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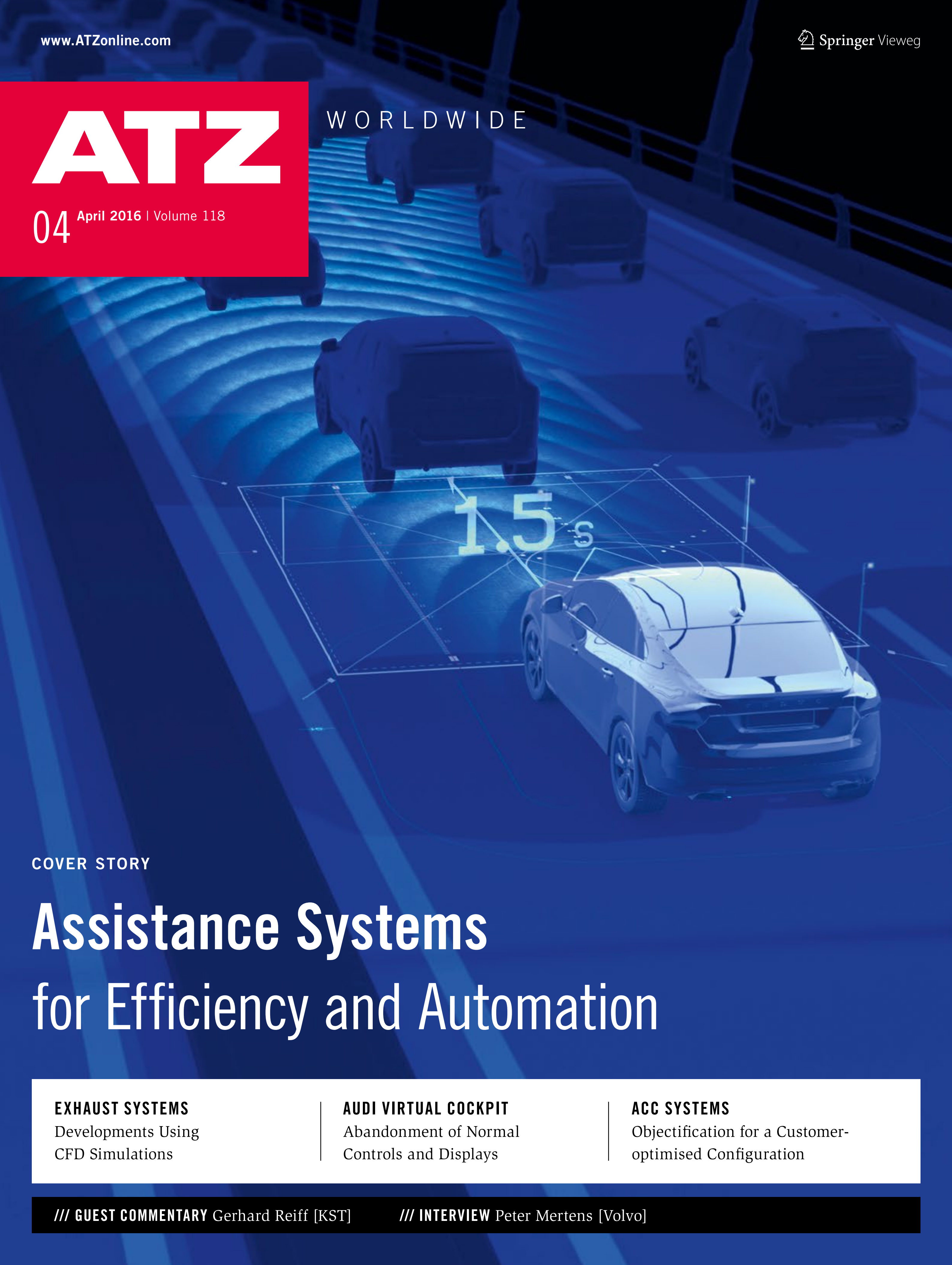


COVER STORY

Assistance Systems for Efficiency and Automation

EXHAUST SYSTEMS
Developments Using CFD Simulations

AUDI VIRTUAL COCKPIT
Abandonment of Normal Controls and Displays

ACC SYSTEMS
Objectification for a Customer-optimised Configuration

/// **GUEST COMMENTARY** Gerhard Reiff [KST]   /// **INTERVIEW** Peter Mertens [Volvo]

Back to the Future

Dear Reader,

Increasingly strict CO_2 emissions legislation necessarily requires a focus on the electrification of the drive system. However, the sustainable success of electrified vehicles – in the sense of making up a significant proportion of the whole vehicle fleet – is a long time coming. It is all the more important, therefore, in the long transition phase to electric mobility, to consistently advance the development of vehicles with efficient internal combustion engines, with or without hybridisation.

Of course, when it comes to efficiency, the pure electric motor is certainly the best component in the chain, and it will be required wherever zero emissions need to be achieved locally. And the driving ranges of electric vehicles are perfectly respectable. Realistic ranges of 90 to 100 km from a fully charged battery are the rule, and with a rapid charging system this range can often be extended by a further 60 to 70 km within half an hour. At the same time, electric vehicles can significantly reduce local pollution caused by exhaust and noise emissions.

Now some may ask: what is this person talking about? We know all that already. Well, what is described above is not from today's news but is actually taken from an article published in ATZ 4 in 1956, with the promising title "The Importance of Electric Vehicles in Road Traffic". It described a DKW delivery van with a 3.6 kW electric motor driving the front wheels and powered by "two batteries suspended at the side of the chassis generating a total output of 200 Ah at a voltage of 80 V". From the outside, the van looked no different from its gasoline-powered counterpart. In addition to discussing technical issues, the authors also considered the question of running costs, stating: "If the cost of renewing the battery is added to the running costs, the energy cost per kilometre for the electric car is 50 to 60 % that of the gasoline-powered version." They calculated "annual costs (without the driver) of 4400 Deutschmarks for a driving distance of 15,000 kilometres", which was 1800 Deutschmarks below those of a "gasoline car". By the way: in 1956, around 23,000 electrically powered industrial trucks and 7000 electric cars were in use in Germany.

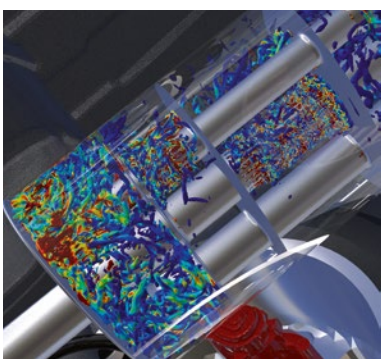
Since then, technology has advanced in leaps and bounds. Batteries have become much smaller and lighter and driving ranges have (slightly) improved. Technically speaking, our engineers have prepared the ground well. It is now up to marketing experts and accountants to convince the customers.

Dr. Alexander Heintzel
Editor in Chief

COVER STORY

Assistance Systems for Efficiency and Automation

It is hard to imagine modern cars without anticipatory driver assistance systems. These are the only functions that can provide information about obstructions around blind bends, improve the point at which the car changes gear and refine the charging strategy of the battery. Drivers must feel that their cars "understand" them in order for automated driving to become widely accepted.


© Exa

Exa and Eberspächer show how CFD simulations can be used to identify the causes of irritating noises and improve the development process for exhaust systems.


© Audi

In the TT, Audi abandons the normal design of its instrumentation and information distribution functions and focuses instead on customising the architecture to best meet the driver's needs.


© Adrian Sonka

In three tests, the TU Braunschweig highlights specific target figures for the ideal adaptive cruise control system.


© KST

COVER FIGURE © Volvo

Obituary | **Death of Manfred Mitschke**

© RWTH Aachen University | ika

Prof. Manfred Mitschke (right) in October 2014 at the presentation of his Springer-Vieweg textbook "Dynamics of Motor Vehicles" in Aachen with Prof. Lutz Eckstein (left)

Professor Manfred Mitschke died on 30 October 2015 at the age of 86. He came originally from the German state of Silesia and was Head of the Institute of Automotive Engineering (IfF) at what is now the Braunschweig University of Technology from 1966 to 1997. Mitschke began his remarkable academic career at the then Technical College in Braunschweig, where he completed his degree in 1955. As early as 1957 he was awarded a doctorate and then qualified as a professor in 1960 on the basis of his publication "Contribution to the theory of vehicle vibration and its experimental confirmation". In rapid succession, he achieved various high-level management positions at the company Bosch from 1960, and in 1966 the TU Braunschweig appointed him as the successor to his highly honoured teacher, Prof. Dr. Paul F. C. Koeßler, who had founded the IfF in 1940.

Mitschke's work heralded a new age in modern, scientific automotive engineering. His life's work and his research and teaching in the fields of vehicle design and dynamics resulted in many highly regarded publications and a number of books which were translated into several languages. [...] With his death, the automotive world has lost a highly esteemed scientist, researcher and teacher. We will always cherish the memory of Professor Mitschke.

Prof. Dr.-Ing. Ferit Küçükay,
Director of the Institute for Automotive Engineering, TU Braunschweig

Valeo | **Takeover of Thermal Management Specialist Spheros**

The Paris located supplier Valeo took over the German thermo specialist Spheros. The acquisition will enable Valeo to extend its thermal management activities to the bus market. French Valeo signed a contract at the end of 2015 for the acquisition of the German company Spheros, which was in the possession of Deutsche Beteiligungs AG (DBAG). Spheros is specialised in air conditioning and ventilation systems for omnibuses and has an annual revenue of around 250 million euros. According to Jacques Aschenbroich, CEO of Valeo, its portfolio is an absolute strategic fit with Valeo's Thermal Systems Business Group.

© Valeo

The company headquarters of the Spheros Group in Gilching near Starnberg

© TechniSat

The TechniSat Automotive site in Dresden

Joyson | **Preh's Parent Company Buys TechniSat Business Unit**

Ningbo Joyson Electronic, based in Ningbo in China, and its subsidiary Preh Holding GmbH, from Bad Neustadt an der Saale in Germany, are each taking over 50 % of the automotive division of TechniSat Digital GmbH in Daun, Germany. The company develops and produces innovative products and software solutions in the fields of car infotainment and navigation, vehicle networking and telematics. Within the Joyson Group, TechniSat Automotive will be integrated into the automotive electronics division and, together with Preh GmbH, will be known as Preh TechniSat Car Connect GmbH.

Volkswagen | **New Board Member for Commercial Vehicles**


© Volkswagen

Harald Ludanek

Dr. Harald Ludanek (57), previously Head of Research and Development at Scania CV AB (Södertälje, Sweden), is the new Board Member for Technical Development at Volkswagen Commercial Vehicles. Ludanek succeeds Hans-Joachim Rothenpieler (58) who will take over as Head of Quality Assurance at the Volkswagen Group from 15 February. He is the successor to Frank Tuch (48), who is leaving the company at his own request to pursue other interests, but will remain available to Volkswagen in an advisory capacity.

Siemens | **Munich-based Company Buys CD-adapco**


© Siemens

Anton Huber

Siemens and CD-adapco have announced that they are entering into a stock purchase agreement for the acquisition of CD-adapco by Siemens. The objectives for Siemens are to sharpen its focus on growth in the digital sector and expand its portfolio in the area of industry software. The purchase price is 970 million US dollars. CD-adapco will be integrated into the PLM software business of Siemens' digital factory (DF) division. By adding CFD simulation software such as Star-CD and Star-CCM+ to its portfolio, Siemens is "greatly enhancing its core competencies in model-based simulation, which creates a very precise digital twin of the product," said Anton Huber, CEO of the DF division.

Leoni | **Fankhauser Becomes Member of the Board**


© Leoni

Bruno Fankhauser

Bruno Fankhauser (44) became a Member of the Leoni Management Board on 1 February 2016. The Supervisory Board of Europe's leading provider of cables and cable systems to the automotive sector and other industries has assigned responsibility for its wire and cable solutions division (WCS) to the Swiss national, who has been with the group for 10 years. Bruno Fankhauser took over the management of the Swiss cable company Studer in 2004 and joined the Leoni Group as a result of its takeover of Studer in 2006. Since 2008, as Member of the Wire and Cable Solutions division's Management Board, he has been responsible for a business unit that specialises in the development, production and sale of cables and cable systems for various industries.

IMPULSES

Dr. Johannes Liebl
Editor in Charge
ATZ | MTZ | ATZelektronik

Digitisation – A Key Factor in Purchase Decisions

The market success of vehicle manufacturers is increasingly being determined by the digitisation of vehicles. More and more customers are prepared to pay extra for intelligent assistance in all types of driving situations. By networking a car with its environment, existing traffic situations can be evaluated quickly and recommendations for action can be given, which allows even inexperienced drivers to adopt an anticipatory driving style. As this can lead in practice to significant reductions in fuel consumption and exhaust emissions, the widespread introduction of systems of this kind makes considerable sense. The new real driving emissions (RDE) regulations should lead the way in this area and take assistance systems into consideration in their approval process.

Customers' requirements for these systems are based on the options available on the Internet and on smartphones. Therefore, it is important for the systems to have an intuitive design. Automated interventions should feel similar to drivers' own behaviour, because unexpected measures will surprise drivers and make it less likely that the systems will become widely accepted. This means that the ability to reproduce human perceptions is an important success factor. The subjective feeling of well-being must be understood and transformed into objective criteria for the engineers, which will result in an even more complex product development process. In addition, the necessary legal and social framework has not yet been fully established.

What effect is this upheaval having on the mechanical engineering-based automotive industry? Our ATZlive conference "Driver Assistance Systems – From Assistance to Automated Driving", which is taking place on 13 and 14 April in Frankfurt am Main, will explain the latest developments. We look forward to meeting you there.

Life Cycle Assessments

Cars and Environment

The main effect that cars have on the environment occurs while they are being driven. But this is only one of several factors involved and the emphasis is now increasingly being placed on the production phase and its upstream processes, together with the end-of-life disposal methods. Life cycle assessments are complex, but they are becoming more and more important for OEMs.

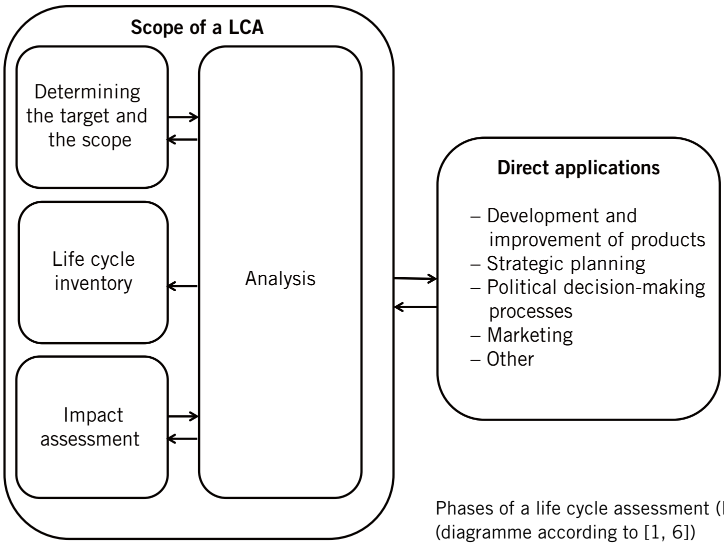
FOCUSING ON THE PRODUCT LIFE CYCLE

The environmental impact of cars occurs mainly during the usage phase, in other words when the car is on the road. This impact is expected to lessen when the full potential of lightweight structures is exploited, powertrains are made more efficient and more electric vehicles are produced. The process is being accelerated by EU legislation which requires all new cars to produce a maximum of 95 g CO_2/km by 2020. There is some disagreement about whether this figure can be achieved with a "sporty driving style" and with the range of models currently available. The ongoing boom in the sales of SUVs is likely to produce the opposite result.

As the use of the car on the road is only one of many factors involved in its environmental impact, the emphasis is increasingly being placed on the production phase and the emissions from its upstream processes. Car manufacturers finally seem to have realised that it is only possible to get a complete overview of the environmental damage caused by vehicles by considering their entire life cycle. This means including the extraction, processing and transport of raw materials, the manufacturing of components and the recycling potential of the end products. In order to ensure that these environmental costs, which have been disregarded for many years, are no longer imposed on society as a whole, life cycle assessments (LCAs) based on ISO 14040 and 14044 are being used to evaluate the effects of every individual process and to bring them together in an overall summary.

In contrast to other environmental evaluation tools, life cycle assessments can be carried out on the basis of a largely standardised procedure. The analysis consists of four phases. In the first, the goal and the scope of the investigation are defined. In the second phase, an inventory is taken which identifies the incoming and outgoing flows of materials in the product system that is being investigated. The third phase is the impact assessment, where the effects on the environment are quantified and assigned to the material flows. The fourth and final phase is the interpretation, which involves evaluating the results of the investigation and presenting them in a way which can be easily understood [1].

Carrying out a life cycle assessment is not a trivial matter. Because of the sometimes contradictory interactions between the various processes and the large volume of data, it can be very time-consuming to come to a reliable conclusion. It would be helpful if modifications to the powertrain of vehicle A inevitably had a



Phases of a life cycle assessment (LCA) (diagramme according to [1, 6])

positive effect on vehicle B, but unfortunately that is not the case.

OBTAINING AUTHORITATIVE RESULTS

Another particular feature of LCAs is that the ISO guidelines have deliberately been made flexible, as Jan Paul Lindner from the department Life Cycle Engineering (GaBi) at the Fraunhofer Institute for Building Physics (IBP) explains. For this reason, the goal must be defined in very precise terms, because there is always the possibility that issues and results will be interpreted in different ways. “Information is sometimes taken out of context by public relations managers and marketing departments,” says Lindner. But it depends how the issues are interpreted and which databases are used. In addition, the databases in their turn access different statistics. The assessment may also be pessimistic or optimistic in nature. As a result, life cycle assessments of the same object can produce different findings and, therefore, come to differing conclusions.

GENERIC DATA

For this reason, the results of an LCA must be evaluated against the background of its goal and its scope. This allows the modelling data to be selected, among other things. “We often work with companies and research partners that process a specific material, knowing little about its origin” says Lindner, the LCA expert. He adds: “The companies have a purchasing department that buys e.g. steel. Provided that the steel meets their quality criteria, the buyers will try to get it as cheaply as possible. This means that it might pass through the hands of three middlemen and, as a result, the companies themselves often don’t know exactly where the steel comes from originally.” Lindner explains that life cycle assessment specialists make use of databases at this point. A lot of information is already available in particular for inventories and technical system models. “In processes that have been aggregated, there will be a dataset, for example, that represents 1 kg of iron from country xy,” he says. There are also datasets that represent the oil import mix or the iron or copper mix in Germany, which are based on statistics from the International Energy Agency (IEA). Detailed models are often produced of what actually happens inside the company involving the factors that can be influenced. All the company’s inputs, on the other hand, such as upstream products, are frequently modelled on the basis of generic datasets of this kind which show a technology or import mix. In this context too, the goal of the LCA is important. In the automotive industry, it is often a case of investigating the potential of a specific process or procedure, for example, and the OEMs will often involve their suppliers.

LCA MODEL FOR STEEL MANUFACTURING

Because the automotive industry expects to receive an increasing amount of environmental data from its suppliers, ThyssenKrupp Steel Europe has produced a life cycle assessment model for its steel production. A special software package takes into account the fact that the different parameters will vary. This means that the alloy, manufacturing route and coating can be modified depending on the type of steel. And in addition to CO_2 emissions, accompanying factors such as SO2, hydrocarbons and heavy metal emissions are also considered.

ThyssenKrupp used the example of a B pillar to investigate the environmental effects of hot- and cold-formed steel. The experts presented the surprising results in ATZ [2]. Despite the high energy use of the hot forming process, which requires temperatures of 900 °C, the LCA showed that the cold-formed component had a greater environmental impact. “If you take into consideration the emissions generated during the manufacturing process, including all the upstream production chains, depending on the route, the coating and the alloy, around 2 kg of CO_2 equivalent is produced for each kilogram of steel sheet,” says Anna Meinke, development engineer for life cycle assessments, who with her colleague Lisa Mohr, works on product-related environmental protection at ThyssenKrupp. Steel used for hot forming produces around 20 % more emissions than conventional steel. But when the lightweight design potential of both types of steel is taken into consideration, the amount of material used is so much less that the hot-formed B pillar has a lower environmental impact than its conventional equivalent as early as the production phase.

The additional energy needed to heat the component is more than compensated for by the significant reduction in the amount of material used. The hot-formed, lighter weight B pillar also produced lower emissions in the usage phase. At Volkswagen this is described as an “example of the successful implementation of intelligent lightweight design, taking into consideration the principles of environmentally responsible vehicle development". On the basis of an overall assessment of the entire life cycle, hot forming is the only lightweight production method "which pays off from the first kilometre".

The current catchword "lightweight design" almost automatically calls to mind specific materials that are often mentioned in this context. But the manufacturing processes for CFRP, magnesium and primary aluminium are highly energy- and CO_2-intensive. For this reason, it is important to avoid making statements such as "material X is always better than material Y". As Dr. Jens Warsen and Dr. Stephan Krinke wrote in ATZ [3], ultimately "additional CO_2 emissions from the production phase of lightweight materials and concepts must be compensated for by fuel savings during the usage phase that result from the lighter weight of the component." We can only use the term intelligent lightweight design if the environmental break-even point is reached as early as possible. Lightweight structures must therefore always be regarded in the context of the entire vehicle and not from the perspective of an individual component.

INVESTIGATING THE POTENTIAL OF NEW TECHNOLOGIES

Life cycle assessments are also a useful tool in other areas, such as the evaluation of electric powertrain concepts, as demonstrated by Dr. Christian Ernst in his PhD dissertation at RWTH Aachen University [4]. He describes both the potential and the limitations of LCAs. From a political perspective, the LCA methodology offers the opportunity to carry out an objective evaluation of the sustainability of technologies that are not yet established on the market. Ernst sees life cycle assessments as a possible further development stage of existing CO_2 legislation. However, on the basis of sample simulations he comes to the conclusion that the large number of influencing factors and the complexity and lack of transparency of the value chains currently present a challenge. If future research projects could improve the transparency of the raw material extraction process and if a consensus could be reached in the automotive industry on a standardised form of assessment, there would be a greater potential for incorporating LCA methodology into the relevant legislation.

ECONOMIC AND SOCIAL ASPECTS

In the context of an overall evaluation of the environmental effects of a product, it should also be possible to trace the product's impact earlier in the production chain. Aid organisations such as Misereor and Bread for the World are constantly reporting that raw materials for the automotive industry are often mined in unsatisfactory conditions. The majority of German raw material imports come from countries where violations of human rights and environmental destruction are commonplace in the mining industry. According to Misereor, more than 70 % of Germany's copper imports come from Peru, Chile, Brazil or Argentina, 73 % of its bauxite from

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Jean-Philippe Hermine
Head of the Environmental Plan of the Renault Group

2 QUESTIONS FOR ...

ATZ _ The Renault group spends 60 % of the research expenditure to CO_2-reduction. How do you verify the state of origin of a certain material and its environment impact?

HERMINE _ Specific environmental requirements are integrated to purchasing specifications through "Renault Green Purchasing Guidelines", which set out the Group's expectations in terms of environmental management, substances and recycling policy in relation to delivered parts and materials. The most binding aspect of these guidelines is the compliance with Renault "substances standard" on every purchased part, material or product: In calls for tenders, Renault explicitly asks suppliers to comply with this standard, which prohibits the use of hazardous substances and substances of concern, lists priority substances for substitution, and requires suppliers to declare the substances used to create their parts and preparations.

How do you monitor the success of your life cycle management strategy?

Renault is using comparative LCA analysis to identify the environmental footprint of its product by using the same method and hypothesis. The same functional unit is used, for example 150,000 km. Moreover to validate our results, we submit our LCA comparative reports and methodology to LCA external experts to perform a critical review both on the methodology and on the specific results for each comparison, for example Espace 5 versus Espace 4. The combination of these approaches enables us to communicate on our results with a high level of transparency.

The components of a complete an entire car are manifold – as well as the origin of the necessary raw materials (© LaCozza | Fotolia)

Guinea alone and 50 % of its iron ore from Brazil [5]. In the so-called copper belt in the province of Katanga in the south of the Democratic Republic of Congo, mining for mineral resources involves systematic destruction of the environment. Misereor explains that serious violations of human rights and large-scale environmental devastation often go hand in hand.

For this reason, as part of an overall sustainability assessment we should be taking economic and social factors into consideration as well as analysing and evaluating environmental parameters. Methodological approaches which go beyond the classic life cycle assessment have already been developed. These include life cycle costing and eco-efficiency analysis, which sees environmental impacts in relation to economic figures, such as product costs and added value [1]. In contrast to the investigation of economic parameters, all of which can be relatively easily evaluated using monetary units, the quantification of social aspects is a very wide-ranging field that is relatively new in life cycle assessments [1]. In order to produce a social LCA, the classic life cycle assessment method has been modified and developed further. This involves recording and evaluating social indicators from the ground up using comparable methodological modules.

Environmental evaluation methods based on the LCA methodology are a tool both for identifying the causes and consequences of environmental problems and for assessing the opportunities for action in a social context. In future, it will be increasingly important for the automotive industry to have a thorough understanding of these methods.

Angelina Hofacker and Ulrich Knorra

REFERENCES

[1] Kaltschmitt, M.; Schebek, L.: Umweltbewertung für Ingenieure. Berlin/Heidelberg: Springer Vieweg, 2015

[2] Meincke, A.; Mohr, L.: Sustainability in the Supply Chain of Steel for Automotive Industry. In: ATZworldwide 117 (2015), No. 7-8, pp. 50-54

[3] Warsen, J.; Krinke, S.: The life cycle approach at Volkswagen. In: ATZworldwide 114 (2012), No. 7-8, pp. 4-9

[4] Ernst, C.-S.: Energetische, ökologische und ökonomische Lebenszyklusanalyse elektrifizierter Antriebsstrangkonzepte. Dissertation, Institut für Kraftfahrzeuge, RWTH Aachen University, Schriftenreihe Automobiltechnik, FKA, Aachen, 2014

[5] Misereor und Brot für die Welt: Vom Erz zum Auto. Dossier 5-2013. Online: https://www.misereor.de/fileadmin/publikationen/dossier-vom-erz-zum-auto-2013.pdf, last access: Februar 2016

[6] Environmental management – Life cycle assessment – Principles and framework (ISO 14040:2006)

"A Means to What End?"

In the automotive industry, life cycle assessments have become an established evaluation tool for strategic environmental issues, which must be seen as a positive development. However, the industry also needs to take a critical approach to the results of these assessments. They should always be considered against the background of the method's limitations, which are the result of selecting a specific excerpt from the real world. In addition, the use of different environmental evaluation methods on the same object can produce different findings and, therefore, also different results. For this reason, great care must be taken before using the results of LCAs as a marketing tool, otherwise the information provided to customers may not be as transparent as it seems.

Angelina Hofacker
is Editor of ATZ and MTZ.

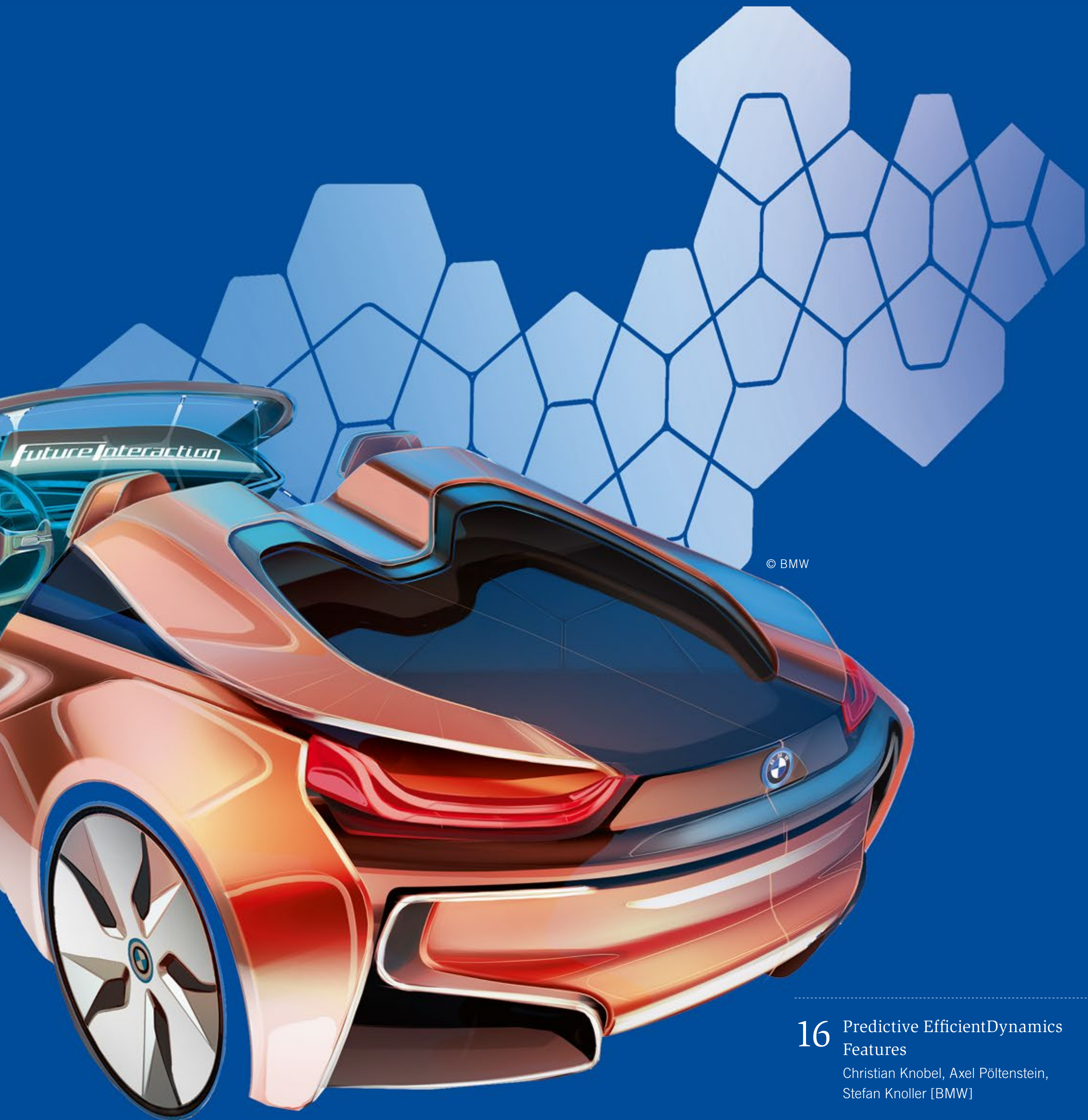
COVER STORY

Assistance Systems for Efficiency and Automation

Assistance systems, environment sensors and car-to-x communication play a key role in reducing fuel consumption in practice. Developers must therefore not only develop and connect a large number of systems, but must also validate them for everyday driving. Only this will guarantee that these efficiency technologies have a reliable effect, in particular in real customer operation, in order to noticeably cut exhaust emissions in urban areas. Even though many drivers still reject help from assistance systems and see them as impractical or quickly deactivate them after a test phase because they find them inconvenient, these assistants are already contributing towards reducing emissions and improving driving safety in plug-in hybrids. After all, no driver can be expected to control the accelerator pedal in such a way as to ensure that the battery is recharged with the optimum recuperation potential on the next downhill situation without damaging it. This interaction between the internal combustion engine, the transmission and the electric motor – deciding when which drive system is activated or deactivated – should rather be left to a technical system to deal with. The system is supported by environment sensors and car-to-x communication. As a result, the use of predictive components means that the car “knows” in advance when a situation for charging the battery will occur or how far it is to the next charging station.

