automotion

01 | 2021

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TECHNOLOGY

IAV develops highly automated, interconnected and compact agricultural machinery with partners.

SOFTWARE

No chance for hackers: Cybersecurity for fully interconnected vehicles.

ENERGY

IAV Optera calculates future-proof power grids with minimal costs.

Hydrogen

What politicians are planning, what industry is demanding and what IAV is contributing in terms of technology and know-how

SIDEKICK SOFTWARE

Dear readers,

Is hydrogen the universal solution for a climate-neutral future or is this just the pipe dream of enthusiastic engineers?

1
Atomic number

1.0079
Atomic mass

2.2
Electronegativity

0.09
Density

H

Hydrogen

It is clear that hydrogen produced from renewable energies is an attractive option thanks to its versatility and environmental compatibility, for example in the energy sector, in transport and in industry. But it is also a fact that hydrogen technologies have been considered the key to a successful Energiewende for many years, but have not yet made the breakthrough to market maturity.

Now politicians in Brussels and Berlin are stepping on the gas and investing billions in funding to create a climate-friendly energy system. This is the vision, based on the many options for using hydrogen, which we examine in our cover story starting on page 10. The fact that the road to the hydrogen economy is not free of hurdles, however, is shown by a guest article from the German Engineering Federation (VDMA), which sums up the to-do list of policymakers (page 16). Far above all the necessary but sometimes tough discussions, the stratospheric flyer is making its rounds, a technical marvel with IAV-Know-how for closing terrestrial radio gaps, powered by a hydrogen fuel cell system. This may sound like a dream of the future, but it has already outgrown the laboratory phase and is enjoying specific usage plans (page 26).

An OEM's future position in fully interconnected and electric mobility depends largely on its competence in the field of software – another focus of this issue. In an interview with our software expert Markus Blonn, we look at competitors from the USA and the role of EDLs in software development. We show how to use the possibilities of digitalization in a targeted way with the health assistant in the car, the smart anti-hacker tool and with intuitive HMI approaches in the field of user experience (pages 32, 36, 40 and 46).

Automotive engineering is and remains IAV's core business, but our aspirations go far beyond this. We want to make the world a little better with our engineering. For example, we support the energy sector with software to optimize power grids. And in agriculture, we are focusing on autonomous, resource-saving machines in the sense of smart drive concepts (pages 50 and 54).

Especially in challenging times, purpose and values are important guidelines for IAV. You can find out how we are realigning our compass to achieve our goals on pages 58 to 61.

In line with the changes in our industry, automotion will be appearing in a new look from 2021. Our goal is to integrate more innovative text and image design as well as more external expertise. With all the change, however, one thing remains guaranteed: We will always be based on clean work with an eye for detail. This applies to our engineering, and to the articles in this automotion.

We wish you a stimulating read!

