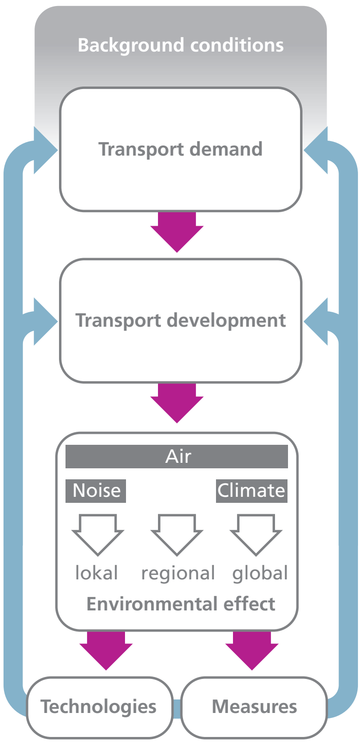
systems. The social need for mobility and the transport of goods is directly linked to the efficiency of the transport system. Both aspects need to be taken into account.

DLR is researching into transport as a whole in order to identify the scope for action between the desired properties of transport and its negative consequences. High transport demand leads to an increase in traffic, and the resulting emissions cause noise, reduced air quality, e.g., through particulate matter or smog, and cause climate change. In order to tackle these environmental effects, new technologies such as particulate filters or jet engines with lower nitrous oxide emissions are being developed and regulatory measures are being taken (e.g., setting emission standards or speed restrictions) which are aimed at lowering overall emissions in absolute terms. Both technologies and measures influence transport demand and traffic development. This creates a closed feedback circuit.

The DLR Institute of Atmospheric Physics is concentrating on the environmental impact of transport. One focus is placed on the impact of transport on the composition of the atmosphere and on climate. Even if the institute was only interested in analyzing the effects transport has on the climate, considering its consequences for the chemical composition and the abundance of particulate matter in the atmosphere is imperative.

Transport not only emits persistent greenhouse gases, such as CO_2 or nitrous oxide, it also changes the climate in other ways. These effects include greenhouse gases which do not become homogeneously distributed in the atmosphere, such as water vapour. Water vapour is particularly important in the case of very high-flying aircraft. Another example are emissions of ozone precursors such as nitrogen oxides, which impact

Process Chain "Traffic and Environment"



the atmospheric ozone abundance through chemical reactions, in particular resulting in an increased ozone concentration at ground level. Furthermore, the emissions of particulate matter or their precursors need to be considered because they influence the radiative balance in the atmosphere through dispersion and reflection. Another aspect to analyze is the formation of additional clouds such as condensation trails (contrails) or so-called contrail cirrus as well as the change in natural cloudiness caused by additional particulate matter in the atmosphere.

The diverse research in this area will provide answers to questions such as the following: How great are the climate effects of individual modes of transport such as road traffic, rail, shipping, or aviation? How can, in on scientifically sound bases, non-CO_2 emissions be integrated into existing emissions trading systems such as is being developed by the EU for the gases listed in the Kyoto Protocol? How great is the benefit of using biofuels or does their use lead to an even stronger climate change?

DLR researchers will be answering these and further questions concerning the effects of transport on the environment over the next few years. The DLR Institute of Atmospheric Physics is thus performing measurements (engine exhaust directly at test rigs, airborne in exhaust plumes of aircraft and ships, from space via satellites) and is simulating the developments in the atmosphere using comprehensive climate-chemistry models.

An example is a cooperation with MAN to analyze gases and particulate matter in the exhaust from ship diesel engines. The DLR research aircraft Falcon measures the exhaust in plumes of large ships. By this means DLR gains information about non-linear conversion and deposition processes that occur when the ship exhaust gases is diluted in the surrounding background air. A good understanding of these processes is required for appropriately taking into account major individual sources of polutants such as ships or aircraft in climate-chemistry models.

Satellite data will be used to study the transformation of contrails into contrail cirrus and to quantify the assoicated cloud clover. Similarly, the cloud cover of ship tracks, (line-shaped low clouds triggered by by particulate emissions from ships) is being determined from satellite data. The information about the cloud coverage will support an estimation of the climate effect of these clouds.