The systems are one thing, human beings are another. It would be good to know how drivers feel during automated driving. It still seems to be the case that they prefer conventional driving to automated chauffeuring because they feel that the systems do not understand them. Drivers should be involved more in the control systems, and the assistance systems should constantly adapt to them. Over the next decades, these steps towards autonomous driving will be more evolutionary than revolutionary. Whereas public discussion is – incorrectly – mostly focused on fully automated driving, the acceptance and use of partially automated driving functions are continuously increasing, as Dr. Konrad Weßner, General Manager of the market research company Puls, rightly points out in his study.

Michael Reichenbach



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Predictive EfficientDynamics Features

Reducing fuel comsumption and improving driving pleasure in common driving situations are the main goals of BMW's predictive EfficientDynamics features. Basic concept of these features is the intelligent connection of onboard sensors und map data in order to generate information about upcoming driving situations.

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PREDICTIVE FEATURES IN ROAD VEHICLES

Due to limited information, the driver is often restricted in making the right decisions, thus not able to exploit the vehicle's full potential. In unfamiliar territory the driver is not aware of upcoming curves or speed limits. Complexity rises when vehicle drivetrains become more electrified. For example, it would be quite challenging for the driver of an hybrid electric car to control the battery's state of charge manually in order to be able to regenerate the maximum amount of brake energy on the next hill-decent. Taking all this into account, it was necessary and reasonable to introduce predictive features in the vehicle itself. [1, 2, 3, 4]

By combining map data information about the route ahead with the vehicle's system states and environment data based on camera and radar systems, the system optimises the operating strategy of the car and assists the driver in pursuing a safe, comfortable and efficient driving experience.

AUTOMOTIVE PREDICTION HORIZONS

The required prediction range and resolution of data varies with the scope of a particular predictive feature. Therefore different sources of information are used, creating discrete virtual horizons stretching from only a few meters to several hundred kilometers. The three prediction horizons are illustrated in **FIGURE 1**.

The longest prediction range is available when the driver uses the vehicle's navigation system (routing active): Based on the map data complemented with real time traffic information (RTTI) and the road characteristics informations such as estimated speed, slope, road type, remaining distance and driving time as they affect the vehicle's energy demand can be determined all the way until the final destination. This particular horizon is relevant for all features that affect long term planning like the vehicle's operating strategy or for choosing the most efficient route.

For the second group of Efficient-Dynamics features the focus lies on predictive longitudinal guiding, using a medium to short range horizon. Typical situations are: changing speed limits and

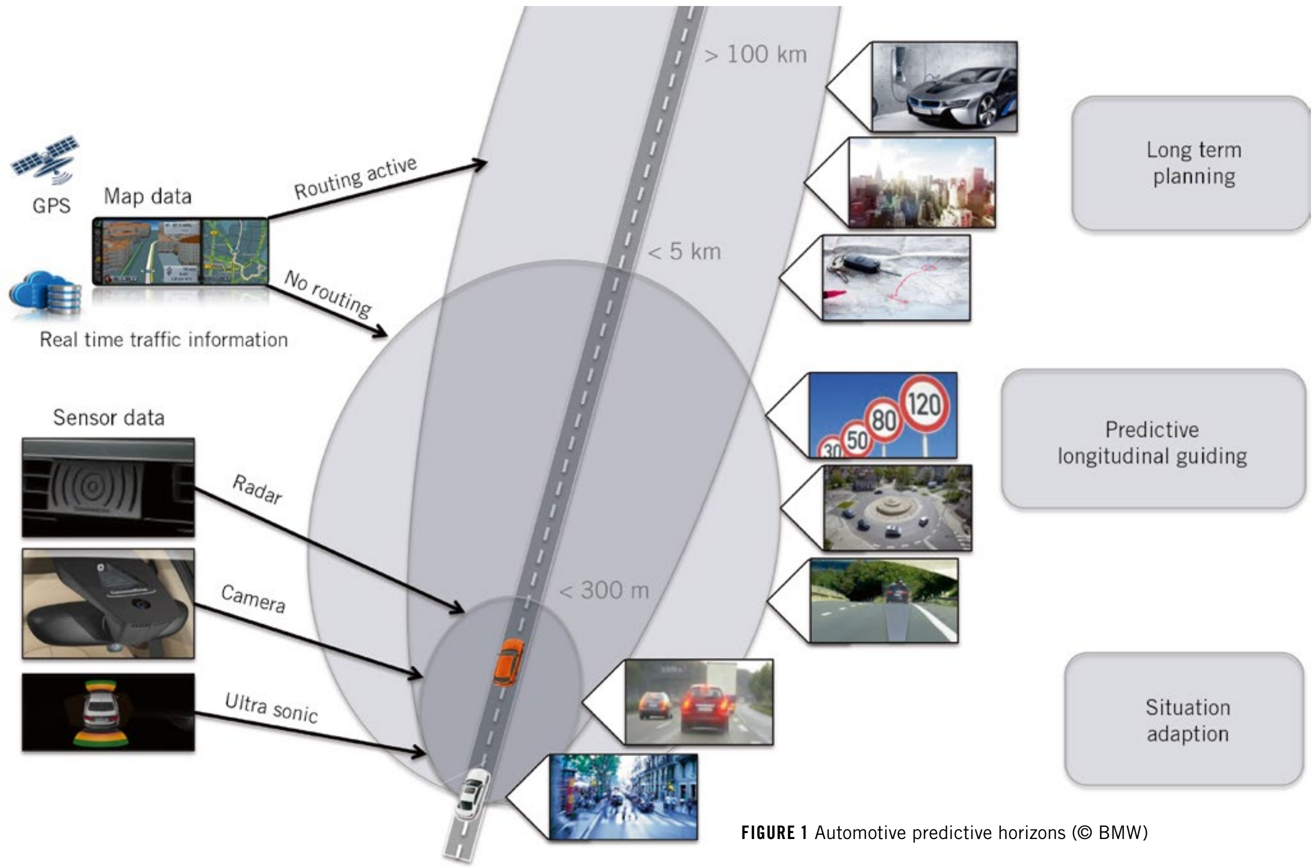

FIGURE 1 Automotive predictive horizons (© BMW)

slopes, curves and turns but also vehicles in front. This horizon consists of a fusion of sensor and map data, **FIGURE 1**. If routing of the navigation system is inactive a most probable path (MPP) is estimated and allows a prediction range up to several kilometers depending on the current road type and number of intersections. The features in this horizon assist BMW drivers in pursuing an efficient and comfortable driving experience.

For situation adaption only short prediction distances need to be covered, thus camera systems play an important role for this feature. Instantaneous decisions of the vehicle's operation strategy like running the combustion engine while idling or not are improved due to situation adaption.

LONG TERM PLANNING: PREDICTIVE ENERGY MANAGEMENT

Based on map data the Predictive Energy Management analyses the route ahead until the final destination of the vehicle and utilises the electric energy for efficient and perceptible electric driving. Predictive Energy Management was launched at first in 2011 for the BMW ActiveHybrid models and then further improved for the BMW i8. With the upcoming BMW eDrive models the functionality is taken to the next level.

Once routing of the navigation system is active the upcoming route is analysed. By using the newest ConnectedDrive Technology like RTTI (Real Time Traffic Information) the car even knows about the upcoming traffic flow and adapts the strategy accordingly. Now the available electric energy, in addition to the amount needed for urban speed zones and at the final destination, is utilised especially for electric driving at sections with low-power demand, **FIGURE 2**. Energy that

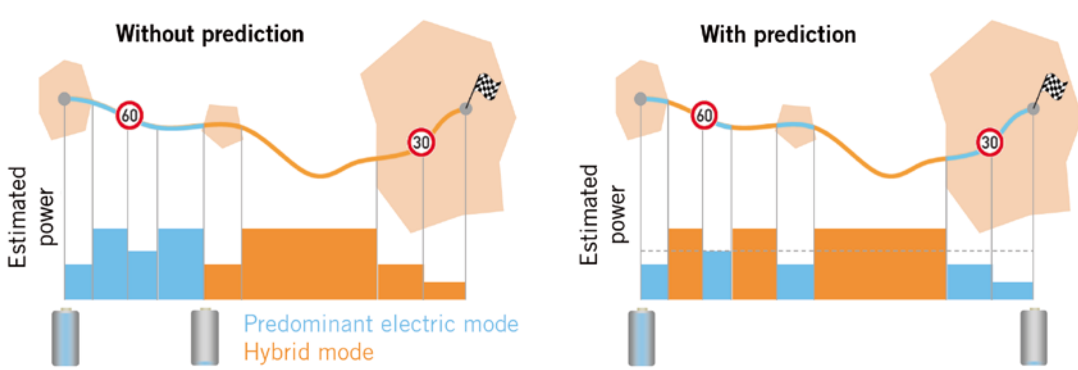

FIGURE 2 Long term planning of Predictive Energy Management (© BMW)

can not be spent on electric driving is made available for electric assist of the combustion engine.

Linking map data with energy management leads to saving fuel, using the available electric energy in an efficient way and emission free electric driving where it is most valuable, see also [5] for more information.

PREDICTIVE LONGITUDINAL GUIDING: ROUTE-AHEAD ASSISTANT

Features optimising longitudinal guiding need to handle the operating modes driving at constant speed, accelerating or braking, cruising in neutral (coasting) and cruising in gear (engine braking). Vehicle fuel consumption and emissions are directly related to unnecessary braking, idling and acceleration periods. In order to reduce emissions and improve fuel efficiency, these situations should be avoided as much as possible, compare [4]. By taking advantage of map data and certain vehicle modes a combination of comfort and efficiency can be achieved.

Since 2011 the BMW Driving Performance Control lets the driver choose between Comfort, Sport, and Eco Pro Mode. The Eco Pro Mode aims for maximum fuel efficiency and intelligently adapts the characteristics of the vehicle. The Route-ahead Assistant is an innovative feature of the Eco Pro mode, which supports efficient and comfortable driving by intelligent processing of sensor and map data. Based on navigation data, it detects speed limits, curves, roundabouts, T-junctions and motorway exits along the route and offers tips in advance. Using these tips, such as lifting from the throttle, the driver is able to reduce speed long before recognising the speed reduction situation. When following these tips, the vehicle uses its own kinetic energy and coasts along the road with minimum fuel consumption. In combination with coasting, this amounts up to an average of 5 % fuel reduction, **FIGURE 3**. Based on the particular situation the fuel reduction is up to 50 %.

By analysing the route ahead with regard to speed limiting events, a target speed profile is determined. In addition, the vehicle's deceleration is calculated every 20 ms based on current mass and speed as well as upcoming slope, drag torque, air and rolling resistance. As soon as the function detects the projected deceleration intersecting the target speed profile, a recommendation for lifting the driver's foot from the throttle is indicated in the instrument cluster and head-up display, **FIGURE 3**.

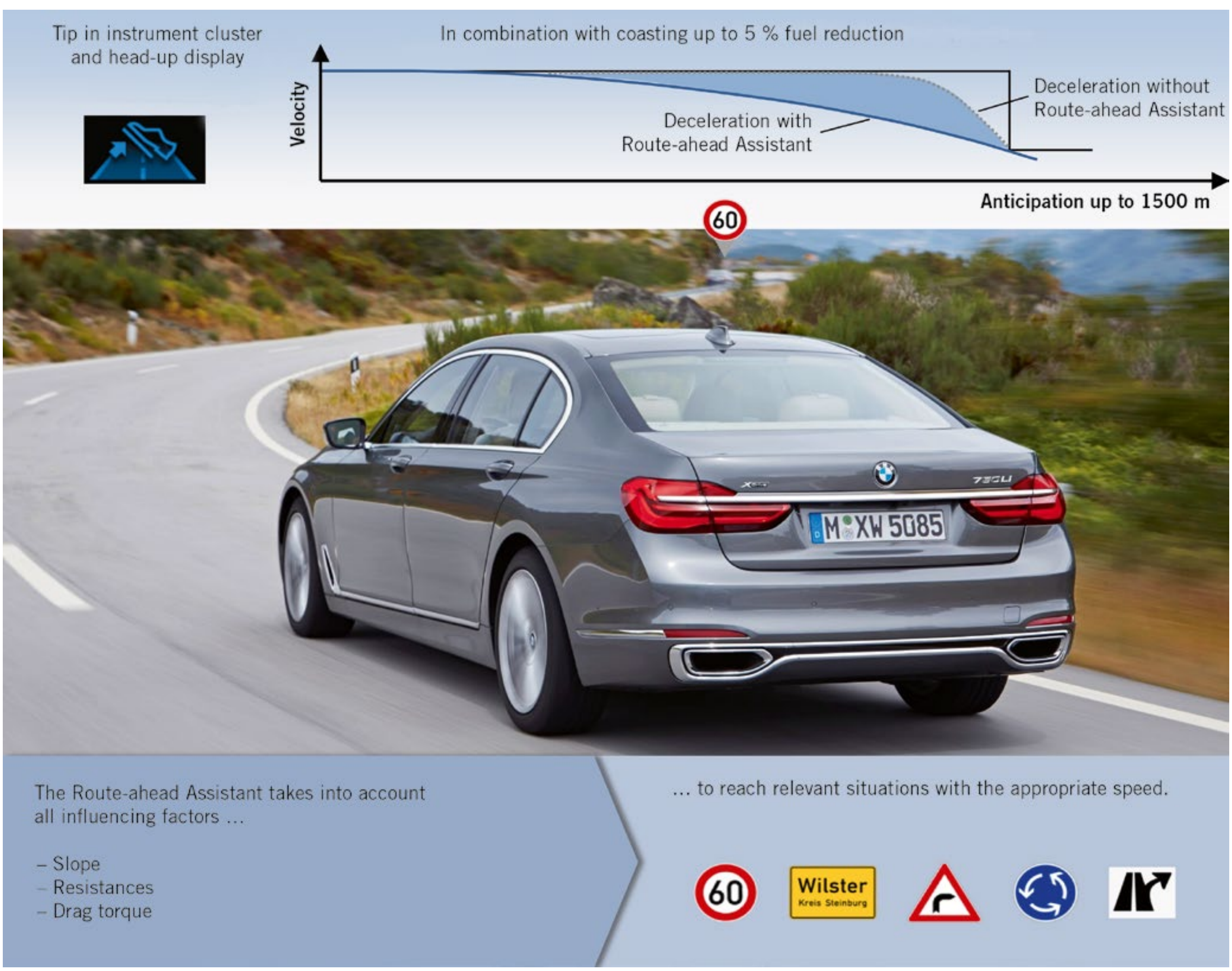

FIGURE 3 Concept of Route-ahead Assistant (© BMW)

PREDICTIVE LONGITUDINAL GUIDING: SPEED LIMIT ASSIST

The development of Advanced Driver Assistance Systems like Active Cruise Control creates the opportunity to automatically control vehicle speed over the complete range from 0 to 210 km/h. Until today, Active Cruise Control was mainly developed to increase driving comfort.

By offering upcoming speed limits as new intended velocity, **FIGURE 4**, the Speed Limit Assist offers a huge potential for efficient driving. Using the Most Probable Path (MPP), a suitable trajectory for the decelaration is caculated. The combination of coasting, engine braking and hydraulic braking in order to optimise travel time or efficiency is chosen individually for every driving mode, **FIGURE 5**. The driver is free in choosing between different modes to set up a speed profile that is appropriate to his actual mood and driving behaviour. The Speed Limit Assist was launched in 2015 in the BMW 7 series additionally to Active Cruise Control.

FIGURE 4 Upcoming speed limit for Speed Limit Assist framed in green (© BMW)

PREDICTIVE LONGITUDINAL GUIDING: CONNECTEDSHIFT

Another benefit of utilising the data of the vehicle surroundings enables the adaption of the automated gearbox to the driving situation ahead. BMW introduced the ConnectedShift feature in 2013 which uses map data to select the appropriate gear for upcoming situations.

A reference speed for upcoming driving situations like curves, intersections, and roundabouts is calculated using properties extracted from map data. Based on the reference speed, driving mode and driver behaviour, the suitable gear for the upcoming event is calculated and will be selected as soon as the driver steps on the throttle. This assists the driver in decelerating ahead of the situation and increases vehicle response when accelerating afterwards, **FIGURE 6**. The function is described in detail in [6].

The driving situation is analysed by including the data from on-board sensors, like radar and camera. In normal operating conditions of the vehicle, it is possible to reduce the rotational speed of the engine to drive fuel efficiently. By means of prediction, it is possible to specifically improve vehicle dynamics in situations where driving pleasure is desired.

SITUATION ADAPTION: INTELLIGENT AUTO START STOP

Beginning in 2007 BMW started to launch the Auto Start Stop function in order to further increase efficiency. Therefore Auto Start Stop turns off the engine whenever it is not needed in standstill instead of wasting energy by idling.

While the current design of the function significantly decreases the fuel consumption especially in urban driving environments, there is still room for further improvement. Turning off the engine, for example at a stop light, will reduce the engine's idling consumption to zero. The cost for the restart is mainly determined by the inertia and losses of the engine. The electric starter and fuel injection will speed up the engine to idling speed. Depending on the duration of the stop, there is a break-even between the cost for the restart and the Auto Start Stop fuel savings. The Intelligent Auto Start Stop feature, which will be available in 2016, will only allow efficient Auto Start Stops. Therefore information from additional sensors such as a camera, radar or GPS will be used to predict the duration of stops before the engine is turned off. An algorithm analyses the available sensor and map data in order to predict the flow of traffic. Based on the identified situation and probable stop time, the engine controller is able to

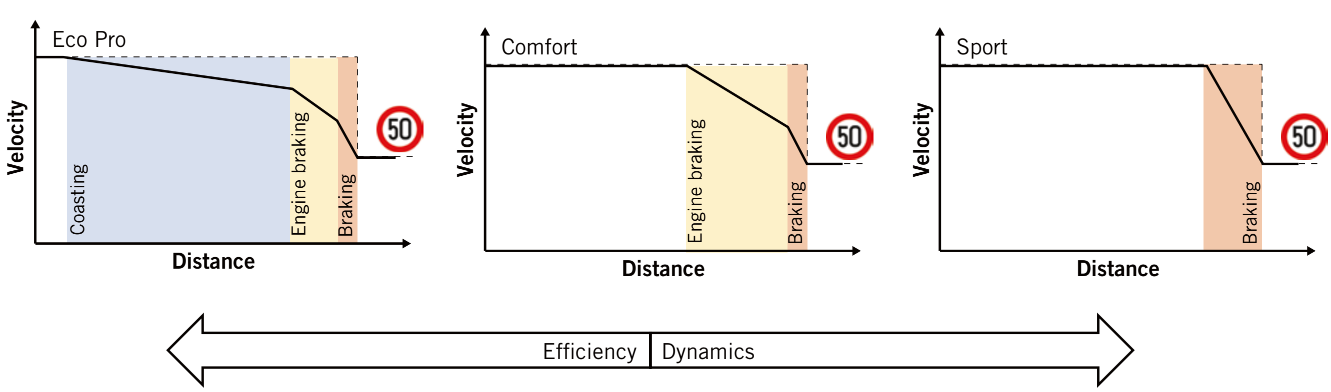

FIGURE 5 Characteristics of Speed Limit Assist for Eco Pro, Comfort and Sport Mode (© BMW)

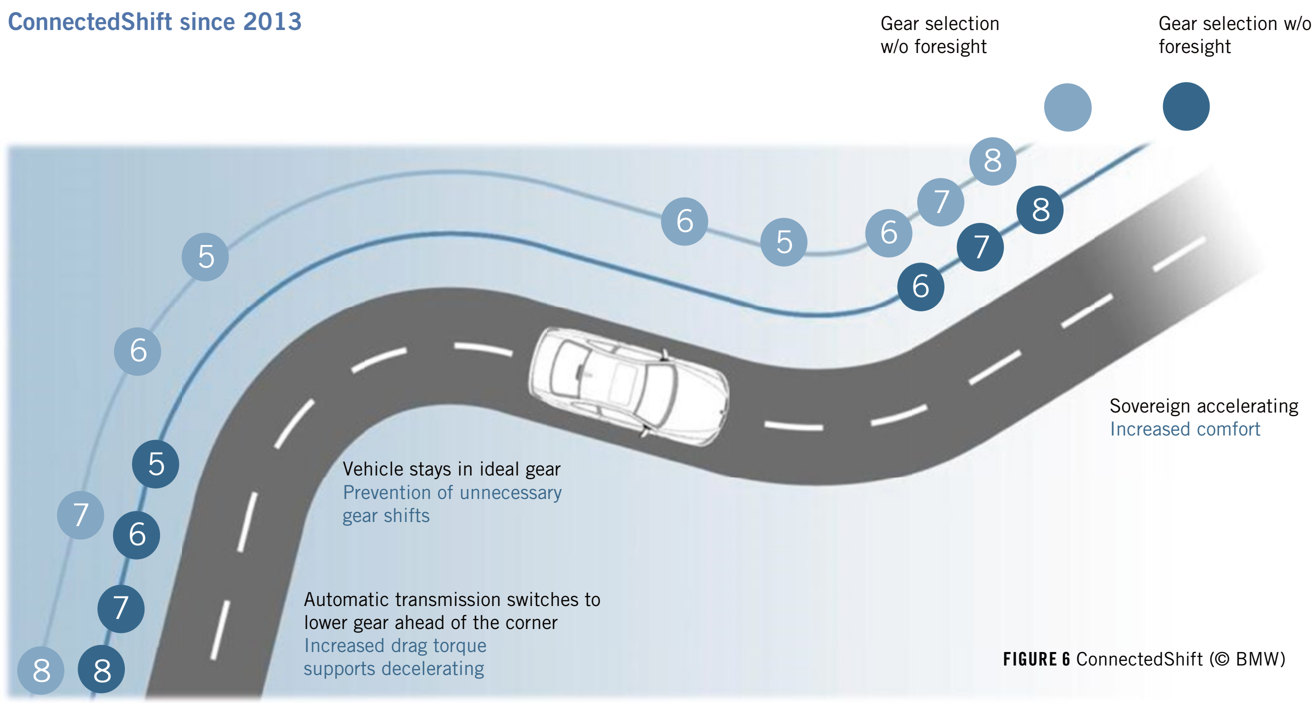

FIGURE 6 ConnectedShift (© BMW)

adapt the operation strategy of the Auto Start Stop feature. Using information from the automotive sensor network, Intelligent Auto Start Stop estimates the probable stop time and compares it to the time where the stop is efficient.

The combination of Auto Start Stop with the automotive sensor network contributes to a more intuitive behaviour of the feature. With the situation-based approach, Auto Start Stop acts like the driver would naturally do. Coming in 2016 intelligent Auto Start Stop will offer both, long, efficient and quiet engine-off stops as well as quick, yet efficient engine-on stops, exactly when the driver needs it.

SUMMARY AND OUTLOOK

Predictive EfficientDynamics features improve both efficiency and driving pleasure. Long term planning of electric driving is optimised due to predictive Energy Management in all BMW's ActiveHybrid and eDrive models with navigation system. This feature ensures electric driving when it's most efficient. In addition, longitudinal guiding is supported while manually driving in Eco Pro Mode by the Route-ahead Assistant since 2011. Using map data, the Route-ahead Assistant is always "looking around the corner" for upcoming speed limit reductions. While driving using Active Cruise Control, Speed Limit Assist increases efficiency and comfort since 2015. The Speed Limit Assist recognises upcoming speed limits and recommends the new desired speed for an efficient and comfortable deceleration. ConnectedShift has been selecting the suitable gear for the recognised situation since 2013. Starting in 2016 Predictive Auto Start Stop will increase efficiency, comfort and dynamics of standstill situations by allowing only efficient engine stops. Increasing amount of camera and radar systems and increasing quality of worldwide map data will push the roll out and allow further development of predictive features.

REFERENCES

[1] Töpler, F.; Antony, P. ; Langhammer, S.; Kube, R.; Köhle, S.: Hybridbetriebsstrategien mit elektronischem Horizont – ein Gemeinschaftsprojekt der Daimler AG, der Volkswagen AG und dem ika. In: Proceedings, Aachener Kolloquium Fahrzeug- und Motorentechnik, 2008

[2] Audi AG: http://www.audi-technology-portal.de/de/elektrik-elektronik/fahrerassistenzsysteme/audi-q7-praediktiver-effizienzassistent, 2014

[3] Wilde, A.: Energiemanagement in Hybridfahrzeugen – Eine modulare Funktionsarchitektur für adaptives und vorausschauendes Energiemanagement in Hybridfahrzeugen. Dissertation, Technische Universität München, 2009

[4] Raubitschek, C.: Beitrag einer Fahrzeug-Umfeld-Kommunikation zu vorausschauendem Energiemanagement. Munich: Dr. Hut Verlag, 2013

[5] Prasser, S.: Intelligent Operating Strategy of BMW Plugin-Hybrid Vehicles. In: Proceedings, 12th Symposium Hybrid- und Elektrofahrzeuge, Braunschweig, 2015

[6] Bohne, W., Schleicher, T.; Bonfigt, M.; Flinspach, T.: Anticipatory drivetrain management. In: ATZworldwide 116 (2014), No. 1, pp. 30-33

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„Developing our own software and IT expertise gives us an advantage“

Safety is one of Volvo‘s core values. The subject of safety has recently acquired even greater importance in the context of the development of highly automated driver assistance systems. Dr. Peter Mertens, Senior Vice President Research and Development at the Volvo Car Group, explains in this interview how the Swedish manufacturer can hold its own against its competitors in this area and put even greater emphasis than before on automation and accident prevention as part of its brand message.

Dr.-Ing. Peter Mertens was born in Germany in 1961. After an apprenticeship as a toolmaker, he studied production engineering at university, graduating in 1984. This was followed in 1985 by a master‘s degree in industrial engineering and operations research at Virginia Polytechnic Institute in the USA. In 1990, he was awarded his doctorate at the University of Kaiserslautern. Between 1990 and 1996, Mertens held a number of positions at DaimlerChrysler. These included acting as Project Leader for the Mercedes-Benz A-Class. After this he became Managing Director and CEO of Tegaron Telematics GmbH, a joint venture of DaimlerChrysler Service AG and Deutsche Telekom AG, until the end of 2002. He then moved to Opel as Executive Director for compact car models. From 2004, he performed this role for General Motors in Europe and then from 2005 for General Motors worldwide. Between 2010 and 2011, he had responsibility for corporate quality at the Tata Motor Group and for worldwide quality and safety at Jaguar Land Rover. Since March 2011, he has been Senior Vice President Research and Development at the Volvo Car Group. Peter Mertens is married and has three children.

ATZ _ At Volvo you are taking a carefully considered approach to automated driving and warning us against setting our expectations too high. Realistically what do you think the next steps are?

MERTENS _ At the moment everyone is talking about autonomous driving. I think it is important for us to discuss and report on the subject and to share our plans with one another. On the other hand, I do not believe it is a good idea to make impressive-sounding announcements and promises that cannot be kept. We know that our existing accident prevention technologies are effective. They have allowed us to make significant progress towards our goal of zero fatalities. We have reached a point where we are testing highly automated cars not with test engineers on the northern loop of the Nürburgring but with end customers in normal traffic. Until end of 2017 we will have up to 100 cars driving autonomously in Gothenburg in Sweden.

"We are already allowed to drive autonomously in the city"

So a test environment like the A9 in Germany is already out-of-date?

A test route or section of the A9 where autonomous driving is permitted under certain circumstances is not really the test environment that we need. It also involves securing the necessary political will and putting in place the basic framework. Our competitive advantage lies in our cooperation with the Swedish government and the city of Gothenburg. They are partners in the „Drive Me" project, with the result that we are already allowed to drive autonomously in the city. This is the only arrangement of its kind in Europe.

That is where you test your relatively advanced systems. Where are you evaluating the newest technologies?

For example at the AstaZero test site in Sweden. We are the one of the companies that helped to develop the site, but it is in neutral ownership. We have set up a test environment there for city safety and autonomous driving that we use to develop our technologies further. This is all about gradually giving drivers more support and relieving them step-by-step of the task of driving. The systems also help when drivers are not paying attention.

That involves a number of risks. How do you bring the driver back into the loop in an emergency?

It's true that this can be a dangerous situation. This is why I always emphasise that in my opinion the scenarios in which the driver can lean back and relax or do other things during the journey are a thing of the future. We manage the approval for autonomous driving and the handover of the task of driving using a multi-level HMI. First of all, the driver has to make a conscious decision to choose autonomous driving. The system is then able to quantify whether autonomous driving is permitted in the area or not. If it is allowed, the system indicates this to driver by means of a green light. The gear shift paddles become a trigger switch for autonomous driving. At the same time, the driver is monitored and his or her capabilities are constantly evaluated.

What is currently permitted and what will the subsequent stages of the process be?

The first level of autonomous driving is already available, for example in our XC90. Pilot Assist is a preliminary phase of autonomous driving at low speed. But the driver must be able to intervene at any point and should keep his or her hands on the wheel. The next stage is to offer the same functionality at higher speeds. We are launching the phase after that in the new S90: semi-autonomous driving up to a speed of 130 km/h on motorways and dual carriageways. But the driver remains in the loop.