MATTHIAS KRATZSCH
President, CEO
IAV GmbH

KATJA ZIEGLER
President, CFO
IAV GmbH

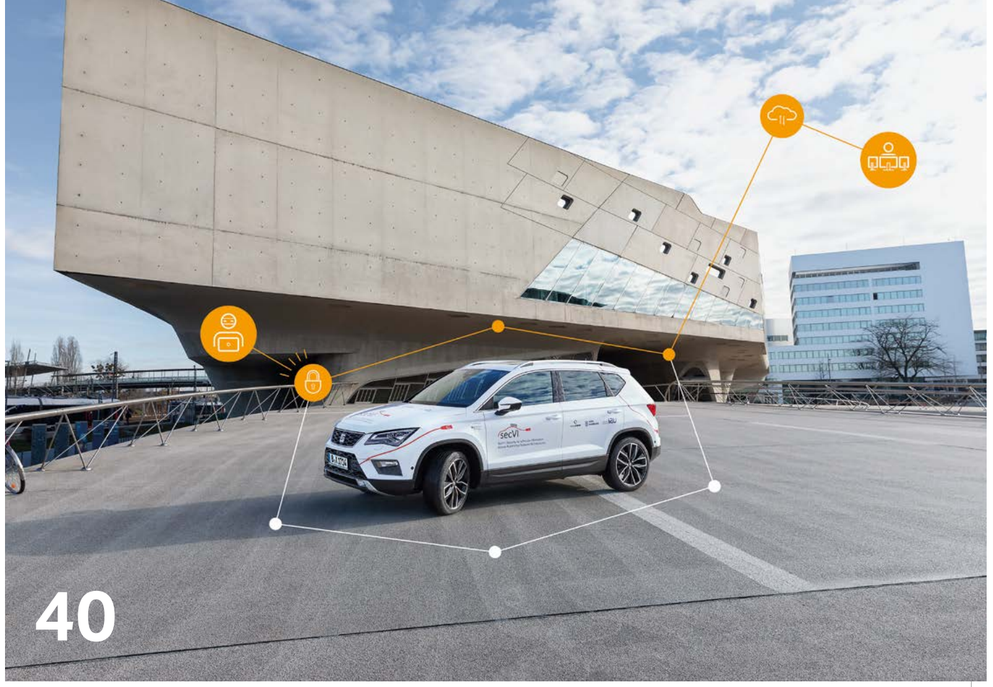
DR UWE HORN
President, CHRO
IAV GmbH

How do you make a Human Machine Interface (HMI) tangible before the vehicle goes into pre-series development? IAV has created a development environment that uses virtual reality (VR) and augmented reality (AR) to configure user interfaces quickly and easily.

32

The central role for tomorrow's mobility is played by the software. Markus Blonn, Senior Vice President Network Software at IAV, on a market in motion.

Content



26

Out of space: IAV is developing a fuel cell system for use in the stratosphere.

A

Automated underground

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IAV is testing the technical use of teleoperating test vehicles in the former Asse II salt mine on behalf of the Federal Company for Final Disposal. These are to be used in the salvage of low- and medium-level radioactive waste. The current WLAN standard WiFi 6 is being evaluated as a possible communication technology. For the project, IAV is setting up a test vehicle including a workstation for the control system. To this end, the automotive developer is equipping a scaled vehicle with sensors, control hardware and software and WiFi 6 communication technology and installing a control station for remote control. Furthermore, IAV is implementing a control instance for communication and recording of measurement data. The appeal of the project stems from the unfamiliar terrain for us and the opportunity to contribute towards the safe operation of underground applications," comments Mirko Taubenreuther, Senior Vice President Automated Driving Functions at IAV.

PHASE II

At every turn

Together with the Karlsruhe-based FZI Research Center for Information Technology, IAV is embarking on the next stage of development with its intelligent Cargobike. Equipped with an electric motor, the cargo bike recognizes the driver and autonomously follows them at walking pace. Via the Digital Service Assistant Dashboard (DiSA), the most important operating and maintenance parameters can be viewed and evaluated – at any time and worldwide.

The prototype presented for the first time at CES 2020 still had a bought-in steering system from the automotive sector. In the second phase of the project, which is funded by the German Federal Ministry of Transport and Digital Infrastructure, this component and the braking system will be replaced by components developed in-house. They will significantly reduce the overall weight of the cargo bike and improve handling. In addition, the software of the cargo bike is to be further developed.

The plan is to bring the cargo bike closer to potential series production readiness in the second phase. In the long term, it could be used in a variety of industries. Logistics companies and mail carriers could use it for their daily work and stow letters and parcels in the bike's access-secured box. It could also be used on factory premises to carry out logistics tasks with the support of the cargo bike.

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"To put it casually: waltzing is out. In the future, the state must also be able to tango in F&I policy!"

PROF. UWE CANTNER
Chairman of the Expert Commission on Research and Innovation, on future research and innovation policy (Source: EFI press release, February 24, 2021)

Street View for waterways

The network of federal waterways is around 7,300 kilometers long and transports around 230 million tons of goods every year. To ensure that this runs smoothly and economically, the waterways must be kept functional and efficient. In the RiverCloud research project, IAV and its partners are investigating whether the rivers and canals can be better managed in the future through the use of AI, drones and unmanned boats. To this end, an autonomous and interconnected system consisting of a watercraft and a missile will investigate waterways in tandem and collect infrastructure data about them. This data will help to manage the expansion and maintenance of waterways more quickly and easily.

The tandem system acts cooperatively and records the required data autonomously using the various measuring systems. In the project, IAV is responsible for integrating the measurement and control technology in the drone and watercraft as well as automating them. Equipped with radars, echo sounders, lasers and cameras, the system is thus able to record all infrastructure data – for example, buildings, properties and green spaces – and to create a digital flat image of the watercourses and their surroundings. A bathymetric lidar built into the flight system can even scan the river course down to the bottom, collecting data on water depth, for example.

