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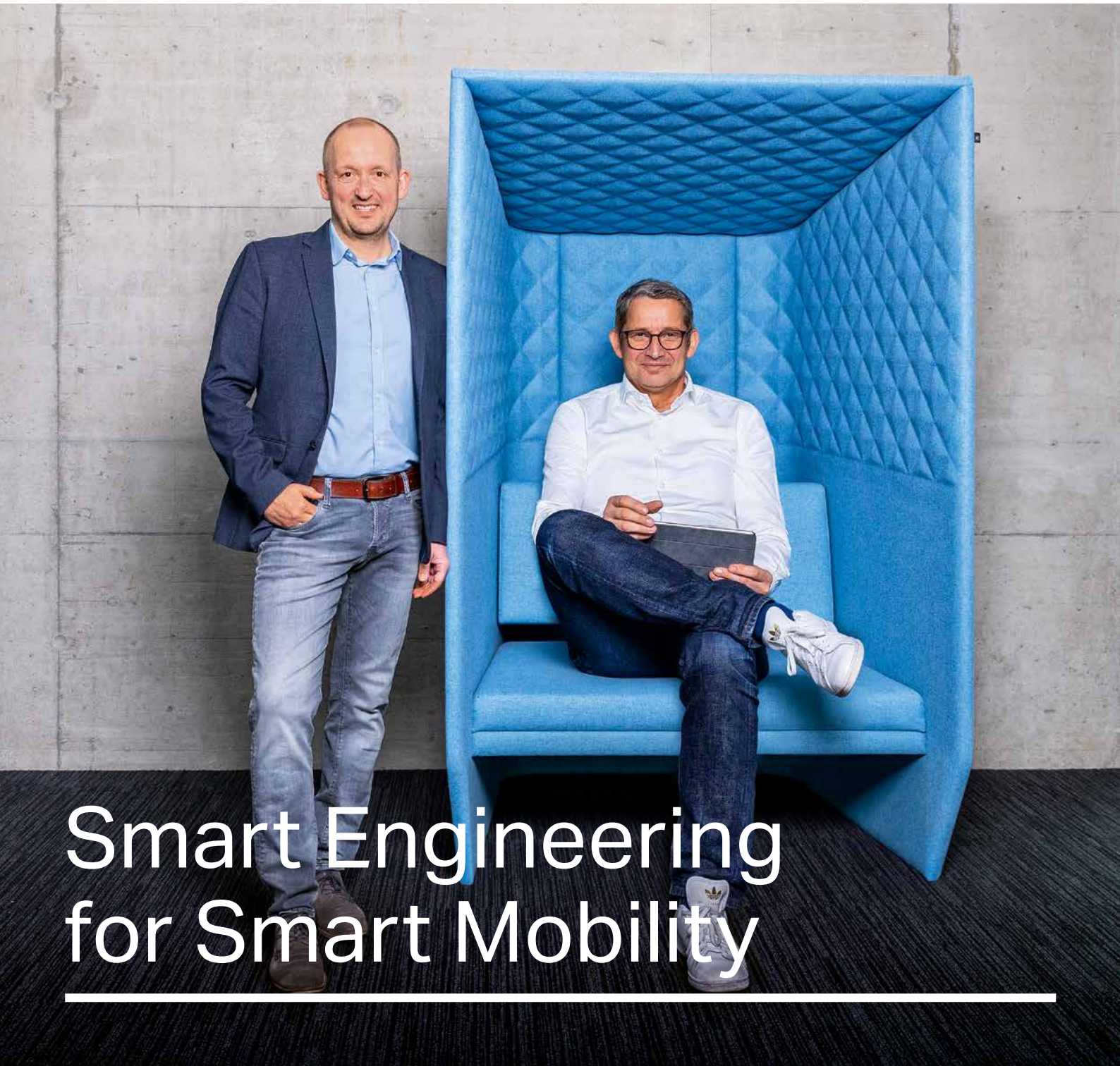

Smart Engineering for Smart Mobility

Dear Reader,

'Smart Engineering for Smart Mobility' is the motto of this first issue of automotion in the new decade. But what does it actually mean? When is a product, a service or a development 'smart'?

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Nicolas Hayek,
Swiss businessman with
revolutionary ideas for
watches and cars

To find out, it is worthwhile taking a look at the compact car of the same name. Did you know that the idea behind this vehicle originated from a Lebanese-born Swiss businessman? Nicolas Hayek, born on February 19, 1928 in Beirut, studied mathematics, physics, and chemistry. It was he who first guided the faltering Swiss watch industry back onto the road to success in the 1980s and then enriched the automotive industry with a revolutionary idea in the 1990s.

The traditional Swiss watch industry came under increasing pressure from 1970 onwards. Thanks to microelectronics, watches with quartz technology were cheaper to produce than mechanical chronometers. In addition, the new technology was more accurate and, apart from changing the battery, maintenance-free. Customers were thrilled by the completely novel, digital watches and their advantages.

Hayek's plan was to merge the best of both worlds. He brought Swiss watch companies and watch movement manufacturers together in the Swatch Group and launched the revolutionary concept of a high-quality electronic watch in 1983. One of the central secrets of the Swatch watches' success was due to the fact that they only contained 50 standardized components, far fewer than the previous 150 individual parts required for conventional quartz watches. Complexity reduction par excellence. Added to this were a molded, interchangeable plastic case as an innovative outer shell, new production processes, and design collections created by artists. In 1984, just one year later, Hayek had already sold 800,000 units. At the same time, he also positioned luxury watch brands such as Tissot, Omega, and Longines, as well as low-price products like the children's watch Flik Flak, precisely on the market. As a result, Swiss watches' global market share had risen to over 50 percent again in 1993. What a comeback!

A further success story emerged at the beginning of the 1990s: Hayek gave birth to the idea of the Swatch mobile, now known as the smart (Swatch, Mercedes, art), as an environmentally-friendly micro-compact car and a response to ever more traffic and increasingly less space in major cities. Perpendicular parking, safety concept, individualization options, marketing approach, and CO_2 output of just 86 g/km in the NEDC – Daimler set standards early on with the little two-seater. Nicolas Hayek died on June 28, 2010, but many of his ideas remain successful on the mass market to this day. At IAV, we are proud to be able to contribute to the success of the smart and many other vehicles and manufacturers.

Nicolas Hayek lived his life according to the motto of "Learn something new each day." The examples of Swatch and smart show how this motto can be put into action. Constantly aligning development projects with customer needs, entering into partnerships, combining ideas from different worlds, and consistently bringing new, courageous concepts to production maturity – all of this is 'smart'. And that is precisely our intention at IAV.

Incidentally, over 8,000 employees from more than 80 nations are currently engaged in developing the technologies of the future at IAV using cutting-edge development methods – and some of them are also from Nicolas Hayek's home country. We take great pride in this as well.

We wish you an enjoyable read!

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All Ears: The Future of Infotainment

Smart navigation and personalized voice recognition

"Changing the Mindset of the Entire Company"

Domain knowledge meets methodological and process knowledge: the Digital Lab as an open space for creative approaches

The Hydrogen Alternative

Trucks have to become much more climate-friendly. The combination of combustion engine and hydrogen can make an important contribution in this respect.

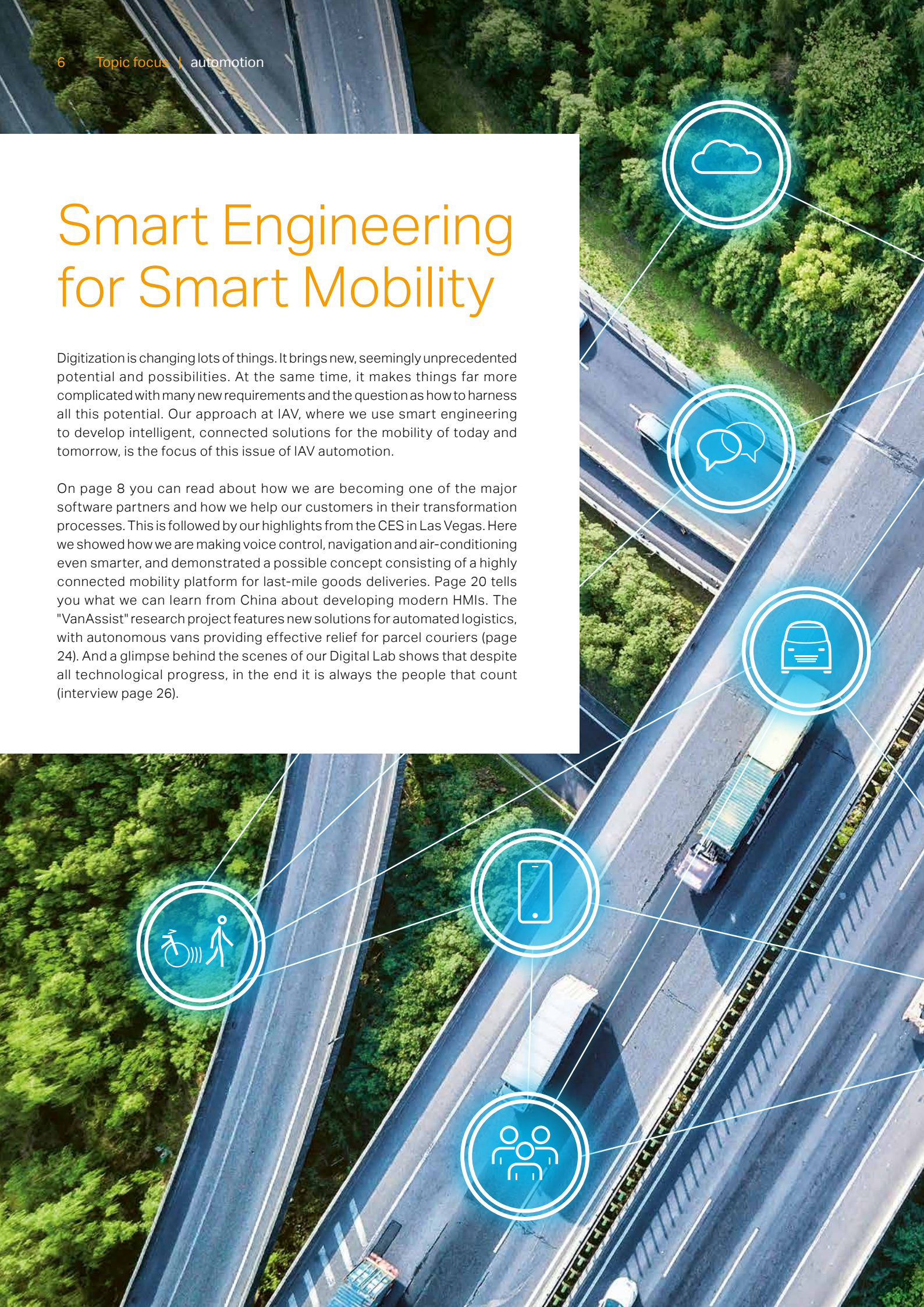
Sensors in the Headlamps for Better Automated Driving Functions

Cameras, radar and lidar for autonomous driving can be fitted in the "smart corners" of vehicles

Smart Engineering for Smart Mobility

Digitization is changing lots of things. It brings new, seemingly unprecedented potential and possibilities. At the same time, it makes things far more complicated with many new requirements and the question as how to harness all this potential. Our approach at IAV, where we use smart engineering to develop intelligent, connected solutions for the mobility of today and tomorrow, is the focus of this issue of IAV automotion.

On page 8 you can read about how we are becoming one of the major software partners and how we help our customers in their transformation processes. This is followed by our highlights from the CES in Las Vegas. Here we showed how we are making voice control, navigation and air-conditioning even smarter, and demonstrated a possible concept consisting of a highly connected mobility platform for last-mile goods deliveries. Page 20 tells you what we can learn from China about developing modern HMIs. The "VanAssist" research project features new solutions for automated logistics, with autonomous vans providing effective relief for parcel couriers (page 24). And a glimpse behind the scenes of our Digital Lab shows that despite all technological progress, in the end it is always the people that count (interview page 26).

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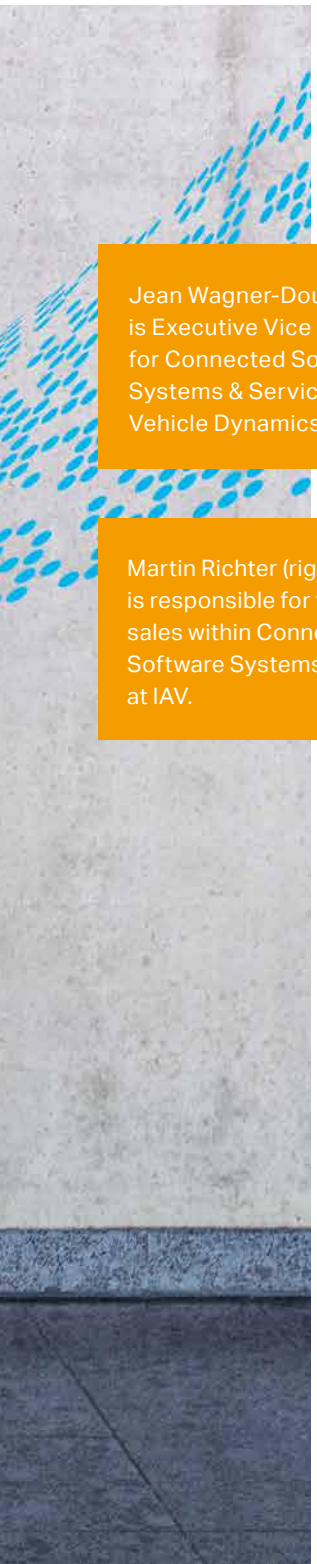
IAV – The Software Partner

Automotive electronics are merging with corporate IT and consumer electronics



Jean Wagner-Douglas (left) is Executive Vice President for Connected Software Systems & Services and Vehicle Dynamics at IAV.

Martin Richter (right) is responsible for technical sales within Connected Software Systems & Services at IAV.

In the future, the classic criteria for buying a vehicle may possibly no longer play a crucial role for individuals. Instead, vehicles will become rolling devices that are defined through software-based functions and add-ons. The know-how required to develop these systems combines corporate IT and consumer electronics with classic automotive electronics. IAV managers Jean Wagner-Douglas and Martin Richter explain how this interaction works.

Automotive manufacturers want to develop more software themselves in the future. Is that good or bad news for IAV?

Wagner-Douglas: Good news. We will be involved in it to the same extent as we were in developing electronics and software in the past.

Richter: 'Do-it-yourself' primarily means that software has been recognized as absolutely critical to success. And the statement represents the effort to think the topic through from the very beginning. Many manufacturers will be unable to undertake these tasks alone due to various factors such as the shortage of skilled workers and increasingly faster development cycles. This is where we come into play in supporting the OEMs with our end-to-end expertise.

We are the partner that has in-depth knowledge in all areas, from system architecture and all IoT elements up to and including the definition of connectivity. In this, we assume responsibility for complex software development, subsequent integration, and validation.

What type of software are we actually talking about here?

Wagner-Douglas: So far, the software in vehicles has been characterized by embedded systems, as in the air conditioning or drive control systems, for instance. More and more connectivity services are being added due to the increase in networking in and around the vehicle. This necessitates seamless interaction between the software in the vehicle, in the back-end, and on mobile devices. We are shifting towards a world in which software updates or new apps for the car will be as common as for a smartphone.