Emergency situations do sometimes arise. In this context what do you think about the much-quoted period of 10 s in which the driver must regain control?

That's pure theory. The system has to respond to emergency situations in milliseconds. People are generally very good at identifying and understanding a situation. However, they find it more difficult to draw the right conclusions and take action quickly. Should I brake, accelerate or steer? Drivers learn this over time. The more driving experience you have, the more effectively you can avoid accidents. The systems that we have today are relatively bad at identifying situations, but once they have done so, they are very good at making the right decisions quickly. We need to combine these two things. There isn't a computer system on earth which could model the world so that it is prepared for every eventuality. There is a cosmos around my car that I have to monitor. Depending on what happens there, I have to make decisions. And to do that, I need a system that learns from experience and particularly from good experience. As a good driver, how do you manage to avoid accidents? The systems have to learn these patterns and,

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"Volvo does not produce safety systems simply to achieve good ratings," explains Dr. Peter Mertens in conversation with ATZ editors Angelina Hofacker (right) and Markus Schöttle (left) until they are as good as a good driver, we cannot hand over the entire responsibility to them.

But aren‘t there limits here too? A lot of people are talking about the death algorithm.
That is a concern that we need to take seriously. Should a system be able to decide in a matter of life and death? And if it should, how does it choose between a younger and an older person? In my view that is not a productive discussion. Because ultimately the important thing is for us to succeed in saving human lives and preventing accidents with the help of the systems.

But you still need to engage in a dialogue with society.
I know that when the first autonomous car causes a serious accident there will be a wave of outrage, just as there was when the three-point safety belt was introduced in 1959. But despite the opposition to safety belts, they have saved millions of lives since then. However, there are a few situations where the consequences of an accident might have been less serious if someone had not been wearing a belt. We just need to get the balance right.

But there are some things that we don‘t need to worry about, such as the issue of liability.
This is why we are gathering experience in our „Drive Me“ project. We need to find out what the problems will be for drivers, passengers and other road users and where we need to take responsibility. In autonomous driving mode, product liability applies.

Will there be a Volvo insurance policy?
That‘s in the planning stages. It will have a dramatic effect on customer loyalty in the insurance industry. Car manufacturers could take out group insurance policies which would lead to a quite different pricing policy. I am certain that we can allay the concerns and fears of everyone who is critical of highly automated driving.

“We just need to get the balance right”

Your goal is for no one to be seriously injured or killed in an accident in a new Volvo by 2020. How realistic is this vision?
The vision is a serious one, but admittedly it is not a promise that we can measure. We have made good progress towards achieving what is currently possible from a measurement perspective. The XC90 is our most important milestone. Realistically we will know in two to three years whether the car genuinely fulfils our expectations.

Your competitive environment is tougher than ever. Can you uphold your core values and continue to stand out from your competitors in terms of safety?
We are further ahead than any other company with our combination of active and passive safety systems. We have the highest Euro NCAP rating ever awarded for active safety. As long ago as 2008, we launched our “City Safety” assistance system in XC60. We can identify pedestrians and cyclists by day and by night. None of our competitors are able to do this. We can also recognise large animals and prevent accidents that occur when a car turns across the oncoming traffic.

So you have a head start?
Not only that. One driving force behind the early introduction of assistance systems is a good performance in the ratings. Most manufacturers are developing their cars with these benchmarks in mind. But Volvo does not produce safety systems simply to achieve good ratings. If you look back, you will find that Volvo has achieved the best marks both in the past and in the present before specific categories were even launched. One example is the small overlap crash test. Safety is much more deeply enshrined in our culture than is the case with other OEMs.

Even in the case of autonomous driving, which has become part of the brand core of all the manufacturers?
Ultimately everyone is likely to be using the same technologies. But the skill lies in integrating all the systems so that they can identify situations, process the data and react in the best possible way. To achieve this, car manufacturers need as much in-house expertise as possible. For example, Volvo has the necessary software skills. All the decision-making algorithms and test scenarios that we use are developed by Volvo engineers. We have one of the largest databases in the industry, which enables us to simulate all the complex systems in every possible scenario, before reproducing them in reality. Developing our own software and IT expertise gives us a competitive advantage.

Dr. Peter Mertens, thank you for this interesting discussion.

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“Until the systems are as good as a good driver, we cannot hand over the entire responsibility to them,” says Mertens

INTERVIEW: Angelina Hofacker and Markus Schöttle

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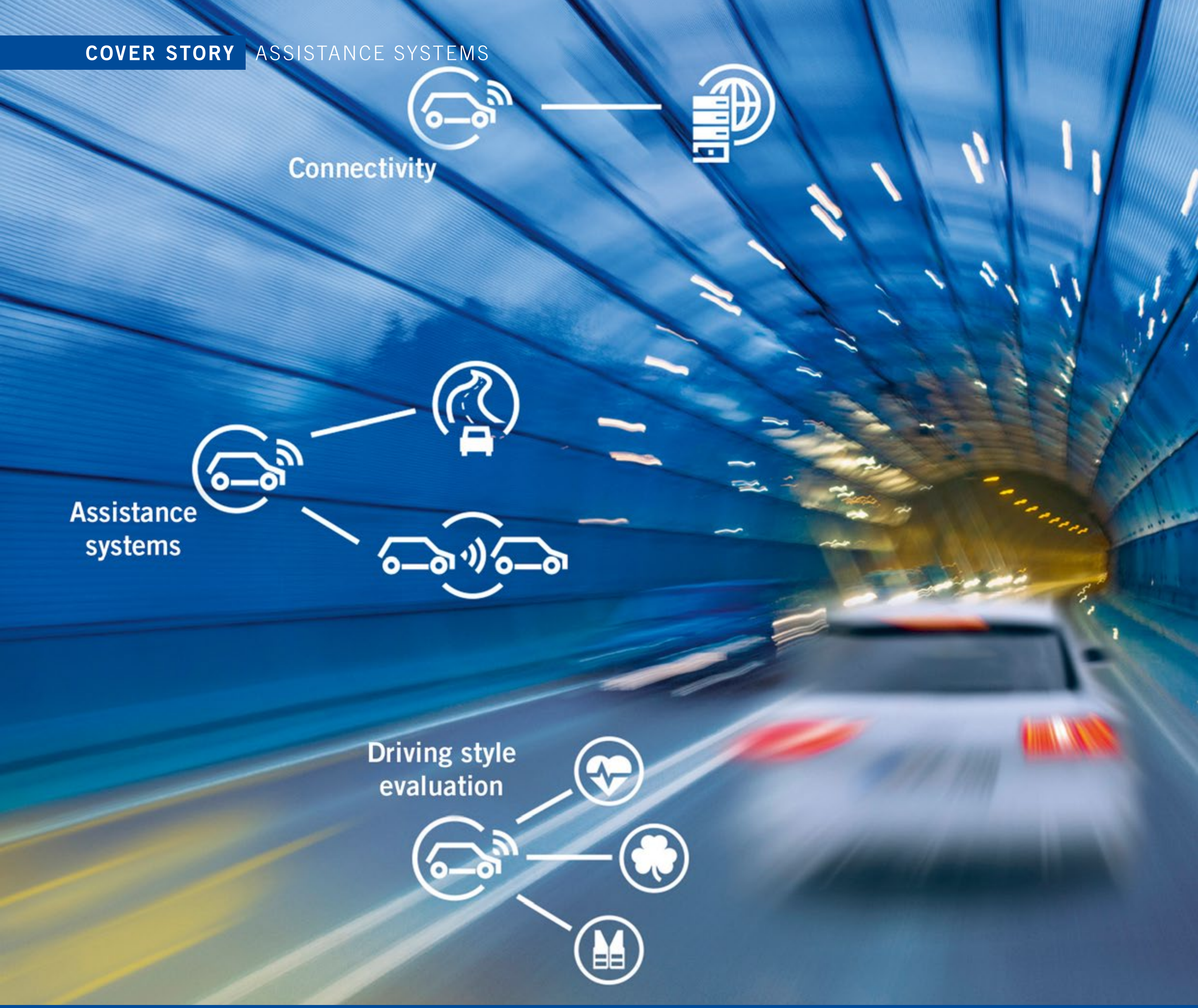

System Adaptation as Key Technology towards Automated Driving

Bertrandt has optimised the human-machine interaction on the basis of driver profiling. The result shows that the recognition of the environmental conditions of a vehicle and the adaptation of assistance systems to the driver are two important components of fully automated individual transport. In the future, driver adaptation will help to increase the acceptance of driver assistance systems and to make automated driving a fixed part of everyday life.

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STATUS QUO

Driver assistance systems should support the driver in longitudinal and lateral motion and provide safe and comfortable travelling. One of the most well-known systems is cruise control, which continuously controls the speed that has been set by the driver. A further development of this is Adaptive Cruise Control (ACC). In this system, radar sensors are used to detect a vehicle ahead and maintain a distance from it as selected by the driver. In most cases, oncoming traffic and stationary obstacles are excluded. By additionally using the evaluation of predictive route data, it is already possible today to adapt the vehicle's speed to the road topology and its geometry. This pioneering development enables the system to control the vehicle autonomously on bends and inclines even if route guidance is deactivated, thus making driving more efficient and reducing fuel consumption.

In addition to the road topography – bends, roundabouts, intersections, upward and downward gradients – speed restrictions are also recognised using map data and camera sensors. Accordingly, predictive ACC is able to react to roads ahead that have speed restrictions, thus enabling drivers to experience stress-free driving without the need to intervene. To allow a smooth and comfortable transition into different speed areas, which are defined by the road topography and speed limits, the system controls the ideal interaction between braking, acceleration, overrun and sailing phases, **FIGURE 1**.

However, when it comes to partially automated control of the vehicle, some drivers have the impression that they are relinquishing some of their own habits and feel misunderstood by the system. Studies – such as those by Forsa [1] or Puls Marktforschung [2] – have shown that drivers still prefer conventional driving over automated driving. Nevertheless, people have had an increasingly positive opinion of the development of autonomous vehicles over the past three years. In order to raise the level of acceptance of driver assistance systems and to gain the confidence of vehicle occupants, the driver should be integrated into the control process. For this purpose, the vehicle's environmental data and the driver's driving style are analysed to enable the assistance systems to be adapted to the behaviour of the driver. Intuitive interaction with the assistance system and its improved reaction to new situations ensure that the driver feels "understood" by the vehicle, and perceived reliability increases.

ADAPTATION OF THE DRIVER ASSISTANCE SYSTEM

For the adaptation of the driver assistance system, three aspects are taken into account: environmental detection and analysis, driving style analysis, and driver adaption.

The first step for the environmental detection and analysis takes place by using data fusion and "data enrichment". Enrichment has the function of bundling the quantity of environmental data and interlinking them logically in order to generate a higher information content (Smart Data). For example, radar, camera and acceleration sensors are used for this purpose. The different sensor signals are then used to derive road conditions and traffic information as well as the time of day and the time of year. As a result, the assistance system can, for example, increase the distance from the vehicle ahead when visibility is poor or reduce the speed on bends in snowy conditions, **FIGURE 2**.

The second part of the adaptation process involves driving style analysis. This makes it possible to characterise the driver through key attributes such as sportiness, safety awareness and energy efficiency. In order to continuously monitor the driving style, the behaviour of the driver in defined situations is observed. Various measured data are used for this purpose – for example, acceleration from a standstill, the average speed during unrestricted driving on a motorway with no speed limit, the average lateral acceleration when cornering and the curve of the distance maintained to the vehicle ahead.

The third part of driver adaption, with the aid of algorithms, the measured environment information and the analysed data of the driving style can be merged. From the combination and the interaction of the two areas, the driver assistance system can be adapted to the driver. The objective is to ensure that the driver assistance system always behaves in the way in which the driver himself would behave in different situations. As a result, the driver feels "understood", **FIGURE 3**.

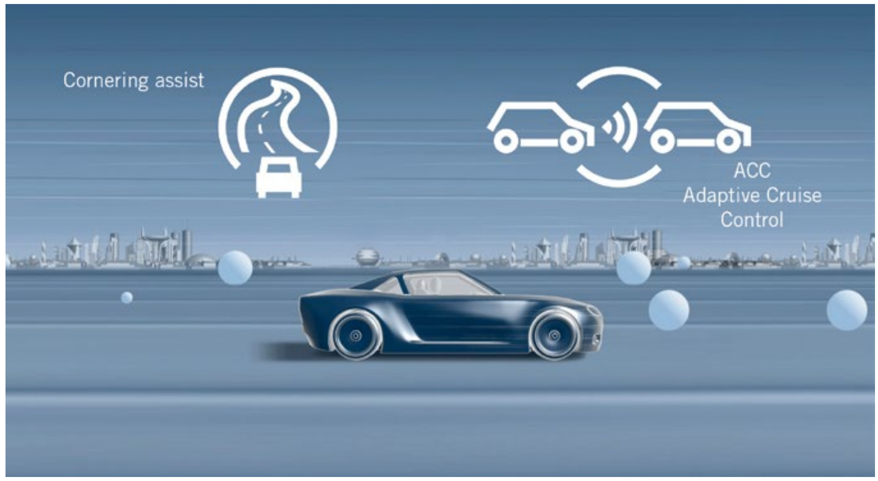

FIGURE 1 The further development and new development of driver assistance systems and the expansion of their areas of application represent an important step towards automated driving (© Bertrandt)

FIGURE 2 The three components of the adaptation of driver assistance system to the driver: driving style analysis – driver identification – environment recognition and evaluation (© Bertrandt)

Some of these analyses are carried out in real time in the vehicle to make sure that the system can react to new conditions at any time. In particular, it is possible to set threshold values for predefined situations, and when these threshold values are exceeded this is a strong indication of a certain driving style. Achieving a more detailed analysis of the personal driving style outside the situation and including environmental data will require processes from data mining and machine learning, and these demand considerable computing time. What is more, access to a large quantity of data from the past is necessary, which is why computation on typical control units is not possible.

Instead, transferring non-time-critical operations to a back end offers a number of advantages. For example, discriminant analysis can be used to determine those external factors that have the greatest influence on driving behaviour, and to do this individually for each driver. The basic driving behaviour can also be identified more precisely by using long-term recordings, even if the driver exhibits a different driving style for a short period. In a further step, cluster analyses allow the current driver to be compared with different driving styles in order to make predictions on his or her own behaviour in new situations – and to do this even if data are not yet available for this situation for the driver in question. For example, for a typically careful driver who drives his car in winter, the cornering speed in snowy conditions can be reduced more strongly than the average value of all drivers, **FIGURE 4**. The knowledge gained in this way forms a kind of long-term profile that describes the driver and which changes only very slowly. However, as the driving behaviour is influenced by the driver's current mental situation on a particular journey, this profile is combined in the vehicle with short-term observations which allow fast adaptation, **FIGURE 5**.

BACK END AND DATA SECURITY

As the current computing power of the ECUs in the vehicle is not sufficient for processing the data and for the different calculations of the algorithms, a modern vehicle architecture that also includes a powerful computing centre (back end) is required. First of all, the data are collected, fused and enriched, and certain time-critical calculations are performed. This information is collected and sent to the back end in order to carry out the time-consuming and non-time-critical calculations for the adaptation. The system remains fully functional in the vehicle at all times even without connection to a server. This requirement regarding functional security and reliability must already be taken into account when the system architecture is designed. Transferring data to a back end not only offers the advantages of increased performance capacity, compared to which the vehicle would soon reach its limits, but also the benefits of high availability and dynamic scaling. Scaling at the back end can be implemented much more quickly than in a vehicle in which all ECUs are installed. The keywords here are virtualisation and software extensions in full operation. A back end also includes properties of dynamic broadband adaptation, even going as far as geo-redundancy for high-availability systems. Elementary damage to the server infrastructure must also be taken into account in the design to ensure that systems in the vehicle can be reliably supplied with data. This will make sure that the data are available at all times and are protected against failure.

At the back end, automated analyses are performed by various algorithms in order to calculate a long-term profile for each driver. The combination of the separately created profiles generates swarm

FIGURE 3 Example of the visualisation of the vehicle status on the instrument panel, including current weather data and future situations, such as bends and speed limits; a special feature is the representation of the recognised driving style in the colours magenta (safety awareness), blue (sportiness) and yellow (energy efficiency) (© Bertrandt)

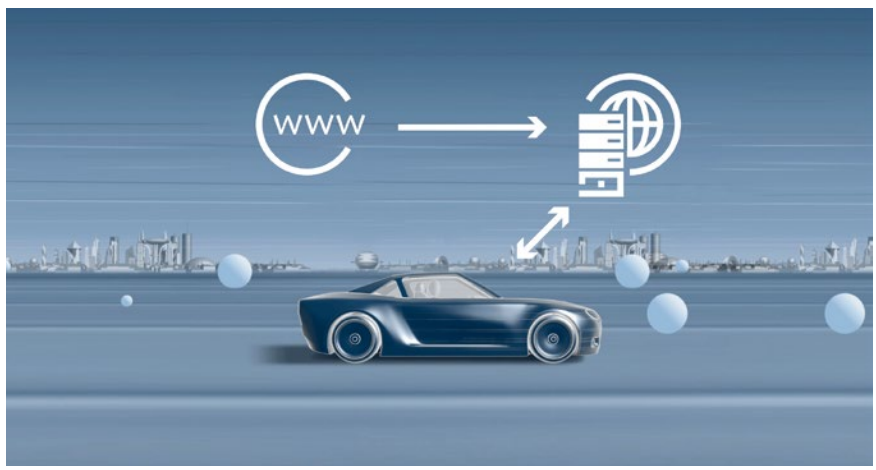

FIGURE 4 In order to further enrich the data from the vehicle at the backend, information from the world wide web is needed, for example traffic or weather information (© Bertrandt)

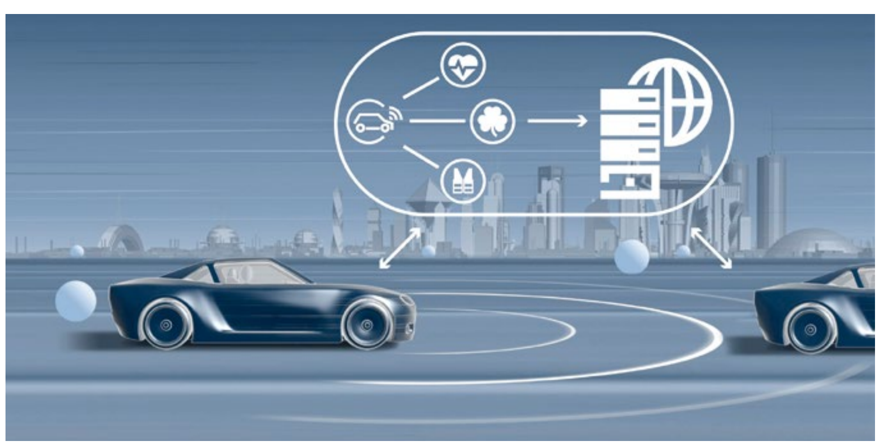

FIGURE 5 Sporty, safety-conscious or energy-efficient driving style? In order to define the individual driving style, the usual vehicle architecture is expanded with the addition of a back end on which non-time-critical calculations can be carried out (© Bertrandt)

intelligence that benefits each individual vehicle – in the end, especially the driver.

The IT structure behind the vehicle offers almost infinite possibilities to verify data and to allow the swarm intelligence to continue learning. For example, it is possible to synchronise data directly from the vehicle with weather data, traffic jam data and many other data. Then, for instance, the speed of all vehicles in a region can be temporarily reduced if the vehicles ahead are already moving particularly slowly and the weather report is warning that there is a risk of black ice.

In order to make the processing of "big data" manageable, filters in the vehicle, algorithms at the communications control unit and the back end can be used to enrich the data to generate "smart data". This process serves to optimise data traffic and security.

The aspect of data protection and data security plays a key role, as any hacking attack on the data connection between the vehicle and the back end must be prevented. Unauthorised access could allow the vehicle to be remotely controlled or could result in incorrect control or the theft of sensitive data. The aim is to avoid manipulation of the data by unauthorised persons thus raising confidence in the reliability of the data processing system. Achieving this aim will be supported by legal specifications, anonymisation in the vehicle, data management and data storage. For that reason, this subject must already be carefully considered at the start of the development process and decisions regarding the scope of functions and the risks involved must be taken.

ROAD TO AUTOMATED DRIVING

Bertrandt is currently carrying out a study in cooperation with a University of Applied Sciences. This study examines to what extent the self-assessment of drivers regarding their own driving style corresponds to an external assessment and to characteristic values of driving dynamics. With the aid of adaptation to the driver and the establishment of data security that this involves, it will be possible in the future to increase the acceptance of driver assistance systems in society. With this key technology, we are going a step further towards making automated driving a fixed part of everyday life in the future.

REFERENCES

[1] N. N.: Forsa-Studie: Deutschland mobil 2015. Im Auftrag von CosmosDirekt. Im September 2015 wurden 2006 Autofahrer ab 18 Jahren befragt. Press release, 13 October 2015

[2] N. N.: Puls-Marktforschung: Deutschlands Autofahrer freunden sich mit autonomen Fahrfunktionen an. Repräsentative Studie bei 1003 Autokäufern zur Akzeptanz autonomer Fahrzeuge. Press release, 20 March 2015

Toyota | **RAV4 Hybrid Produces 145 kW**

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Toyota has launched the new RAV4 Hybrid. Its full hybrid powertrain combines a 2.5-l Atkinson cycle gasoline engine with an electric motor, a generator, a 204-cell nickel-metal hydride battery, plus a power control unit for energy and powertrain management and a power split device. The 2494 cc, 16 valve, DOHC, VVT-i (Variable Valve Timing-intelligent) gasoline engine develops 114 kW at 5700 rpm and maximum torque of 206 Nm between 4400 and 4800 rpm. The permanent magnet synchronous electric motor produces 105 kW and maximum torque of 270 Nm from zero rpm. With a total system power output of 145 kW, the RAV4 Hybrid can accelerate from 0 to 100 km/h in 8.3 s and has a top speed of 180 km/h. According to Toyota, the fuel consumption is 4.9 l/100 km.

Luk | **Damping Torsional Vibration**

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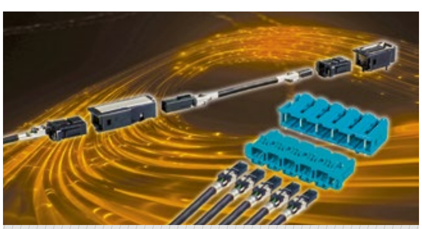
Luk, the specialist powertrain company and member of the Schaeffler Group, has developed another method of reducing torsional vibration in the powertrain. The new system consists of a clutch disc with a torsion damper and a centrifugal pendulum-type absorber (see also the article in ATZworldwide 1/2016). It is primarily aimed at engine developers working in the field of downsizing. According to Luk, the system is less efficient than a dual mass flywheel (DMF) and more efficient than a clutch disc with torsion damper. It can be used in combustion engines with a torque range up to around 250 Nm and with a high tractive power at low engine speeds. The crucial innovation in the clutch disc with a torsion damper and a centrifugal pendulum-type absorber is the use of a trapezoidal pendulum. In contrast to a parallel pendulum, the trapezoidal pendulum not only moves sideways but also rotates.

© Jaguar Land Rover

Jaguar Land Rover | **Testing Networked Vehicles in Great Britain**

Jaguar Land Rover is testing the latest technology for networked and automated driving on British roads. Vehicle-to-vehicle and vehicle-to-infrastructure systems will be tested with a fleet of 100 cars. The new CAV (connected and autonomous vehicle) test corridor, which includes 66 km of roads around the company's sites in Coventry and Solihull, will be used to evaluate assistance systems in real-world driving conditions. New roadside communications equipment will be installed along the route. The fleet will test a range of different communication technologies that can share information at very high speeds between cars and between cars and roadside infrastructure, including traffic lights and overhead gantries.



© TE Connectivity

TE Connectivity | **Scalable Connector**

TE Connectivity has developed a modular and scalable connector for automotive Ethernet which is specially designed to withstand the tough environment in vehicles. The connector, called the MATEnet, can transmit up to 1 Gbit/s and is based on miniaturised standard automotive terminals, such as NanoMQS, Generation50, MCON 050 and the 0.50 series. The new product can be used with TP (twisted pair), UTP (unshielded twisted pair) and STP (shielded twisted pair) cables for Ethernet applications. It complies with the IEEE 100-Base-T1 (100 Mbit/s – project IEEE802.3bw) and 1000 Base-T1 (1 Gbit/s – project IEEE802.3bp) standards.

© SKF

SKF | **Deep Groove Ball Bearings with New Seals**

SKF has introduced a deep groove ball bearing with a new type of seal which is designed for car drive shafts. The special seal concept means that the ball bearing needs no external protective components, for example cover plates or additional seals. Despite its lean design, the new seal also provides improved protection against water and mud. The new deep groove ball bearing is ideal for the intermediate shafts on front-wheel-drive cars and vans and for the main drive shafts on AWD and rear-wheel-drive vehicles.

© Continental

Continental | **Urea Sensors for Diesel Engines**

The urea sensor developed by Continental reduces the nitrogen oxide emissions from diesel engines. The sensor provides the data needed to ensure that the correct quantity of urea is injected for every type of engine operation. As Continental explains, SCR systems can only reach their full efficiency when the amount of AdBlue injected corresponds exactly with the volume and composition of the exhaust gases. The data is also used for the on-board diagnostic function of the exhaust gas treatment system. The urea sensor contains piezo elements, a negative temperature coefficient (NTC) thermometer and an application-specific integrated circuit (ASIC), all of which Continental is already using successfully for measuring oil levels.

© IAV

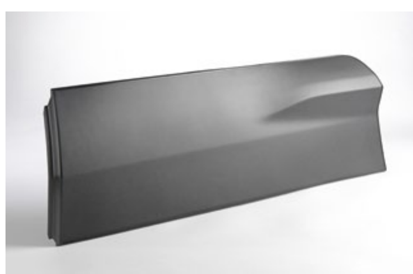
IAV | **Traction Battery in the Chassis**

In future, a lithium-based high-performance battery could be directly integrated into the chassis of a vehicle. ThyssenKrupp System Engineering, IAV and the Fraunhofer Institute for Ceramic Technologies and Systems IKTS are now devising a suitable method. As part of the Embatt project, they are developing the concept and coordinated production techniques for a planar-constructed lithium-based high-performance battery. According to Wolfgang Reimann, Head of the E-Traction department at IAV, this will allow far more compact energy storage systems with energy densities of 450 Wh/l and thus extending the range to up to 1000 km. Moreover, the system costs of lithium-ion batteries can be reduced to 200 euros/kWh. Before that however, there are still technical hurdles to overcome. This is why all three partners are pooling their specialist experience and capabilities in this joint project.

© In-tech

In-tech | **Plug & Play Measurements System**

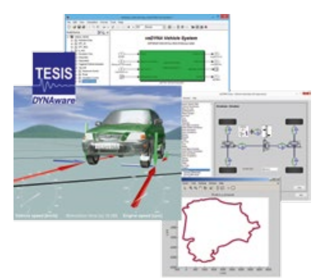
In-tech, a company based in Garching in Germany, has developed orangeRack, a measurement system that provides a power supply and energy management functions for all the measurement devices in a car. In addition, it offers quick access to all the communication bus systems used for live analysis. In order to avoid interfering with the car's electrical system during the measurement process, orangeRack has an integrated power supply. During testing, the battery in the rack is charged by the car's alternator or by a DC/DC converter in the case of electrical vehicles.



© Milliken

Milliken | **Healthier Plastics**

At the international VDI Plastics in Automotive Engineering congress in March 2016, the chemical company Milliken presented a range of improvements to lightweight components made from polypropylene (PP) and polyurethane (PU). One of the products on display was the company's antioxidant Milliguard AOX-1 which according to the manufacturer significantly reduces the VOC (volatile organic compound) content and the outgassing condensation (FOG) content commonly associated with antioxidants, when compared with the requirements of industry standards. As a result, it complies with strict environmental and health and safety regulations and meets the high standards for air quality in vehicle interiors.



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Tesis | Magna | **Real-time Simulation of Driving Dynamics**

At the Virtual Powertrain Creation 2015 Congress organised by MTZ, Magna Powertrain presented a method of front-loading-based function development for traction and driving dynamics control systems. The supplier used the veDyna software package developed by Tesis Dynaware which allows complex driving dynamics simulations to be run in real time. The possibilities range from conceptual vehicle development on the PC through to real-time component testing on virtual or real-life test benches. Other applications include function development and testing driving dynamics control systems in software- and hardware-in-the-loop environments.