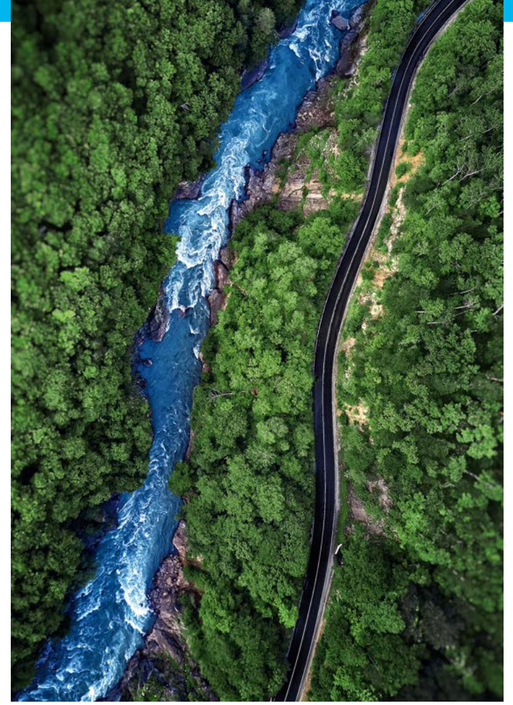
The system will be deployed in the test area, a section of the Rhine in the Koblenz area, starting in the spring. Then the collected, high-resolution data will be compiled and integrated into models and workflows in water management and transport hydraulic engineering.

Supported by:

Federal Ministry of Transport and Digital Infrastructure

mFUND Das Startkapital für die Mobilität 4.0

on the basis of a decision by the German Bundestag



Around

7300

kilometers is the length of the network of federal waterways.

www.rivercloud.org

RIVERCLOUD" PROJECT

PARTNER: RWTH Aachen University, Geodetic Institute and Chair of Civil Engineering Informatics & Geoinformation Systems (consortium leader); Research Institute for Water and Waste Management at RWTH Aachen e.V.; IAV GmbH; SEBA Hydrometrie GmbH & Co. KG; Orthodrone GmbH; Federal Institute of Hydrology; Federal Waterways Engineering and Research Institute. The project is funded by the German Federal Ministry of Transport and Digital Infrastructure.

Vienna stage clear for hydrogen

IAV presentation at the Vienna Motor Symposium

Hydrogen not only opens up great opportunities in the energy, industry and power sectors, but can also play a central role in the mobility of the future. With its study "Hydrogen drive in competition with combustion engines for fossil fuels and battery-electric drive," IAV will be demonstrating at the Vienna Motor Symposium (April 29-30, 2021) the different potentials of H_2 mobility in various vehicle classes, both in comparison with each other and with battery-electric drive. Furthermore, it becomes clear that waiting for sufficient "green" hydrogen in terms of rapid CO_2 reduction is not an option, but that both turquoise and blue hydrogen make sense as transitional solutions. In addition, the paper presents technical solution approaches to enable further improvements in the energy efficiency of H_2 propulsion concepts.

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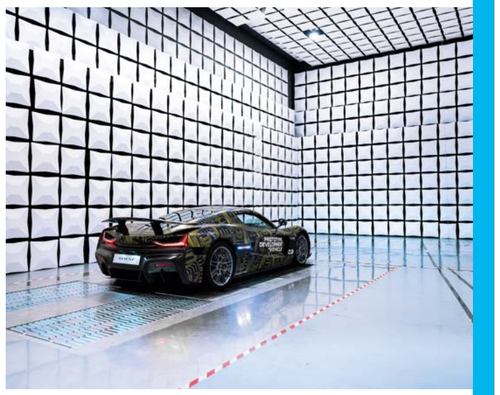
A

At the limit



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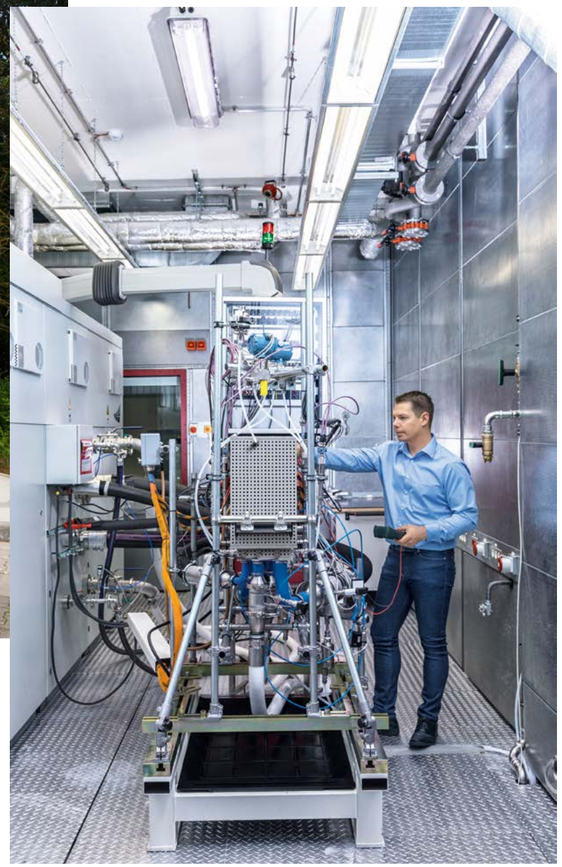
412 km/h fast, an engine torque of 2,300 Nm and acceleration from 0 to 100 km/h in less than two seconds: With the C_Two, e-sports car manufacturer Rimac is pushing the limits of what is technically possible. And, quite incidentally, with their new top-of-the-range model, the Croatians are showing that vehicles without exhausts can also thrill and raise the pulse of die-hard car fans. IAV cooperates with Rimac in testing the electric powertrains of the C_Two, carries out the environmental tests on the powertrains and the EMC tests with a partner and advises the manufacturer on the final development of the components. "The high performance of the drive system is unique. It means an endurance test not only for the components, but also for our test benches, which have to operate with up to 1 MW of power," says Erik Schneider, Senior Vice President E-Traction & Hybrid Drivetrain at IAV. "The test bench infrastructure in Stollberg allows us to test the components repeatedly under laboratory conditions with reliable and reproducible test parameters. In this way, we can specifically search for weak points and eliminate them in the final development steps with Rimac."