By performing numerical climate-chemistry simulations the DLR Institute of Atmospheric Physics will calculate the dispersion, conversion, and dry and wet deposition of traffic emissions. Results will be information about the long-range transport of the emissions and their follow-up prodcuts, and their impact on the composition of the atmosphere.

Eventually, the contribution of individual modes of transport to climate change will be able quantified and patterns of transport-related climate change can be revealed. The knowledge of these complex interactions will finally enable the definition of suitable measures for evaluating and regulating transport emissions.
http://ip-quantify.eu

Author:
Prof. Dr. Robert Sausen has been managing the department "Atmospheric Dynamics" at the DLR Institute of Atmospheric Physics since 1991. The department is primarily concerned with the climate-chemistry modeling and the propagation of sound in real atmospheric conditions. An important field of application are the environmental effects of transport. Prof. Dr. Sausen coordinates the EU projects QUANTIFY and ATTICA.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Shipping and the Climate

An interview with Dr. Veronika Eyring, by Thomas Bührke

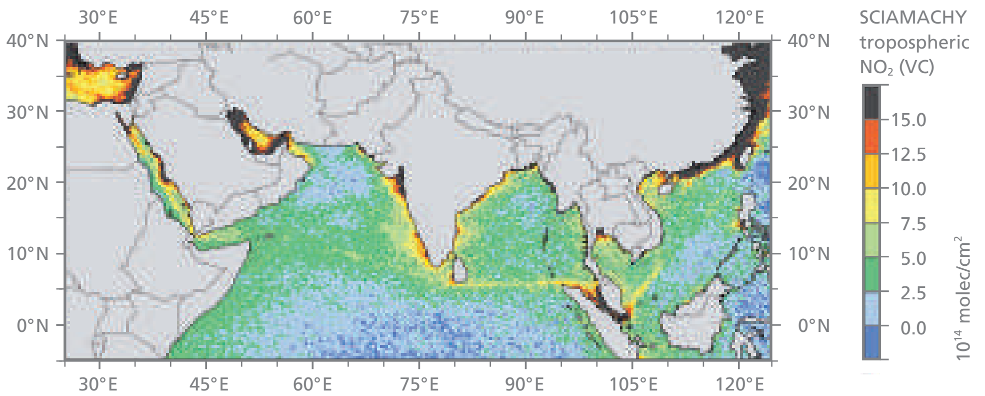
The exhaust gases from factories, cars, and aeroplanes have been scrutinized for quite some time now because they are noticeably changing the Earth's atmosphere and the global climate. Only shipping has remained unnoticed for a long time. A research group at the DLR Institute of Atmospheric Physics in Oberpfaffenhofen led by Dr. Veronika Eyring has now analyzed the emissions caused by ships more thoroughly. The result? While the emitted airborne particles (aerosols) may cause the climate to cool down, they are still polluting the air.

Several fortunate conditions resulted in the foundation of the research group led by Dr. Veronika Eyring. The scientist, who is today a mother of two, gained her PhD in 1999 at the Institute of Environmental Physics (Institut für Umweltphysik – IUP) at the University of Bremen. Her research focus back then was the modeling of the higher atmosphere (stratosphere). A few years later, Horst Köhler, in charge of the promotion of technology at the Augsburg-based company MAN Diesel, started to engage in the analysis of ship emissions, which is a research subject hardly anybody had been concerned with until that point.

In order to be able to compare the global ship emissions with those from aviation, Köhler got in touch with an expert in this area: Prof. Dr. Ulrich Schumann, Director of the DLR Institute for Atmospheric Physics. At DLR, Köhler was met with receptive ears as DLR had already been considering not only analyzing aviation emissions in an isolated manner in future but rather in a comparative form across all other means of transport. The beginning of the joint research project was forged with several workshops at both DLR and MAN.

Dr. Veronika Eyring, who was involved in the analyses right from the outset, recognized the opportunity which arose with an application for funding from the Helmholtz Association for Young Investigators Groups. Relying on a high level of dedication and the support of Professor Schumann, she submitted an application. Former colleagues at the University of Bremen also supported her, especially Professor John Burrows who is a project scientist for the spectrometer SCIAMACHY on board of the European environmental satellite Envisat. Burrows and his team had already had many years of experience with evaluating satellite data as well as with handling global datasets. Satellite data is essential for the task of quantifying climate effects and evaluating model results.