BorgWarner | **Thermally Effective Auxiliary Thermal Coolant Pump**

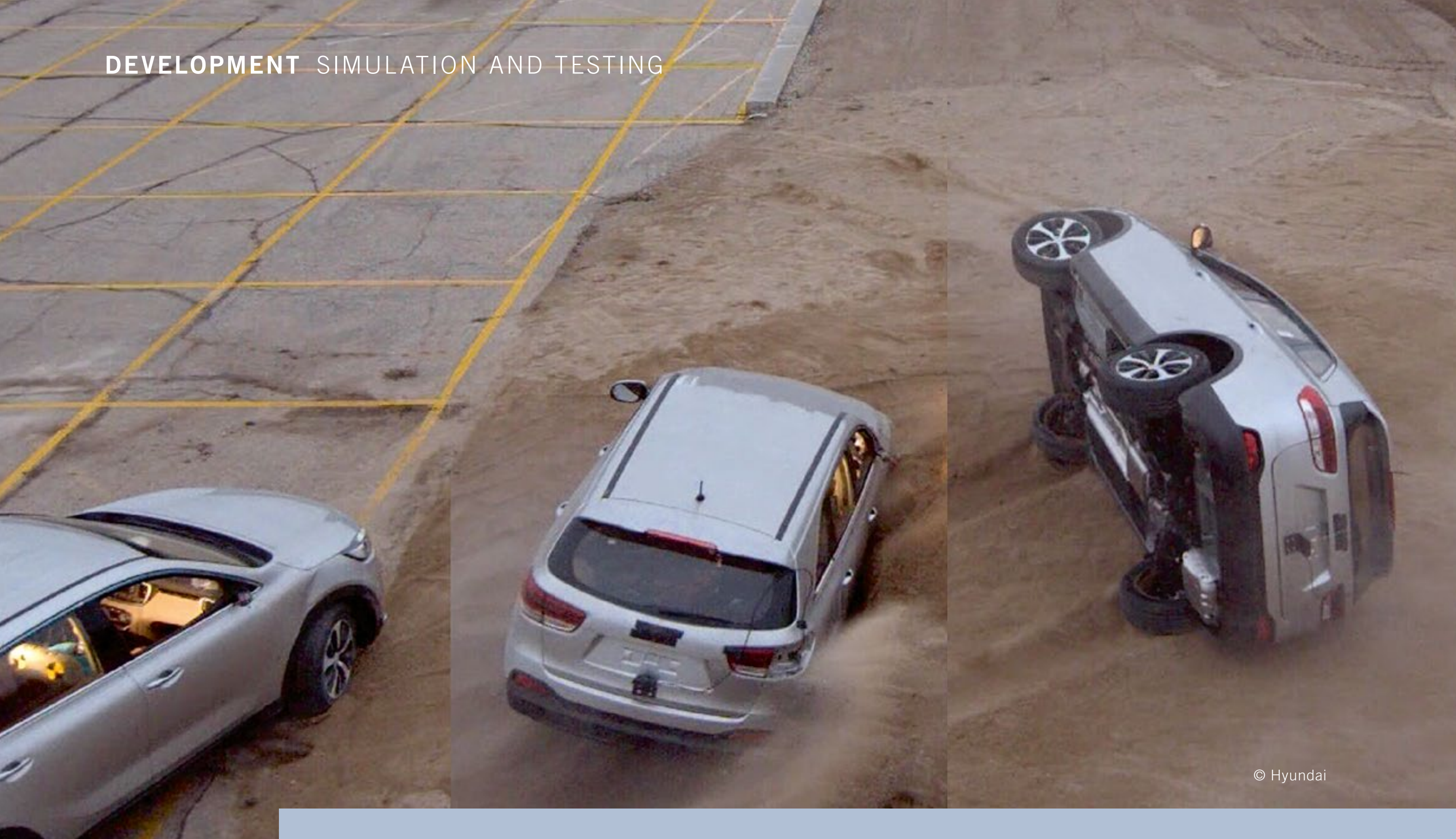
Powertrain specialist BorgWarner can now supply an electric thermally effective auxiliary thermal coolant pump (ATCP) for a compact SUV with turbocharger. Company sources said the vehicle will be produced by a "leading Chinese OEM". The special auxiliary coolant pump features a brush-free, leakage-free and low-noise design and a built-in micro controller, according to the automotive supplier. When the engine is shut down, the pump delivers a constant flow of coolant via auxiliary cooling circuits, allowing the optimal operating temperature for additional components to be maintained. This means it should help components last longer, boost fuel efficiency and generate lower emissions. In this application, a 100 W ATCP helps cool the turbocharger and assists indirect intercooling.

© BorgWarner

© Lexus

Lexus | **LC 500 Series Version with 348 kW**

Four years after showcasing the LF-LC concept car, Lexus unveiled the LC 500 series version of the two-by-two seater coupé at the NAIAS Motor Show in Detroit. The model marks a turning point in the development process and kicks off a new era for the brand. The four-seater is powered by a 5.0-l V8 naturally aspirated engine with 348 kW output at 7100 rpm and torque of 527 Nm at 4800 rpm, which also features in the RC F and GS F models. A ten-speed automatic gearbox transmits power to the rear wheels with minimal shift times, comparable to a dual-clutch transmission. This model can accelerate from 0 to 100 km/h in under 4.5 s. The LC 500 is the first Lexus model to be based on a newly developed chassis platform that is part of a global architecture and which will be at the core of future Lexus vehicles.



© Hyundai

Development of Steer-induced Rollover Test Method

There are many types of accident modes in the field, such as steer-induced rollover. Hyundai has developed an internal steer-induced rollover test methodology to simulate field case scenarios. The vehicle data signals in steer-induced rollover accidents are different from those gathered during typical one-direction laboratory development tests. To consider numerous accident cases for the calibration of rollover sensing data, it is very helpful to make an algorithm and a system for determining rollover situations.

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BACKGROUND

For more than ten years, many automotive OEMs and suppliers have worked on test methodology development for rollover protection. After performing numerous physical tests, analysing the result of CAE simulation and physical tests, Hyundai was able to improve the typical laboratory test method and reduce test items for developing the rollover protection system, and then to develop the next generation of the rollover test method [1]. These procedures are typically proprietary to each OEM. Currently, there are no worldwide regulations and NCAP with respect to occupant protection because it is very difficult to describe the numerous rollover scenarios that can happen. Even in FMVSS226 (ejection mitigation) that have already released and e-Call that are under rulemaking, there is no reference to rollover sensing performance because running rollover tests is very complicated.

In today's vehicle development industry, some companies have four or more developmental test modes to determine the proper time to deploy the rollover protection system. In these test modes, the vehicle motion is in a linear direction from the position of time 0 to each rollover event. The vehicle is towed by its longitudinal axis for the ditch and ramp test modes. For other modes, the vehicle is positioned on a flying floor test fixture. On this fixture, the vehicle is positioned laterally on the floor, and then it is towed by its lateral axis for the soil-trip, curb-trip, and frictional test modes. These test modes are somewhat limited since the test vehicle is moving in a linear direction. In the actual field, there are multiple events such as steering that are happening simultaneously. Therefore, these simulations do not accurately represent field cases of rollover accidents because the vehicle does not spin on the ground. Vehicle and occupant behaviour are also different in field accidents when compared to these developmental test modes. The challenge is to develop reproducible test methodologies that allow more accurate simultions of field accidents. If this can be accomplished, improvements and greater safety can be expected from rollover protection systems.

ROLLOVER TEST METHOD USING A STEERING ROBOT

Hyundai has developed a new steer-induced rollover test to simulate some field accident modes. To perform the steer-induced rollover tests, the engineers make use of multiple pieces of equipment namely a steering robot, acceleration/braking robot, data acquisition devices and differential GPS. **FIGURE 1** indicates the main differences between steer-induced rollover and one-direction laboratory rollover test. In the steer-induced rollover test, the vehicle moves along the longitudinal direction, turns on its vertical axis, and finally rolls on its longitudinal axis.

It is very important to describe the rotational behaviour of the vehicle in the driving event because the field accident data indicates that many rollover accidents usually happen right after the driver suddenly steers to avoid some obstacle (vehicle or other object) on the roadway. During the development of this methodology, two other possible methodologies had to be considered: using the frictional coefficient difference between the left front tire and right front tire on the ground [2] and using the rotation of the vehicle on a huge turning table cart during the one-direction test. Finally, the engineers decided to use a steering robot system due to its ability to actually drive the vehicle on any type of surface and in any direction, similarly to a human driver. The motion and path of the vehicle is controlled by the differential GPS.

FIGURE 2 indicates the test equipment used for steer-induced rollover tests. The steering robot is attached to the steering column after removing the steering wheel. The acceleration/braking robot is located on the vehicle floor in front of the driver seat. After configuring the equipment, practice tests were performed

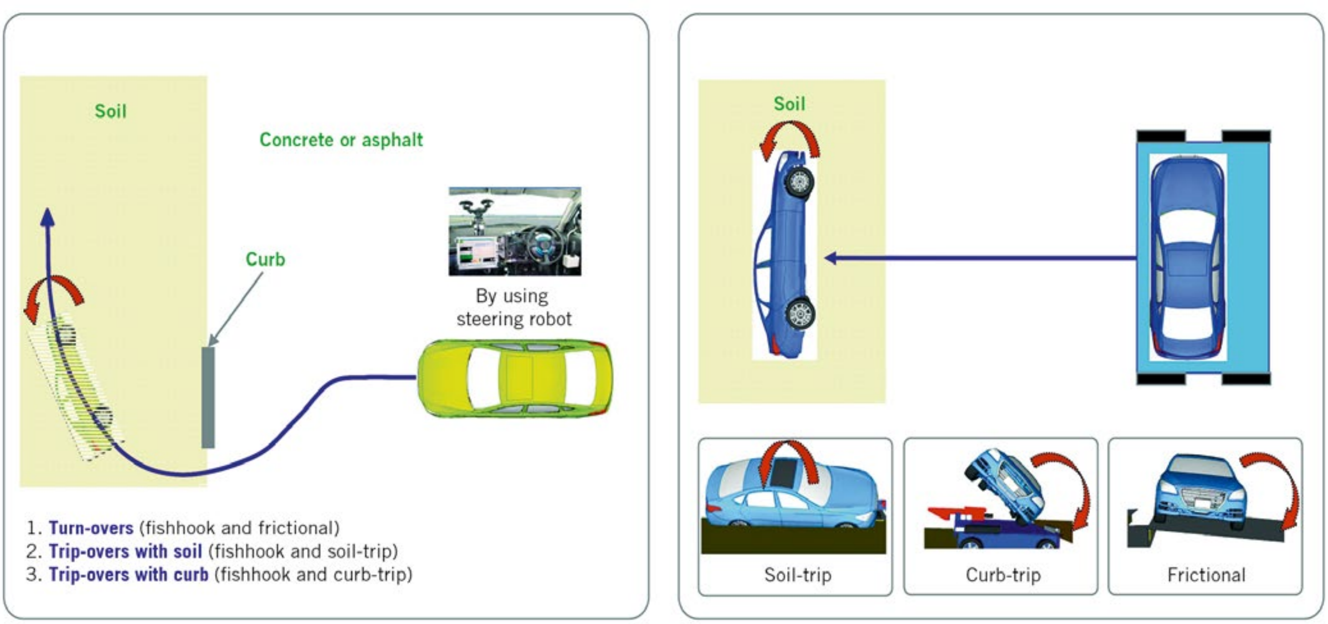

FIGURE 1 Comparison between steer-induced rollover (left) and one-direction laboratory rollover test (right) (© Hyundai)

to verify the overall system response and to determine the path according to the characteristics of the robot system. These checkout tests include validating the steering robot's performance in driving manoeuvres including driving in a straight line, driving in a circle, and making lane changes. Additional trial tests were performed to verify the position of the test vehicle in the differential GPS coordinate system. The steering robot system was set to duplicate the driving path including the starting point and driving direction, and the vehicle yaw angle in front of soil and curb was also created. Once the trial tests were completed, the main test event was performed by using all the coordinates and driving maneuvers developed during the trial tests. The main test event duplicated all driving manoeuvres into the soil and curb trip events.

In the main test event, the vehicle is initially placed at the start position and the robot system is engaged. The vehicle then automatically drives to what Hyundai calls T0, a position that is remembered by the differential GPS. When the vehicle passes T0, the robot starts turning the vehicle steering system. In this case, the robot turns clockwise, steering to the right. Once the vehicle enters this right turn, the robot is programmed to steer hard to the left, which typically causes tire to road frictional sliding. The vehicle then moves to the entrance of the soil or curb trip surface. From the various sensors on the test vehicle, we can understand the entrance velocity of the longitudinal and lateral direction as well as approach angle from the trial test. The error of the velocity and angle is typically below 3 km per hour and 3°. This is deemed acceptable by Hyundai, and the results are reproducible for the same test conditions. We can see the position of each event from the data that is recorded by the GPS system; a vehicle trace is shown in **FIGURE 3**. The robot can be configured by changing various parameters such as steering rate, angle, and torque for each type of test condition. After verifying the test reproducibility, multiple roll and no-roll tests were performed under various conditions. **FIGURE 4** shows a panoramic view of the steer-induced rollover test.

FIGURE 2 Steering, acceleration/braking robot and setup of data acquisition device (with DGPS) (© Hyundai)

ANALYSIS OF OCCUPANT BEHAVIOUR

Many studies have been performed to describe occupant behaviour in vehicle accidents. They usually focus on improving dummy behaviour in frontal and side crash modes, not rollover modes. In frontal and side crash events, the total time to complete these events is typically below 200 ms. For rollover type events, the total event duration is commonly ten times as long, which accounts for thousands of milliseconds. Therefore, the occupant reactions are much longer in rollover type events.

During the rollover, the occupant usually moves to the opposite side of the vehicle during the yawing event. At the same time, the occupant's head and upper body react and move toward the inside of the vehicle. Therefore, we should consider the reaction of the occupant's head in the steer-induced rollover test. As mentioned before, we already decided upon T0 as the point when the robot begins to steer clockwise (turning to the right). It takes 2 to 4 s from the T0 position to a one-time rollover event (T1).

Before this steer-induced research project, Hyundai had performed an internal study to compare the reaction of people and test dummies in rollover type events. From this study, the engineers collected data to understand the reclined angle and position of the head in severe driving conditions and rollover situations. Using these results, they realised that they needed to adjust the dummy head from 0° to some other angle to simulate human active behaviour during the time between T0 to T1. The results showed that using a modified dummy for rollover is necessary in order to figure

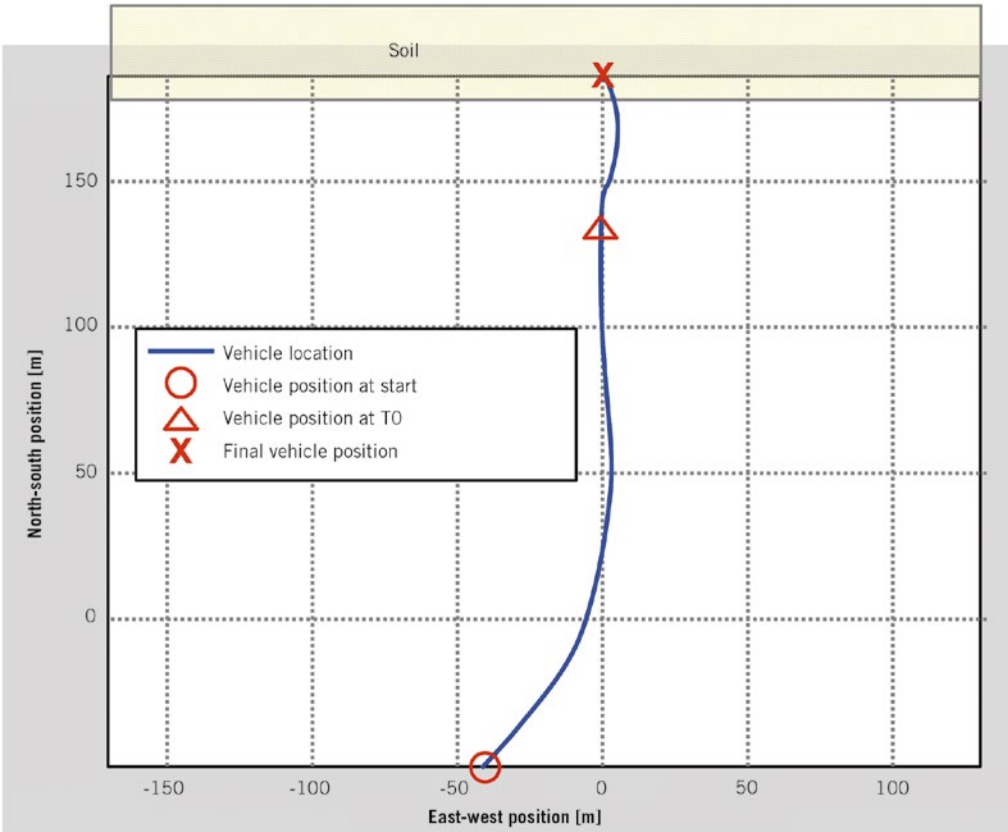

FIGURE 3 Position of each event recorded in GPS and vehicle trace (© Hyundai)

out the RTTF (Required Time to Fire) since the dummy head and arm interact with the side window and door trim before the vehicle enters the soil or curb trip event. Using a modified dummy head angle will help the involved parties to understand the RTTF of the various rollover modes more accurately and to better predict what happens in real accidents.

ANALYSIS OF SIGNAL BETWEEN TRIP-OVER WITH SOIL AND SOIL-TRIP FOR DATA CALIBRATION

There are differences between the results of steer-induced rollover compared with the current one-direction (linear) test mode. During the steer-induced test, the yaw rate from the vehicle induces the vehicle to roll more easily. In other words, the maximum value of the roll rate of the trip-over test with soil is less than the roll rate of the current soil-trip test in a similar rollover situation. A similar trend can also be seen in the lateral and vertical acceleration data. Even with the same initial vehicle speed, different approach angles and longitudinal velocity at T1 result in different lateral acceleration, lateral velocity, and roll rate.

FIGURE 4 Panoramic view of steer-induced rollover test (© Hyundai)

FIGURE 5 shows the difference of data signals between trip-overs with soil and soil-trip. The maximum angle of trip-overs (green) and soil-trip (blue) are almost identical. However, the shape and roll rate of both signals are quite different. The tests showed that the maximum angle and roll rate for full soil (red) and half soil (green) are extremely different, even with the same initial velocity of trip-over modes. In the case of full soil, the vehicle enters the soil in the middle of steering. But in the case of half soil, the vehicle enters the soil right after completing the steering event.

We are going to analyse those results and revise the system requirements because the signals of field accidents are different from the current one-direction laboratory test. As soon as Hyundai can fully understand the difference between the steering-induced test and one-direction test, it is possible to make a more accurate algorithm and develop a better system for rollover situations.

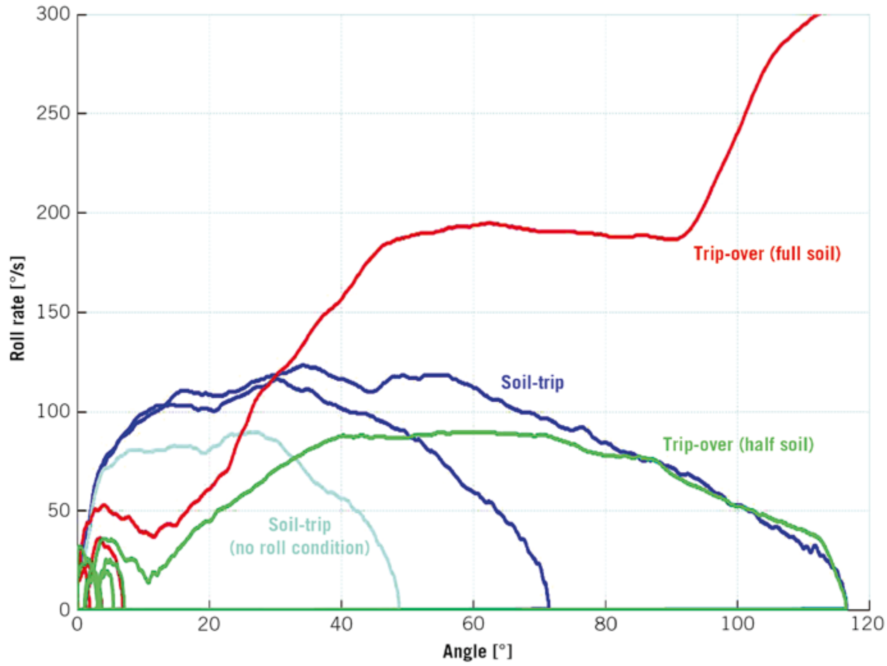

FIGURE 5 Comparison of the signal between trip-over and soil-trip (© Hyundai)

CONCLUSION

Hyundai has developed a steer-induced rollover test method by using a steering robot, acceleration and braking robot, and data acquisition device with DGPS. By applying the differential GPS, the engineers achieved good test reproducibility for requested position, velocity, and approach angle. By applying the data Hyundai gains from steering-induced rollover tests, it should be feasible to improve the performance of rollover sensing systems. Gathering additional data signals from these steer-induced tests should also help with the development of both in-house and supplier safety algorithms.

REFERENCES

[1] Hong, S.-H.; Lim, J. M.; Park, H.-W.: Development of CAE Methodology for Rollover Sensing Algorithm. SAE Paper 2009-01-0282

[2] Berg, A.; Rucker, P.; Kroninger, M.: A Realistic Crash Test Setup to Assess the Real World Performance of Advanced Rollover Sensing System. ESV Paper 07-0362

Unlocking New Ways of Exhaust System Development Using CFD Simulations

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CFD simulations using Exa's Powerflow software, based on the Lattice-Boltzmann method, offer a high level of accuracy when determining total noise levels as well as detailed frequency band analysis. These attributes enable Eberspächer to identify the cause and source of unwanted noises, as well as improving the overall development process for exhaust systems.

PROGRESS IN ACOUSTIC SIMULATION

Within the development methodology for exhaust systems, acoustic simulation has greatly advanced in recent years. The order-based level of flow-induced noise to be expected at the tailpipe can be predicted fairly well via 1-D gas dynamics simulation tools.

However, aeroacoustic noise simulation – focusing on additional noise caused by the flow through the exhaust system and its impact on interior comfort – is in its early stages of development. For this reason flow noise is typically analysed only when prototypes are available.

LIMITED AVAILABILITY OF EARLY PHYSICAL PROTOTYPES

In fact, such prototypes are increasingly hard to obtain for suppliers during the early development phase, which means the system can only be planned and tested late in its finalised mounting position. For instance, the shape of the decorative tailpipe end cap, which is governed by design considerations, can influence acoustics. Also, the integration into the rear apron can have an effect on the thermal load of the end muffler and its immediate environment. To spot this type of problem early on, simulation tools are becoming more widely used during exhaust system development. It is not only the cost benefit brought about by avoiding or reducing physical prototypes which makes the use of Computational Fluid Dynamics (CFD) simulation so attractive. Simulation results can also point to the underlying mechanism of the occurring issues and their potential interdependencies with other phenomena within the system's boundaries. This is an added value and something that is not possible using physical prototypes – at least not without substantial effort.

Adverse flow conditions identified late-stage have repeatedly resulted in costly design changes, as well as extensive additional testing, which can only be integrated with great effort and often at high cost during a late phase of the development process. For a supplier it is of high priority to minimise this risk because of the potential to negatively impact several areas at once. During ongoing projects late-stage changes can cause additional work while R&D requires additional samples for redundant testing, in addition to the extra tooling costs that can arise. In a worst-case scenario the supplier may have to pay penalties to vehicle manufacturers. This risk alone is commercial motivation enough to seek an earlier and reliably precise predictability in the performance of the acoustic system.

LOCALISATION OF AREOACOUSTIC NOISE SOURCES

State-of-the-art and more precise simulation tools offer an efficient solution to fulfilling the increasingly severe requirements of modern exhaust gas systems, driven by legislation and technological specifications. Together, Exa and Eberspächer have greatly advanced simulation methods for developing exhaust gas system acoustics. Above all, it is locating aeroacoustic noise sources, which Exa's Powerflow software facilitates with great relevance and precision by utilising the Lattice-Boltzmann Method (LBM). As this considers both the aeroacoustic sources and order-based noise components, the complete noise can be simulated for the relevant frequency band.

Most of the established CFD approaches describe the macroscopic continuum by solving Navier-Stokes equations – a system of partial differential equations. The LBM approach, however, is based on a mesoscopic kinetic equation of particle distribution. The subsequent macroscopic transient fluid dynamic behaviour of the system is the result of the particle distribution development within a certain spatial area over time. Thus, the LBM very efficiently models transient compressible flow processes and thereby provides the basis to also model the sound field caused by the flow and propagating through the fluid at the speed of sound, plus potential interactions between flow structures and acoustics. Flow and acoustic fields are automatically processed in a single field simulation. There is no need to use acoustic analogies or subsequent acoustic computations.

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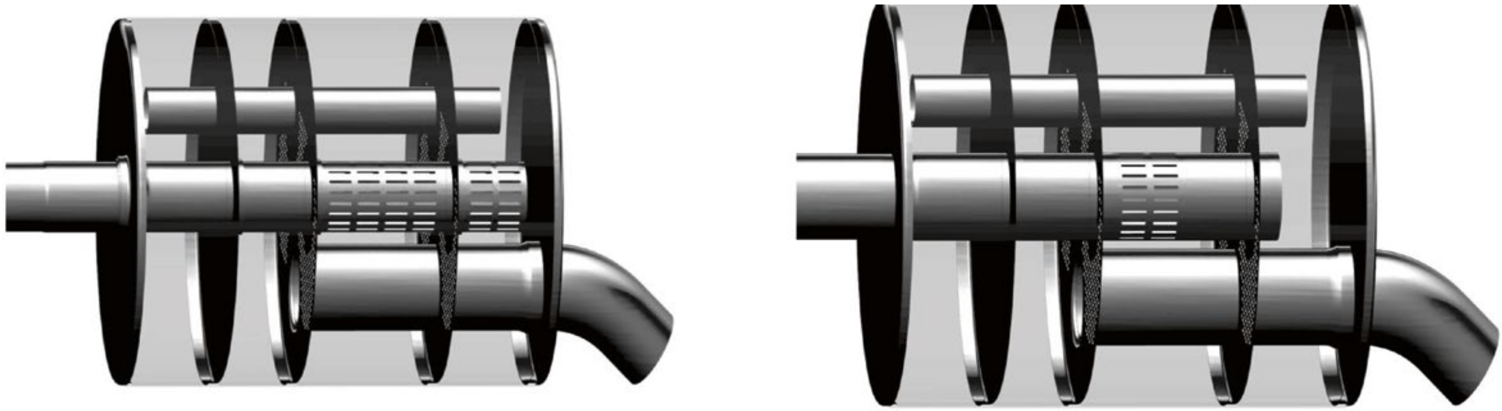


FIGURE 1 Base model A (left) and variant B (right) with shorter inlet pipe and fewer oblong holes (© Exa)

NUMERICAL IDENTIFICATION OF THE NOISE FORMATION MECHANISM

In addition to meeting the main development goal of predicting the maximum total noise level, Exa and Eberspächer have carried out an exemplary study on two design variants of a typical end muffler with the aim of identifying highly annoying noise components such as whistling sounds.

The boundary conditions of the simulation were defined in a way, which reflected in all detail the documented physical variables of the real-world testing in order to achieve the required accuracy and also to facilitate the correlating validation. The end muffler interior is segmented into single chambers by several plates perforated with 3.5 mm holes. These plates are then penetrated by pipes. The inlet pipe is structured by a pattern of slots or oblong holes with 2 mm width. As a modification of the base model A, the geometric variant B (hereinafter B) with a shorter inlet pipe and a lower number of oblong holes has been analysed, **FIGURE 1**.

For certain mass flow rates – for example, dependent on specific engine speeds during a typical drive cycle – the base model A shows significant narrowband tonal phenomena which cause undesirable effects during transient system behaviour. This requires counteractive measures. In contrast, variant B, which was modified compared to the base model, shows no such tonal effects while the level of the broadband noise remains unchanged.

This result was verified during measurement, as depicted in **FIGURE 2**. The comparison of measurement and simulation is shown for the base model A. The tonal effect observed only occurs during mass flow 2.

Variant B, on the other hand, does not show a distinct tonal share. Test and simulation also correspond well in this case, **FIGURE 3**.