Richter: In the future, the vehicle will be embedded in a complete mobility ecosystem. This will result in new services for users that will, of course, also give rise to new requirements. At the same time, integration into new operating models such as car and ride sharing, for example, will also play a role.

But classic software on embedded systems will still be around as well, won't it?

Wagner-Douglas: When you take a look in a car, a distinction is classically made between safety-relevant systems such as those in the suspension and services for entertaining the occupants, for instance.

Richter: The basic function surrounding driving will continue to be implemented as an embedded function on Classic AUTOSAR. The interaction with service-oriented structures, for example based on Adaptive AUTOSAR or Linux directly, then ensures an integration into the IoT world.

»We are shifting towards a world in which software updates or new apps for the car will be as common as for a smartphone.«

Jean Wagner-Douglas

Will powerful servers remotely control the entire vehicle in the future?

Wagner-Douglas: That will be a well conceivable scenario for completely autonomous vehicles. To achieve that, you require a highly available data transfer bandwidth which will almost certainly not be available everywhere even in five years. We are already seeing this shift increasingly often in partial areas that do not access driving functions. If we look at the chassis, adaptation to the road conditions is worth mentioning. The next step would be for the vehicle to independently download a data record with which it can perfectly cross a specific alpine pass. This example shows that comfort functions and safety-relevant functions can no longer be completely separated. Nevertheless, certain amounts of intelligence will remain directly in the vehicle in the future. This is necessary, particularly to ensure the safety of the vehicle occupants even when connectivity is not unreservedly available.

To what extent will vehicles be characterized by the manufacturer-specific operating system in the future?

Richter: Electromobility, autonomous driving, and connectivity are changing vehicles fundamentally. Software-based systems enable the automotive manufacturers to keep this development in their own hands – and by no means least to safeguard their added value. Just think of operating systems from the world of classic software. The differences between Apple and Windows are conscious product decisions that are market-relevant. The operating systems actively influence the user experience and thus influence purchase decisions and brand loyalty.

Is added value shifting from hardware to software?

Wagner-Douglas: Definitely, yes. Here too, the chassis can serve as a good example. Instead of steering linkage, the car is driven using 'steer-by-wire'.

Richter: Added to this is the trend towards distributing the processing power in the vehicle among significantly fewer control units. Some of these are high-performance computers on which software from several dozens of suppliers is implemented.

And does that work?

Richter: Yes, but only if the architecture was properly thought through beforehand and there is a development platform that supports this mammoth task.

Wagner-Douglas: It is important to take a holistic approach to the software structures. That is precisely what our new Connected Software Systems & Services business unit does at IAV.

You've bundled end-to-end software development in one unit?

Wagner-Douglas: Of course, IAV is continuing to develop in domain-specific units such as the drive or chassis. In this regard, software is still represented throughout the entire company as a basic competence. In total, we're talking about over 3,000 software developers and software-related specialists. Thanks to the new structure with a central software unit, in which we have brought 800 of these specialists together, we are establishing a cross-sectional function for all of these topics at IAV. We are also combining the know-how from the embedded world with the topics of the IT world. This enables us to pursue a holistic architectural approach across various areas such as vehicles, back-end, and mobile devices. In this way we can effectively address new topics such as data analysis and cloud applications.

Richter: Our teams are structured accordingly so that we can also implement this in practice. For instance, experts from both worlds work together depending on project requirements. At the same time, we are developing the software unit as an internal service provider so that all other divisions receive the specialist support they need at all times.

How well does the cooperation between these worlds function?

Wagner-Douglas: Just six months after setting up our new division, there are still some points at which not everything is running absolutely smoothly, of course.

After all, we're talking about some 1,000 colleagues who have to regroup. We are using the agile principles as orientation to offer all of them an optimal basis in their daily routine and to foster collaboration. At the same time, we benefit from this working method by being able to respond more flexibly to increasingly faster development cycles and individual requirements.

Is that possible without any loss of quality?

Wagner-Douglas: It is a myth that agile work leads to lower quality. The opposite is the case. We have been practicing agile work in some teams for a number of years and have noticed that mistakes are discovered much more quickly. The reason being that all process stages are run through in every sprint, just in small steps. The team members also push each other in a positive sense so that they are finished on time. If the method is applied correctly, the work is much more structured than in a classic, cascading project organization – although a classic approach is certainly sensible for specific topics and has by no means become obsolete.

Richter: To transfer agile practices to our software engineering routine, we have implemented an agile project landscape that we call 'AgiPro'. What's special about this is that we can combine agile working methods with various tools from embedded and IT development to comply with the Automotive SPICE standards.

»In the future, the vehicle will be embedded in a complete mobility ecosystem.«

Martin Richter

Where do all of these IT specialists come from?

Wagner-Douglas: We have recruited a lot of new colleagues to cope with this growth. We also rely on a role-based qualification program at IAV. This means that we offer various training options – online, in-house, and also externally – to enable continuous further development at the very highest level.

Richter: We are also taking new approaches to recruiting by participating in pitch nights, for example. We have also been working intensively together with universities for many years and will continue to rely on such strong partnerships. Above all, many top talents find IAV so exciting because it is possible to shoulder responsibility early on and to work on a very wide range of topics.

Wagner-Douglas: Of course, relying solely on the new and the young all the time doesn't work either. It is crucial to have the right mix of newcomers and experienced developers on board to work together on new ideas for our customers.

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Record Demand at the CES in Las Vegas

Considerable interest in IAV solutions: focus on urban mobility

The Consumer Electronics Show (CES) in Las Vegas has long since developed into more than just a trade fair for entertainment electronics. It has now become the global hot spot for all tech topics and a platform for companies from around the world that want to think outside of the box. Under the motto of 'Smart Engineering for Smart Mobility', IAV focused its presentation on urban mobility at this year's trade show. Successfully so, because interest in the stand has never been higher.

"We conducted over 600 documented discussions at our stand alone – more than ever before. That is a great record and confirmation of the relevance of our products and focus topics," sums up Martin Richter, Senior Vice President Connected Software Systems and Services at IAV. One particular aspect was that we not only came into contact with companies from the automotive sector but with players as diverse as Amazon or representatives of metropolises in the USA and South Korea, for instance. This alone makes it clear that the revolution taking place in mobility is a challenge that extends far beyond classic industry boundaries.

Over 30 IAV colleagues from different divisions oversaw the exhibits and answered visitors' questions on the 225-square-meter stand. "The team spirit was fantastic. We were a colorful mix of colleagues from various locations in Germany, the USA, France, China, and Japan. It worked outstandingly," states a delighted Richter. Thematically, IAV presented a number of show-stoppers. This was due to a number of impressive exhibits and highlights of technological development. The 'Smart Guide – Next Level Navigation' showcase, for example, provided a glimpse of future navigation systems. An innovative routing algorithm calculates all possible alternative routes in the background and shows them, highlighted in color, in the routing. This means that the driver can keep his eyes on what is happening on the road and does not have to rely on imprecise voice instructions.

Nevertheless, language remains a very relevant topic. 'Smart Speech' from IAV is a further step towards a vehicle that can be completely voice-controlled. In this, the voice assistant responds individually to each driver, appropriately, and foresightedly.

Thanks to intelligent voice recognition and rights assignment, it is possible to determine individually who is permitted to control what in the vehicle and who is not. This even makes sending personal messages or individual online shopping tours possible by means of voice control.

Convenience and well-being – two additional complexes that are becoming increasingly important for customers in the vehicle. This also includes climate control, which is based on artificial intelligence (AI) at IAV. During the CES, visitors were able to test 'Simply Cozy – AI-driven Climate Control' based on a simulated drive through various weather conditions. In this feature, self-learning algorithms record and evaluate different data and physical statuses. The result is a perfectly and individually adjusted temperature in the vehicle.

However, future mobility will not only be focused on cars. Alternative ideas and concepts are also gaining in importance due to the consolidation of living spaces and the constantly growing number of road users. A good example of this is intelligent and networked mobility platforms such as the 'Smart Cargobike' from IAV. It can automatically follow a courier in an urban setting and is able to lock and unlock itself automatically. The Cargobike can help to significantly relieve the workload in goods deliveries, particularly in urban settings. Besides the 'Follow-me' function, the smart networking surrounding the Cargobike particularly thrilled trade fair visitors. The bike uses a cloud connection to transmit relevant maintenance and operating parameters to IAV's Digital Service Assistant (DiSA) as the basis for predictive diagnoses. The system can also be used to manage the entire fleet. Predictive diagnostics, mobility platforms, and digital services offer undreamed-of possibilities and therefore attracted particular attention.

Martin Richter is convinced: "Focusing this year's CES presentation on the topic of 'urban mobility' was precisely the right decision for IAV."

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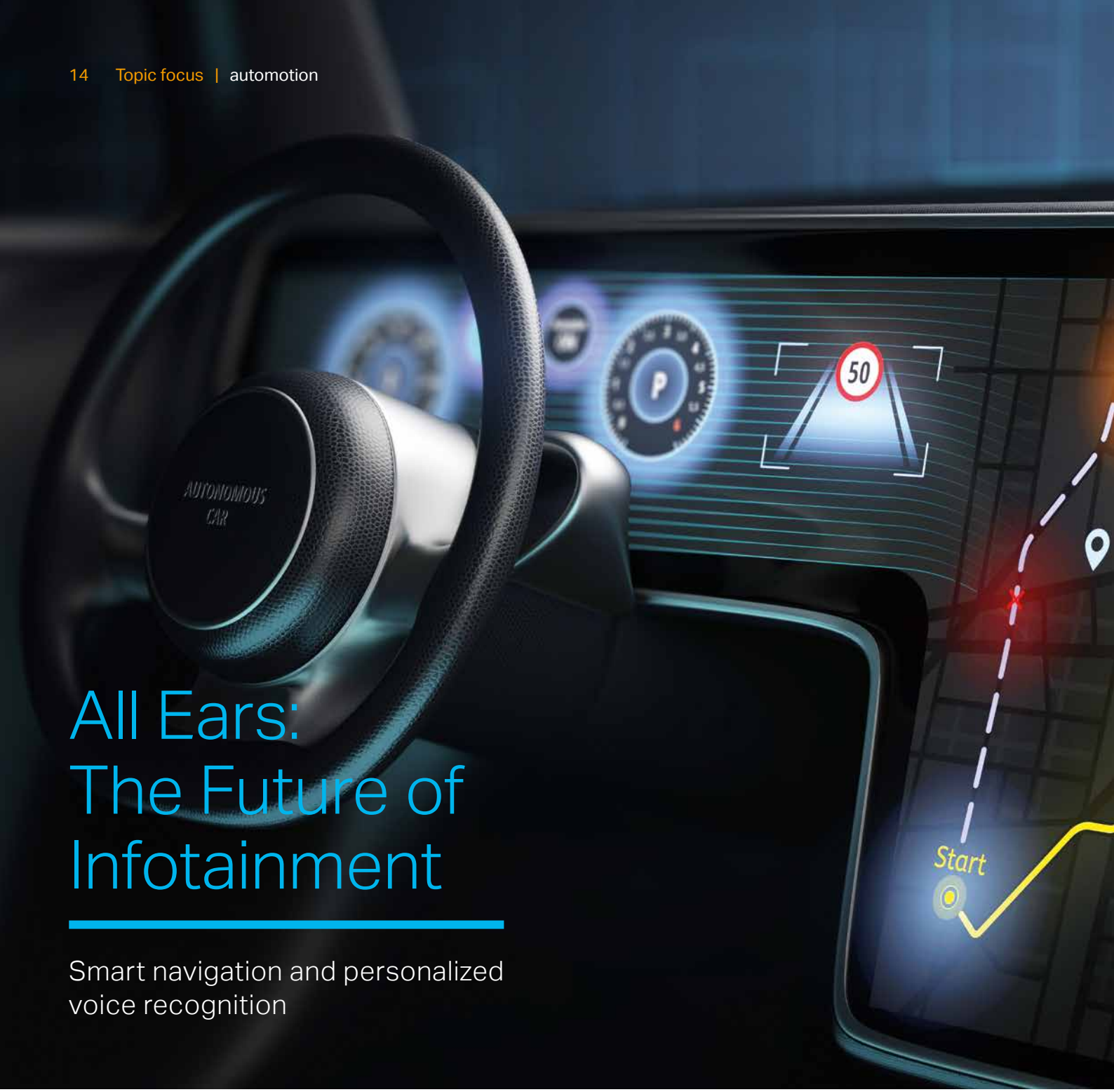

All Ears: The Future of Infotainment

Smart navigation and personalized voice recognition

The future of automobile infotainment has already begun. Visitors were provided with first-hand proof of this at the CES in Las Vegas. IAV presented its innovative navigation which requires no visual maneuvers or voice output thanks to augmented reality. A further highlight was a voice control system that knows exactly who is talking to it.

When cars of the future are seen in science fiction or modern super-spy movies, the design and technology are particularly eye-catching, of course. Information is projected onto the windshield in the blink of an eye and the driver no longer has to press any buttons to do so, instead issuing voice commands to the vehicle during reckless pursuit scenes. The latest infotainment platform from IAV shows that this technology proves helpful even when no James Bond-style chase is in progress.

Everything in sight thanks to augmented reality

Just like in the movies, the 'Smart Guide' software module developed by IAV displays information over the entire windshield, making it appear as if it were lying on the road ahead of the vehicle thanks to augmented reality. AR services are not only on the advance due to their increased availability on smartphones. High growth rates will also particularly be seen in the automotive sector over the coming years: the business consultancy Deloitte recently forecast that one in four Germans will regularly use AR services as early as in 2022. In the automotive industry and the manufacturing and supply industries, AR is already used in every third company – and this trend is set to continue.

'Smart Guide' will make navigation even more intuitive and safe. The days in which the driver had to follow his route on a small display are therefore consigned to the past,

because it is now shown in the field of vision at all times. The routing is unobtrusively projected into the real world without distracting the driver. Route instructions in the form of voice announcements are therefore no longer necessary either. This is particularly helpful if the traffic situation ever becomes unclear – at a busy, multi-lane intersection, for instance. In parallel, the routing algorithm integrated in 'Smart Guide' calculates all possible alternative routes in the background and shows them, highlighted in color, in the routing. The driver can therefore constantly see which alternative routes best take him to his destination in the calculated time window.

'Smart Guide' with AR from IAV

He therefore arrives not only stress-free but also safely.

The smartphone can also be used as an interface: if the telephone is connected to the vehicle, for instance, 'Smart Guide' can access appointments and navigate the vehicle to the place listed in the calendar entry.

Who's that talking?

As many of the functions in modern vehicles can be controlled using voice commands, it is important for the vehicle to know who is permitted to issue which instructions. Because if junior on the rear seat would suddenly prefer to go to the nearest ice-cream parlor or the toy store, the vehicle should be able to refuse if necessary.

Thanks to 'Smart Speech' from IAV, assigning individual rights in the vehicle is no longer a problem. The intelligent voice and zone recognition function means that the vehicle not only knows who is currently speaking but also where the occupants are sitting in the vehicle. The software recognizes various persons and adapts the voice dialog's choice of words and interaction options to the user group.