Dr. Veronika Eyring has been leading her own junior research group since 2004. Her research project is SeaKLIM – the influence of shipping emissions on the atmosphere and the climate. Her team is comprised of one post-doc researcher at the DLR Institute for Atmospheric Physics in Ober-



Vertically integrated nitrous oxide concentration (NO_2) from measurements taken by SCIAMACHY (taken from Richter et al., 2004, Copyright American Geophysical Union)

pfaffenhofen as well as two PhD students at the IUP in Bremen and one supervisor on location. "This was an optimal way of combining the expertise of the two institutes. The satellite data is evaluated by the IUP and the DLR institute provides atmospheric models as well as measurement facilities with the research aeroplane Falcon," explains Veronika Eyring.

For the first time, the SCIAMACHY data enabled the SeaKLIM group to determine the contribution of ships to air pollution, which is caused by increasing the concentration of nitrous oxide along shipping routes.

Clouds along shipping routes

The findings of the SeaKLIM group were indeed somewhat surprising. In the year 2000, approximately 800 million tons of carbon dioxide (CO_2) were caused by ship engines, which equates to approximately 2.7 percent of all anthropogenic CO_2 emissions. For nitrous oxides (NO_x), the emissions account for 15 percent and for sulfur dioxide (SO_2) 8 percent. This means that shipping causes as many CO_2 emissions as aviation. The NO_x and SO_2 emissions are even ten times and a hundred times higher respectively. Climate effects thus cannot be excluded.

Shipping contributes to global warming through emissions of the greenhouse gas CO_2. However, the high SO_2 emissions counter this effect. This is because sulfur dioxide and other sulfuric compounds react to sulfuric acid in the atmosphere. Together with water, they lead to the creation of very small sulfuric droplets, so-called aerosols. These function like a reflector and send the sunlight back into space. Additionally, the aerosol creates condensation nuclei on which water vapor can condensate, creating clouds.

In some parts of the world, this process can be studied very precisely. On satellite images, regions along the busy shipping routes are covered with long-stretching low layers of clouds, which are definitely not of natural origin. These so-called "Ship Tracks" are a result of ship emissions.

The analysis of these Ship Tracks is best carried out with the instrument AATSR (Advanced Along Track Scanning Radiometer) onboard the Envisat satellite. It captures images in different spectral ranges. These images especially reveal Ship Tracks in the North Pacific, along the Western Coast of North America and the South African West Coast. Ship Tracks are thus more of a local phenomenon, which is strongly dependant on the seasonal properties of the atmosphere and the oceans.

Ship Tracks, however, only reveal the directly visible consequence of ship emissions. Some of them mix with normal clouds and strengthen them, others dissolve. However, the aerosols still remain in the atmosphere and can change the properties of clouds similar to the way in which condensation trails can change into contrail cirrus which can then no longer be clearly attributed to aeroplane emissions. Contrary to the condensation trails and cirrus clouds in high air layers, the change in cloud properties caused by shipping traffic occurs in the lower troposphere, which is in an altitude of approximately 1,500 meters.

Against global warming

Their effects on the climate have been analyzed using computer models by Dr. Eyring's research group. Even if some of the variables such as the size distribution of the droplets or the total global shipping SO_2 emissions are associated with a degree of uncertainty, all of the model simulations reveal the same result: The sulfur dioxide emissions of shipping traffic cause a "lightening-up" of low maritime clouds which can thus reflect more sunlight back into space than in their natural state. This means that the sulfur emissions of shipping traffic are counteracting global warming.

Even though this effect is restricted to the areas along the main shipping routes, shipping at its global average causes 17 to 39 percent of all anthropogenic changes in the radiation balance through aerosols. Overall, the effect of cooling the climate through clouds weighs stronger than the heat increase caused by the greenhouse gases. However, it would be wrong to draw the conclusion that the sulfur emissions from ships only have a positive effect on the atmosphere. The climate effect is confronted with massive air pollution at sea borders and ports. Additionally, the sea absorbs the sulfur compounds, which leads to an increase in ocean acidification.

Alternative ship fuels

The aim of the Helmholtz Young Investigators Group SeaKLIM is to continue the analysis and quantification of these effects over the coming years. Veronika Eyring's team is therefore closely cooperating with national and international institutes as well as the industry, especially MAN Diesel. The current emissions from international shipping are being estimated and future emission scenarios are being developed together with experts from the company.