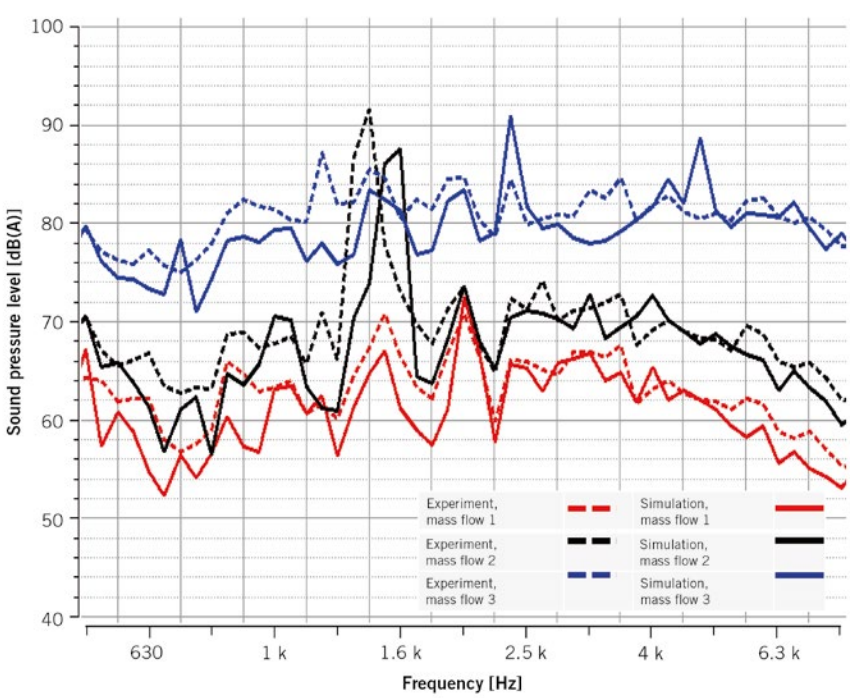


FIGURE 2 Base model A: comparison of simulation and measurement as recorded at the microphone level (© Exa)

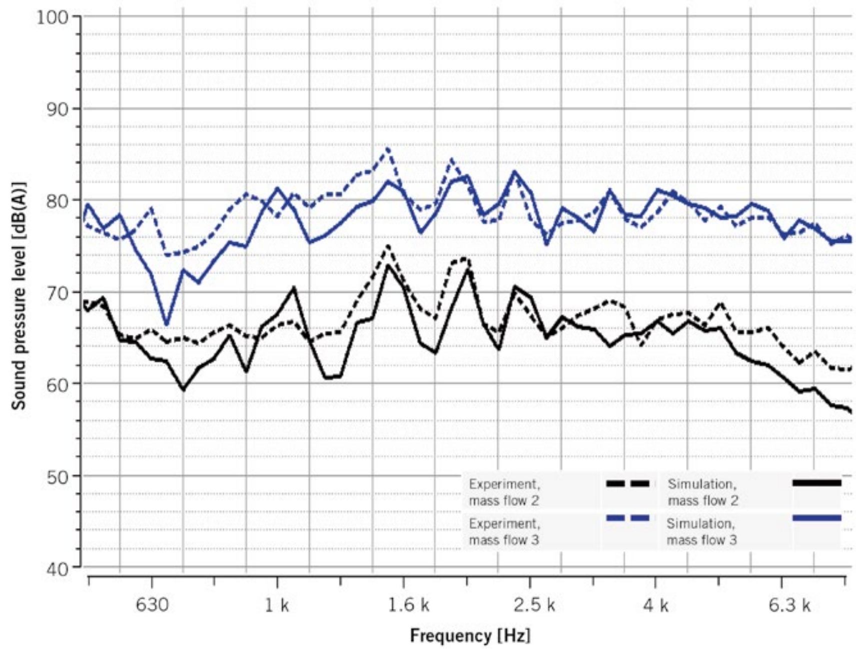


FIGURE 3 Variant B: comparison of simulation and measurement as recorded at the microphone level (© Exa)

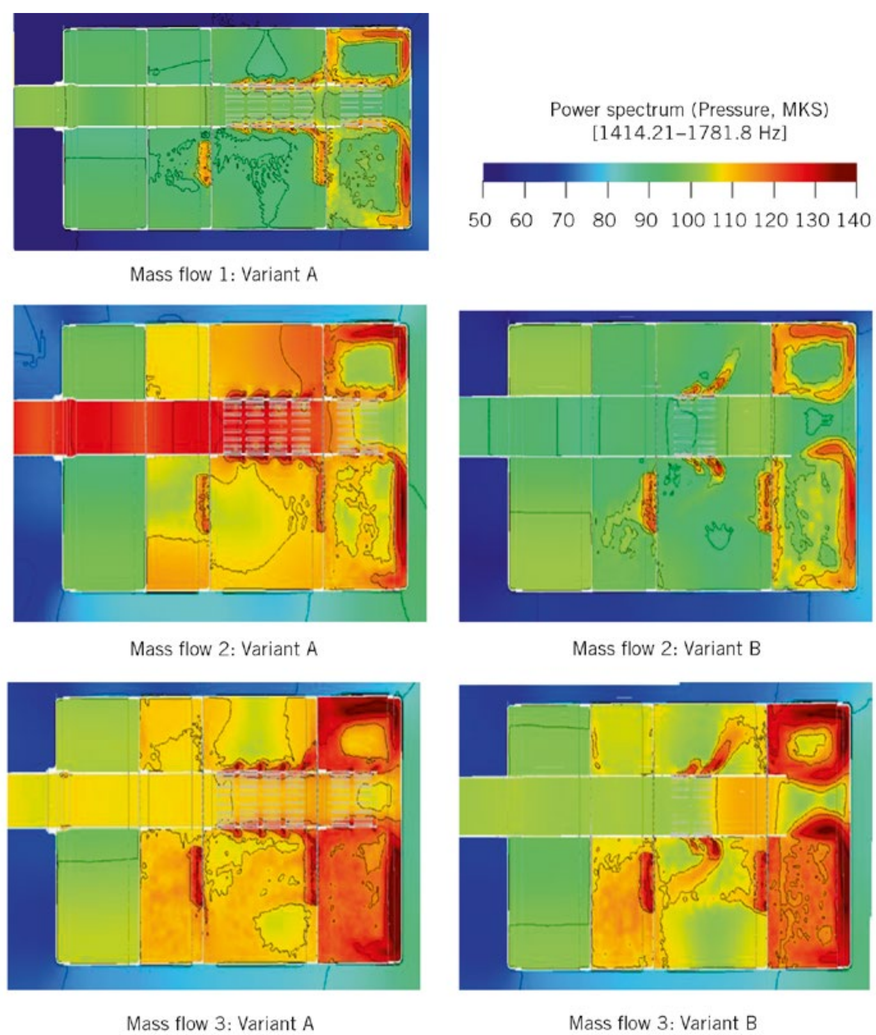


FIGURE 4 Variant B: comparison of simulation and measurement as recorded at the microphone level (© Exa)

DETAILED OBSERVATIONS BASED ON FAST-FOURIER-TRANSFORMATION

To be able to make detailed statements about the acoustic phenomena observed, the flow field is analysed in the frequency range. **FIGURE 4** shows the resulting so-called dB maps. To achieve this, the existing transient time data are transferred into the frequency range for each scale via Fast-Fourier-Transformation (FFT). The results gained by this method are exemplified here within a cross section of the flow field.

With certain mass flows, the turbulent separation of the flow at the oblong holes causes substantial resonances in the cavity of the muffler in some cases. It can be seen in **FIGURE 4** that variant A triggers this kind of resonance, while variant B does not.

If you transfer these results back into absolute time via inverse Fourier-Transformation, you will get bandpass-filtered transient results, which confirm how the cavity mode of the base model A is stimulated at mass flow 2, **FIGURE 5** (centre left), however, remains unaffected by the mass flows 1 and 3, **FIGURE 5** (top left and bottom left), just like variant B, **FIGURE 5** (centre right).

It becomes clear that the formation mechanism of undesirable effects can be considered identifiable, analysable, and thus plannable during the virtual

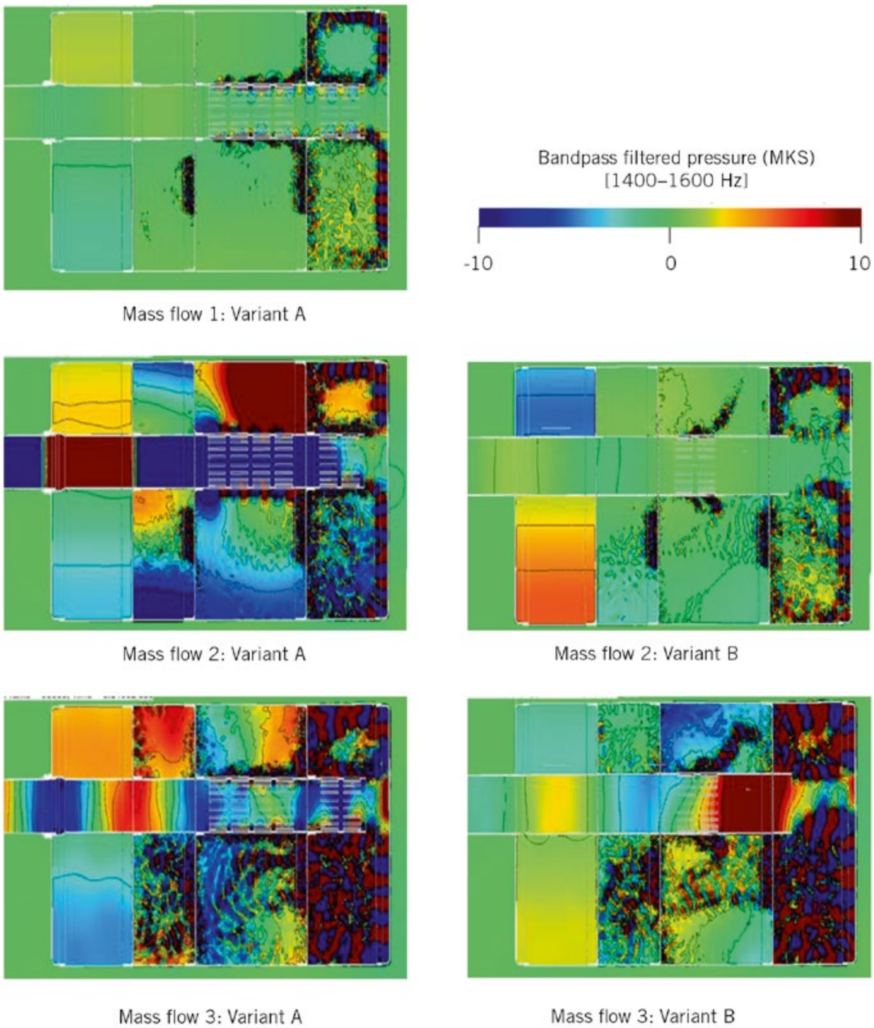


FIGURE 5 Bandpass filtered pressure, 1400 to 1600 Hz, snapshots in time; mass flow 1 (top), mass flow 2 (middle), mass flow 3 (bottom) (© Exa)

development phase. The new Exa Find method (Flow Induced Noise Detection) will improve the detection and determination of noises even further. Possible flaws of the system can thus be designed out plus laborious and costly late changes are avoided, which may have only been detected during physical pilot production testing.

SUMMARY AND OUTLOOK

CFD simulations with the Exa Powerflow software, based on the Lattice-Boltzmann method, demonstrate a high level of accuracy for predicting both, the total noise level and the detailed frequency band analysis. Further in-depth analyses of the results reveal the cause of noise and aeroacoustic noise. Based on these insights, designs changes can be agreed and implemented early in the product development process thanks to simulation-driven design.

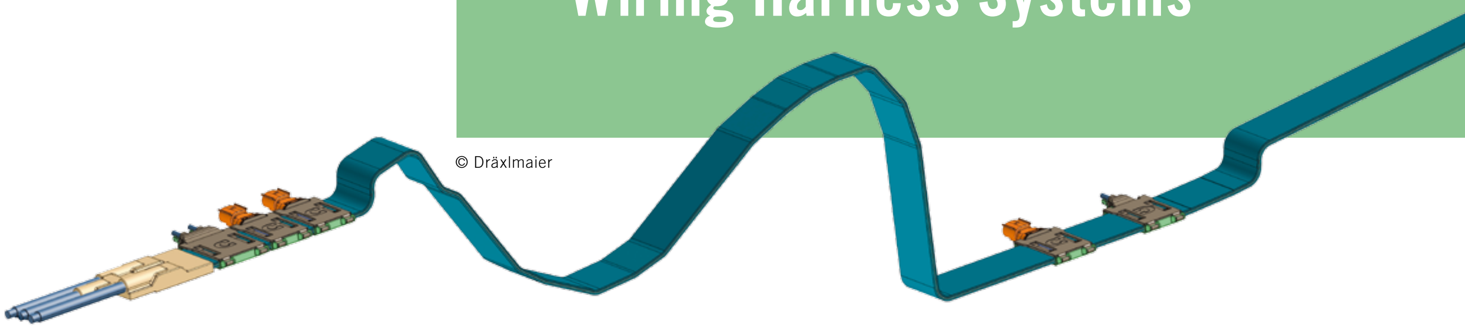
Additional analytic potential is added by the future use of acoustic source detection via the patented Exa Find method. The software makes it possible to analyse the fluid flow of a design and rank the different noise sources in order of importance, providing engineers with the insight they need. This expanded application will improve work in complete areas already addressed, such as greenhouse noise, underbody insulation, heating, ventilation, air conditioning (HVAC), and blower noise.

Through a consistent and predictive use of simulating virtual models with Powerflow, the effort that goes into physical prototyping, and the associated development time, can both be considerably reduced. By thoroughly validating the method, its effectiveness and efficiency were proven.

REFERENCES

[1] Chen, H.; Kandasamy, S.; Orszag, S.; Shock, R.; Succi, S.; Yakhot, V.: Extended Boltzmann Kinetic equation for Turbulent Flows. In: Science 301 (2003), pp. 633-636
[2] Rose, Th.; Krüger, J.; Neuhierl, B.: Strömungsakustische Simulation von Abgasanlagen. Symposium für Motor- und Aggregateakustik, Magdeburg, 2014

Solutions for Distributed Supply of Electrical Wiring Harness Systems



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Wiring harnesses are getting heavier, their energy supply is getting more complex and installation space more valuable. New solutions will have to be found for the design of future electrical system architectures. The Dräxlmaier Group has now taken a first step with a groundbreaking project.

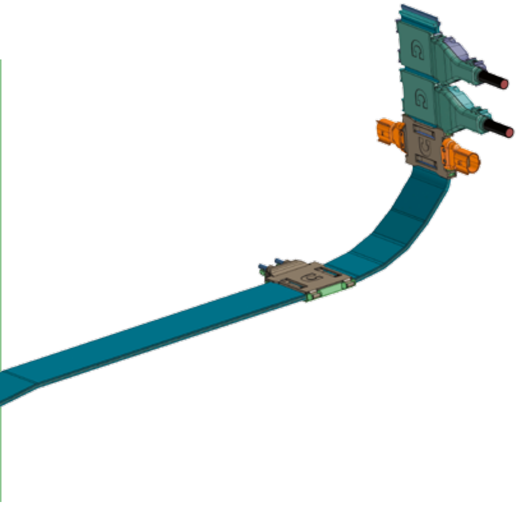
GROWING NUMBER OF FUNCTIONS IN A CAR

Mobile communication experts, entertainers, intelligent navigators: Today's vehicle is much more than just a car in the classical sense. The public is eagerly waiting to see what features tomorrow's car will have. Because the possibilities – particularly in the area of communication and intelligent driver assistance systems, are far from exhausted – the number of functions in a car will continue to grow in the future. Automated driving, which has already been partially realised in many new premium-class cars, is basically only a predecessor of the actual goal: autonomous vehicles. But even with all these technical achievements, how will automakers be able to satisfy the demands of all consumers in the future, such as economising on installation space and reducing weight?

Innovative, technological approaches are needed to deal with the challenges in current and future supply networks. In the past few years, the Dräxlmaier Group has concentrated its research and development on working out various basic approaches and has merged the results in the Dräxlmaier smart KSK experimental vehicle, a prototype with which Dräxlmaier presents viable solutions to future demands on electrical wiring systems, **FIGURE 1**.

Thus, the entire 12-V supply network that is normally implemented as a tree structure in vehicles was replaced in the Dräxlmaier smart KSK by a backbone structure – starting with the battery distributor, and ending with the front and rear power distribution. The entire grounding concept was also adapted in the course of this. As the focus in future body construction will increasingly be placed on non-conducting materials, such as CFRP or other compound materials, the backbone concept is integrated into central mass distribution.

A triple-layer multi-bus will help provide centralised 12-V power supply on the one hand and grounding return on the other – all in a single component. The use of the multi-bus has also proved to be beneficial in other respects, namely in terms of the stability of the electrical system. For example, the sandwich con-



struction of the multi-bus caused almost complete EMC field obliteration. In addition, considerably less installation space is required when using the multi-bus: Thanks to its special form and its limited height, it can easily be included in body designs. Based on the concept of lightweight construction, the Dräxlmaier smart KSK uses aluminum instead of copper; this has a beneficial impact on the overall weight of the vehicle.

INTEGRATED AND DECENTRALISED SUPPLY ARCHITECTURE

More reliable, safer, lighter, more space-saving: Not only can the new concept optimise the current electrical system, it also provides solutions on how to deal with future demands, **FIGURE 2**.

Three different contacting methods were selected for the connection: welded contacts, screwed contacts and plug contacts. While the generator and the battery are connected by a welded or screwed contact for the 12-V power supply and the ground connection, the power distribution is connected by plug contacts. That provides multi-drop capability, which makes decentralised connection of each of the power distributors possible. In addition, this means that the design of the wiring harness can be optimised because it allows decentralised functional power supply, enabling the feed lines to be shortened by an average of 1 m.

The second important improvement, which is excellently demonstrated in the Dräxlmaier smart KSK, is the new fully electronic power distributor. All seven power distributors installed in the experimental vehicle are identical in construction. The only difference is in the configuration of the various load paths.

SOLUTIONS TO OPTIMISE THE WIRING HARNESS

If each of the individually considered parts named above can now be described as being innovative, the combination of these parts in the experimental vehicle has resulted in innovatively integrated, decentralised supply architecture with intelligent electronic power distributors, **FIGURE 3**.

This required extensive vehicle measurements during research and development, which ascertained the individual load profiles of the connected functions. Based on these, an optimised cable gauge was identified for each function, **FIGURE 4**.

So, for example, the power supply of the seat heating was reduced from 2.5 to 0.75 mm². In the rear window defroster, there was a reduction from 2.5 to 1.5 mm². Supply of the electrically operated tailgate lock now requires only a gauge of 0.35 mm² instead of 1.5 mm². On average, the cable gauge has dropped by 50 %.

Ascertaining the load profiles had further benefits, as integral energy management could then be set up on that basis. The bus system to integrate power distribution is a private CAN. The master takes over the terminal signals of the vehicle and controls the individual power distributor across them. The system

FIGURE 1 The triple-layer multi-bus in the Dräxlmaier smart KSK experimental vehicle includes front and rear connection technology (© Franz Haslinger | Dräxlmaier)

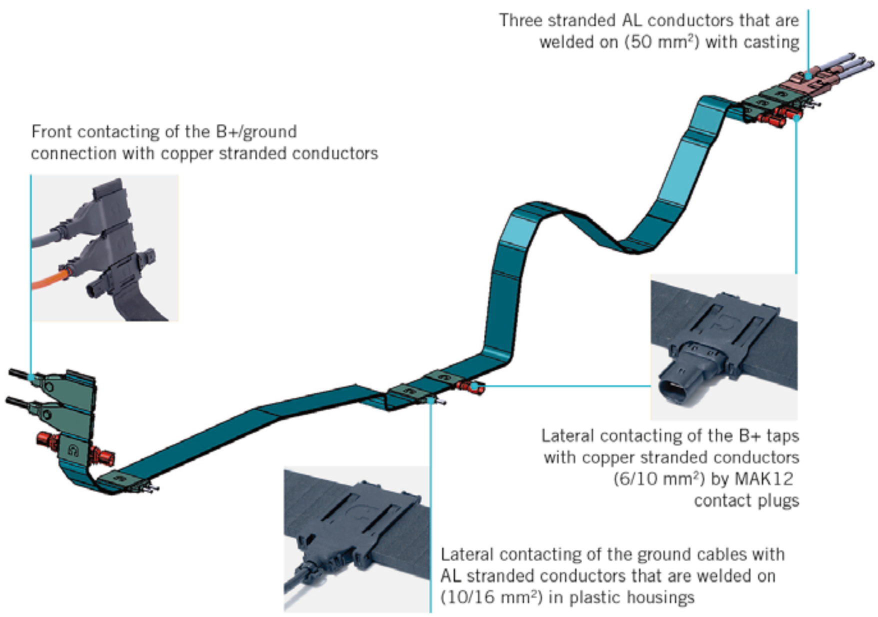


FIGURE 2 Detailed illustration of the triple-layer multi-bus including the various connection methods, such as welded contacts, screwed contacts and plug contacts (© Dräxlmaier)

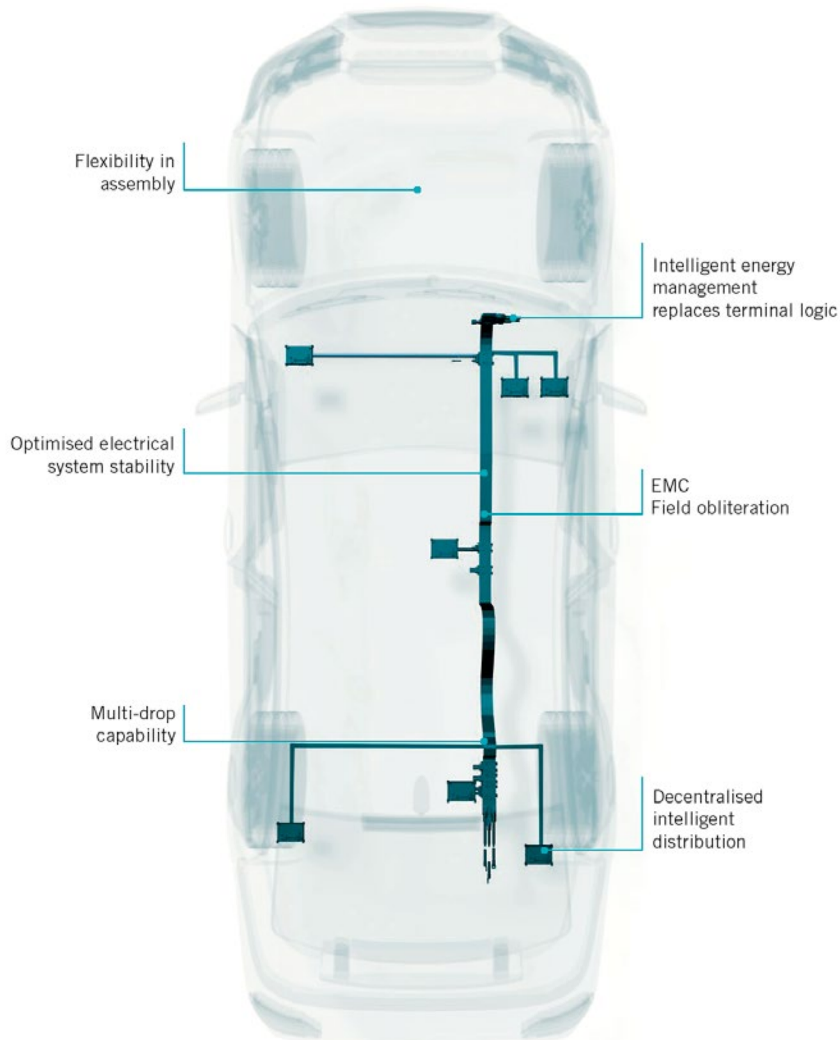


FIGURE 3 Backbone vehicle electrical system architecture in the Dräxlmaier smart KSK (© Dräxlmaier)

functions also support energy management by way of temporary overload cut-off and enable fast, autonomous access control to stabilise the electrical system. A particular challenge was designing the concept for the intelligent power distributor that was suitable for low voltage and quiescent current, **FIGURE 5**.

An electronic switch now takes over the function of the former three control elements: It is a clamping circuit, a fuse protection and functional circuit all in one. This type of redistribution will produce a whole new generation of electrical system architecture concepts, although in the case of the Dräxlmaier smart KSK, only the clamping circuit and the fuse protection can be put into effect for the time being, as a functional circuit would require accessing the communication architecture of the vehicle. This is one of the next targets for future experimental vehicles.

The results of the developments speak for themselves: Reducing the load paths in the lengths and decreasing the cross-section of the wires has reduced power dissipation. The power balance of the vehicle is therefore positive. The weight of the wiring harness in the experimental vehicle has been reduced by 10 %. When projected to the various equipment variants, the electrical potential varies between 6 and 14 %. Thus, an optimised design of the load path could result in up to 2 % cost savings in the wiring harness.

The task now is to promote development by gaining experience with the experimental vehicle. Based on the overall electronic approach and the described decentralised supply topology to optimise the energy flow in the vehicle, future cross-linked energy management should form the basis of a concept for fail-operational functions in the supply layer. Moreover, it could show considerable potential for wiring harness development.

It is too early to predict the extent of an electronic design. The goal should be to find a worthwhile combination of proven and new methods. Being able to monitor and control the supply of functions may be particularly crucial in the fail-operational range and thus of special interest for the realisation of autonomous driving.

One approach here lies in modularising according to need and function in each power distributor. Cross-linking the power distributors, as has already been

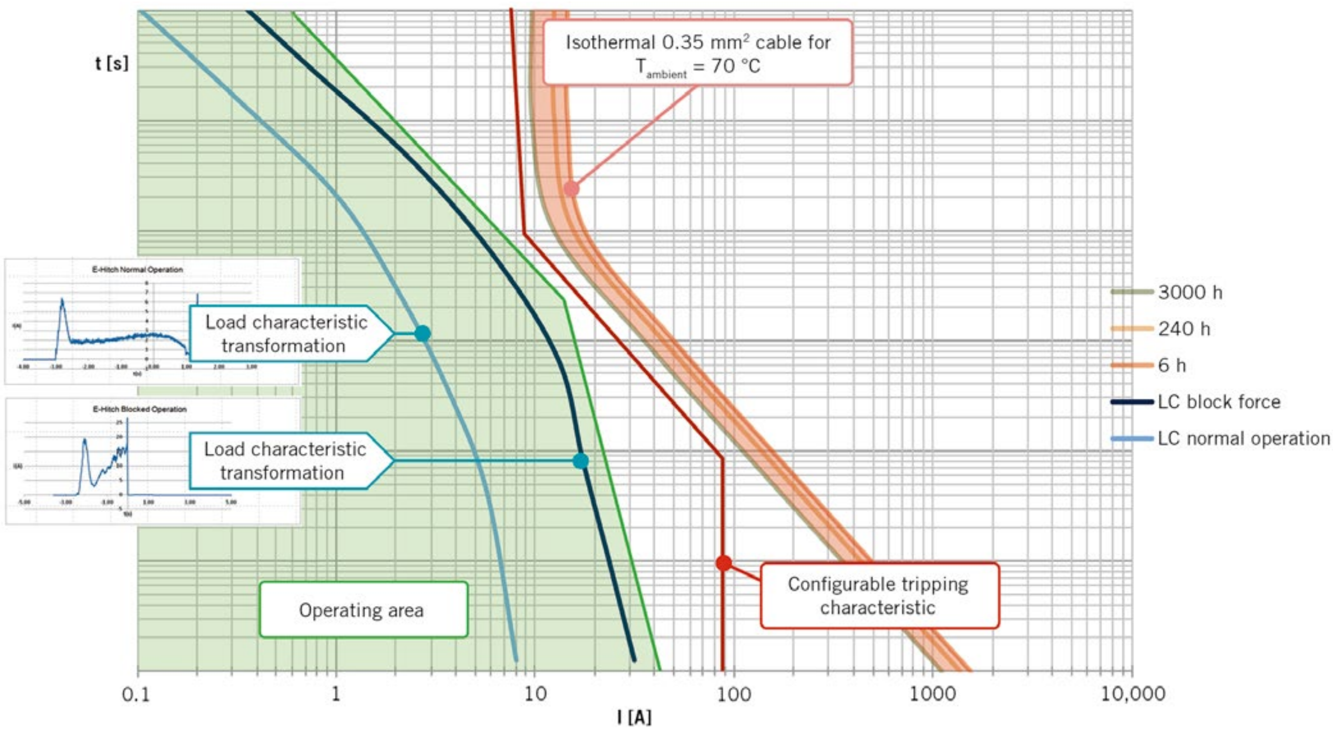


FIGURE 4 Example of using load characteristics for the design of a cable – in the example, the cable was reduced from 4 to 0.35 mm^2 (© Dräxlmaier)

done in the experimental vehicle, will also be indispensable here. However, modularity like that will also interfere with the setup of the power distribution. Ultimately, some communication functions will have to be retrofitted. From a production point of view, this will doubtlessly be a challenge because up until now, installing electronic parts in wiring harnesses is not usual in the industry.

The integration of the power distribution will also involve functions in the electrical system in the future because the electronic switch, as already indicated above, can take over the actual operation of the functions. This will result in package advantages, as fewer energising leads will be needed. In order to guarantee high-scale integration of the power distributors, the communication interfaces will be flexibly designed. To do this, it will not be absolutely necessary to use CAN; LIN or Ethernet integration would also be conceivable.

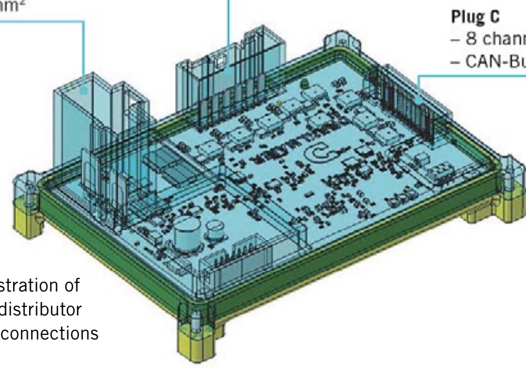


FIGURE 5 Detailed illustration of the intelligent power distributor including the various connections (© Dräxlmaier)

OUTLOOK

The experimental vehicle is the first to apply the new decentralised vehicle power supply with distribution, sensing, switching and fusing functions. In the next stage of expansion, integration methods will be researched for circuit switching, fuse protection, functional operation and energy management, and also for the power distributors. Special importance will also be attached to the integration of the fail-operational functions.

As a partner to the OEMs in the development of vehicle power, the Dräxlmaier Group aims at meeting new demands in the automotive area and providing solutions. The Dräxlmaier smart KSK experimental vehicle was able to set a new milestone for this.

The next step will be to examine system designs on the basis of a new vehicle power system structure with a modular approach. Focus will be on showing functional and design engineering in integration levels – from the application of an integrated circuit, right up to fuses. Development is in full swing because the goal is to derive practical system solutions for the challenges of the OEMs with regards to package, bundle cross-sections, weight and power system stability.

Limits of Self-tapping Screws for Part Joints Made of Die Cast Aluminium

© Ejot

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Mainly metric steel screws are currently used for fastening aluminium parts in the field of transmission, chassis or other supporting automotive components. These are fastened into formed or machined threads in the drill hole. As an alternative, self-tapping screws can now be used, which are able to form their thread in a pre-casted core hole. Since there is currently no meaningful independent research available about this cost reducing technology, the German research association FVA with the collaboration of the screw specialist Ejot has completed its research project No. 608/I and worked out practice-oriented investigations and solutions.

SELF-TAPPING FASTENING ALSO FOR HIGHER LOADED JOINTS

The process comparison between conventional and self-tapping fastening in **FIGURE 1**, shows the high economic potential of the thread-forming technology compared to a conventional metric joint, provided that the nominal screw diameter and the installation depth do not have to be increased.

Self-tapping screws are already used in automotive engineering for subordinate and not loaded or only slightly loaded component joints, in most cases torque-controlled fastened. But until now, the loading and application limits of aluminium parts fastened with self-tapping screws made of strength category 10.9 steel are mostly unknown to the user.

The objective of the research project Nr. 608/I [1] of the project participants research association FVA, Audi, BMW, Daimler, Ejot and ZF was, a well-founded, academic based statement, whether steel screws may be substituted by self-tapping screws of the same size. The main focus was on screw installation beyond yield strength, which should be applied in order to reach consistent and highest clamp loads and thus contribute to the best possible configuration of a screw joint. The examined material combination was a common die cast aluminium alloy AlSi9Cu3 in combination with steel screws of the strength category 10.9.

Aluminium screws were not analysed within this research project. Past findings of the project participants showed, that the Al screw dimensions had to be increased in order to reach the clamp load level of the steel screw.

It has also been proven, that aluminium screws made of the common 6056 alloy in combination with components made of Gd-AlSi9Cu3, loose more than 50 % of the initial clamp load under heat exposure of 140 °C [2]. Due to the necessary larger dimensioning, more installation space is required and no weight advantage can be generated. For that reason aluminium screws are only suitable for magnesium applications in outdoor areas and/or for magnesium components being subject to high temperatures.

Due to wear and tear of the pin inserts, variations in the core hole size are possible in a serial casting process. It was thus necessary, with regards to costs, to define a feasible and repeatable tolerance window of core hole diameter and draft angle. The agreements with the casting companies were done in terms of the existing service life of the casting tools, as well as the manufacturer specifications for self-tapping screws. The maximum size of the drill hole (GM) was defined with 7.71 mm for the drill start and at the end of the installation depth of 2.5 × d with 7.38 mm.