To do this, a speech pattern is created just once in the system for the passengers. Who is and is not permitted to address and control what in the vehicle can then be determined flexibly and individually. If only the driver should therefore be able to specify the destination, that is not a problem. Instead, the children may then literally have a say in what radio station is played. The command 'I would like to listen to my favorite song', for example, can be used to call up individual playlists, with the result that each passenger has a separate profile. This is because 'Smart Speech' can be linked to individual accounts at streaming providers and online retailers, for instance, and intelligently merges these services with the voice control system. Commands from unknown persons can be completely prohibited, which also hinders or helps to clear up thefts. The possibilities are diverse and can be individually tailored.

Voice control is interesting for both manufacturers and customers: according to the Society for Consumer Research, one out of every three Germans already use digital voice assistants and 29 percent use them in the car. In addition, 38 percent operated their navigation system verbally during the past year. So thanks to IAV's vision of future infotainment, the driver's eyes can remain where they belong: on the road.

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Automatic Air Conditioning with Smart Factor

The temperature plays a crucial role in our well-being in vehicles – and also in our safety. With 'Simply Cozy', IAV has set itself an ambitious goal: relieving the OEMs' development departments and determining and providing the perfect climate for occupants without complications. At the CES in Las Vegas, IAV offered an initial glimpse of the future of automatic climate control.

Reduction of development effort

IAV is implementing an AI-based, intelligent system for the automatic climate control of the future - with advantages for users and developers. This is because the system combines previously complex functional development and coordination of the automatic air conditioning in one single work step - thus relieving the burden on the developer. All of this is made possible by a complex neuronal network. It processes and analyzes several dozen sensor data in combination with the user inputs and uses this information to learn the conditions under, and the automatic air conditioning settings with, which an optimal interior climate can be created.

Individual feel-good climate

Users benefit from the adaptability of 'Simply Cozy', because the system gradually adapts increasingly to individual preferences. The driver defines which climate he considers to be cozy and pleasant – depending on weather and situation – and the system makes sure that this remains the case in the car. If, for instance, the interior becomes warmer because the sun suddenly comes out, 'Simply Cozy' recognizes this and automatically adjusts the temperature to the respective preferences without the driver having to do anything himself.

To be able to offer each user the individually ideal climate, the vehicle collects all relevant data and links them to defined user profiles. Each time the user wants to make a change, the system becomes more familiar with him and adapts to his preferences. In the future, the system should be able to automatically identify different drivers so that an individual wellness profile can be assigned to each of them without further intervention. 'Simply Cozy' can already be implemented in multi-zone air conditioning systems in the premium segment.

Foolproof operation

'Simply Cozy' also stands out because it is considerably easier to use than current operating concepts. The system orients itself to the user's perceptions and asks him how he feels, and whether it is too cool or stuffy for him. Further questions concerning humidity, for example, can optionally be added. An input on the touchpad or a simple voice command then suffices and the vehicle adjusts the climate control accordingly. This does away with the multitude of possible inputs that are necessary today and offers the user improved clarity and intuitive operation.

The future

Harmonizing climate profiles with energy efficiency will prove to be a particular challenge in the new generation of electric vehicles. The reason being that the more energy required for a climate profile, the more the vehicles' range will be reduced. However, IAV has also thought this through. Soon, it will be possible to align the personal wellness profiles with a "power saving profile' so that cosiness and consumption are not at loggerheads.

Systems such as 'Simply Cozy' can already be integrated into future vehicles. IAV is working on this in close coordination with the automotive manufacturers, as the IAV systems are not yet add-on solutions that can be subsequently integrated into the vehicle. But even that is conceivable in the future.

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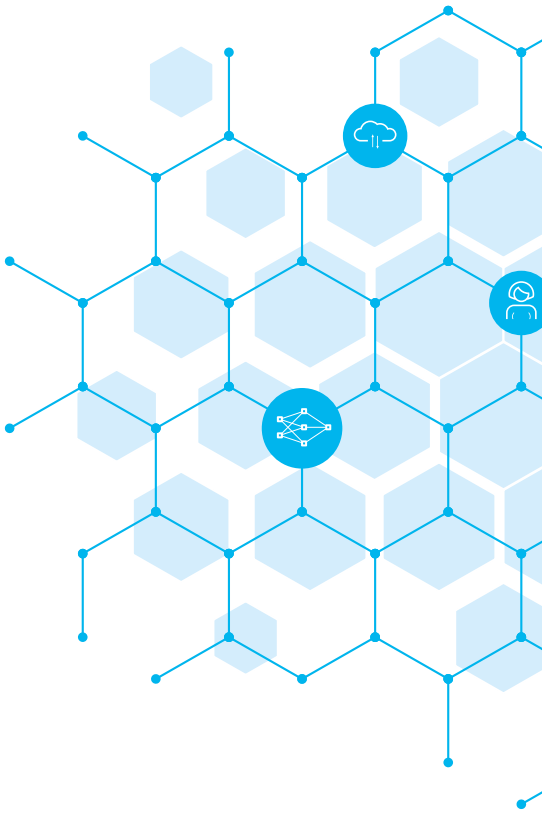

The Eternal Quest to Find a Parking Space is Over

Loomo, the parking robot

What should developers do? Exactly, develop – particularly when they are still students. All the better if this leads to solutions to everyday woes such as the tiresome search for a parking space. But it may then be the case that car drivers no longer rule what happens on company car parks. This is what happened at IAV in Gifhorn. In successful pilot tests, a small, mobile robot has guided vehicles searching for somewhere to park directly and autonomously to free spaces.

Our 'Connected Software Systems & Services' division made this possible. Created specifically for students, this project enabled two interns to gain scientific and result-oriented work experience in the fields of robotics and autonomous driving as part of their final thesis. The result is called "Loomo", the parking robot.

Loomo – a Segway and robot in one – is a platform for developers and designers. We equipped it with various sensors and an open-source computer, thus transforming a Segway into an autonomous vehicle. The free parking spaces are detected by a camera system called 'Eagle Eye' positioned on the neighboring building. Blessed with this perfect overview, image recognition algorithms identify suitable spaces between the cars and transmit these to the robot. Then Loomo takes over – what happens next is already known.

But standstill is not an option for Loomo – another student has already embarked on its further development. Lidar sensors and 'differential GPS' are on the list – Loomo will soon benefit from the advantages of 'sensor fusion': the most autonomous navigation possible thanks to a number of different data sources and the holistic evaluation of these.

And what does IAV gain when students are allowed to research and try things out at the company? More know-how and new, skilled employees. The two former student researchers are now part of the development team surrounding head of division Kai Feuerstake and will be ensuring that such developments are successfully put into production in the future.

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The Cargobike Follows at Every Turn

Making the last mile convenient

In future, digitization will have an ever-growing impact on mobility, regardless whether we are talking about two, three, four or even more wheels. And IAV has the corresponding innovative solutions. This article looks at a mobility platform with logistics focus. Today, nearly everything can be purchased by mail order, from clothing to medicine. As a result, delivery companies are facing major challenges, particularly in urban areas. Often there is nowhere for the vehicles to park or the last mile is car-free. The parcel courier has to cover long distances and deliveries take even longer, which in itself is a problem in a sector with such a high time pressure.

The problem is illustrated by a current study conducted by Bitkom, Germany's digital industry association. 46 percent of the mail order companies complained about streets being blocked by too much delivery traffic. 48 percent even indicated that rising logistics and delivery costs were becoming a growing problem. Companies, towns and local authorities are therefore looking for solutions and alternative concepts for delivery traffic.

But even those who manage without large delivery vehicles have their problems. If the courier is on a bicycle, for example, he cannot take enough parcels with him, and is constantly forced to get back on his bike for even the shortest distances. IAV has the answer. At the digital trade show CES in Las Vegas, we presented the Cargobike as a mobility concept for the future which will be popular especially with couriers and delivery agents. It is in urban areas in particular that the new mobility platform really scores.

Relieving the pressure on traffic, and also on the courier

The key feature is that the cargo bike recognizes "its" courier. After initial registration it follows him or her at every turn, thanks to the camera-based "follow-me" function. But the bike is not just a blind follower. It is able to detect and avoid passers-by or obstacles in its path, benefiting from its dynamic design and variability.

The time-consuming search for a parking space or even double-parking is no longer necessary. Nor is there any need to constantly get on and off the bike, and the goods being delivered are safe and secure all the time even without constant supervision. The large transport box only opens when the courier is nearby. It is secured with proximity sensors, thus ruling out the risk of it being opened by unauthorized people.

Even if in future the Cargobike operates on its own without human assistance, the recipients do not need to worry about the security of their parcels. The bike can find its own way thanks to route management and the ability to evade obstacles. The recipient is sent his personal access code to open the Cargobike's transport box. The result is easy delivery of meals, for example, without putting any further burden on resources.

In situations where a courier is necessary, the Cargobike platform also works with a smartphone app. It lets delivery agents plan their personal route and view all the technical details of their bike. All processes come together on a backend server.

Predicting repairs

The Digital Service Assistant (DiSA) not only manages larger fleets but also monitors the technical condition of the vehicles, regardless whether we are just talking about Cargobikes or also cars, trucks or buses. For example, if one of the vehicles has low tire pressure, the system reports this automatically before it becomes a problem,

thus saving valuable time for maintenance and repairs while clearly enhancing service quality and reliability. If a major fault should occur nevertheless, the system makes a direct appointment with the nearest service center. DiSA also helps with route and resources planning, working on the basis of several algorithms that pool orders and allocate them to suitable vehicle types and routes depending on scope and deadlines.

As a result, deliveries are spontaneously adjusted, planned and optimized, saving not only time and money but also reducing the pressure on the courier and shortening the distances they have to cover. Last but not least, our smart route management also helps to reduce urban traffic.

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An HMI for China

IAV has designed the cockpit of the future for a Chinese OEM

Digitalization and autonomous driving are changing the user interfaces in vehicles. However, cultural differences also play an important role in new HMI concepts. Timm Kellermann, managing director of IAV's consulting subsidiary consulting4drive, and Marcus Heinath, head of IAV's UX, HMI & Instrument Cluster department, report on the challenges and opportunities involved in HMI development for the Chinese market.

Why are you thinking about new HMI concepts?

Kellermann: Because everything is changing as a result of digitalization. Modern cars with new displays and operating concepts are just the beginning. We ask ourselves how concepts have to change. What experience will thrill customers in the future? What are the technology drivers on the market? This is where consulting4drive's and IAV's competencies complement each other perfectly: we are particularly good as regards strategies, concepts, and requirement management, while Marcus Heinath's IAV team offers a wealth of practical experience from various projects and knows exactly what works in the field. If you combine the two, you can develop a truly pioneering and human-friendly HMI for the digital era.

Heinath: We already have specific ideas about new HMI concepts and have discussed these with a variety of customers. This has shown that digitalization and autonomous driving are the two most important drivers in HMI evolution. In the future, the systems will also have to independently adapt more extensively to their users and pro-actively respond to their preferences and behavior patterns as well as taking environmental variables inside and outside of the vehicle into account. And another aspect also plays a central role in this: the digital user cosmos. The majority of users are at home in the Apple or Android world and are characterized by this. Future HMIs will have to adapt to these preferences, which are acquired outside of the vehicle, and give consideration to the operating habits that have been learned. The smartphone world should be reflected in the vehicle.

»In China, for example, people would like an avatar that welcomes them when they enter the vehicle, that anticipates their wishes as a 'companion', and that supports them.«

Marcus Heinath

Is there a solution that works in all markets?

Kellermann: Probably not, because we have to adapt operation to what people are already familiar with and use in that locality. In China, practically everybody uses WeChat and Alibaba. Customers' expectations are therefore influenced by user interfaces that are completely different to those in Germany and Europe, for example.

Cars will change significantly over the coming years. How can you determine today what customers would like in the future?

Kellermann: To attempt to answer this question, we surveyed around 1,500 people from all age groups and from urban and rural environments in China. But we didn't only want to know which specific functions they would like in the future – instead, we were interested in how they live and what habits they have. How do they drive? How do they navigate? What do they do in the car? For example, the Chinese like to eat while driving, which affects the HMI and safety, of course.

Heinath: Other questions that are extensively dependent on the culture can also be asked, though. How important are data protection and privacy? Do customers attach value to prestige or do they prefer understatement? We used all of this information to determine a list of requirements for the design and functions of the HMI.

And what did you learn from that for China?

Heinath: In China, for example, people would like an avatar that welcomes them when they enter the vehicle, that anticipates their wishes as a 'companion', and that supports them. To implement that, you have to collect a lot of data and constantly keep learning with artificial intelligence – whereby the learning process can also take place externally in a cloud, not just in the car. Data protection is, of course, an important topic around the globe for us at IAV, even if many people in China apparently take comparatively little notice of this aspect.

Kellermann: Such a companion could be a mobility assistant that pro-actively helps the user to plan a journey, regardless of whether it is undertaken in one's own vehicle or with public transport, via a cell phone, watch or tablet. At present, there is no such service that genuinely supports people well and consistently in this. It should anticipate people's wishes and reduce stress while driving without being annoying. However,

»In the future, the same vehicle will present itself slightly differently to each user. As yet, no series production vehicle can offer this flexibility and self-learning individualization.«

Timm Kellermann

AI can also learn entirely practical things such as adapting intelligent seats with more than 20 adjustment options to the needs of the driver, for example. Proactive adjustment of the air conditioning and ambiance or assisted driving are also conceivable.

Why are the Asian manufacturers so active in this regard?

Kellermann: Many manufacturers in Europe and the USA believe that their current vehicles are outfitted with a matured HMI – which is true to a certain extent, of course. However, some people in Europe still have very traditional needs in terms of user interfaces and functions. The case in Asia is different. There, people interact much more intensively with their smartphones, and their entire lives are permeated by digital services to a far greater extent than here – for payment, for instance. The Asian manufacturers want and have to take this into account when developing their vehicles. After a period of time, we are likely to experience a similar trend in Europe and the USA as well. But even then, we have to retain a certain degree of flexibility, because people will also continue to carry out the same things in different ways in the future. This means that, in the future, the same vehicle will present itself slightly differently to each user. As yet, no series production vehicle can offer this flexibility and self-learning individualization.

Why should a customer come to IAV to develop a new HMI concept?

Heinath: Because we have all of the expertise for such innovative and series development projects in-house: design, technology, and business models. And we can implement everything on site together with our customers – in this case, in China for China. We are represented there, in Shanghai and Beijing, with our own engineering locations and more than 100 IAV developers. We have over 20 years of local project experience and employees on the ground who are thoroughly familiar with the market and the conditions there. Because simply adapting the language in the HMI to the respective country is not enough. We have to continuously refine our understanding of culture and people's needs to be able to offer customers an HMI experience with genuine added value – an experience that links the world of the vehicle to the outside world.

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Intelligent Assistant for Couriers

State-funded project "VanAssist": autonomous vans relieve pressure on parcel couriers

The parcel and goods logistics sector is booming, thanks above all to online retail trading. That means a lot of work for the delivery agents. But today they spend most of their time in traffic jams and in the depot, with little scope for customer contact. The funded project "VanAssist" is developing an intelligent system for autonomous, remotely monitored vans in parcel logistics in order to optimize the delivery process. IAV is responsible for localization and for the high-precision maps.

Life isn't easy for parcel couriers. Before they can actually start work, first thing in the morning they have to go to the depot, load their vehicle and then head off to their delivery area through the worst of the traffic. In the evening, the same happens in reverse: back to the depot, unload parcels that couldn't be delivered and load new parcels in the vehicle. Parcel delivery staff spend about half their working hours on these tasks – time that they then don't have for personal customer contact and actual deliveries.