This cooperation has revealed that the globally existing engine performance of freight ships increased by 30 percent between the years 2001 and 2006. Emissions are expected to have grown accordingly at the same rate. This enormous increase has already led to the first countermeasures. For example, only ships whose fuel contains a maximum of 1.5 percent sulfur are allowed in the Baltic Sea. In the North Sea and the English Channel, the same regulations have been effective since 2007. The European Union even wants to ensure that by 2012 only ships whose fuel contains a maximum of 0.1 percent sulfur may dock in EU ports.

Desulfurized fuels or catalytic converters are already technically feasible today but are not used much, mainly due to higher costs. DLR also wants to contribute to resolving this issue through its research. Since mid-2006, the SeaKLIM group has been part of a new project by the name of BIOCLEAN, which is coordinated by Veronika Eyring's colleague Dr. Andreas Petzold at DLR. In cooperation with MAN, the team is planning to research whether bio or regenerative fuels are suitable for use in ship engines and how much pollutant emissions can be reduced this way. A key factor will be incorporating all relevant chemicals, such as CO_2, NO_x, hydrocarbons, SO_2, H_2SO_4, and soot particles, in the studies.

At the same time, technical improvements for ship engines will be investigated. The planned BIOCLEAN work package includes measurements of experimental and complete engines with alternative and regenerative fuels and exhaust gas measurements.

From a theoretical point of view, the research group wants to use computer simulations to analyze the expected climate impact of using alternative fuels. To conclude, transport plays an important role in the progressing globalization process. Forecasts predict the traffic volume will continue to strongly increase in the years to come. The challenges for science, technology, and politics thus remain multifaceted.

Author:
Thomas Bührke is a freelance scientific journalist;
Dr. Veronika Eyring is a member of the DLR Institute for Atmospheric Physics in Oberpfaffenhofen where she manages a Helmholtz Young Investigators Group.

The HelmholtzYoung Investigators Group of Dr. Veronika Eyring unites scientists from the Institute of Environmental Physics at the University of Bremen (IUP) and scientists from the DLR Institute for Atmospheric Physics (DLR-IPA) in Oberpfaffenhofen.

From left to right:
Dr. Heinrich Bovensmann (IUP), Dr. Axel Lauer (DLR-IPA), Dr. Veronika Eyring (DLR-IPA), Mathias Schreier (IUP), and Klaus Franke (IUP)

The "Young Investigators Group" funding instrument was established by the Helmholtz Association in order to promote cooperation between universities and Helmholtz institutes as well as to provide young scientists and researchers with good career opportunities. If after three or four years an independent expert review panel considers the research positive, the group leader receives an unlimited employment contract with their institute. Additionally, the Young Investigators Groups provide training for PhD students and graduate students and provide young postdoc researchers with an opportunity to establish themselves in science and earn a reputation. The groups are funded with an average of 250,000 Euros per year for a maximum of five years.

At the end of their student internship, Oliver Schade (right) and Robert Marx (by the window) are able to guide school students on a day-trip to the DLR_School_Lab Berlin-Adlershof through the traffic simulation.

TRAFFIC MANAGERS FOR A DAY

By Dr. Bernd Kirchner

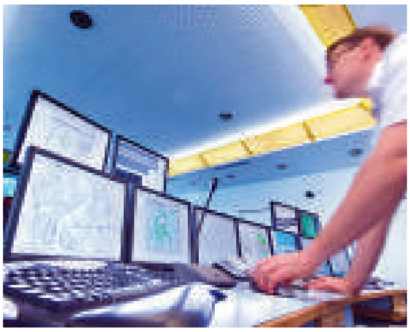
DLR_School_Lab experiment covers PC simulation right through to the traffic tower

Summer 2007: Robert Marx and Oliver Schade from the 9th grade of the Berlin Archenhold secondary school are working at the DLR_School_Lab in Berlin-Adlershof for two weeks. They were really taken with the traffic simulation experiment. After tutors had explained the program to them, they were practically glued to the computer. Robert thinks the simulation is great and Oliver added: "It's a shame that I can't take it home with me." The pair was also filled with enthusiasm when it came to carrying out the traffic simulation with a school class.