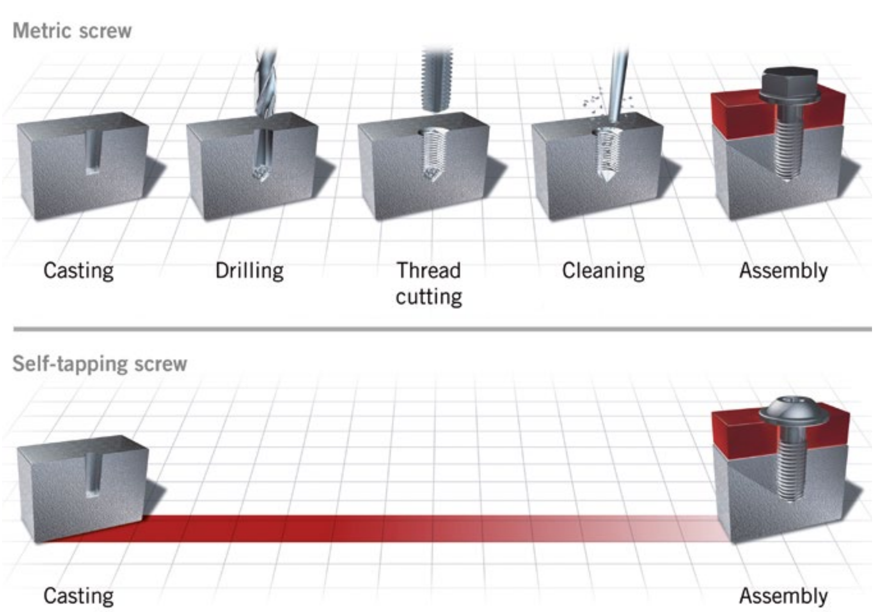

FIGURE 1 Process comparison of metric screws and self-tapping screws (© FVA)

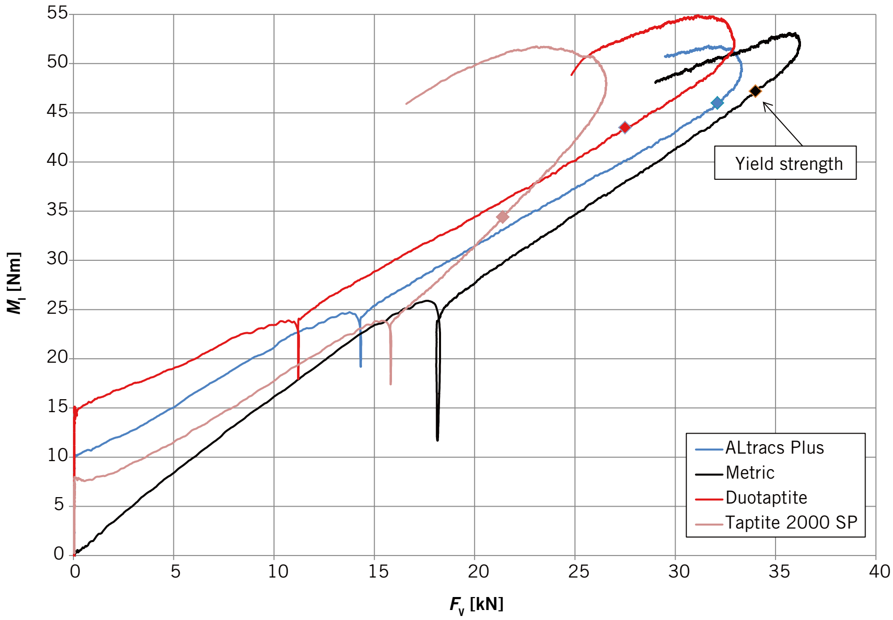

FIGURE 2 Torque curve M_l for maximum sized drill hole (example curves) (© FVA)

Experience shows, that the wear is only minimal at the connection to the tool, therefore the minimum diameter of 7.66 mm has been specified for the drill hole opening. For the drill hole end the diameter has been defined with 7.03 mm. The resulting drill hole mean value is between 7.35 and 7.55 mm. The overall draft angle changes from 1 to 2°. The influence of these cast hole deviations on the functional properties of the self-tapping screws, or rather on possible limitations of the application, should be examined and evaluated in the following.

OVERVIEW OF THE EXAMINED FASTENING ELEMENTS AND PARTS

Apart from the thread form, the screws with a nominal size of 8 mm have been manufactured identically with regards to geometry. The head style is an external Torx with a minimum head connecting surface diameter of 15.8 mm. All screws were hardened to a 10.9 strength and plated with Geomet 321+VL. The self-tapping screws were coated with the usual additional DF921 slide wax coating. The following three self-tapping screw systems, available on the market, have been examined:

1. Duotaptite: trilobular screw with a generous lobulation at the thread forming zone, rounded off towards the shaft, in order to reach a higher thread engagement (company Reminc).
2. Taptite 2000 SP: trilobular screw with radius flank profile for improved material forming, shortened thread forming zone SP for light metal (company Reminc).
3. ALtracs Plus: Circular cross section after the thread forming zone to prevent surface pressure peaks, a 33° thread flank angle adapted to light metal, to realise a more stable female thread (company Ejot).

Part was a serial transmission housing from the company ZF made of Gd-AlSi9Cu3 (AL226), casted by ZF Gußtechnologie Nürnberg, with formed metric thread.

SCOPE OF TESTING

In order to reach the research goal, strength and hardness tests with screws and parts count for the scope of testing. But also the installation torque and installation type based on the specifications for metric 10.9 screws were stipulated as well as the installation and stripping torques with recording of the torque curve and the clamp load curve over rotation angle were determined, **FIGURE 2**.

Furthermore the clamp load C_l was determined of during installation with torque, and torque-rotation angle control with additional recording of the break-loose torque M_l. Also the repeat assembly of the various types of self-tapping screws with torque and torque-angle controlled installation with maximum core hole tolerance. Also, repeat assembly was carried out with both metric screws and self-tapping screws into the formed thread – both with maximum core hole tolerance.

The determination of the pull-out strength F_z with tensile tests at maximum core hole tolerance was likewise part of the scope of testing as static relaxation tests at 140 °C for 100 h. Measurement was continuously of the clamp load with load cell.

Micro-sections of the screw joints were made after the dynamic relaxation tests and hardness tests of the thread flanks of the self-tapping screws and metric screws at half of the installation depth were done, too, **FIGURE 3**. Dynamic relaxation tests were executed at an increased temperature of 140 °C with superimposed pulsating operating load.

EXPERIMENTAL PROCEDURE

In preparation of the dynamic relaxation, the project partners measured as they are shown in **TABLE 1**. Resulting from this, the assembly parameters 30 Nm and 90° have been specified for the rotation angle controlled installation and 37 Nm for the torque controlled installation. In the area of the formed thread, an increased hardness of approximately 25 % compared to the base material, was

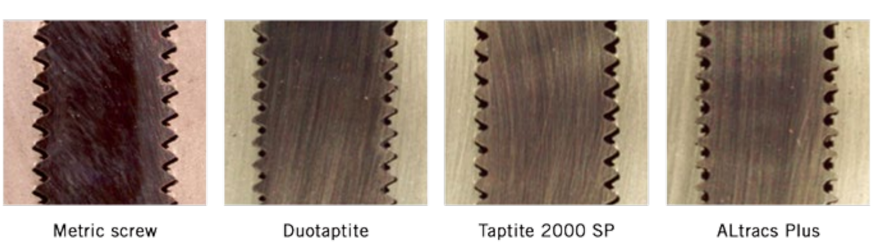

FIGURE 3 Overview of the microsections at maximum sized drill hole for the four screw types investigated (© FVA)

Screw	Unit	Metric M8 10.9	Duotaptite		TT 2000 SP		ALtracs Plus	
Hole		Molded	GM 1°	KM2°	GM 1°	KM 2°	GM 1°	KM 2°
Dimension	mm	M8	7.65-7.35	7.60-7.05	7.65-7.35	7.60-7.05	7.65-7.35	7.60-7.05
Tests for installation and stripping	**i**	**10**	**5**	**5**	**5**	**5**	**5**	**5**
T_i	Nm	0.5	14.2	22.5	7.7	14.3	11.3	22.0
T_s	Nm	55.1	54.4	54.0	52.3	51.9	50.3	50.3
$C_{l,\,max}$	kN	36.1	33.4	32.6	28.3	31.9	33.1	32.1
Angle from head contact till failure	°	500	420	335	–	370	460	360
Mode of failure	SB or Alu	SB	SB	SB	Alu	SB / Alu	SB	SB
Torque at yield strength	Nm	48.2	43.5	48.0	34.3	41.7	46.9	49.2
Clamp load at yield strength	kN	34.1	29.3	29.5	23.0	28.4	32.1	31.9
Tightening torque (chosen)	Nm	37	37	37	37	37	37	37
Tightening torque and rotation angle	Nm + °	30 + 90°	30 + 90°	30 + 90°	–	–	30 + 90°	30 + 90°
First and five times repeat assemblies on T + A (after each repetition a new screw was used)	**i**	**2**	**2**	**2**	**0**	**0**	**2**	**2**
T_i	Nm	0.7	14.8	20.4	–	–	12.2	23.1
Pre-tightening torque and angle	Nm + °	30 + 90°	30 + 90°	30 + 90°	–	–	30 + 90°	30 + 90°
T_t	Nm	53.0	50.7	46.9	–	–	47.9	47.7
C_l at T_t	kN	35.7	32.9	33.7	–	–	34.9	30.9
T_l after tightening	Nm	35.1	30.2	30.8	–	–	29.3	31.7
T_s after five times repeat assembly	Nm	65.0	22.4	49.4	–	–	46.9	49.6
C_l after repeat assembly	kN	35.9	16.6	30.6	–	–	33.2	37.6
Mode of failure	SB or Alu	SB	Alu	Alu / SB	–	–	Alu	SB
Number of achieved assembly repeats	count	5.0	3.5	4.5	–	–	4.5	5.0

Legend
T_i installation torque — T_t tightening torque — Alu femal thread stripp
T_s stripping torque — M_l break-loose torque — GM maximum hole diameter
C_l clamp load — SB screw break — KM minimum hole diameter

TABLE 1 Overview of all measured fastening values for the four screw types investigated (© FVA)

measured for the formed metric thread as well as the self-tapping screws.

The dynamic relaxation tests have been carried-out at the Chair of Mechanical Engineering at the Montan University in Leoben, Austria, by a study group, **FIGURE 4**. The test samples were fastened at room temperature, and the installation parameters were then defined by the study group on the basis of the previously carried-out static trials with 30 Nm and 90° or 37 Nm respectively. After the through heating phase the screw connection was dynamically loaded with 3 kN medium load and 3 kN amplitude (stress ratio $R = 0$). The test frequency was 15 Hz, the number of load cycles was 2.5 million. After the end of the load application the temperature cell was removed and the sample cooled down for 2.5 h to room temperature.

The fastening was carried-out with automatic fastening equipment by Weber company – a WSG 100 control and a TT160-155S-3 screwdriver. The different sizes of core holes (lower or upper tolerance respectively) were measured with individually manufactured set pins. After completion of the tests the individual screw types were evaluated and compared based on the realised installation clamp loads and particularly also based on the remaining clamp load in the joint after the dynamic relaxation tests. An extrapolation based on the law on creeping after F. H. Norton was carried out.

TEST RESULTS

The four screw types showed varying performance with regards to clamp load and repeat assembly. The static clamp load loss measurement was extrapolated after Norton to approximately 5000 hours of operation. These showed the tendency that the ALtracs Plus screw reaches the level of the metric screw.

A similar result was also proven with the dynamic thermal tests. **FIGURE 5** graphically depicts all initial clamp loads and remaining clamp loads for torque controlled installation as well as installation with torque-rotation angle control. The metric screws, together with the two ALtracs Plus screws tightened up to 90°, thus realise similar initial clamp loads and also the highest remaining clamp load for the upper and lower tolerances.

The least remaining clamp loads are realised by the Taptite 2000 SP at the upper tolerance due to lacking flank coverage and by the Duotaptite for lower tolerance due to high thread forming torques caused by undersized drill holes. To reduce the effect of thread forming torques onto the applied clamp load during torque controlled installation, a reversible installation is recommended.

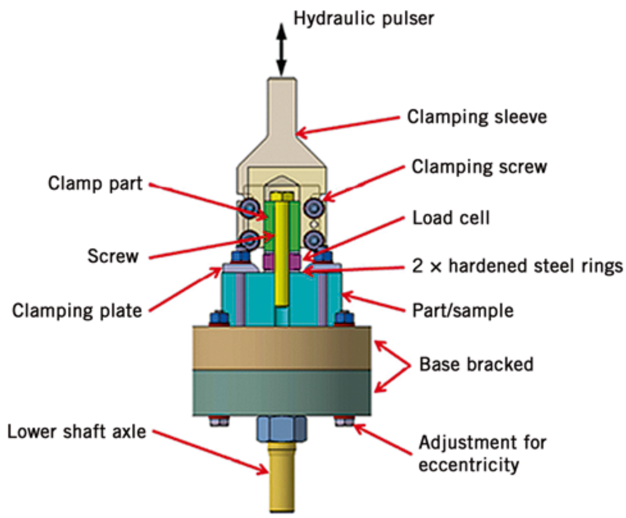

FIGURE 4 Graphical representation of the experimental set-up (© FVA)

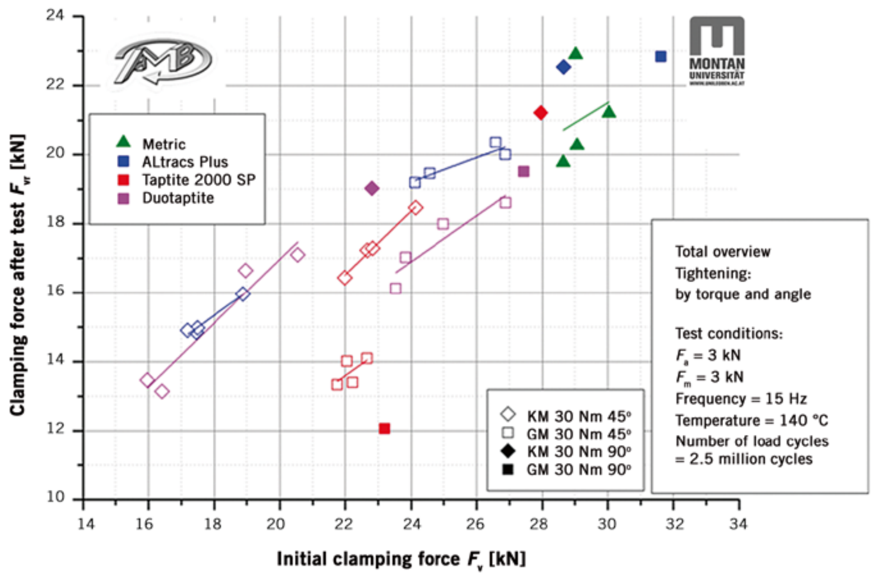

FIGURE 5 Graphical representation of the dynamic-thermal clamp load loss measurement (© FVA)

SUMMARY

The detailed and practice-oriented investigations of the FVA research project No. 608/I show, that metric steel screws of the strength category 10.9 can be replaced by appropriately designed steel self-tapping screws, also for installation beyond yield strength with torque-rotation angle control. It is also possible to cast the drill hole in a process reliable way, resulting in a high economic potential by reducing the overall joint costs by up to 50 %.

REFERENCES

[1] Forschungsvorhaben Nr. 608/I: Gewindeformschrauben. FVA, Frankfurt/Main
[2] AiF-Vorhaben Nr. 12574 B: Gebrauchseigenschaften von Aluminiumschrauben
[3] Friedrich, C.; Thomala, W.: Berechnung der drehwinkelgesteuerten Montage von Schraubverbindungen. In: Mat.-wiss. U. Werkstofftech. 31 (2000), pp. 6-17
[4] Pfaff H.: Berechnung der Vorspannkraft an der Fließgrenze überelastisch angezogener Schrauben. In: Konstruktion 47 (1995), pp. 237-240
[5] DIN 267-30: 2008-04: Mechanische Verbindungselemente – Technische Lieferbedingungen – Teil 30: Metrische gewindefurchende Schrauben der Festigkeitsklasse 10.9. Berlin: Beuth, 2008
[6] VDI-2230-Richtlinie: Systematische Berechnung hochbeanspruchter Schraubenverbindungen. Düsseldorf, 2003

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Controls and Displays in the Audi Virtual Cockpit

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The interior of the new Audi TT departs from the well-trodden path of instrumentation and distributed information. The focus is on optimally tailoring the architecture to the target group of sporty vehicles and drivers. The guiding principle during development was to provide direct operation from the steering wheel for as many features as possible, coupled with displays of the customary range of functions positioned in the optimum field of view.

FOCUS ON THE INSTRUMENT CLUSTER

A new operating concept on the steering wheel makes it possible to operate 90 % of functions with the left thumb. The concept envisages doing away with a separate display on the centre console and showing the entire range of functions centrally in the instrument cluster, right in front of the driver. That has several advantages. First, the area around the centre console is neater and the driver's attention is focused on the road, and second, the optimum presentation of information in the instrument cluster makes the driver's interaction less distracting than when information is displayed in the centre console.

The challenge here is to combine the range of functions from the centre console with the instrument cluster and to develop a highly integrated, low-distraction system. This makes it necessary to define a flexible display concept that can cover the range of functions. The use of an instrument cluster comprising a large display surface is the ideal solution. The ambition to use this flexibility as intelligently as possible was central to the new TT.

MENU OPERATION FROM THE STEERING WHEEL

A fundamental feature of the new TT is the logic units that Audi customers will already be familiar with from existing models; for instance, it is of course possible to continue calling up the main contexts such as on-board computer, driver messages, audio, telephone and navigation directly from the steering wheel buttons. The volume control, a button to which the customer can assign a variety of functions, and the voice control button are also still directly within reach on the steering wheel, **FIGURE 1**.

New features on the steering wheel are direct audio control with skip forward and back, a back function, and a telephone button for answering and ending phone calls. While there are quick access buttons for operating the infotainment on the right steering wheel spoke, the left steering wheel spoke has all functions for browsing through the menu structures.

One key function in the Audi virtual cockpit is the View button on the steering wheel. When the driver presses this button, they can choose between two fundamentally different views of the information displayed. The more classic view comprises a large, easy-to-read revolution counter and speedometer in the style of the familiar instrument clusters. The central section with on-board computer, audio and navigation retreats into the background.

If the driver presses the View button again, the emphasis shifts along with the arrangement of information in the display. The circular instrument dials retreat into the background and more space is devoted to the central section's displays. List entries open up and make more information visible. The map, too, can occupy more space and provide a better overview of the surroundings.

FIGURE 1 Controls on the multifunction steering wheel in the Audi TT (© Audi)

THE FUNDAMENTAL OPERATING AND DISPLAY CONCEPT

This flexible display concept for toggling between various views can be exploited both by the driver and by the system itself. For example, if settings in the vehicle menu or input of a navigation destination call for a larger-scale view, the system automatically shrinks the large circular instrument dials so that there is ample space for the controls. When done, the system automatically reverts to the previous display.

But flexibility also means that display areas can be assigned according to the vehicle's operating status or the driver's preferences. In the conventional analogue instrument cluster, the driver always has to choose a preferred display context in the central section. For audio control, the audio context must be called up. Likewise for views of the on-board computer or navigation display, **FIGURE 2**.

With destination guidance active, the Audi virtual cockpit uses the centre of the speedometer to display the main navigation data. The system displays the arrival

FIGURE 2 Classic display with large circular instrument dials (top) compared to the information view (bottom) focusing on the central section, here with the example of the navigation map (© Audi)

time as well as the distance to destination and to the next manoeuvre, along with delays in the traffic flow; there are also realistic navigation arrows for an upcoming manoeuvre. This information is always visible in the display even if the circular instrument dials are shrunk with the View button or the driver is browsing through the various contexts. As well as the permanent navigation display in the speedometer, the driver can configure a display space themselves.

FIGURE 3 Audi TTS display with large revolution counter at centre (© Audi)

The centre of the revolution counter is available to the customer for this. Their favorite on-board computer reading (consumption, driving time, distances, etc.) can be set to be permanently visible in the display. On top of its functional flexibility, the virtual cockpit adopts an entirely new guise when it moves into the sport and supersport territory of the TTS and TTRS by bringing revs more sharply into focus and providing extra vehicle status displays, **FIGURE 3**.

THE NEW MMI OPERATING CONCEPT

The new Audi TT heralds in an entirely reengineered generation of the MMI operating concept. The purpose of its reengineering is to make the most important functions even quicker and easier to operate. All frequently used functions are now directly accessible as soon as the menu in question is called up. For example in navigation, the search box for new destinations, navigation to the home address and the last destinations are listed directly on the opening screen. This means the user will have direct access to the function they want for almost all everyday user requirements. This approach applies throughout the entire system; within the telephone area, for instance, the contact search, mailbox and call history are again immediately available in the opening screen. The bulk of interaction with the system now proceeds without any toggling, **FIGURE 4**.

As well as arranging information in a more efficient, user-focused way, the new-generation MMI also offers an entirely new form of information search. The highly advanced MMI search needs just one input line, in a similar way to an Internet search engine, enabling its sleek integration into the MMI menu. For a navigation destination input, for example, the MMI search accepts parallel real-time searches of all addresses and special destination within Europe, all contacts, last destinations and the user's favorites, with hitlist display while the input is still being made. If the desired information is not available on-board, an online search can be launched. So the user does not need to decide in advance how to search and what to search for; they merely enter their chosen search term.

During the input the driver receives optical and acoustic confirmation of the letters identified. That makes it possible to search for phone numbers, navigation destinations or preferred artists without looking away from the road. The MMI search is available in every important menu: Radio, Media, Telephone, Navigation, Vehicle, Audi connect. In each of these contexts, the search line is always at the top of the list. In the compilation of hitlists, previously entered destinations or special destinations are given a higher weighting so that the destination will appear in the list after inputting fewer letters. In that respect the system is effectively an adaptive one. In conjunction with the further significant refinement of handwriting recognition, the input process has now been reduced to a minimum. As well as via the touchpad, it is still possible to enter letters and digits in the conventional way using the rotary pushbutton control.

Along with efficiency, there is another purpose behind the basic analogy to an Internet search engine. Analogies with known interaction mechanisms have

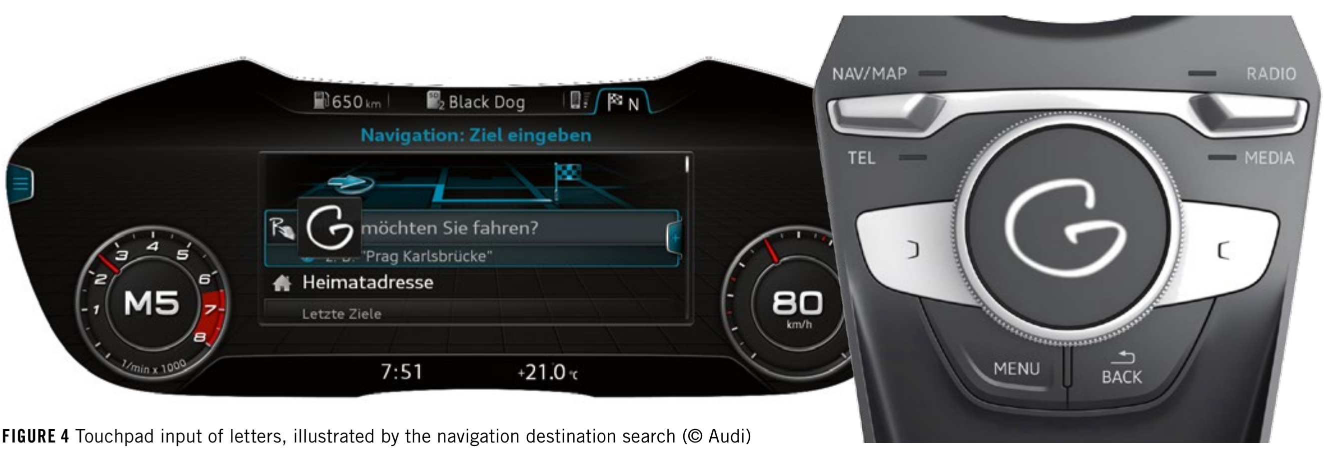


FIGURE 4 Touchpad input of letters, illustrated by the navigation destination search (© Audi)

specifically been implemented to make the system more accessible to users. Users are accustomed to processing high data volumes with search engines. Meanwhile users are also familiar with having a variety of options available by right-clicking the mouse. For this reason, a separate options menu has been implemented, **FIGURE 5**.

Here, the user finds all possible options for the entry over which the cursor is currently hovering. Available options are symbolized by a small plus symbol to the right of the entry or context.

NEW APPROACHES TO SPEECH CONTROL

The significantly simpler voice control concept for the MMI is another innovation. To achieve a more natural form of communication between driver and vehicle, there is a much wider range of usable expressions available. Unlike the established command-based dialog, expressions from everyday speech can be used in the new TT. To phone a contact, you can simply say for instance: "I want to talk to Peter", or "I'd like to call Peter." Once again, the aim is to keep the number of different commands that the driver needs to learn to an absolute minimum.

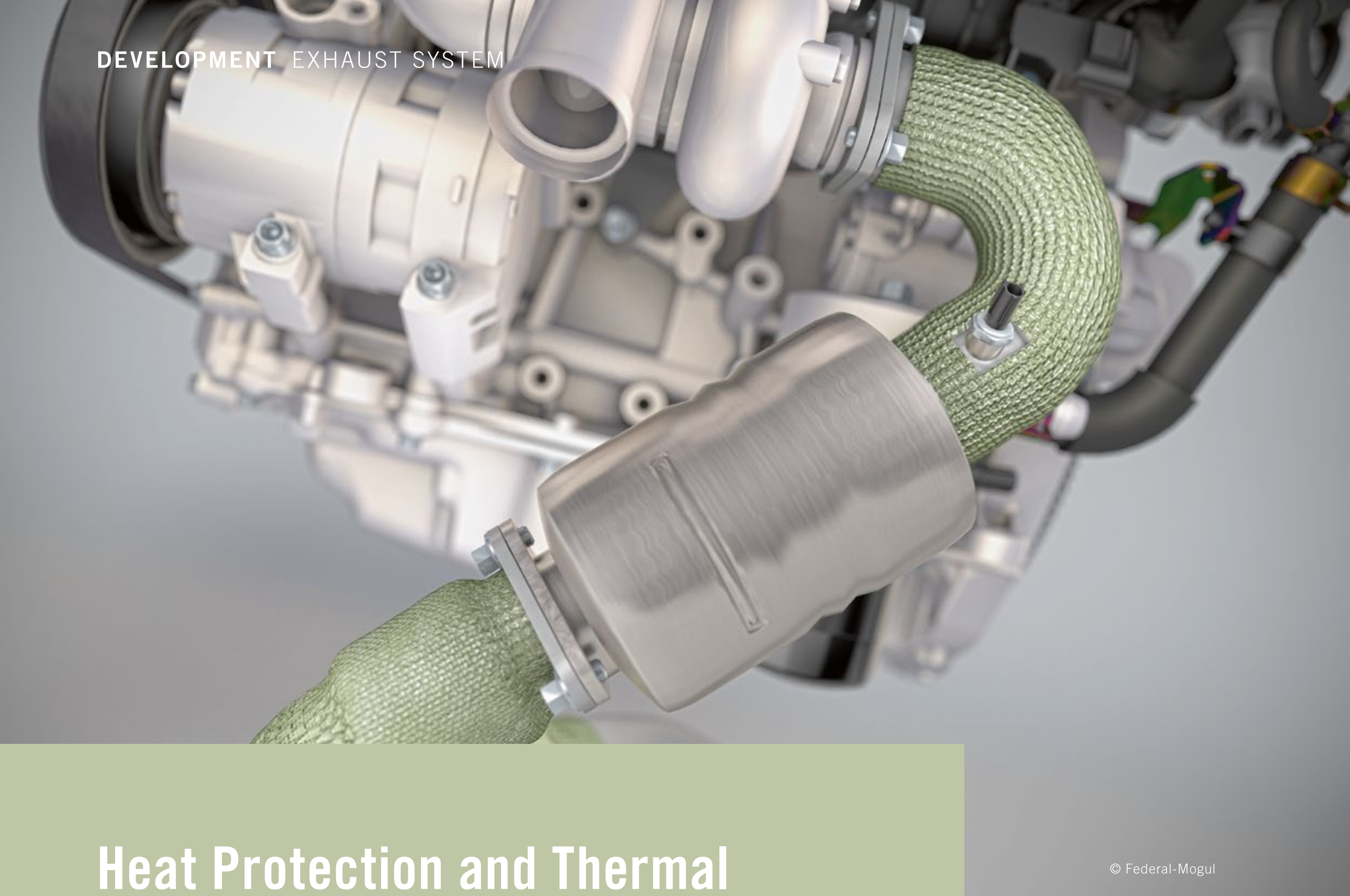
AUDI CONNECT

In modern life we are connected always and everywhere – at home, at work and while out and about. Audi connect offers the driver access to the connected world in real time. Whether for weather information, fuel prices, online news, events or flight information, the driver can obtain this information from neatly arranged, easy-to-read menus or have it read out. The connect package also provides access to a navigation map with satellite images for greater ease of orientation, as well as access to social media such as Twitter. Wherever possible, the data module does this using the LTE standard, which is up to ten times faster than the 3G standard. The passenger also benefits because WiFi makes the new TT a mobile hotspot. Online streaming of Internet radio and services such as Aupeo! and Napster now also become available in the vehicle.

SUMMARY

Today, Audi is already setting new standards with its control and display functions. Highlights are the Audi virtual cockpit and the new MMI operating concept including MMI free-text search and natural-language control, which are available in the new generation of the Audi TT, Audi R8, Audi Q7 and Audi A4 model series.

FIGURE 5 Opening the available options, exemplified by a list entry in the navigation destination search (© Audi)



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Heat Protection and Thermal Management in the Exhaust System

Modern exhaust systems must be compact and lightweight, yet still able to provide the necessary level of heat protection while also maintaining the high temperatures needed for efficient emissions aftertreatment. To address these complex thermal management challenges, Federal-Mogul Powertrain developed the so-called ThermFlex sleeving, a knitted, flexible and insulating textile heat shield.