The state-funded project "VanAssist" (interactive intelligent system for autonomous, remotely monitored vans in parcel logistics) aims to overcome these inefficient processes and give the couriers more time for the actual job. This is the basic idea: in the morning, an autonomous delivery van drives up to the loading bay in the parcel service depot and is loaded by a logistics employee, who knows the planned route. With the assistance of an app, he loads the parcels into the van in the right

order. Once everything is loaded, the control center gives the signal to depart. The van leaves the depot, steers autonomously through the traffic and reaches the meeting point with the delivery agent, for instance at a ride-sharing car park near the delivery area. The courier gains access to the van with his smartphone and sets off to the customer's address. He can either steer the vehicle himself or let the autonomous technology do the driving.

Permanently learning system

The delivery sequence is planned in the background, taking account of the current traffic situation (such as congestion or road works) in addition to the street map. The system also integrates acquired knowledge, such as the accessibility of individual recipients. "The delivery agent can adjust the sequence according to his own experience", explains Paul Czerwionka, IAV project manager for VanAssist and expert for maps. "Human knowledge is thus also integrated so that the system keeps learning all the time."

At the moment, delivery vehicles often have to double-park because there is simply no alternative. The developers involved in VanAssist want to put an end to this. In future, the courier could unload three or four parcels, send the vehicle on to an official stopping point and make his way to the recipients. Indoor navigation helps him to find his customers even in larger buildings. Once the parcels are delivered, he sends a message to the van with his smartphone to meet up at an agreed location. This could be at the other end of a pedestrian zone to unload and deliver the next parcels.

In the evening, the delivery agent leaves the vehicle again at some point between the delivery area and the depot and sends the vehicle autonomously back to the logistics center. On reaching the depot, parcels that couldn't be delivered are unloaded and replaced by new ones. The depot also has a service department for cleaning and maintaining the vehicles together with infrastructure for recharging the batteries. Next morning, the whole procedure starts again at the beginning.

Lidar sensors and cameras recognize landmarks

IAV's role in the VanAssist project consists in localization and in producing high-precision maps. "GPS on its own isn't enough because a higher level of precision is needed", says Czerwionka. "And so we're using lidar sensors and cameras for precision positioning down to the last ten centimeters." Two lidar sensors (front and rear) and four cameras (in all four directions) register landmarks such as trees or road signs whose positions have been precisely defined in advance and entered in high-precision maps. The delivery vans detect when something has changed in the surroundings, such as a newly erected road sign, and update the map accordingly. If a vehicle is not able to drive autonomously anymore, the control center takes over and selects a driving maneuver from a predefined catalogue.

At the moment, the first prototype delivery van is being developed on the basis of a rolling chassis. By the end of the year, the VanAssist project partners aim to demonstrate the vehicle at a test track on the premises of Braunschweig University of Technology, showing that the technology works reliably and that the couriers really will notice a considerable relief. "We want to build an autonomous vehicle that fits in perfectly with the delivery process", emphasizes Czerwionka.

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VanAssist

Other participants in the VanAssist project alongside IAV include DPD (consortium leader), bridgingIT, Ibeo Automotive Systems, Braunschweig University of Technology, Clausthal University of Technology, Mannheim University and Offenburg University of Applied Sciences. It is being funded by the Federal Ministry of Transport and Digital Infrastructure

Read on:
www.vanassist.de

"Changing the Mindset of the Entire Company"

Domain knowledge meets methodological and process knowledge: the Digital Lab as an open space for creative approaches

IAV tests new methods and approaches to work in the Digital Lab. Matthias Schultalbers, Chief Digital Officer at IAV, and Maike Ohmenzetter, Agile Master at IAV, report on their experiences from the first two years, the new innovation process, and the latest topics from the company's future laboratory.

Mr. Schultalbers, you are IAV's new CDO. What are you planning to do?

Schultalbers: I am counting on continuing to bring the latest knowledge into the company via our extensive research network. Our aim is to be familiar with the latest state of the art and to always make the latest findings accessible to all of our colleagues. At present, our business is characterized by a number of new trends and increasingly shorter development cycles, which is why we are also establishing agile working methods such as design thinking or BarCamps in the company. We are at the heart of IAV's continued development and have already made a good deal of progress.

What role does the Digital Lab play in this?

Schultalbers: The Digital Lab serves as our platform for transporting these innovative topics and working methods into the entire company. In the operational business, it is difficult to test and evaluate new methods and processes. In the Digital Lab, we can try out new working methods but also new technologies such as artificial intelligence or the Internet of Things and harness them for all 8,000 of IAV's employees and also for our customers, of course. We don't just want to implement lighthouse projects; we want to change the mindset of the entire company.

Ohmenzetter: The Digital Lab plays a key role in this. It is an open space in which we can try out new, creative approaches and in which there is also a particularly open error culture. Because one thing is certain: the world around us is becoming increasingly diverse, the challenges ever more complex. This necessitates new creative and innovation techniques. This is why colleagues from the IAV divisions come together with specialists for advanced technologies and new working methods in the Digital Lab. Experts from the domains encounter artificial intelligence or agile work experts, for instance.

How is the Digital Lab organized?

Ohmenzetter: There is a core team of around ten employees. These include the methodology experts who are familiar with artificial intelligence, data science, autonomous systems, and computer vision, for example. Other colleagues are specialized in new processes such as agile work and design thinking. Besides this core team, we always have around 20 colleagues from the IAV divisions with us; they spend three to four months in the Digital Lab to implement their ideas there.

How does an IAV employee get to work in the Digital Lab?

Ohmenzetter: Four times a year, we launch a thematic campaign and invite all IAV employees to apply to us with their ideas using an online platform. The pitch session is open to all IAV employees and always attracts around 100 spectators. These are volunteers who are interested in what's going on – anyone can take part. Within this session, a jury decides who makes it through, so it assesses the presented ideas. The winners are then appointed as product owners and can select members for their team from among all IAV colleagues throughout the company. This is followed by a trial sprint lasting four to six weeks, a review, and the development of a 'Minimum Viable Product' (a minimum functional product/service) – constantly accompanied by a scrum master from the core team who coaches them.

Schultalbers: In this, it is very important to us that the technical divisions are also involved early on. As management sponsors, the Executive Vice Presidents take on the role of sparring partners for the project teams. Even during development and as soon as the 'Minimum Viable Product' is available at the latest, we in the IAV management decide how we want to proceed further. We could initiate a corresponding doctoral program or start directly with acquisition, for instance.

Which campaigns are planned this year?

Ohmenzetter: One of the topics is 'automation/digitalization'. It deals with the question of where we can automate routine tasks in administration or development in order to become more efficient and effective. Other campaigns involve the areas of 'non-automotive', 'powertrain', and 'vehicle/mobility'. Interest among the staff is very high: each time, we have received far in excess of 50 proposals, ten of which were selected for the pitch. The idea presentations were attended by around 200 colleagues as spectators, either live or via Skype.

Maike Ohmenzetter

Matthias Schultalbers

»We are in the midst of a fundamental transformation in which we are an active part with the Digital Lab.«

»In the Digital Lab, we can try out new working methods but also new technologies such as AI or IoT and harness them for everyone – employees and customers.«

Many of the new methods and approaches to work come from the world of IT. Are these companies the new benchmark for IAV?

Schultalbers: Of course we are concerned with our new competitors. Besides IT companies, these also include start-ups from the digital sector. However, we won't simply adopt everything from them, but will go our own way. Because we have a unique methodological depth and breadth compared to these companies. We are highly familiar with our domains – what we now have to do is to combine this domain knowledge with the methodological and process knowledge from the Digital Lab and integrate this combination into our series production projects. This will put us in an even better position to find optimal solutions for our customers.

Ohmenzetter: We are in the midst of a fundamental transformation in which we are an active part with the Digital Lab. It is important to us that we are not perceived as an island within the company therefore we are closely networked with the technical departments. We use showcases to make digitalization tangible in practice, and we integrate it into the entire company with the aid of our network. By doing so, we take all of our colleagues along with us into the digital future.

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Dr. Uwe Horn

New President and Chief Human Resources Officer

»I'm looking forward to working with the more than 8,000 employees who are meanwhile deployed by IAV all over the world.«

Dr. Uwe Horn joins the top management at IAV on January 1, 2020. He succeeds Kai-Stefan Linnenkohl, who has left the company after almost five years to take up a position with Volkswagen.

CEO Dr. Ulrich Eichhorn: "We are pleased to have found such a qualified successor for Kai-Stefan Linnenkohl. We are a rapidly growing company. Our know-how is in great demand, both for developing modern combustion engines and as expertise for future technologies, such as electromobility, connectivity and autonomous driving. Dr. Uwe Horn will be exactly the right person to continue successfully reinforcing the development of our human resources."

In the past, Horn was employed as Head of Human Resources at the Volkswagen plants in Zwickau and Poznan (Poland), among other things. Since 2018, he has been a member of the management board of Autostadt in Wolfsburg.

In his new role at IAV, he is responsible for human resources as well as occupational health and safety. His remit also includes initial and advanced vocational training, as well as social and pension benefits.

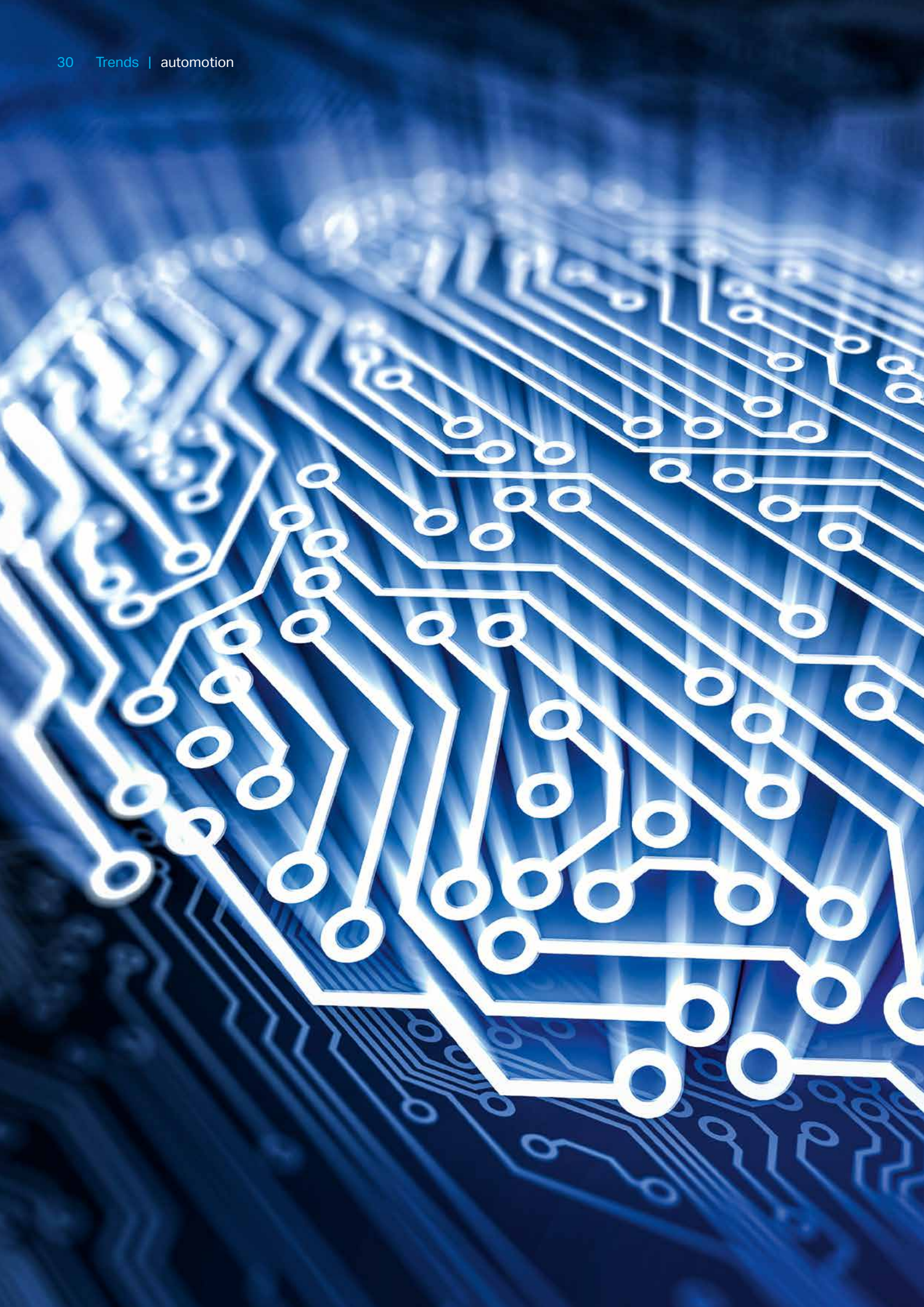
IAV Teslin: Maximum Efficiency for Testing and Appraisal

Today, various tools such as Excel, Word or PowerPoint are used to record data from functional or endurance testing, before the data are then stored on drives or in several databases. This process is not only very slow and error-prone: it also makes it very difficult to compare different endurance runs at great manual effort.

IAV Teslin remedies the situation. The intelligent tool manages the data in a central server database and makes them available intuitively on a client (Windows or Linux PC) for subsequent analysis, comparison and reporting. Component owners and diagnostic experts working for OEMs, suppliers and service providers benefit from far greater efficiency as well as improved evaluation possibilities during and after test runs. Besides standardized data recording, the tool also offers flexible add-ons, depending on customer or project demands. Furthermore, IAV Teslin produces semi-automatic reports in various formats and makes it easy to compare test specimens in different test programs, among others. Interfaces integrate the tool smoothly in existing system landscapes.

Customers in the non-automotive sector will also benefit from these advantages when diagnosing or assessing their products after tests or endurance runs. IAV Teslin has been in productive use at IAV since 2014. It undergoes continuous optimization and has already proven its worth in numerous customer projects.

Interested? To make swift arrangements for an online demonstration without any obligations, simply contact **teslin@iav.de**.



Semantic AI Systems

Automatically establishing complex relationships in data

IAV's new prototype "Sajama" is based on a graph database that processes and structures large quantities of heterogeneous data and uses artificial intelligence to generate new knowledge. Applications go way beyond engine control units. Sajama also offers added value for the financial and medical sectors as well as smart grids that combine power generation, storage and consumption.

The software in engine control units is changing all the time. This applies not only to the adjustment variables (characteristics) that software functions revert to but also to the functions themselves. Some are no longer needed, others are added. Furthermore, each new version also brings changes to the scope of functions. It is a great challenge for calibration engineers to keep an overview and recognize the many interrelationships.

Digital twin of an engine control unit

IAV Sajama is capable of depicting the software functions of an engine control unit as a "digital twin". The digital twin combines different data in a graph database to form one single entity, from the inner structure of the software through to the measured data generated in the control units.

"The graph database reveals and evaluates structural differences and similarities in various software parts", explains Dr. Kevin Fuchs, Lead Developer (Sajama) at IAV. "It is thus possible to derive which software parts belong together, so that a calibration engineer sees which software parts have to be taken into consideration during troubleshooting and modification processes. The aim is to simplify and accelerate time-consuming work processes in diagnosing and calibrating control units." Another application: Sajama detects similarities and irregularities in measured data. For example, the Sajama team is working on how to predict wear in vehicle components (predictive maintenance).