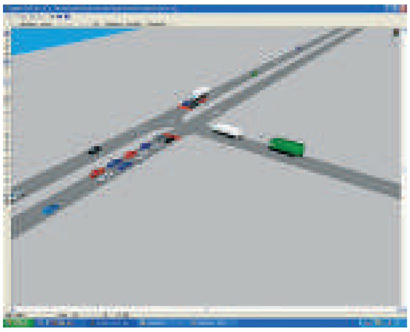
Robert and Oliver described the course of the student experiment for DLR Nachrichten:

What is a simulation and what is it needed for? This and other basic facts are explained by a tutor in an introductory presentation in small groups of three to five people. Then we go on to the intersection, only in the simulation of course.

For the sake of simplicity, the intersection consists of just one main road and one side road. The problem is quickly identified by the students: Since the cars on the side road have



During a visit to the DLR virtual transport management center, the Traffic Tower, students gain an insight into the complexity of traffic in reality.



The computer simulation shows the results of various measures with which traffic can be influenced. The simulation program VISSIM was provided by the company PTV Vision AG in a reduced test version for the student experiments.

to give way to all road users on the main road and as there is no traffic light, a traffic jam quickly forms. But even a traffic light is not enough to put an end to this. Only after the length of the green and red phases has been doubled, does the traffic flow fluidly. The students have just been familiarized with one of the simple factors that enables freely flowing traffic.

What effects do speed limits have before bottlenecks? How many cars does a road have capacity for? How does a gradient, traffic light or blocking a lane affect the flow of traffic? – You can either illustrate or simulate these questions using a specially developed program, which is easy to operate even for students, or you can use the more realistic traffic tower, the virtual transport management center of the Berlin Transport Research Institute.

Through induction loops and cameras you can see how traffic is counted and how the data is analyzed. The task consists in observing and finding out how the traffic flow can be improved. Diagrams of the analyzed data are also created and sections of the Berlin highway are depicted. Even entire cities, such as Cologne, are depicted with their transport network. In this way, you can realistically experience the problems and difficulties with traffic planning and see how intersections, for example, in the city center, could have been planned better.

After a bit of practice, all of the students were able to use the complex simulation program. They designed their first intersections and looked at real road sections in the traffic tower and their traffic composition and peculiarities.

For Robert and Oliver, this marks the end of their student internship. As tutors for the traffic simulation experiment at the DLR_School_Lab Berlin-Adlershof, they independently guided the students through the experiment. They will now receive certificates to confirm the successful completion of their student internships.

Author:

Dr. Bernd Kirchner is Head of the DLR_School_Lab in Berlin-Adlershof

Further experiments at the DLR_School_Lab Berlin-Adlershof:

Infrared light –
How can heat be made visible?

Solar cells –
Sunny prospects for alternative energies

Fuel cells –
How is electricity created from hydrogen?

Data collection –
On the road with the GPS mouse

Stereo images –
The third dimension

Mini drop tower –
Experiments in weightlessness

Mars express images –
Geologists research Mars

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French Companion

Cooperation for More Safety on the Roads and Railways

Transport crosses borders. DLR mainly cooperates with European partners in the area of transport research. Strong contacts link it with France.

The French National Institute for Transport and Safety Research (INRETS) is a state-funded scientific and technological institute for transport research under the joint responsibility of the French ministries of research and transport. INRETS was founded in 1985 and currently employs 600 staff. They are shared among the 17 research institutes in Lille, Lyon, Marseille, and in the greater Paris area.

The French research institute is active in the areas of traffic safety, transport networks, environmentally friendly transport, freight traffic, and new technologies. INRETS coordinates and analyzes research and development processes for improving traffic and transport systems. National customers are the French government, state authorities, and private companies, such as Alstom, Renault, and the French Railway (SNFC).

In France, INRETS manages the French transport research program within the networks for research and technological innovations. At the European level, INRETS scientists are in charge of a series of projects of the European research framework program. Internationally, INRETS cooperates in particular with the USA, Canada, Australia, Japan, and Korea.

DLR and INRETS are working together on topics such as driver assistance, safety in road and rail transport, transport management, and environmentally friendly traffic. Both institutions are united by their commitment at the European level in the European Conference of Transport Research Institutes (ECTRI). Regular coordination of strategies and research programs, more intensive personnel exchange, and mutual use of research facilities are planned for the near future.

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