INCREASED SYSTEM COMPLEXITY

The exhaust system and the exhaust gas recirculation (EGR) system of combustion engines, especially modern turbocharged engines, is increasingly package-constrained. Additionally, exhaust system engineers are faced with the demand for improved isolation and containment of high temperature components, required due to the high exhaust gas temperatures needed to achieve the stricter emission levels set by the authorities.

In addition, the geometry of the exhaust system is becoming more complex and the development time is getting shorter so that problems which cause design changes may appear in a late development phase. Federal-Mogul Powertrain has developed the ThermFlex exhaust insulating sleeving family, **FIGURE 1**, of products for the isolation of hot components in the exhaust and EGR system. In addition to protecting surrounding components from radiant heat, these products thermally insulate the exhaust system, keeping the exhaust gas temperature high during engine cold starts and saving mass, additional tooling and costs.

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FROM CLASSIC HEAT SHIELD TO NEW TEXTILE HEAT SHIELD

Rigid heat shields are usually used in the exhaust system to protect the surrounding environment from radiant heat and to keep the temperature of the exhaust gas high by encapsulating heat within the system. These rigid heat shields are made of multilayer aluminium or stainless steel with glass fibres as an inlay. They need to be die-forged then welded or crimped during assembly onto the exhaust pipe.

The intention in developing the new textile heat shield was to have a lightweight design product which can be installed with a minimum of tools and capable of withstanding temperatures up to 1100 °C; depending on the materials used, even temperatures up to 1800 °C can be contained. The target was to provide thermal efficiency comparable to a rigid heat shield as a minimum and to reduce mass by 40 to 60 %, depending on design and requirements.

PROTOTYPE MANUFACTURING AND SERIES PRODUCTION

The first step in the new design of a ThermFlex insulating sleeving is to select materials based on the thermal requirements of the customer. The materials have different characteristics such as heat transfer rate, specific heat capacity and latent heat. Inorganic fibres are carefully selected to comply with European regulations [1]. After material selection, a 3-D model of the component to be shielded or the component itself is required in the next step. The design of the protection is done using CAD, aligning the material with every area of the component in order to ensure an optimal function during operation.

Depending on the configuration of the application and the number of branches, the design is fine-tuned and the knitting machines adapted to accommodate specific shapes. This includes to choose from a portfolio of machines those that are best suited for installation and heat containment targets. The insulating sleeving final product should be both easy to install (less than 5 s for a length $0 < L < 500$ mm) and perfectly to adapt to the application geometry, while performing to the requirements, **FIGURE 2**.

During the knitting process one continuous yarn is used with a specific needle stitch to create the different knit structures. Several continuous yarns can be used to add further product properties. Through incremental and computerised design iterations, the engineers can fine-tune the final textile solution so that it offers the correct mix of fibre assembly while ensuring long term mechanical stability. As an additional operation the product can be modified with snaps, **FIGURE 3**, sewing and adding rivets to get the correct fit and facilitate further installation possibilities. The prototypes need to be modelled on the customer part and adjusted after ThermFlex prototype manufacturing, to ensure proper alignment. It takes approximately one to two weeks to prepare prototypes and incurs no additional tooling costs.

The installation of the new textile heat shield in the vehicle or onto the engine is considered during the design. Depending on the application, diameter jumps or cutouts for brackets can be used with different knitting structures. Expansion can also be tailored from 1.5 to 2 times the diameter of the application, enabling the sleeving to be slid over an end termination while maintaining a very good fit and avoiding use of additional fixing systems. To accommodate brackets or

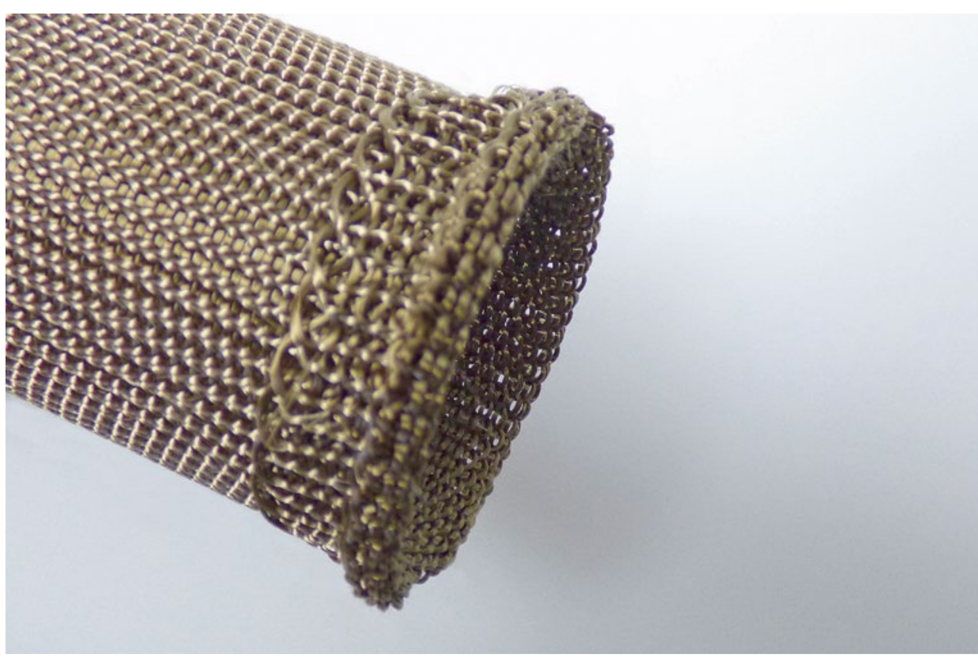


FIGURE 1 Tubular knitted textile heat shield from the ThermFlex insulating sleeving family (© Federal-Mogul)

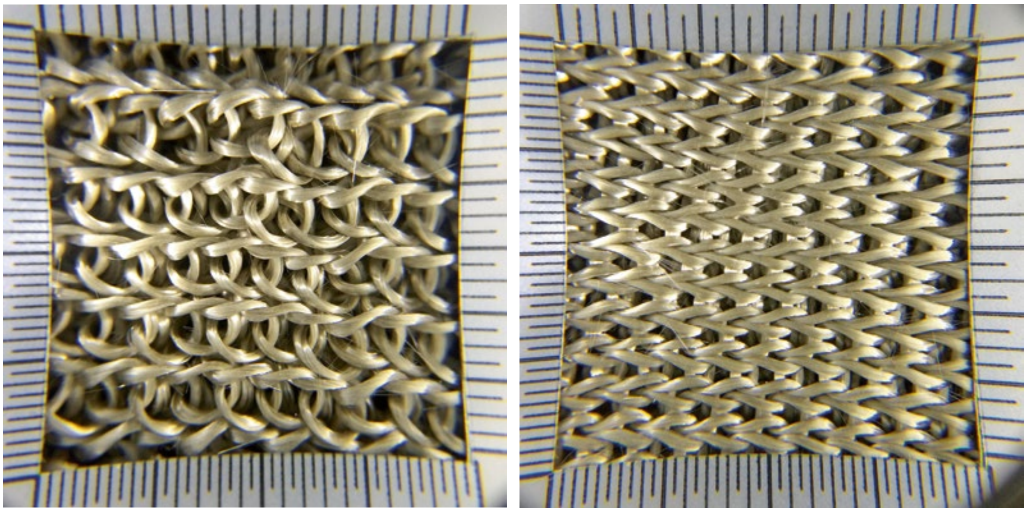


FIGURE 2 Rough (left) and fine knitted (right) structures of the textile heat shield (© Federal-Mogul)

flanges, easily used tools are designed which help to protect the insulating sleeving during installation. Following customer validation, the confirmed design parameters are transferred directly to manufacturing for series production.

CALCULATIONS AND TESTS FOR THERMAL CONDUCTIVITY

Textiles have been used for thermal insulation and isolation since the 1930s, but the science behind the behaviour of the textiles for this kind of protection was not developed. All knowledge about the behaviour was taken from empirical tests. In order to design products with a good performance/cost ratio it was necessary to understand the underlying science. One of the most significant characteristics of these products is: the thermal conductivity.

To understand this more fully, the knitted structure of the textile heat shield was created in textile pre-processor software and the geometry was transferred to a finite-element analysis (FEA) programme. A unit cell, which combines the geometry of the knitted structure and the volume of air, was generated and meshed for heat transfer analysis. In this analysis the material properties of basalt fibres were used with air and the associated boundary conditions were input to the solver to solve the three-dimensional energy balance equations.

The boundary conditions were created according to the requirements specified for a guarded-hot-plate thermal transmission measurement according to the ASTM C 177 [2] standard. Afterwards the results were post-processed into thermal contour plots and the calculated total heat transfer rates along with cross-sectional area and thickness of the unit cell were used to compute the effective thermal conductivity of the product structure. Therefore, the heat conduction equation, Eq. 1, was used:

Eq. 1 $$Q = \frac{-kA(T_1 - T_2)}{t}$$

Here, Q is the average total heat transfer rate, k is the thermal conductivity, A is the cross-sectional area, T_1 is the outer surface temperature, T_2 is the inner surface temperature, and t is the unit cell thickness.

FIGURE 4 shows the thermal contour FEA results of the product structure with the specified boundary conditions and material properties. The effective thermal conductivity, which took both the fibre and air volume fractions into

FIGURE 3 Flat knitted textile heat shield with snaps (© Federal-Mogul)

account, of the two different structures in **FIGURE 2** was computed to be 0.030 and 0.028 W/mK [3], respectively. To correlate the calculations against physical test results, a thermal containment test was performed according to an internal standard using basalt fibre, knitted in a double layer design. The test setup and procedures were developed based on customer requirements.

During the test, the sample is installed on a pipe with a specified diameter and length, to give repeatability. Pipe and sample are connected to an EGR testing apparatus which is capable of different temperatures, to observe the behaviour of the product in relation to the "gas" temperature. Several thermocouple are used in this test. One thermocouple is inserted to measure the inlet gas temperature from the EGR and another is attached to the pipe surface, to measure and control the pipe surface temperature. Another thermocouple is installed on the sample, at the same distance from the inlet as the pipe surface thermocouple, to measure the sleeve surface temperature. Further thermocouples measure the ambient temperature of the surroundings and the temperature above the pipe surface at specified distances. Average temperatures were calculated once temperatures had stabilised.

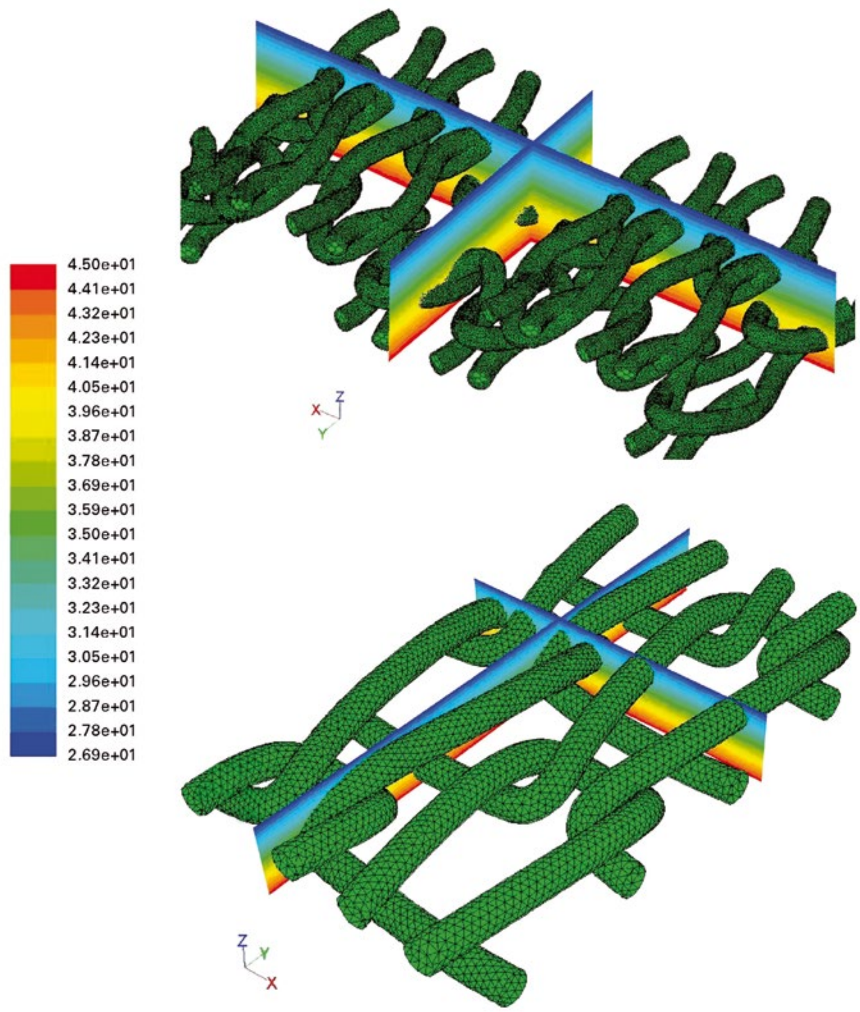


FIGURE 4 FEA results of the knitted structures – rough (top) and fine (bottom) (© Federal-Mogul)

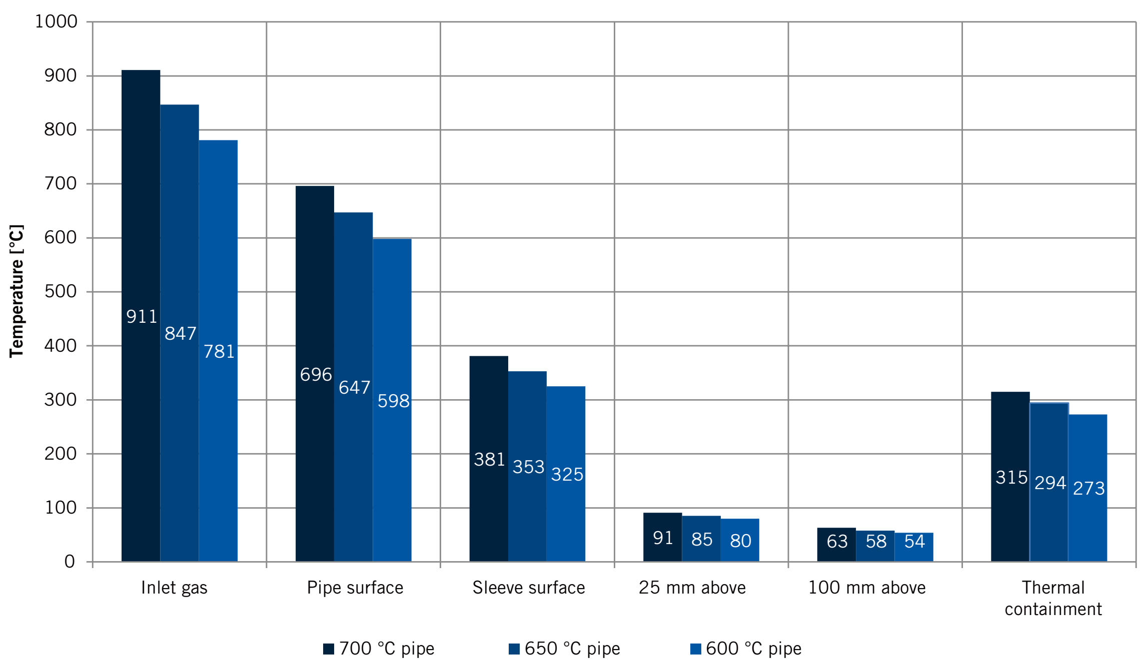


FIGURE 5 Thermal insulating behaviour of the textile heat shield in the exhaust system (© Federal-Mogul)

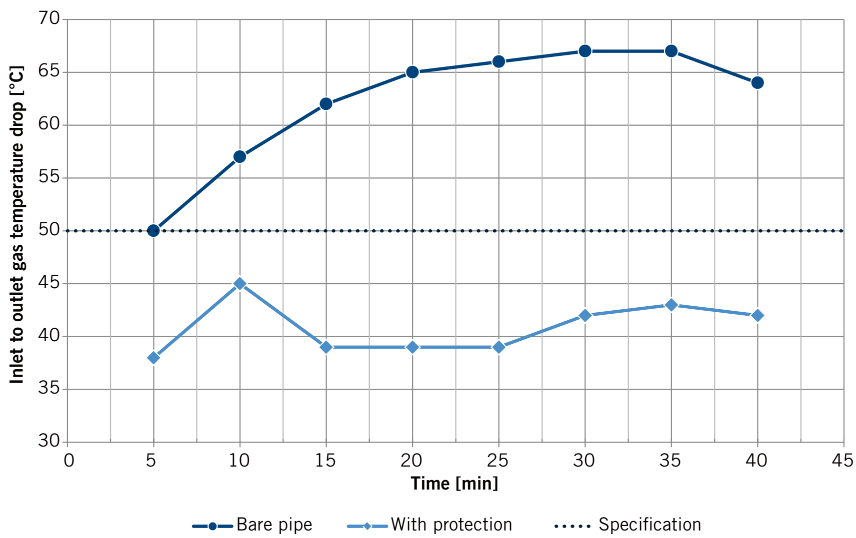


FIGURE 6 Exhaust gas temperature drop during cold start phase without and with ThermFlex protection (© Federal-Mogul)

Thermal containment is defined as the difference between the pipe surface and sleeve surface temperature. Thermal conductivity increases or decreases depending on the exhaust gas temperature, as shown in **FIGURE 5**. Following cold engine start, the exhaust gas temperature drop between the inlet and outlet gives a good performance indication.

A high exhaust gas temperature helps the catalyst to work more efficiently, reducing HC and CO emissions during cold start in order to meet increasingly stringent environmental regulations. In order to confirm the effect on exhaust gas temperature, a test similar to the thermal conductivity test was carried out, but with the addition of temperature measurement at the exhaust pipe outlet. **FIGURE 6** shows the comparison of exhaust gas temperature drops with and without protection.

In order to confirm the functionality of the protection product a number of mechanical tests were performed to validate it for use in passenger cars area, light vehicles, trucks and other applications. As the insulating sleeving is used in an under floor engine environment, the range of validation tests included a salt spray test, fluid compatibility, burning behaviour and resistance against cold temperatures.

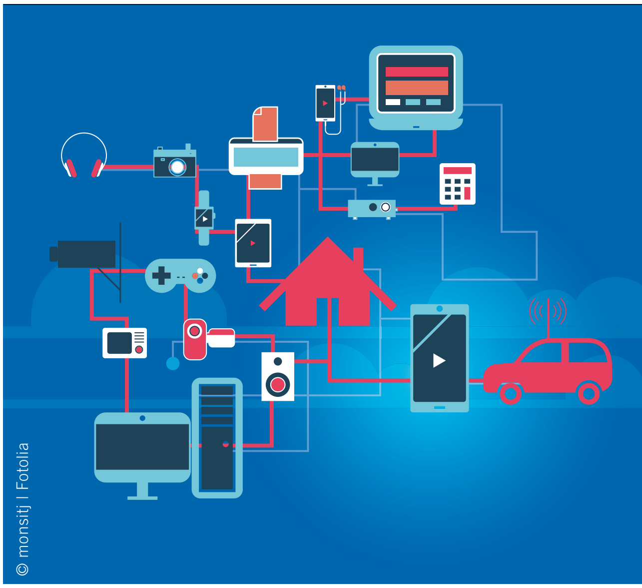
SUMMARY AND OUTLOOK

Depending on the particular application, shape, geometry and performance targets, it is important to select the right material, appropriate knitting structure and fabric density to suit the exhaust system. Developments by Federal-Mogul Powertrain are ongoing into new materials, mixtures of materials, treatments and new processes for a knitted heat protection, all of which will increase robustness and add more features to the final product, helping future combustion engines to fulfil environmental and legal regulations.

Vehicle manufacturers need to have a holistic approach when it comes to thermal management. Standardised driving cycles are used for certification of vehicles to regulatory requirements; these cycles mean a succession of transient states, each showing a certain amount of energy that affects the various systems and components. Federal-Mogul Powertrain is ready to support the engine developers and OEMs both pro-actively and reactively to develop smart textile heat shields that will optimise thermal management.

REFERENCES

[1] European Commission: Directive 97/69/EC
[2] ASTM C177-13: Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus. 2013
[3] Teal J. E.; Zhang Z.-H.: Thermal Analysis of Textile Structures in Automotive Applications. 2007-01-0547 SAE 2007



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Fraunhofer SIT | **Connected Vehicles**

The Internet is now a familiar feature of the automotive industry. The huge volume of data being generated opens up opportunities for new applications and business models, but also gives rise to new risks and major data protection problems. The goal of the SeDaFa project is to develop **PERSONAL DATA PROTECTION** solutions for drivers and passengers which vehicle manufacturers, infrastructure providers and developers of car apps can use to ensure that their business models are compatible with data protection requirements. Car users will be provided with clear and transparent information about the data that is being transmitted and the purposes it can be used for. This will enable them to decide for themselves which data they want to disclose. The flow of data from the vehicle will not be stopped altogether, but the access to it will comply with data protection regulations.

Coburg UAS | **Stability of Fuels at Low Temperatures**

Winter diesel should be able to withstand temperatures of at least minus 20 °C. When the temperature falls well below freezing, there is the risk that fuel in vehicle tanks will freeze. If this happens, the supply of gasoline or diesel to the engine is cut off and the car comes to a standstill. This generally happens a few minutes after the engine has started, so the car is left stranded by the side of the road. At the Automotive Technology Transfer Centre (TAC) of Coburg University of Applied Sciences (UAS), a **SENSOR** has been developed which measures whether the fuel in the tank is about to solidify. It identifies the preliminary stage of fuel crystal formation and warns the driver or switches on the heat to the fuel filter. The cold sensor is so small that it can be incorporated into standard fuel filters. It also has the potential to form the basis for a new and reliable standardised procedure for measuring the properties of fuels in cold weather.

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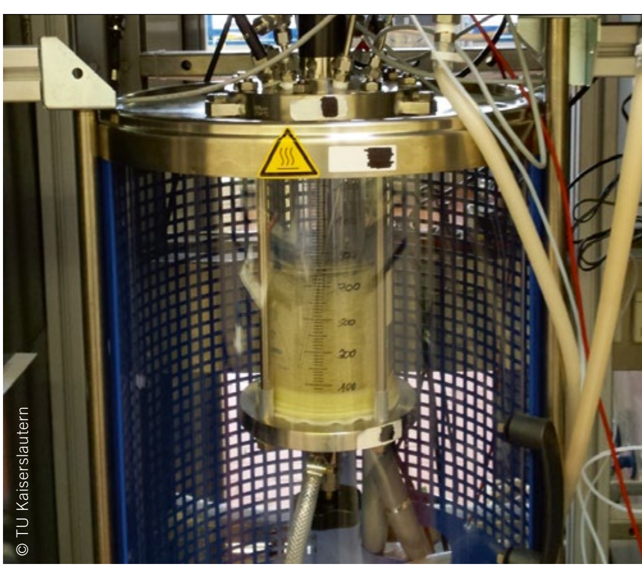

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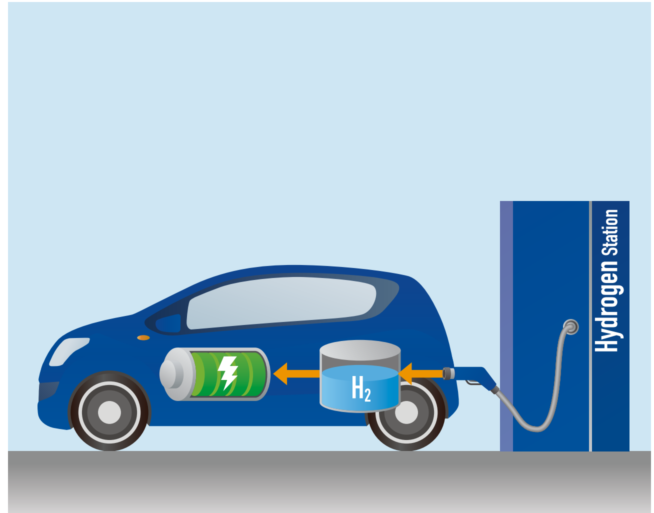
TU Kaiserslautern | **Alternative to Costly Exhaust Gas Treatment**

“The use of fuel additives allows soot and nitrogen oxide emissions to be reduced without having a noticeable impact on fuel consumption or performance,” explains Jakob Burger, Junior Professor in the Thermodynamics department at Kaiserslautern University of Technology. “The oxymethylene ethers (OMEs) that we are researching are a **FUEL ADDITIVE** of this kind.” OMEs are organic compounds ($CH_3O(CH_2O)nCH_3$) which prevent the formation of pollutants during the combustion phase because of their high oxygen content. However, producing OMEs cost-effectively on a large scale still presents a challenge. The development of these additives is being funded for three years as part of a joint project supported by the German Federal Ministry of Food and Agriculture via the central coordination agency Fachagentur Nachwachsende Rohstoffe (FNR).

Jacobs University Bremen I
Cost-effective Fuel Cells

Conventional fuel cells with platinum catalysts are too expensive for large-scale use, but cheaper systems are considerably less efficient. Now an international group of researchers, which includes Jacobs University, has developed a catalyst for fuel cells that contains **NO PRECIOUS METALS** but remains highly efficient. These fuel cells are made using a compound of graphene oxide and polyoxometallate (POM). Graphene is more tear-resistant than steel and, at the same time, is light, flexible and transparent. It is also an excellent conductor of electricity. If graphene is bonded with oxygen compounds, the result is graphene oxide. This is easier to process than pure graphene and has been produced by the researchers. They have applied a polyoxometallate (POM), which performs the catalytic function of platinum, to a thin layer of graphene oxide.



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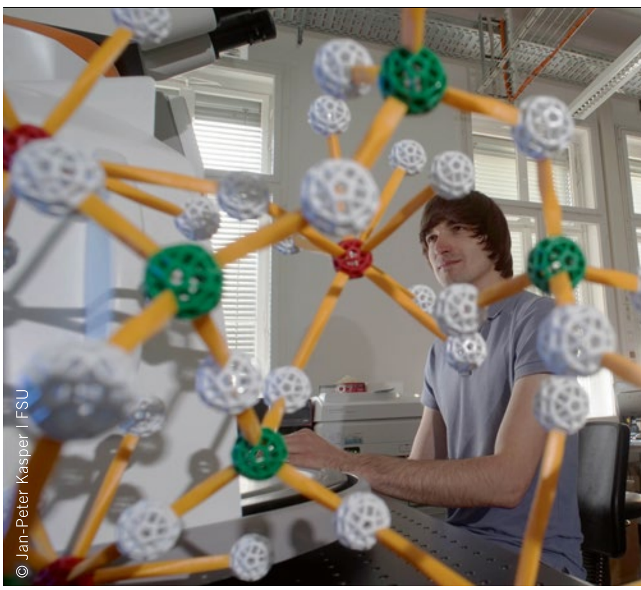

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Jena University I
Defect-resistant Lenses

The main problem with modern lenses, in particular those used in cars, is how easily they can be damaged, for example by impacts. The aim of the priority programme Topological Engineering of Ultra-Strong Lenses organised by the German Research Foundation (DFG) is to improve the **MECHANICAL RESISTANCE** of glass materials. "Because of the poor resistance of glass in particular to surface damage, we have not been able to make the best possible use of its unique mechanical properties," explains Prof. Lothar Wondraczek of Friedrich-Schiller University in Jena (FSU). "The main question is how we can develop strategies to prevent damage of this kind from forming in its early stages because of our improved knowledge of the molecular structure of glass materials." The research network is investigating classic inorganic oxide glass and, in particular, metallic glass materials.

Fraunhofer IKTS I
New Battery Concepts

Driving pleasure and electric cars are two concepts that are no longer mutually exclusive. Almost every car manufacturer now has an electric vehicle in its model range. But in order for **ELECTRIC CARS** to finally become a common sight on our roads, in-depth research is needed into the development of storage materials and concepts and into the ongoing improvement of the accompanying production methods. The partners in the EMBATT research project – thyssenkrupp System Engineering GmbH, IAV GmbH and the Fraunhofer Institute for Ceramic Technologies and Systems (IKTS) – are developing a concept and the related manufacturing technologies for lithium-based, high-performance batteries with a planar structure which can be incorporated directly into the vehicle's chassis. This will allow for much more compact storage solutions with energy densities of 450 Wh/l and a range of up to 1000 km.

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PEER REVIEW

Peer Review Process for Research Articles in ATZ, MTZ and ATZelektronik

Scientific articles of universities in ATZ Automobiltechnische Zeitschrift, MTZ Motortechnische Zeitschrift and ATZelektronik are subject to a proofing method, the so-called peer review process. Articles accepted by the editors are reviewed by experts from research and industry before publication. For the reader, the peer review process further enhances the quality of the magazines‘ content on a national and international level. For authors in the institutes, it provides a scientifically recognised publication platform.

In the Peer Review Process, once the editors has received an article, it is reviewed by two experts from the Advisory Board. If these experts do not reach a unanimous agreement, a member of the Steering Committee acts as an arbitrator. Following the experts’ recommended corrections and subsequent editing by the author, the article is accepted.

In 2008, the peer review process utilised by ATZ and MTZ was presented by the WKM (Wissenschaftliche Gesellschaft für Kraftfahrzeug- und Motorentechnik e. V./German Professional Association for Automotive and Motor Engineering) to the DFG (Deutsche Forschungsgemeinschaft/German Research Foundation) for official recognition. ATZelektronik participates in the Peer Review since 2011.

THE SEAL OF APPROVAL FOR SCIENTIFIC ARTICLES IN ATZ.
ATZ PEER REVIEW
REVIEWED BY EXPERTS FROM RESEARCH AND INDUSTRY.

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Objectification Method for a Customer-optimised ACC System Configuration

Driver assistance systems have found their way into vehicles in the last few years. For their long-term establishment on the market and with a focus on the development towards higher automated systems, control strategies need to be optimised with regard to customer use. This particularly applies to integrated basic functions, for example adaptive distance and speed control. A team at the TU Braunschweig focuses on the question, in which manner customer demands and expectations should be taken into account. An objectification study provides results and identifies precise target parameters for ideal brake intervention strategies in selected ACC driving scenarios.

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1 MOTIVATION

Encouraged by the democratisation of driver assistance systems and the customers' increasing interest in technical innovations, the development trend shifts from assisted to automated driving. In order to increase the market penetration, the consistent consideration of customer demands becomes more important. With the objective of specifying functional requirements derived from customer use and taking them into account in the early development phase, a goal-oriented system evaluation is required.