Bots enhance the graph with new knowledge

The core of the new IAV prototype is a knowledge graph that saves data in combination with their semantic relationships. The first step consists in importing the data from many different sources, such as databases with measured values or Excel spreadsheets. Semantic technology is then used to link the data in a knowledge graph. Various AI bots (small-scale autonomous software programs) operate on the knowledge graph and conduct various analyses. For example, statistic bots use data science methods, machine learning bots use machine learning methods and reasoning bots perform logical reasoning on the graph.

"The bots write their results in the graph as new data, classifications or semantic relations", explains Sebastian Gerhardt, Product Owner (Sajama) at IAV. "The results of one bot can be used as input by other bots. They enhance the graph with new knowledge that could not be derived just from the individual data sources." The bots thus cope with predictions, pattern detection, classification and automated logical reasoning even for large quantities of distributed data.

In future, the plan is for Sajama to support calibration engineers with specific recommendations. "A calibration engineer working on certain software parts receives an e-mail that draws his attention to other relevant software parts and relationships", says Gerhardt. "The tool acts as his smart or digital companion."

Many different possible uses

But there are many more possible uses for IAV Sajama. The tool is ideal whenever new knowledge is to be generated from large quantities of distributed, heterogeneous data. One example is smart creditworthiness testing of bank customers. Someone requesting a loan to redeem his obligations from two credit card contracts could be given a poorer rating by mistake because on paper it looks as if he suddenly has three lots of debt. However, semantic relationships operating in a knowledge graph would quickly see that the loan replaces two other obligations. "Of course, a human bank clerk would see that straight away, but it's not so easy for a machine", says Fuchs, before drawing attention to two other applications: "Apart from the financial sector, the tool is also ideal for healthcare system, for optimizing and troubleshooting wind turbines, or for controlling smart grids."

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The AI-Based Mailroom

New automation solution uses AI to classify incoming service tickets

Support staff have to deal with thousands of service enquiries every day. It is already a full-time job just to allocate the enquiries to the right team. IAV has developed an automation solution to perform this task. Artificial intelligence classifies the incoming service tickets, forwarding them automatically to the right experts. To this end, the automation solution analyzes the text of the enquiries and the content of accompanying error logs and screenshots.

Whether a computer crashes, has a software bug or a license problem, there are lots of reasons why the support teams maintained by manufacturers receive enquiries from users. The service staff specialize in specific topics, because no-one could answer absolutely every question. The large number of possible topics and the wide range of wording used in the enquiries means that correct distribution is a full-time task. Thousands of e-mails have to be looked at and forwarded to the right team. Furthermore, enquiries are received in many different languages from the users, making ticket analysis and allocation even more complicated.

IAV has developed an AI solution that automates this task. It currently recognizes 19 languages with various scripts, including English, German Chinese and Japanese, regardless whether the text is in an e-mail, part of an automatic error log or featured in accompanying pictures such as screenshots showing the problem.

Text from pictures is extracted into character strings

Where pictures are concerned, ticket analysis begins with image processing. Among others, the software improves the contrast and detects where the attached photo contains text. It then automatically recognizes the specific language and forwards the text as extracted character string to the next processing level. Initially, the software analyzed texts in English, German, Spanish and Danish simultaneously, with other languages to follow.

After extracting the text information from e-mails, error logs and screenshots, it is transferred to a neural network as input. This is where the actual classification takes place: the received tickets are allocated to one of several defined categories for automatic forwarding to the corresponding service team. The first machine learning processes were based on training data taken from around 25,000 tickets that had been initially dealt with manually.

Flexible solution for many applications

The automatic classification system was evaluated internally at IAV and works reliably. "It's a very flexible solution", reports Warda Khan, who was in charge of developing the system at IAV. "It can be used in many other sectors and not just the automotive industry. We adapt our service individually for every customer to generate the maximum added value for every project and topic."

The crucial requirement is to have enough training data for machine learning. But this restriction could soon become irrelevant: in the next step, IAV's experts want to use unsupervised machine learning so that incoming tickets could be classified without any previously categorized training data.

Two features make the IAV solution unique: it is capable of analyzing information in pictures, processing a large quantity of data and extracting useful information even from poor-quality photos. Furthermore, it processes different languages without having to translate from one language to another. "With sufficient training data, we can adapt the system for many different sectors and applications", says Dr. Remo Lachmann, Team Manager for Software Test Automation & Data Quality at IAV.

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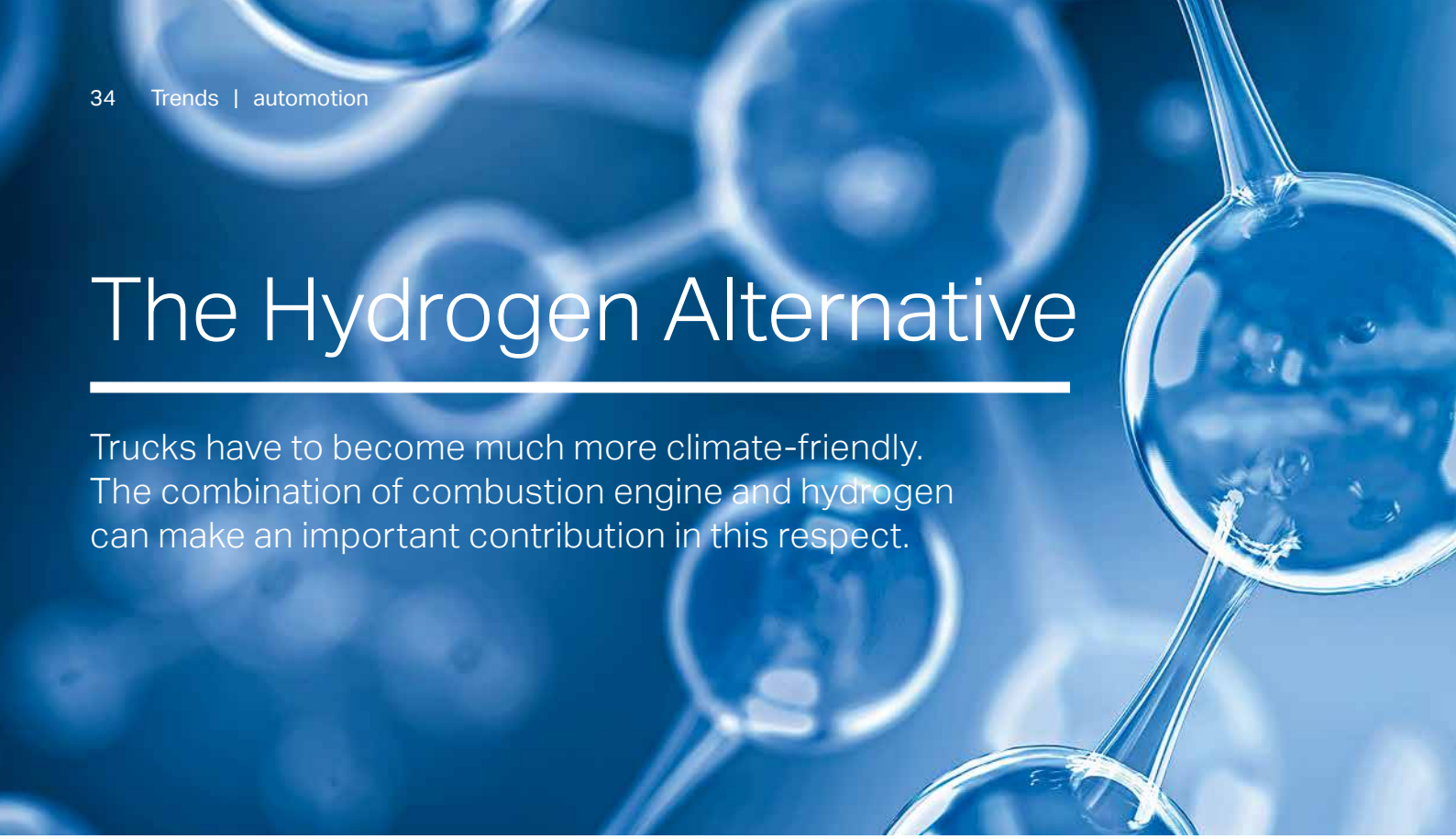

The Hydrogen Alternative

Trucks have to become much more climate-friendly. The combination of combustion engine and hydrogen can make an important contribution in this respect.

By 2030, CO_2 emissions from trucks with an overall weight exceeding 16 tons have to be cut by 30 percent. Combustion engines running on hydrogen can help to meet these requirements. Furthermore, they offer a similar mileage than diesel engine powertrains and can be ready for series production in time. IAV has analyzed this approach in detail and is therefore familiar with the opportunities and challenges of the H_2 engine.

CO_2 limits on passenger cars were imposed by the EU already years ago; since 2019, it is now clear that trucks with an overall weight exceeding 16 tons will soon have to reduce their carbon footprint as well. Emissions should fall by 15% by 2025 and again by the same amount by 2030, always referred to the status in 2019 and calculated with the tank-to-wheel consideration. Furthermore, the EU demands that two percent of the share in a truck fleet must be low-emission or zero-emission vehicles. As a result, the development of commercial vehicles will be dominated by technologies to avoid CO_2 in the next years.

Various alternatives to the conventional diesel drive

A number of technologies have the potential to make a contribution. Conventional diesel engines could fulfill the CO_2 targets if operated with climate-neutral synthetic fuels. However, for this to have a positive impact on fleet consumption, legislators would have to introduce well-to-wheel balancing instead of the tank-to-wheel approach.

Battery-powered electric trucks are named as the first alternative in current discussions. However, the energy density in the batteries is still so low that they would have to weigh several tons to keep a long-distance truck running. But this means less load, and therefore less turnover for the hauler. "Current battery technology is not suitable for long-distance commercial vehicles", says Jörn Seebode, Senior Vice President for Commercial Vehicles at IAV. "They need batteries with roughly ten times the energy density."

Hydrogen is another potential successor to diesel fuel, although discussions usually refer to using hydrogen in fuel cells. Fuel cells still face a few hurdles before they can be used in commercial vehicles: "Fuel cells currently still have a low specific power output. Given the situation at present, this would result in prohibitive costs because heavy trucks need several fuel cells. However, this could definitely be an alternative in the medium to long term", says Marc Sens, Senior Vice President for Powertrain Advance Engineering at IAV. "Furthermore, fuel cells are very sensitive to impurities in the hydrogen. And at the moment, they also fail to comply with the demands of commercial vehicles in terms of durability." But hydrogen offers other possibilities apart from being converted to power for electric motors in fuel cells. It can also be used as fuel in a combustion engine in a process that is nearly free of emissions, because hydrogen burns without generating carbon-based pollutants.

Hydrogen combustion engine: climate neutral, zero emissions

A few years ago, IAV was already involved in intensive development of turbocharged hydrogen combustion engines with direct injection and is therefore familiar with the technology. "We know the opportunities and challenges; moreover, we also know how to get a hydrogen combustion engine ready for SOP", says Seebode. The opportunities are actually considerable: regenerative hydrogen is climate-neutral and would therefore be treated like an electric drive, i.e. with 0 grams CO_2/km. What's more, the right operating strategy could reduce NOx emissions practically to zero in a concept that might even manage without any exhaust aftertreatment

Hydrogen Engine Dyno for Heavy-duty Applications

As of now, IAV has test facilities for hydrogen combustion engines at its Gifhorn Development Center.

Specifications:

- 600 kW / 3,500 Nm
- transient dyno
- complete emissions testing and certification capable

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system. "Trucks powered by a hydrogen combustion engine not only meet the CO_2 limits but also comply with the zero-emission target"; explains Sens. "In other words, they would be allowed to run in conurbation areas in future."

The technical challenges can be resolved. In principle, a hydrogen combustion engine is similar to a gasoline engine, with practically no differences even in compression ratio. Hydrogen burns efficiently even when highly diluted, thus allowing for a lean mixture and generating scarcely any NOx engine-out emissions. However, a lean-burn H_2 drive needs a highly efficient supercharging system, otherwise there won't be sufficient energy density in the cylinder to generate appropriate specific power output. "Development work is still necessary here", says Sens. "The supercharger needs to be more efficient with higher variability."

Another challenge encountered in developing H_2 combustion engines is the hydrogen injection system. Preferably, the hydrogen should be injected directly in the combustion engine cylinder on account of the power density and for safety reasons. However, no direct injection valves proven in volume production are available on the market at present. This is another area where IAV offers a wealth of expertise from many years of experience in developing injection systems for gaseous fuels.

The third challenge consists in the hydrogen storage/tank system, which must be capable of holding enough fuel in the smallest possible space. Low-temperature and pressure storage solutions are available here. Pressure storage solutions are used for passenger cars at pressures of up to 700 bar, but this is only feasible for relatively small tanks. As far as large tanks are concerned, the hydrogen would have to be cooled during refueling, resulting in high costs. Pressures of 350 or 500 bar would probably be preferable for commercial vehicles. Other possible alternatives would include technologies such as cryogenic storage systems or LOHC. Refueling takes only slightly longer than with diesel, with ranges suitable for long-distance operations.

But at the moment there are simply not enough hydrogen fuel stations: 75 are already in operation, with a target of 100 by 2020. Initially it would suffice to expand the facilities available at HGV traffic nodes: in contrast to recharging a battery, refueling with hydrogen is much quicker so that far less infrastructure and space will be needed along the highways.

Fit for purpose and ready for volume production by 2025

"The combination of combustion engine and hydrogen offers sufficient range for logistics operations, with high durability and low costs, and uses established technology", summarizes Seebode. "IAV therefore sees this as a very good way of helping the HGV sector to fulfill the CO_2 targets. Furthermore, it is a solution that would be ready for volume production by 2025." This depends on manufacturers reaching agreement on a standard tank technology and on using as many standard components as possible to reduce unit costs. It would then be possible for hydrogen combustion engines to drive 28-ton, 25-ton and 40-ton trucks in just a few years.