Against this background, a consisting approach [1] was improved through a procedure for an objective system evaluation at the Institute of Automotive Engineering at TU Braunschweig (IAE). Considering methodological expertise of many years [2, 3], this forms the basis for an ACC objectification study, which involves regression methods besides correlation analyses [4, 5, 6] for the first time. That way, objective mark models, which quantify concrete target criteria, can be obtained und applied.

2 METHOD

A high level of experience in analysis and development of systems for longitudinal guidance lead comprehensively to a method with an objectification process to identify ideal ACC intervention strategies and the development of a customer oriented ACC controller [7] as its key elements. Due to the functional structure and the capability of being parameterised, many different system characteristics can be represented. For the application the developed function and all required interfaces are implemented in a simulation environment, in which an optimiser determines the most suitable function parameters fully-automated according to [8]. Basic comfort and safety requirements resulting from customer use as well as target criteria from the objectification can therefore be integrated into the development process with high efficiency and quality.

2.1 DRIVING IN QUEUES WITH BRAKING INTERVENTIONS

The investigation focuses on driving in queue manoeuvres, in which the vehicle in front (leading vehicle) starts a defined braking process, causing a brake intervention in the ACC vehicle. This scenario describes a manoeuvre type which occurs significantly often and therefore becomes highly representative for customer use, **FIGURE 1** (manoeuvre type IV). Clear results for assisted driving (ACC on) and non-assisted driving (ACC off) can be derived

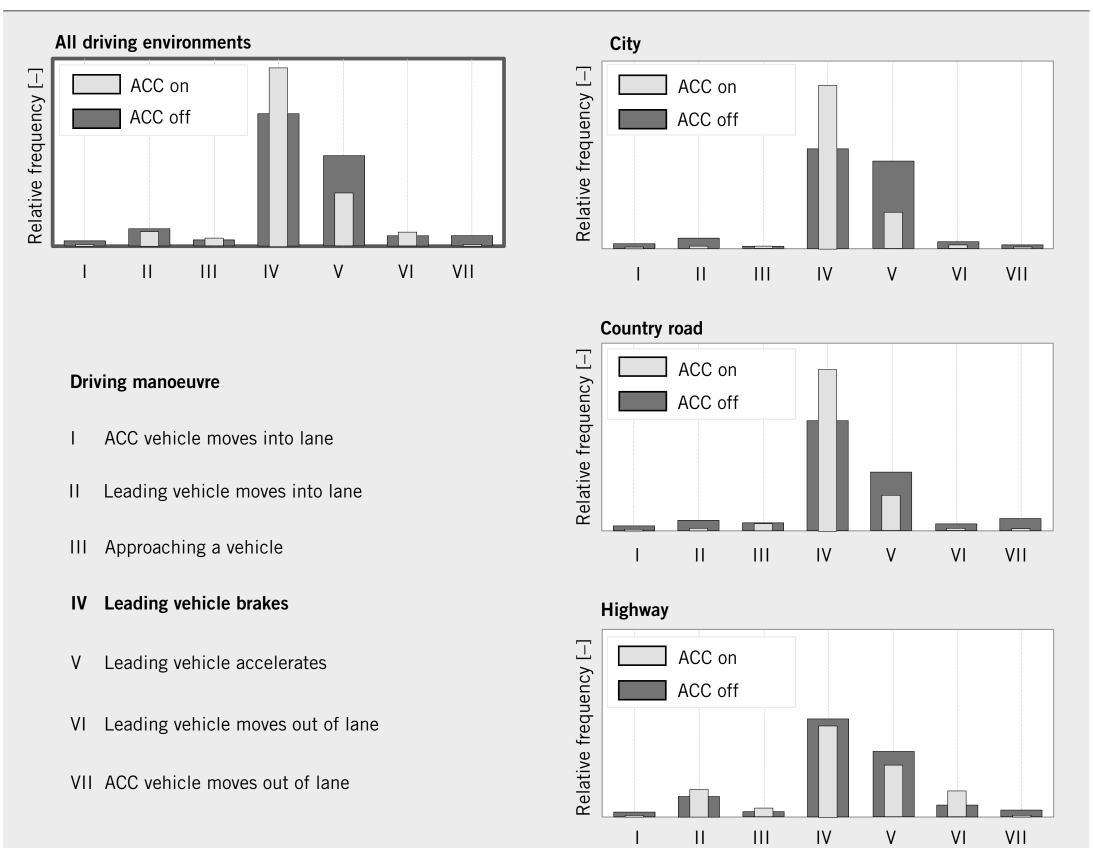

FIGURE 1 Occurrence probability of defined driving manoeuvre types for customer's use (© Torben Pawellek)

being valid for specific driving environments as well as the overall evaluation. The shown statistics are based on data analysis from IAE related to vehicle-vehicle-interactions in public traffic as driving in queue, approaching a vehicle and moving into or out of the lane. In the sense of an appropriate consideration of customer use, the objectification study includes four representative manoeuvres of the braking in queue scenario, two for urban and two for highway traffic. Manoeuvre characteristics derived from data analysis (initial/ final conditions for distance and speed, etc.) as well as specified actions for the leading vehicle (duration or intensity of brakings, etc.) are integrated into a manoeuvre catalogue. For both, urban und highway traffic, one manoeuvre with lower driving criticality (ACC standard case) and one with higher driving criticality (ACC border case) are considered to cover a broad range of application.

2.2 CONCEPT OF THE MANOEUVRE EXECUTION

In order to execute the defined manoeuvres, a test concept is developed and used under clinical conditions. For this purpose, two experimental vehicles of the IAE are used, **FIGURE 2**. The installed measurement equipment guarantees robust and high-precision recordings of the vehicles' state and their relative behaviour. A VW Passat Variant B7 (3.6 V6 4Motion, 220 kW, six-speed DSG) is used as the leading vehicle. According to manoeuvre specifications the integration of additional functional units and direct interfaces to engine and brake control allow defined interventions in longitudinal vehicle dynamics. The ACC vehicle is a VW Golf VII (1.4 TSI, 103 kW, seven-speed DSG). The ACC system, developed at the IAE, is embedded in the existing system architecture [7]. Furthermore, integrated functional units allow brake control independent of the ACC system. The precise decoupling of ACC-based regularities offers high potential to this approach concerning a free design of individual deceleration characteristics. Thus, different brake interventions can be applied for test drives.

With the help of an application-oriented sequence control, the overall concept allows an automated and functionally coupled longitudinal assistance of both vehicles. The principle can be illustrated by four steps. The sequence starts with a stationary ACC driving in queue in step 1, **FIGURE 3**. By pressing a button in the leading vehicle, step 2 is initiated actuating the internal sequence control for a defined brake intervention. At the same time, a trigger signal is transmitted to the vehicle behind through WLAN communication. It immediately switches from ACC mode to cruise control, so that an ACC related brake intervention is prevented. After a configurable reaction time (Δt), step 3 is initiated in the ACC vehicle through a simulated ACC brake intervention. Finally, step 4 follows with stationary ACC driving in queue.

3 OBJECTIFICATION STUDY

The overall study is subdivided into three test series. First of all, the ideal ACC reaction times for the focused manoeuvres in normal and sport mode are determined in a preliminary test. Based on these results different brake intervention strategies are evaluated in the main test. Afterwards the performance of the developed ACC controller is optimised according to the derived knowledge and validated in a final test. To represent a customer-oriented serial use the test drives take place on public road. In addition to technical experts normal drivers as representative ACC users are part of the group of test persons.

3.1 RESULTS FROM THE PRELIMINARY TEST

The brake intervention strategy of an ACC system is mainly determined by the reaction time of the system. In this context, the reaction time is the interval between the points when the vehicle in front starts braking and a system intervention in the ACC vehicle is noticed. If the delay is too long, the brake intervention is correspondingly intense, if it is too short, the intervention is consider-

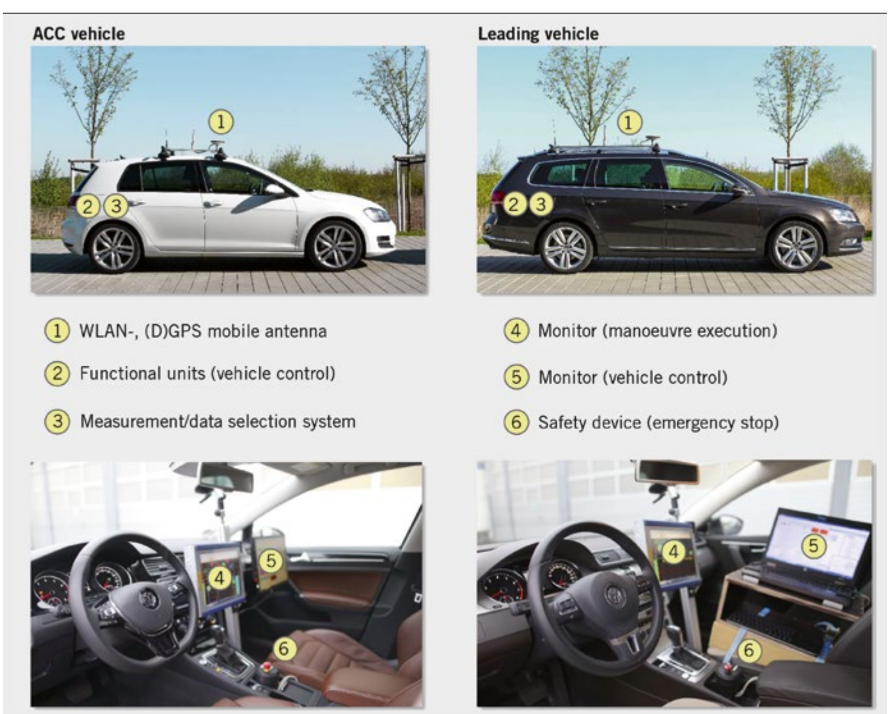

FIGURE 2 Test vehicles (ACC vehicle and leading vehicle) (© Adrian Sonka, Christoph Nippold, Torben Pawellek, Louisa Liesner)

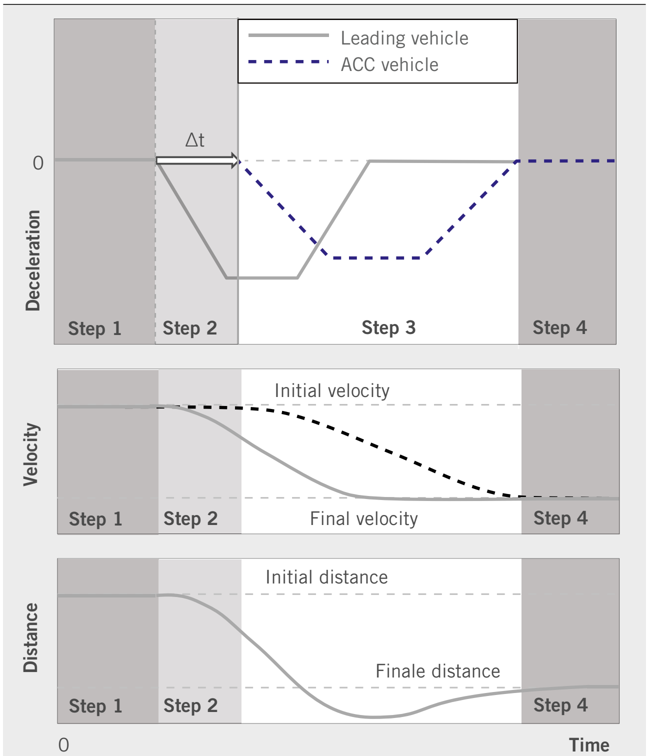

FIGURE 3 Steps of automated sequence control (© Torben Pawellek)

ably weaker. In order to identify optimal intervention conditions, the ideal reaction times are determined in the preliminary test on a test ground. By using the described concept for automated sequence control, arbitrary ACC reaction times can be adjusted. To guarantee realistic test conditions, current ACC series systems were tested in advance and analysed in terms of their reaction times. These values are used as appropriate initial values and modified within further steps. In a first measurement series, four technical experts identify ideal values for the reaction time. In a second measurement series, these values are varied by a defined interval of time (Δt) and evaluated in accordance with the ATZ scale [9]. Based on the results of measurement series 1, two conclusions can be drawn. Related to all considered manoeuvres, desired reaction times of an ACC system in normal mode are approximately 25 % shorter than in sport mode. In this regard, the measured ACC series systems do not show any significant differences, which points out first optimisation potentials.

Moreover, in comparison to manoeuvres with lower criticality (ACC standard cases) higher critical scenarios (ACC border cases) lead to approximately 40 % shorter desired system reaction times in both ACC modes. This also applies for the measured ACC series systems which follow this behaviour with moderate intensity. This can be illustrated in extracts for a representative urban scenario (urban scenario I, ACC standard case), **FIGURE 4**. Compared to the average reaction time of the measured series systems (*t_series* as mean value of the green coloured area) the desired time of system intervention for an ACC normal mode (blue coloured diamonds) is reduced to 0.2 s. The time for sport mode (red coloured diamonds) is desired 0.3 s later. Viewed as a percentage, the deviation is about 20 %. More than that, the results from the second measurement series (blue/red framed diamonds on right and left side of the optimum) show to what extend the positive perception decreases when modifying the optimum towards an earlier or a later system response time.

3.2 RESULTS FROM THE MAIN TEST

With regard to the optimum point of intervention the ACC control strategy can be designed through a variety of different brake intervention strategies. This can be managed particularly precise with the use of characteristic parameters of the vehicle's longitudinal acceleration as the most sensitive motion value. Against this background the definition of intervention alternatives is based on three characteristic properties of the vehicle's deceleration curve. The average gradients of brake initiation, the average value of the deceleration level as well as the average gradient when releasing the brake are part of them. Referring to the experimental design, these characteristic parameters are varied by ± 30 % (*gradient of deceleration*) and by ± 15 % (*level of deceleration*), **FIGURE 5** (right). The traffic law as well as standardised guidelines of the ISO 22179 are considered for the design of the deceleration curves and the resulting distance behaviour. Safety-critical braking variants and such with high discomfort are categorically excluded (cross-hatched array elements), **FIGURE 5** (right). The knowledge of measured ACC systems and the natural driver behaviour [1, 7] are also taken into account for the test design. Three stylistic examples of deceleration characteristics extracted from the study are shown in **FIGURE 5** (left). The practical implementation of all variants proceeds on the test ground with the same technical experts as test persons. Similar to [6, 10] the subjective evaluation refers to the classical, in the area of automotive engineering accepted, evaluation categories comfort and dynamics, whereby the feeling of security is an indirect part of the second category. Aspects of comfort include the experienced driving comfort and a harmonic alignment of the brake strategy. With regard to the dynamics, the intensity of intervention as well as an appropriate connection to the leading vehicle are regarded. Thus, impressions of the vehicle's behaviour and the vehicle-vehicle-interaction have influence on the overall evaluation. According to the ATZ scale, **FIGURE 6** shows the distribution of the overall system evaluation marks for the seven brake

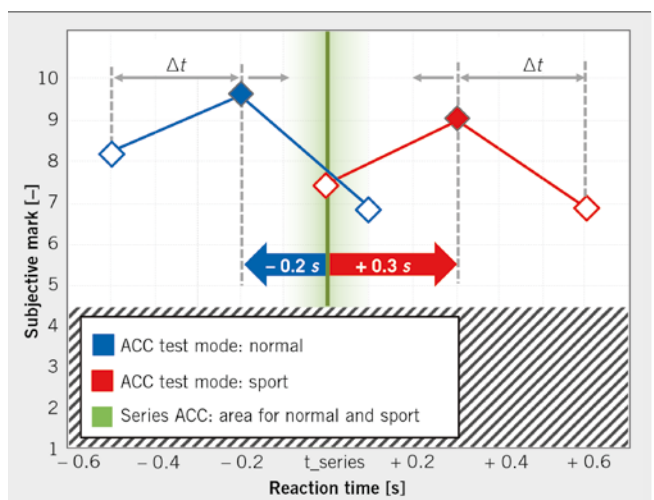

FIGURE 4 Overall evaluation of ACC reaction times (urban scenario I, ACC standard case) (© Torben Pawellek)

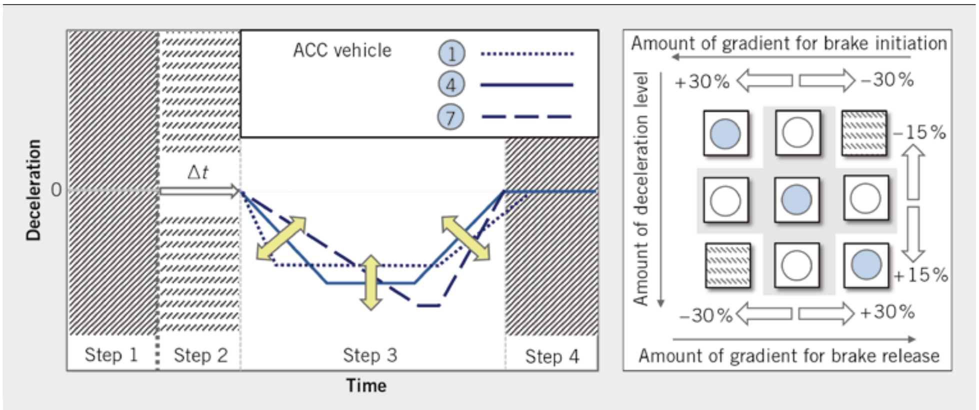

FIGURE 5 Schematic representation for the variation of ACC brake strategies (© Torben Pawellek)

intervention variants of ACC normal mode (blue coloured diamonds) and ACC sport mode (red coloured diamonds) in the already known urban driving scenario I (ACC standard case). Here, the average value over all test persons is plotted. The results demonstrate that an ideal brake intervention strategy is identified for both ACC modes (variant 4).

Furthermore an appropriate spread of subjective marks to the limit of system standard is achieved (variants 6 and 7). This statement is valid for all driving manoeuvres. According to the methodological objectification standards established at IAE the statistical data processing, the correlation and the regressions analysis are carried out based on the collected data. As a result of this statistically verified procedure models of marks are identified which can be used for the mathematical determination of objective marks. These represent the subjective perception of test persons. The calculation base consists of significant parameters with high correlation to the subjective marks. As an example, **FIGURE 7** shows the quality of a model for the already known urban scenario I. Here, the overall system behaviours for ACC normal mode (left) and ACC sport mode (right) were evaluated. The averaged subjective marks are plotted on the abscissa, the calculated objective marks on the ordinate. In case of an ideal model all data points are located directly on the angle bisector and the objective marks conform to the subjective marks. In the given example, there are only minor optical deviations between the data points and the angle bisector, which is pictured by the blue and red lines of the best fit. The adjusted coefficient of determination r^{*2} with values from 0 (invalid model) to 1 (ideal model) enables a quantified evaluation. For both ACC modes these characteristic values are located approximately in the range of the optimum (ACC normal mode: r^{*2} = 0.93; ACC sport mode: r^{*2} = 0.96). Regarding all driving manoeuvres this value is r^{*2} (in total) = 0.95. Thus, the models are perfectly suitable for quantifying target parameters.

3.3 RESULTS FROM THE FINAL TEST

The overall method is verified in a final test on public roads. In the run-up of this study the results of the objectification process have consequently been used for optimising the ACC controller of IAE [7]. With regard to the objectification process the focus of the test series is on driving in queue manoeuvres in urban and highway traffic. In addition to technical experts ten normal drivers at the age of 23 to 33 with previous practical ACC experience participate in the study. The optimised ACC system is tested in comparison with a series version (basic version) in normal and sport mode and evaluated by aspects of comfort and dynamic. Regarding the considered driving manoeuvres (urban scenario I and II, highway scenario I and II) **FIGURE 8** gives an extract of the test results. Compared with the ACC basic version, the improvement of the overall system perfor-

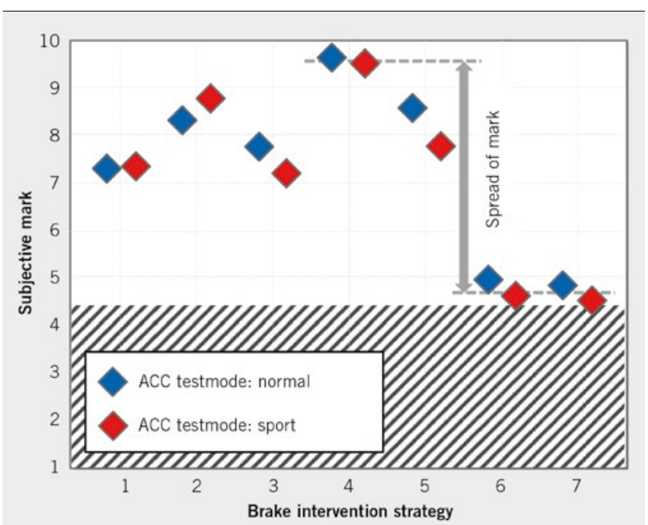

FIGURE 6 Overall evaluation of ACC brake intervention strategies (urban scenario I, ACC standard case) (© Torben Pawellek)

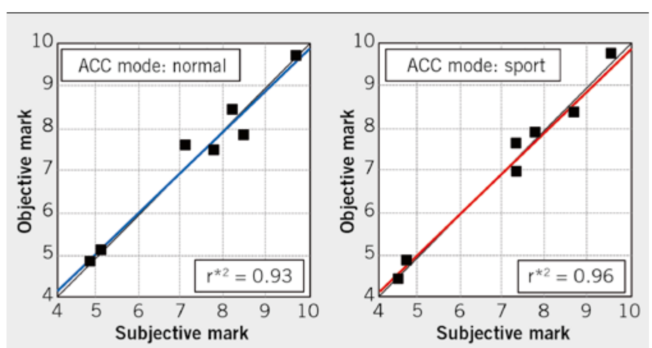

FIGURE 7 Models of objective marks for the overall system evaluation (urban scenario I, ACC standard case) (© Torben Pawellek)

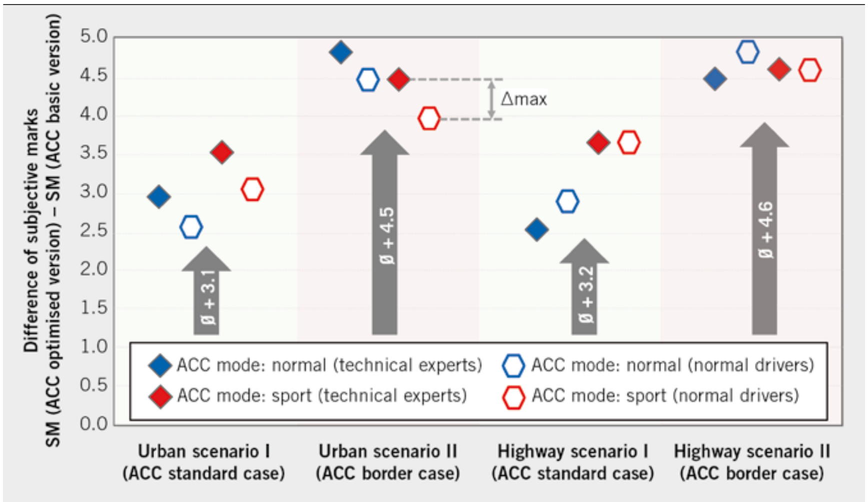

FIGURE 8 Improvement of overall system performance (all considered driving scenarios) (© Torben Pawellek, Louisa Liesner)

mance of the optimised system is represented clearly. Thereby, the average ratings for one driving manoeuvre are between 3.1 to 4.6 points based on the ATZ scale. These marks refer to comfort and dynamic characteristics of both ACC modes. The main improvement is reached in border case manoeuvres. This can be justified by the optimised reaction times and thus the reduction of the resulting criticality. Moreover, the evaluation results of technical experts and normal drivers are very similar and differ only in a maximum value of 0.5 points. Therefore, the selected procedure is permitted for single use of technical experts in preliminary and main test. Finally, the method of ACC objectification and optimisation is applied and realised successfully.

4 SUMMARY

The formulated goal of the objectification process could be verifiably fulfilled. Thereby ideal brake intervention strategies for ACC systems and thus models of objective marks could be identified. With a focus on costumer relevant braking in queue manoeuvres the orientation of the objectification study lead to concrete statements towards optimum ACC system behaviour related to a normal and a sport mode. Within the context of the overall research project these results could directly be transferred and applied to the controller development of IAE. Thus, objective marks were used as target parameters for the automated application process. While past investigations had already shown that a transfer to simulation work is possible, the current approach verified the results even in real road tests. Finally, significant performance optimisations within the considered braking manoeuvres were pointed out compared to a series system.

REFERENCES

[1] Pawellek, T.; Liesner, L.; Henze, R.; Küçükay, F.: Eine Methodik zur Analyse, Bewertung und Auslegung von ACC-Systemen. 13th Braunschweiger Symposium, 2012

[2] Hagerodt, A.: Automatisierte Optimierung des Schaltkomforts von Automatikgetrieben. Braunschweig, Technische Universität, dissertation, 2003

[3] Henze, R.: Beurteilung von Fahrzeugen mit Hilfe eines Fahrermodells. Braunschweig, Technische Universität, dissertation, 2004

[4] Schick, B.; Büttner, R.; Baltruschat, K.; Meier, G.: Evaluation Methods for the Function and Quality of Driver Assistance Systems with Active Brake Control. In: ATZworldwide 109 (2007), No. 5, pp. 14-18

[5] Holzinger, J.; Schöggl, P.; Schrauf, M.; Bogner, E.: Objective Assessment of Driveability while Automated Driving. In: ATZworldwide 116 (2014), No. 12, pp. 24-28

[6] Strasser, B.: Vernetzung von Test- und Simulationsmethoden für die Entwicklung von Fahrerassistenzsystemen. München, Technische Universität, dissertation, 2012

[7] Liesner, L.; Pawellek, T.; Krauns, F.; Henze, R.; Küçükay, F.: Kundenoptimales Design von längsführenden Komfortsystemen. 16th Braunschweiger Symposium, 2015

[8] Birge, B.: PSOt – a particle swarm optimization toolbox for use with Matlab. In: Swarm Intelligence Symposium, 2003, SIS`03, proceedings of the 2003 IEEE, pp. 182-186

[9] Aigner, J.: Zur zuverlässigen Beurteilung von Fahrzeugen. In: ATZ 84 (1982), No. 9, pp. 447-450

[10] Didier, Muriel: Ein Verfahren zur Messung des Komforts von Abstandssystemen (ACC-Systemen), 2006

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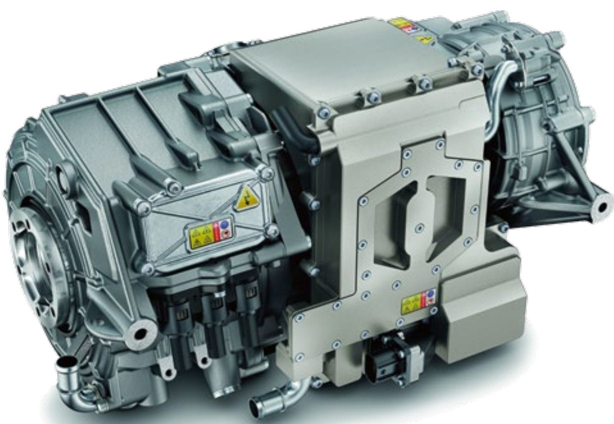

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COVER STORY

Moving Towards Electric Transport

Electric cars promise to reduce emissions and be fun to drive. Nevertheless the sales figures for electric vehicles on the German market remain very low. The main challenge in the current development process is the conflict between efficiency, safety and the driving experience.

In the cover story of the next ATZ, the SpeedE research project at RWTH Aachen University not only identifies revolutionary solutions to the problems, but also presents a high-performance tool with open interfaces. The strategic goal of the project is to highlight the comprehensive innovation potential of electrically powered vehicles and automated driving.

One of the problems for electric cars is their low battery capacity. Bosch, FZI and IPG explain the influence of meteorological factors on the range of electric vehicles using the example of selected variables. The companies carried out simulation-based investigations with simplified constraints, together with virtual driving trials and real-life road tests.

In the ATZ interview, Peter Gutzmer, Head of Development at Schaeffler, discusses the increasing electrification of vehicles from his perspective and the contribution made by his company's commitment to Formula E.

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Prof. Dr. Gerhard Reiff
Chairman of the Executive Board,
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A Changing Market for Testing Service Providers

Who will ultimately decide on the end of the internal combustion engine in individual mobility? Will it be the customer, full of enthusiasm for the seamless and overwhelming acceleration of electric motors? Or the established industry, which would like to make a profit from its installed capacities for as long as possible? And we must not forget the oil and gas industry, which, without gasoline and diesel engines, would no longer be able to sell sufficient quantities of certain distillates from its refineries. Or will the future generation of drivers even care about what kind of drive system their car has – as long as it is fully connected and takes them from A to B as autonomously as possible?

A long-established engine testing service provider like KST must learn how to deal with all of these uncertain future scenarios. In the first decades of the company's history, which now spans almost fifty years, it was still relatively easy to meet the demands of the market. Engines became bigger or smaller, but always more efficient – and more complex with regard to their exhaust system and powertrain. But one thing remained the same: cars were still powered by gasoline or diesel.

Then, in the past decade, it became obvious that complexity will increase. At KST too, the focus of investment has shifted towards electric motors and complex powertrains. We must now prepare ourselves for the future. It is not yet foreseeable whether the fuel cell will be the favourite or whether an improved battery will make it superfluous – at least in passenger cars. And the economic and ecological benefits of hybrid drive systems still raise additional unanswered questions, at least for the time being, due to their consumption of primary resources.

A medium-sized company can hardly afford to pursue all trends and to prepare for them with a testing portfolio that is relevant for each individual application. In such cases, a single strategic error will have serious consequences. That applies not only to the purely financial aspects but also in particular to the essentially important human resources. Meeting the requirements of all developments that accumulate at a service provider requires a well-considered strategy for human resources and their development.

But do these exciting events not also open up special opportunities for a testing service provider? The answer must clearly be "yes". It is already the case that there is a clear shift in the development risk for new powertrain technology from OEMs to Tier 1 suppliers. And these, in turn, often shy away from the not inconsiderable investment in new testing expertise. Those service providers who position themselves in this changing value chain with the right sensitivity for the core competences of tomorrow and beyond will stand out above their competitors in the next few decades and will make a positive contribution towards further change in our industry.