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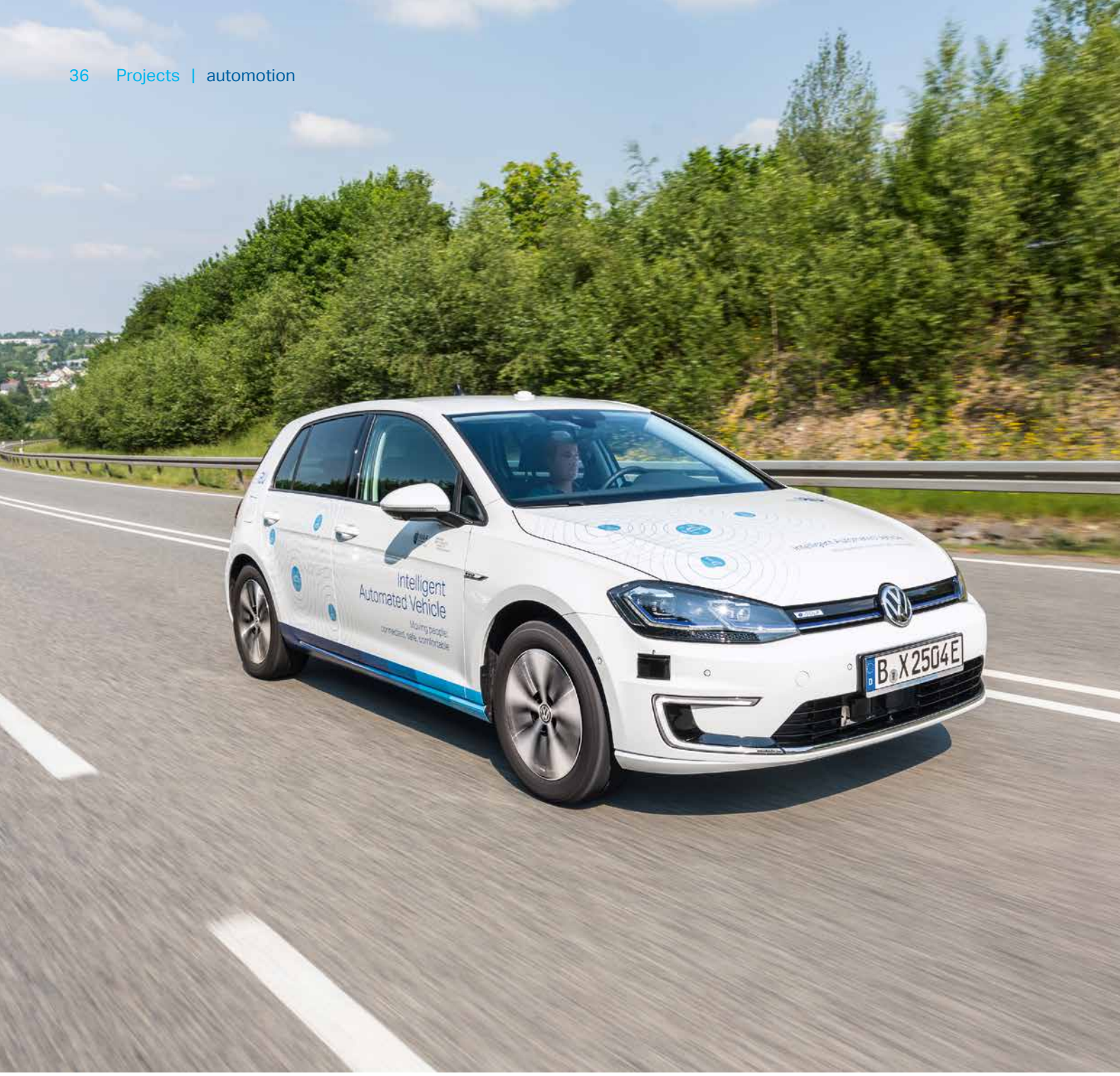

The Future of Mobility Is Connected and Synchronized

Projects in the Digital Test Site Dresden create the basis for autonomous driving in the city

The Project Initiative "Synchronized Mobility 2023"

Alongside IAV, the participants in projects under the "Synchronized Mobility 2023" initiative have also included Dresden University of Technology, Preh Car Connect, BMW, NXP, Fraunhofer Institute for Transportation and Infrastructure Systems (IVI), Fusion Systems, Chemnitz University of Technology, FSD, Dresden Elektronik, Mugler, Noritel and Vodafone. Projects in the "Synchronized Mobility 2023" initiative receive funding from the European Union under the European Regional Development Fund (ERDF), from the federal state of Saxony and from the German Federal Ministry of Transport and Digital Infrastructure (BMVI).

Interim review in Dresden: the results of several projects in the "Synchronized Mobility 2023" initiative were presented at the end of last year. The focus was on cooperative driving maneuvers of automated connected vehicles, new communication technologies and automated charging of e-vehicles. IAV's contribution consisted among others of two test vehicles.

Dresden offers an opportunity to see what the mobility of the future may look like. Since 2016, the Saxon capital has joined Berlin, Braunschweig, Düsseldorf, Hamburg, Ingolstadt and Munich in becoming a "digital test site" for automated and connected driving. Here "synchronized mobility" is to become reality by 2023 with the first connected volume-produced vehicles on Dresden's streets. This ambitious undertaking was kicked off in 2015 with the REMAS project – "Resources management system for highly automated urban traffic" – with the aim of dynamic traffic control based on real-time data. IAV is also involved in other projects that were launched under the REMAS umbrella: HarmonizeDD, SYNCAR, AULA, IVS-KOM and IVS-LOK. On October 9, 2019, the project partners all came together in the Conference Center at Dresden Airport for a presentation of the key results.

"Alice" and "Hugo" as test vehicles on the streets of Dresden

Among others, IAV is involved in Dresden's projects with "Hugo" and "Alice". The names stand for two test vehicles for investigating automated driving functions. IAV is using Alice to test its proprietary driving functions with cameras and radar, lidar and ultrasound sensors. "The vehicle is thus capable of driving autonomously in urban areas, from the airport junction to the motorway", reports IAV's Tim Alscher who was responsible for the projects in Dresden. Hugo is a test vehicle fitted with underbody contacts for automatic recharging. The additional technical equipment was installed in both vehicles at IAV in Chemnitz.

IAV's role in the HarmonizeDD (continuous support of connected and automated driving for mixed traffic with heterogeneously equipped vehicles) and SYNCAR (synchronized automated driving in urban areas) projects consisted in developing cooperative driving maneuvers such as making automatic lane changes or approaching traffic lights. "All projects work on the basis of intelligent connectivity to create the essentials for predictive, cooperative driving in the urban setting", says Tim Alscher.

The underlying communication and localization technologies are also being examined in Dresden: IVS-KOM (communication technologies for intelligent transport systems) looked at V2X communication with WLAN11p and cellular communication (LTE/5G). IVS-LOK (lane-precise localization for intelligent transport systems) is running through to spring 2021 with a focus on validating a localization solution that uses dGPS (differential GPS), promising precision of just ten centimeters, compared to three to four meters with conventional GPS. Dr. Alexander Jungmann underlines the relevance of this project: "Communication and localization technologies are thus able to extend their perception of the surroundings beyond the range of individual sensors."

The AULA project (autonomous electric vehicles with automated charging infrastructure) examined how autonomous cabs can be recharged without human intervention, using an underbody system. A contact mechanism docks into a vehicle interface from below to connect it to the power grid. IAV was responsible for integrating the necessary high-voltage interface in the test vehicle Hugo.

Dynamic traffic control: complex challenge

"Basically, all goals have been achieved", summarizes Alscher. "And we gained a lot of new findings over the past years. For example, in practice dynamic traffic control has proved to be a special challenge for longitudinal control. Dresden gives priority to local public transport at traffic lights so that the traffic situation on the streets is changing all the time. In future, it will be necessary for all traffic control systems to be permanently connected." In the next phase, OEMs can start testing in the qualified environment in Dresden to get the new technologies ready for SOP. "We are familiar with the traffic conditions and the technology on site, so that we can provide our customers with optimum support", says Alscher.

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Predictive Truck Reduces Emissions

IAV has developed predictive optimization algorithms for trucks in the "optiTruck" project

The EU has stipulated that by 2050, CO_2 emissions in the transport sector must be reduced by 60% compared to 1990. The "optiTruck" project brought together eleven companies, research institutions and users to examine ten purely software-based individual measures for noticeably reducing the fuel consumption of a diesel truck without changing the hardware in the engine or vehicle. IAV developed the basic structure for the software, the overall system simulation and three optimization algorithms for the powertrain. The project partners have now presented their results.

Many aspects influence the amount of CO_2 emitted by a truck during its journey from shipper to consignee. Factors include the truck type and its aerodynamic drag as well as the cargo's weight and the tare weight. Then there are external factors that can change at any time, including traffic conditions or the weather. A change in the wind direction also alters the amount of CO_2 emitted on the various routes from start to destination.

In the EU project "optiTruck" (optimal fuel consumption with predictive powertrain control and calibration for intelligent trucks), a cloud solution should help to find the route with the lowest CO_2 emissions on the basis of all these various influencing factors. The main idea is as follows. Before starting the journey, the logistics dispatcher sends important key data to the data cloud such as starting point and destination, load and delivery deadline. The data cloud uses this information to calculate a choice of alternative routes with the lowest possible CO_2 emissions. Due consideration is also given to changing traffic and weather conditions: the software on the cloud checks constantly whether the truck is still on the ideal route.

If necessary, it sends the driver an update by mobile communication. The truck and cloud are therefore in constant contact.

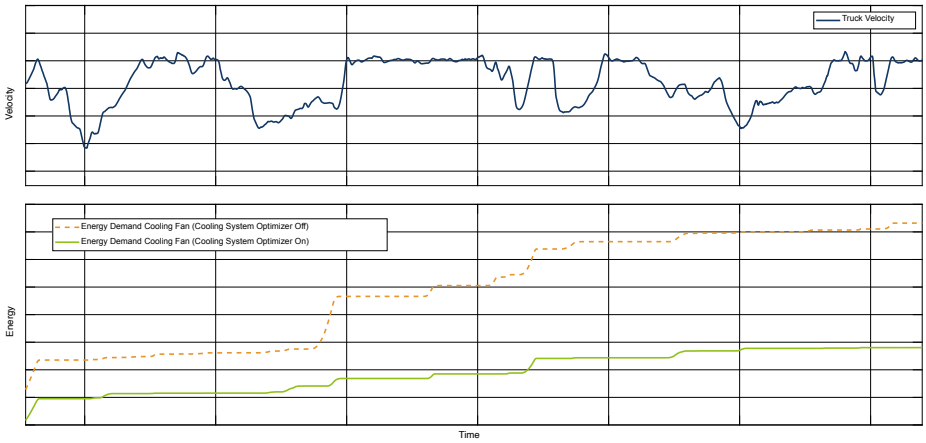
Predictive management of components

But the road directly ahead of the truck also offers scope for optimization. For example, if the truck is approaching a longer downhill section, the actuation of accessory units such as the compressed air supply can be delayed because potential energy will then become available while driving downhill. A similar approach can be taken to reducing energy consumption in the exhaust gas aftertreatment system. Regeneration of the diesel particulate filter can be delayed just before reaching an uphill climb because the exhaust temperature will increase anyway during the ascent. Predictive management can also save energy in the cooling system by taking account of the operating points expected in each case. This depends on having precise and real-time knowledge of the route ahead and the traffic conditions.

In the OptiTruck project, IAV was responsible for the basic structure of the control unit software, a rapid prototyping unit and the software development environment for the partners. The platform for overall system simulation and three other innovation elements were also part of IAV's remit: the model-based coordinator for the exhaust gas aftertreatment system as well as predictive management for the cooling system and for the auxiliary units.

Practical test with two trucks

The aim of the optiTruck project was to reduce the fuel consumption of a 40-ton truck by 20% while at the same time complying with the Euro VI emission limits. In July 2019, the big moment had finally arrived. Two trucks set off in Turkey to deliver their freight to Italy and then to return to Turkey. One truck was fitted with conventional technology and the other with the optiTruck innovations. After evaluating the trip of roughly 5,000 kilometers, it transpired that the optiTruck vehicle consumed up to 13% less diesel fuel on certain sections of the journey. "The 20% goal can only be achieved under ideal conditions with all individual measures interacting perfectly", says Oliver Dingel, IAV Project Manager for optiTruck. "It was not possible to achieve more under the prevailing circumstances. The results were sure to have been better on another route." What's more, the technology has gone through further development since the project began in 2015. The comparison truck in 2019 already exhausted some of the optimization potential in 2019.



Comparing the energy demand in the cooling fan with and without cooling system optimizer

That is why the IAV experts are satisfied with the results. "We worked with different partners from across Europe to set up a complex system and get it to work", says Dr. Dennis Jünemann, development engineer for performance engineering at IAV. "That on its own was already a great success". Furthermore, solutions were found for major technical problems, such as transferring data from the cloud to the vehicle and on to the individual control units. The limited capacity of the truck's data buses made it necessary to reduce the volume of data and to divide the data into packages. The project also saw the emergence of a simulation environment for developing new algorithms that could then be transferred to a vehicle control unit almost without adjustments.

Good basis for subsequent projects

"optiTruck was a great success. We learned a lot during the project, and it has provided a good basis for subsequent projects", summarizes Dingel. "We have identified which points can be tackled and where it is possible to tap into further potential". The cloud data, for example, were not ideal: further reductions in a truck's CO_2 emissions could be achieved with more accurate maps and better route planning algorithms. IAV will work with customers to develop the identified potential on the basis of experience gained in the project.

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optiTruck

Other stakeholders in the EU project OptiTruck alongside IAV include the truck manufacturer Ford Otosan, ERTICO ITS Europe (coordinator), the universities of Aalborg, Leeds and Okan, the Hellenic Institute of Transport, the ICOOR and ISMB research institutes and the user companies Eliadis Transport and Codognotto Italia. optiTruck was funded from the EU research framework program "Horizon 2020". It was launched in September 2016 and ran until August 2019. The EU contributed € 4.5 million to the total project costs of € 5.3 million.

www.optitruck.eu

Sensors in the Headlamps for Better Automated Driving Functions

Cameras, radar and lidar for autonomous driving can be fitted in the "smart corners" of vehicles

Camera Radar Lidar IR/MS camera USS

ZKW

Around 50 sensors will have to be fitted in vehicles at the latest for automated driving functions on SAE level 4 and 5. The question is, where is the best place to put the sensors? IAV is working with the ZKW Group in the "Dragonfly" project to see whether the front and rear headlamps would be suitable for this purpose. Initial results already show them to be clearly superior to conventional setups in a number of different situations.

Our development is modeled on nature. Dragonflies, for example, do not miss anything. Thousands of tiny eyes register every movement in a flash. Furthermore, the insects also have 360° all-round vision. It is therefore no great surprise that IAV and the ZKW Group have called their joint project "Dragonfly", because the focus is on providing autonomous vehicles with sensor systems that are also capable of registering all relevant signals from their surroundings.

But this demands a large number of individual sensors. And the number is sure to increase even further, at the latest with the introduction of highly automated driving functions on SAE level 4 and 5, including above all cameras as well as radar and lidar sensors. Some companies, particularly in the USA, accommodate the complex technology in roof superstructures. The advantage is that the superstructures are easily transferred to other vehicle platforms.

On the other hand, they spoil the look of the vehicle, are detrimental to its aerodynamic drag and restrict the use of parking garages.

The vehicle's smart corners: protection from dirt and damage

IAV and ZKW therefore advocate a different solution. Both companies want to fit the sensors and corresponding evaluation algorithms in the "smart corners" of the vehicle. This refers to the front and rear headlamps. "There are a number of advantages here. The sensors are relatively well protected from damage and also from dirt, for example with cleaning systems, the lotus effect and anti-fog coating. Thermal management is already present, and there is also scope to accommodate the interfaces to the vehicle", says Carsten Simon, who is in charge of IAV's Perception & Concepts team.

ZKW's contribution to the Dragonfly project consists in supplying the headlamps with integrated sensors. IAV gets the test vehicle ready and supplies the algorithms for HMI and for autonomous driving. The company already has a wealth of experience in this respect gained, for example, from the Symbioz project for Renault (highway chauffeur) and the HEAT project (driving on SAE level 4 in an urban area). Altogether, IAV test vehicles have already completed several hundred thousand kilometers in autonomous driving mode and provided valuable insights.

The engineers focus on various scenarios for their tests: firstly, as a "highway chauffeur" that can see ahead and back and is capable of changing lane automatically. Secondly as an assistant for crossroads or for parking garage exits with the ability to see round corners. And thirdly, as a solution to fulfill the future ENCAP 2024 requirements including the ability to detect an approaching cyclist when maneuvering the vehicle out of a parking space.

Good view of adjacent traffic

Since mid-2019, a test vehicle has been providing proof that the Dragonfly concept already works well in practice. IAV and ZKW have fitted the front headlamps of a production vehicle with four cameras: two to see to the front and two to register adjacent traffic at the sides. "The sensors work very well on the motorway and in urban traffic", reports Simon. "In a crossroads situation, for example, the cameras in the corner give a clear view with good visibility of vehicles crossing from the right or left, far superior to what a human driver can see, particularly at complex crossroads."

And that is not all. The new concept also scores better than the standard setup today (a camera in the middle of the windscreen, together with radar and lidar sensors as well as front and surroundings cameras in the radiator) by offering better protection from parking rowdies and other environmental factors. "It is therefore quite likely that in future, numerous sensors for vehicles on SAE level 4 and 5 will in fact be fitted in the front and rear headlamps. There is even a smart module for driver assistance SAE level 2 consisting of a complete package of sensor systems and functions for integration in headlamps", says Simon.

Gradual upgrade of the test vehicle

At the moment, the test vehicle only has cameras at the front headlamps. But that won't be all. The next step will add two lidar sensors for better depth information and even more detailed environment recognition thanks to sensor fusion. The plan is then for two cameras in the rear headlamps to provide information about the traffic behind the vehicle. With the fourth upgrade, the test vehicle will be equipped with a whole range of sensors. The already integrated systems will be joined by two additional cameras at the front and two lidar and radar sensors at the rear. By this point at the very latest, the test vehicle will truly deserve the project name.

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Smart Engineering for Smart Mobility: Out of the Comfort Zone

Stefan Schmidt, Executive Vice President Project Management Office on Smart Engineering

The automotive industry is facing its greatest challenges – with huge impacts on the development process. Our engineering has to adapt and become smarter. Only whoever implements that with all speed will remain viable in the future. But what exactly does the term 'smart engineering' mean?

First of all, smart engineering is the prerequisite for something that is the only possible solution: smart mobility. Smog in cities, climate change, the overloaded infrastructure, land consumption, and Vision Zero are all increasing the pressure to shift away from individual urban mobility and towards new forms such as sharing or pooling. Naturally, vehicles ultimately form the backbone of mobility in this case as well, but it is their control that makes the difference and mobility 'smart'. By this, we mean an intelligent system that transports people and goods efficiently and as sustainably as possible. Low-emission and economic drive technologies are crucial, of course.

We need smart engineering for smart mobility. I regard this as a modern, digitally supported development process for intelligent, networked mobility. To achieve this, it is not sufficient to simply want a 'smartphone on wheels'. Instead, the specific analysis of all components and systems along the entire added-value chain is required, so we have to learn to analyze not only vehicles but also their subsequent operators and passengers. The use of a requirement-controlled shuttle therefore requires not only a state-of-the-art vehicle but also a booking platform and an operator with corresponding logistics planning. The integration of municipalities, local public transport, and the local utilities for providing the charging infrastructure is also necessary. This example shows that the requirements of all stakeholders also have to be considered from the word go.

This is something completely new for our industry. And this is why there are currently no engineering systems with which we can cover the entire added-value chain. We are already good at analyzing vehicles or fleets, but the stakeholder chain has become longer, so the stakeholders will also have to be 'given a voice' in future development processes. 'Systems engineering' was introduced in the 1960s as an interdisciplinary approach for the development and implementation of complex technical systems and projects. It is based on the assumption that a system is more than the sum of its subsystems in terms of its functionality. At that time, development was focused on analyzing the overall contexts.

While classic systems engineering methods are document-based, model-based systems engineering (MBSE), as a continuation of the idea, enables a development concept that focuses on the integration of models along the system life cycle. MBSE is based particularly on development phase-specific digital system models that are created and integrated throughout the product development process. This enables the modeling of a complete system that accompanies the entire development process and includes all model elements. In this process, the developers use the customer requirements to determine exactly what the right tools for their needs are. They are then described at different abstraction levels with the aid of various models. The consistency of the data and the avoidance of media discontinuities and duplicate entries pose a challenge.

We are in the process of implementing such a new engineering platform at IAV. It will support this holistic approach, for example, by handling all product features in structured form and having a 'single point of truth' for each data point. Our new engineering platform will form the foundation for numerous, proven domain tools that we implement throughout the development process. Depending on discipline, we also employ the latest methods such as virtual and augmented reality, artificial intelligence, and agile working methods in smart engineering.

In addition to the technology, the employees and their qualifications are especially crucial to this transformation. They have to speak a common language and rely on a coordinated development process. Smart engineering will also involve new roles such as the system architect, the requirements engineer, or the systems engineer. We will define these roles in the context of our strategic personnel planning. In our Digital Lab, IAV employees can familiarize themselves early on with the requirements of smart engineering.

Smart engineering is the fundamental transformation of our way of thinking in development. This new paradigm necessitates a major effort and creative thinking right now, because it offers the only possibility of also being able to meet the complex challenges of smart mobility in the future. This does not involve following every fashion trend or buzzword but specifically taking new approaches on the basis of sound analyses. In other words, whoever wants to remain relevant in the coming years must leave their comfort zone right now.

»Smart engineering is the fundamental transformation of our way of thinking in development.«

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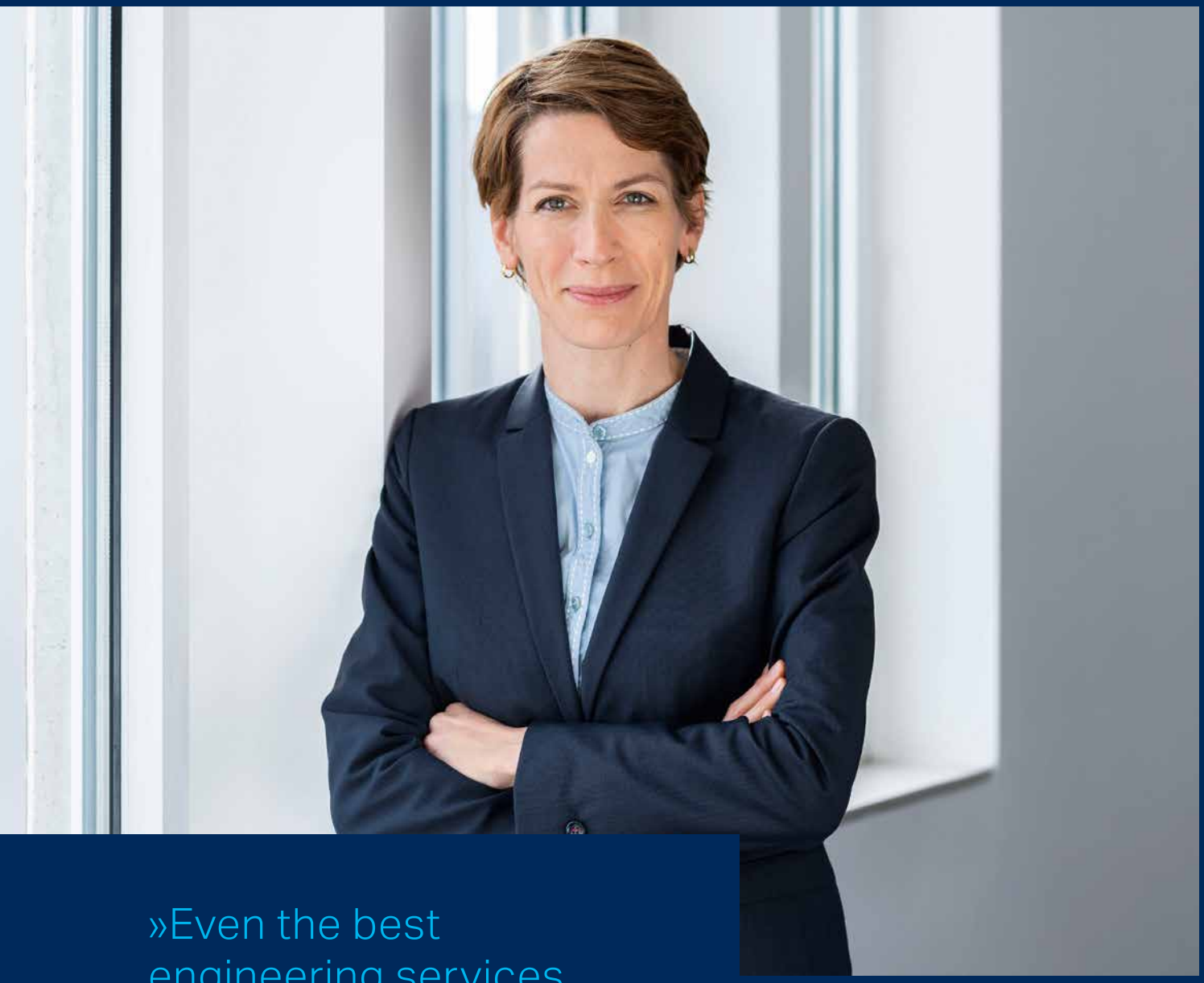

»Even the best engineering services are worthless if we do not ensure that we act in conformity with the rules and with integrity.«

Ms Hahn, how is compliance wchanging at IAV?

Hahn: I'll be honest: we are restructuring. But we have a solid basis on which we can build to satisfy our high demands on our compliance standards and to meet international requirements.

Internally, we are calling this Compliance 2.0. I think that expresses it rather well. This versioning indicates a new level of maturity, the only difference being that this involves a management system rather than a technology. It reaches deep into the company's management, into governance tasks, and therefore into the day-to-day business of the operational units.

Compliance work never stops. Each further measure, each further training course, and our work on penetration within the company indicate that there will probably be a 3.0 as well. That is part of our system: we are a continuously learning organization that recognizes when it is time for the next stage.

The Culture Makes All the Difference

Christiane Hahn, Chief Compliance Officer at IAV, on the reorientation of the compliance organization.

And what exactly defines the leap from IAV compliance 1.0 to IAV compliance 2.0?

Hahn: For the first compliance generation, we concentrated on establishing structures within headquarters at IAV. These are defined points of contact that offer the managers and employees advice whenever it is needed.

We developed our Code of Conduct, added guidelines for risk prevention, and conducted training courses for all employees by means of e-learning and using face-to-face training for managerial staff. At the same time, we developed processes and structures that safeguard day-to-day business in terms of compliance and support the operational units in the development processes with internal compliance standards.

If I can just interrupt you there: that sounds rock solid.

Hahn: Yes, that's right. But it isn't enough. We critically analyzed the existing system and asked ourselves: What do we already have? What do we want? And how can we get there?

As a result, we are now specifically extending and improving in the direction of IAV Compliance 2.0: we are consistently aligning our compliance strategy with the corporate strategy. As the highest responsible entity, the management has bound 'compliance' closely to itself as a staff function. Thanks to this, we now have a completely different perception of our role as governance advisors to the management. I personally report directly to our CEO, Dr. Ulrich Eichhorn.

In addition, we are intermeshed on a partnership basis with the operational units, the first line of defense. The consequence of this is that compliance is integrated better into daily business – in Germany and equally at all IAV sites around the world.

We intensively examined what image we want to have within the company, and we are working continuously to achieve that. We want to make it crystal clear to everyone how compliance measures safeguard the company's success.

One major challenge is to establish and integrate our technical compliance in a form that is tailored to IAV. As yet, there is no best practice that we were able to use as a guide. There is practically no other engineering company like IAV anywhere in the world – with so many employees, customers, projects, and new technologies. But we can also make good use of our spirit of innovation in this.

You mentioned technical compliance: what exactly does that mean?

Hahn: Technical compliance is intended to help the management and the technical team leaders and project managers in the operational units make compliance-conformant decisions and to assist each employee in acting accordingly. This means that everybody recognizes technical risks in their turbulent daily routine. Gray areas are revealed and viable solutions are developed with a competent team. The whole process takes place quickly, clearly, and verifiably.

We are now taking an iterative approach during the establishment phase of our technical compliance. We are developing new organizational structures, systematically extending our information systems, and simultaneously turning specifically to our managerial staff and employees in order to ensure effectiveness.

So that we become 'enablers' rather than 'show-stoppers' we have established a company-wide team of experts. This is the core element of our technical compliance. These colleagues carry a huge responsibility, and I am delighted that committed and experienced IAV employees and managers are ensuring penetration, making sure that all of the technical divisions are involved, and therefore assuming responsibility.

New technologies are developing rapidly and are continuously leading to changes in regulatory requirements.

Christiane Hahn, who has been IAV's Chief Compliance Officer since July 1, 2019, wants to foster a culture of compliance and integrity that backs up the company's self-perception. She has made it her aim to ensure that technical compliance risks are also reliably controlled worldwide throughout the company.

What do you believe is the most convincing argument for IAV employees to turn to this expert team?

Hahn: Even the best engineering services are worthless if we do not ensure that we act in conformity with the rules and with integrity. That should be reason enough to seek the support of the expert team in the event of uncertainties or anomalies.

Let me make this clear using a couple of example situations. In the same way that we are familiar with gray areas in the case of gratuities or events in commercial dealings, there are also gray areas for technical regulations that require interpretation. This is where our employees can turn to our experts in order to clarify questions regarding conformity with technical regulations. However, the team will also raise questions by itself.

Another situation is when IAV moves into a new business area or we are working on innovations and do not yet know which laws will apply to them in the future. As a responsible company, IAV does not want to exploit a legal vacuum. In such situations, our expert team will pose particularly demanding interpretation questions and advise colleagues.

However, the team also acts as a 'reporting channel'. This means that if an employee or also a business partner suspects irregularities in technical processes or solutions, they can turn to the team. The advantage of this expert team is that it offers professional scrutiny without any conflicts of interest.

Did the diesel issue give rise to the establishment of a technical compliance system at IAV?

Hahn: Yes.

Did IAV not have any comparable measures beforehand?

Hahn: Of course, our engineers and managerial staff have always integrated risk assessments and necessary review processes into their developments and customer projects. However, there are cases in which two parties' objectives clash and cannot both be met in unison. It is then fascinating how the conflicting objectives are dealt with. In such situations, the compliance goals should always prevail in the future. And in my view, that is the expression of a good compliance and integrity culture.

Integrity culture is an interesting keyword. Is that a trend followed by all companies undergoing a renewal process after a legal compliance incident?

Hahn: I can't say whether it applies to all companies that are undergoing such a process as we are. But I can explain what our objective is and how we arrived at it.

Although the motivation for compliance arises from legal risks, it has to be implemented using completely different tools. The employees should never be given the impression that there is a department within the company that tells all of the others what is and is not legally and ethically permissible, and that's that.

That would be a false image. Instead, it is much more concerned with anchoring a deep and fundamental set of integrity values in all employees. We are all fully aware that excellent engineering also needs an excellent corporate culture. That is what we are working on.

You are currently being chaperoned by an independent compliance monitor ...

Hahn: That's correct – and the result of events whose origins go way back. The compliance expert Frances McLeod and her team are acting as the monitors here. Although being chaperoned by a monitor is quite a challenge for us, we are convinced that we are not only doing the right thing in terms of the changes being demanded by the monitor but that this is also appreciated by our customers. Because ultimately, of course, our customers are equally interested in the fact that an engineering partner does not compromise on legal conformity as they are in the technological quality of the services that are provided. At the end of the day, it is our customers' name on the products, not ours.

But isn't it worrying for customers when IAV suddenly has US American authorities at the company?

Hahn: That image is incorrect. We do not have US American authorities at the company; we have an independent monitor that acts as a certifier.

The monitor checks adherence to the conditions to which we committed as part of our settlement agreement with the US Department of Justice. They particularly include continuing to strengthen our compliance. The crucial point is that Frances McLeod and her team are offering us a wealth of expertise and experience. This is a major opportunity for us, and we intend to make the best possible use of it.

So how exactly do you make sure that confidential customer data remain protected?

Hahn: Know-how protection and protecting the confidentiality of our customers' information and data are our top priority. Naturally, this also applies in our relationship with the monitor. The monitor has no access whatsoever to customer-specific information or data that are subject to corresponding non-disclosure agreements. The monitor is interested in how we ensure adherence to compliance measures in our processes – which therefore involves an insight into our internal working methods and procedures.

Compliance is occasionally accused of slowing things down and complicating them. How do you deal with that?

Hahn: There may be situations in which a timeout is appropriate. But confronting the risks of new technologies and digitalization with deceleration? That would be like somebody lighting a fire because he is cold and then pouring water on it!

That's not our style. We are a company that is involved in shaping progress. Our engineers are not technology fanatics. Naturally, we always want to fulfill the customer's order as well as possible. But the developments that we work on also always have to benefit man, the environment, and society now and in the future. That is only possible if rules are strictly adhered to and our employees rely on their individual judgment at the same time, because there will not and cannot be a precisely appropriate regulation for each and every situation.

Our leadership team plays a very special role in all of this, because it exemplifies this attitude and has to project it into the team. I see a great willingness to do this here, and that gives me a very positive feeling.

Ms Hahn, what is your personal wish for IAV?

Hahn: I assume that, in the future, we will encounter a high number of challenging, completely new, and different situations and questions that we cannot even begin to imagine or assess yet. That is precisely when a strong corporate and integrity culture will help us to make the right decisions. This is the contribution that compliance can, intends to, and will make in safeguarding the future of IAV.

An upright and moral attitude and a strong backbone will help us and our customers to safely reach our destination even over rough and unknown terrain.

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Always at the Optimum Operating Point

Set-up of the test bench

Drive power: 75 kW
Delivery rate up to 900 kg/h
System pressure range up to 4 bar
Tank volume: 3,000 l
Heat output: 57 kW
Temperature controlled up to 250 °C

Test bench operating points

Absolute pressure: 1.2 bar to 4 bar
Air mass flow: 125 kg/h to 900 kg/h
Temperature: room temperature up to 250 °C
Minimum coolant temperature: -7 °C
Coolant volume flow: 0 to 30 l/min
Coolant concentration: any

The heat exchanger test bench supplies data for parameterizing cooling circuit models

IAV's heat exchanger test bench permits detailed analysis of different components in the vehicle's cooling system. Among others, it is thus possible to elaborate model-based thermal management strategies that bring about noticeable reductions in the energy demand for cooling circuits in passenger cars and commercial vehicles.

Vehicles have to become more efficient. Temperature control can make an effective contribution in this respect. In the past, cooling circuits were designed for maximum load. Nowadays, however, the desire to keep the whole system at its optimum operating point drives the development of model-based temperature

control. The target of such an approach is to reduce the vehicle's overall energy demand. In combustion engines, savings of this kind reduce fuel consumption. Optimized temperature management is also beneficial to alternative drive concepts. They can be deployed as an attractive means for expanding efficiency and range. However, achieving this goal depends on precise parametrization of the models on which the control system is based. IAV therefore has a heat exchanger test bench which does precisely that: it generates a compressed air flow with precisely defined characteristics such as temperature, mass flow and pressure. It is possible to define the volume flow, coolant temperature and concentration for the coolant circuit.

The heat exchanger test bench produces measurement readings such as temperature of the incoming and outgoing flow of compressed air, air mass flow, pressure, surface temperature, temperature of the incoming and outgoing coolant flow, coolant delivery rate and coolant pressure. Measurement data is logged with MATLAB via the CAN bus. "The heat exchanger test bench can be used to examine charge air coolers in cars with combustion engines, as well as cooling components of electric and fuel cell vehicles", reports Dr. Alexander Herzog, Technical Consultant for Air Systems and Energy Distribution at IAV. "It has already been put to successful use in various development projects for volume production."

Automatic parametrization

IAV's heat exchanger test bench is ideal for precise measurement of various components in vehicle cooling systems at different steady-state and dynamic operating points. This includes charge air coolers or exhaust gas recirculation coolers, as well as temperature-controlled parts in alternative powertrains. Our experts are thus also able to find critical load points and profiles. It can moreover be used to automatically generate parameters for physical models of the coolant circuit saved in the engine control unit. In addition, test processes can be defined and run automatically.

The test bench has already proved its worth in a research project to find a model for the coolant concentration in the vehicle. "This is important because heat exchanger efficiency depends on the glycol level in the coolant", says Herzog. "Now, if the vehicle user tops up the coolant, this will alter the concentration." Precise model-based control of the temperature therefore depends on having a model to compute the current coolant concentration. IAV has already proven this and generated a patent (DE 10 2016 124 652 B3 2018.02.01), based on model computation parameters from IAV's new heat exchanger test bench.

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Our Engineering – What We Develop

Passenger cars and vans

Chassis
- Axle systems
- Brakes and traction control systems
- Chassis control systems
- Steering systems and power-assisted steering
- Tank systems
- Testing and calibration
- Wheels and tires

Cockpit
- Cockpit concepts
- Cockpit electronics
- Instrument panel
- Operating concepts

Combustion Engine
- Charge motion
- Computation and simulation
- Diesel engine: thermodynamics and combustion
- Engine algorithm calibration
- Engine development and design
- Exhaust gas aftertreatment
- Exhaust gas recirculation (EGR)
- Gaseous-fuel engines
- Gasoline-engine thermodynamics and combustion processes
- Injection and fuel supply systems
- Mechanical system and endurance testing
- Supercharging

E-Traction
- E-fleet operation
- Fuel cell systems
- HV energy management
- HV energy storage systems
- HV safety
- Powertrain electrification

Exterior
- Body structure – doors, flaps and lids
- Body styling parts and glazing
- Front-end and rear-end systems

Gaseous-Fuel Vehicles
- Concepts
- Dealerships
- Gaseous-fuel vehicle construction (CNG/LPG)

Hybrid
- Components
- Energy management
- Integration

Interior
- Audio and voice
- Insulation
- Interior / details
- Seat systems

Mobility
- Car2X
- Fleet support
- Mobile applications
- Mobility concepts
- Telematics solutions

Powertrain Concepts and Integration
- Energy management
- Powertrain concepts
- Powertrain integration
- Powertrain NVH
- Product data management
- Prototyping
- Thermal management

Powertrain Electronics
- Algorithm and software development
- Control unit hardware
- E-drive management
- OBD development
- Powertrain calibration
- Release and production support
- Sensors and actuators
- System architecture and powertrain design

Product Life Cycle
- Aftersales
- Quality assurance

Transmissions
- Algorithm and software development
- Automatic transmissions
- Computation and simulation
- Concept development
- Continuously variable transmissions
- Design
- Dual-clutch transmissions
- Hybrid systems
- Mechanics and software testing
- Transmission control calibration
- Transmission geometry integration

Vehicle Electronics
- Antenna layout and integration
- Body electrics / electronics
- Electromagnetic compatibility
- Hardware and software development
- Light and vision
- Low-volume production vehicles
- Vehicle electric system

Vehicle Functions
- Air-conditioning
- Driver assist systems
- E/E architecture integration
- Energy management
- Functional safety
- Integral safety
- Overall vehicle validation
- Special-purpose vehicles
- Thermal management
- Vehicle concepts
- Vehicle NVH

Vehicle Safety
- Occupant safety, partner protection, restraint systems
- Overall vehicle crash testing
- Safety electronics

Moves You

Commercial Vehicles and Work Machines

Chassis
- Brakes and retarder
- Chassis

CO_2 Efficiency
- Aerodynamics
- E-drives and hybrids
- Gaseous-fuel engines

Driver Assist Systems
- Cooperative functions
- Driver warning functions
- Light assistant
- Longitudinal and lateral guidance control

Driver cab
- Cockpit electronics and infotainment
- Exterior
- Interior
- Air-conditioning
- Light and vision
- Structure

Functional architecture
- Vehicle electric systems
- E/E architecture
- Functional safety

Hardware and Software Solutions
- Apps
- Control units
- Production-ready software modules
- Telematic systems

Powertrain
- Calibration and diagnostics
- Exhaust gas aftertreatment
- Internal combustion engines
- Powertrain electronics
- Transmissions
- Tank systems

Safety
- Cooperative / anticipatory safety
- Occupant protection
- Partner protection

Transport and Logistics
- Market and business models
- Telematics and fleet management
- Truck-trailer combinations
- Vehicle diagnostics

Work and Agricultural Machines
- Display and control terminal
- Electrification
- Engines for mobile work machines
- ISOBUS

Energy Supply

- Autonomous energy supply
- Energy conservation
- Energy distribution
- Energy generation
- Energy storage

Methods and Test Facilities

Development Methods
- Design of Experiments (DoE)
- Model-based calibration
- Test bench automation

Patents and eDiscovery
- Data analysis
- Defense against patent lawsuits
- Research

Project Management Office
- Coaching and training
- Methods and processes
- Project management and steering

Test Facilities and Laboratories
- Components
- Overall vehicle
- Overall system and subsystems

Quality Management

Product Solutions

- Electronic systems and components
- Development tools
- Vehicle retrofitting

Digitization

- Competency development
- Business models
- Solutions
- Change management

We look forward to hearing from you!

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IAV Vaal

Simulation System for Valve Trains

IAV Vaal simulates the complete system behavior of fully variable valve trains for use on HiL test benches. Errors can be implied in the motion sequence for diagnosis and testing of typical error patterns.

IAV Meru

Indication System

The most recent generation is available as IAV Indicar
IAV Indicar is a measuring instrument for calculation, display and evaluation of thermodynamic variables of combustion engines.

IAV Meru

Knock Indication System

The most recent generation is available as IAV KIS4
IAV KIS4 is a measuring instrument for calculation, display and evaluation of thermodynamic and knock-specific variables of combustion engines.

INCA-FLOW

Guided Calibration and Automation

The calibration tool INCA-FLOW supports project managers, algorithm developers, software developers and calibration engineers by accelerating and improving the development process as part of calibration. It makes expert know-how available throughout the company.

IAV Kasai

Model-Based Calibration

The most recent release is available as IAV EasyDoE

Design of Experiments (DoE) is a method that permits efficient parameterization of engine control units. The software permits a complete DoE as well as calibration and optimization of control unit maps.

IAV Mara

Automated Measurement Data Analysis

IAV Mara is used for the search and flexible analysis of measurement data. Complex analyses and visualization can be configured according to the user's specific requirements, without needing any programming skills. For sophisticated use, recurrent tasks can be automated and calculated by means of distributed computing on cloud-based systems.

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IAV Engine is an integrated tool for all-encompassing dimensioning and optimization of mechanical drives in the powertrain.

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Processing, Validating and Visualizing Calibration Parameters

IAV Macara is used to visualize, compare, collate and re-generate calibration data.

IAV Flexmore

List comparison, processing and analysis

IAV Flexmore quickly and easily provides an overview of different list information so that it can be easily analyzed and processed.

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Efficient and automated reporting

IAV Teslin is a high-performance tool for the consistent reporting of endurance runs. It accompanies the entire diagnostic process from data acquisition to visualization and automated reporting.

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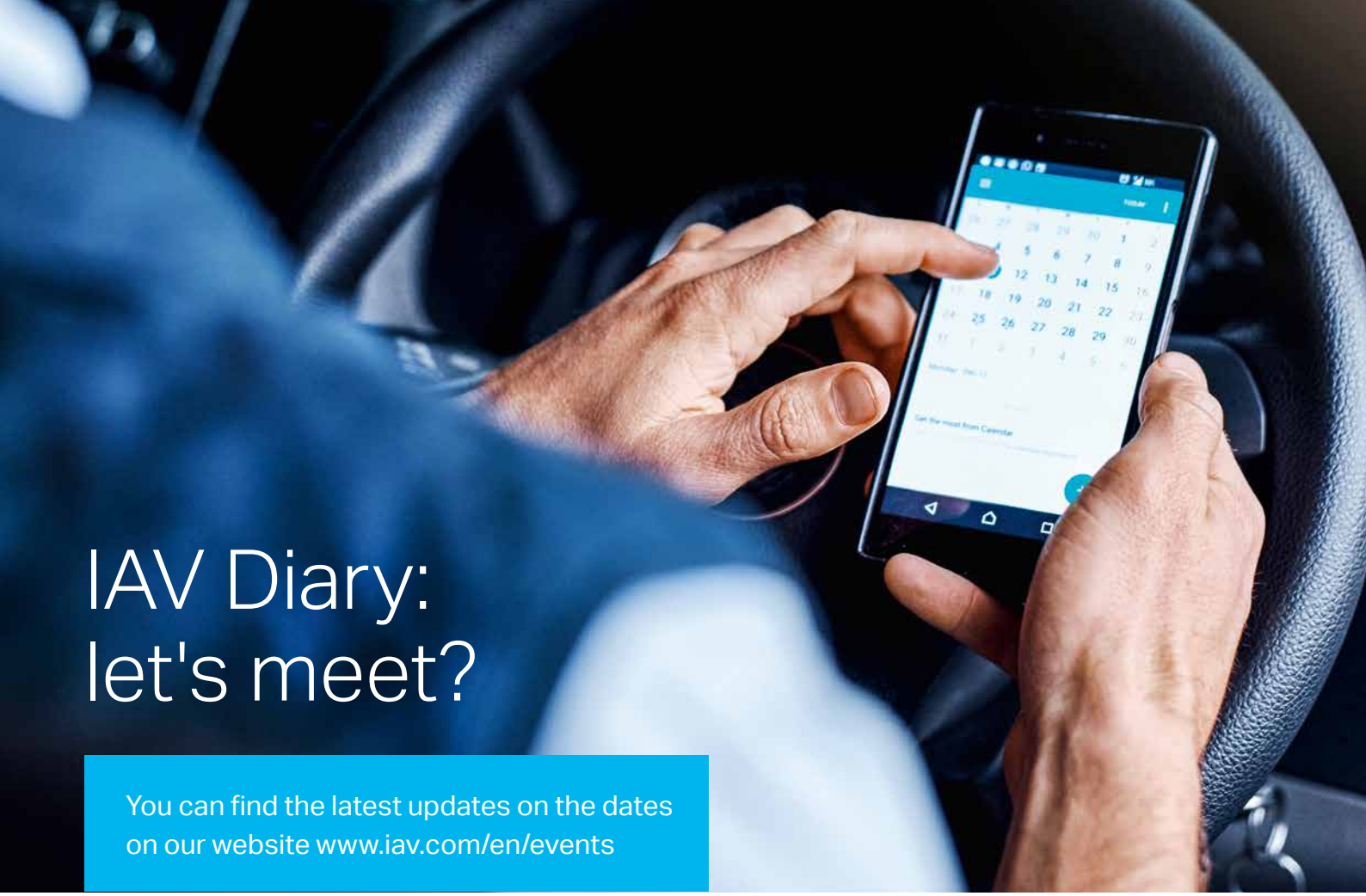

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