More information at iav.com

Turning the tide



The start of the hydrogen era

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Hydrogen has long been regarded as the energy carrier of the future. Until now, there has been a lack of regulatory pressure to give this beacon of hope a specific perspective for its breakthrough. This has changed, particularly as a result of the Paris climate protection agreement of 2015 and numerous international H_2 programs. The versatile gas is also experiencing a renaissance in Germany. The time seems ripe for an Energiewende driven by hydrogen, as an overview of the resource's potential, its deployment options and political action shows.

Efficiency improvements throughout the development process of fuel cells and electrolyzers

T

The potential of hydrogen and its importance for the defossilization of entire economies are undisputed: H_2 moves vehicles via fuel cells and combustion, can be used industrially – for example in the chemical industry and steel production – and can replace fossil fuels in aviation and building heating. In Germany, hydrogen could solve the storage problem for renewable energies and, in the production of synthetic fuels, contribute towards lower CO_2 emissions from the new and existing fleet.

And that's not all: Hydrogen could supply energy to areas that cannot be electrified and serve as a key link in sector coupling, the energy dovetailing of transport, electricity, heat and industry:

GREEN DEAL
The EU Commission's concept is intended to make the transition to a resource-conserving economy in Europe a success. The roadmap for making our continent climate-neutral by 2050 includes measures in all sectors of the economy. These include boosting the economy through green technologies, creating sustainable industry, promoting green mobility, curbing pollution and decarbonizing the energy sector. The use of renewable hydrogen will play an important role here in the future. As part of the Green Deal s, the EU plans to mobilize at least 100 billion euros between 2021 and 2027 in regions struggling most with economic transformation.

NATIONAL HYDROGEN STRATEGY
With the National Hydrogen Strategy, the German government is setting a framework for action for the future production, transport, use and further use of green hydrogen. The NWS defines steps to help achieve the Paris climate protection targets, create new value chains for industry and advance energy policy cooperation at the international level. The German government is providing 7 billion euros for the market ramp-up of H_2 technologies in Germany, plus a further 2 billion euros for international partnerships. Electrolysis capacity of up to 5 gigawatts is to be achieved by 2030, with a further 5 GW to be added by 2040 at the latest.

With the conversion of renewable energies to hydrogen (power-to-gas), green electricity can be stored in the medium and long term and used in a variety of CO_2-reducing ways between sectors.

"There will be no getting around the need to introduce hydrogen as an energy carrier and the products based on it to the market much more quickly in the next few years if we want to gradually achieve the climate targets," says Stefan Siegemund, Head of Sustainable Mobility and Alternative Energy Sources at the German Energy Agency (dena).

NATIONAL HYDROGEN STRATEGY, EU GREEN DEAL

The political course for this has been set: With both the German government's National Hydrogen Strategy (NWS) and the EU Commission's Hydrogen Strategy, authoritative decisions were made in 2020 for the development of a hydrogen economy. The core objective: Hydrogen should make a significant contribution towards climate neutrality. The German government is providing 7 billion euros for the market ramp-up of H_2 technologies in Germany and a further 2 billion euros for international partnerships – in the view of policymakers, valuable impetus for overcoming the economic consequences of the coronavirus pandemic.

The background to the plans to make hydrogen the central lever for a CO_2-neutral economy is the European "Green Deal." The EU Commission's concept is intended to make the transition to a resource-conserving economy in Europe a success. With the NWS, Germany is setting the regulatory framework to push research and development as well as the export and use of innovative H_2 technologies.

RESEARCH FUNDING FROM THE FEDERAL GOVERNMENT

H_2 and fuel cell technology is not yet competitive as an alternative to battery-electric and internal combustion engine drives in transportation due to excessively high costs, including the still low volumes. The National Organization Hydrogen and Fuel Cell Technology (NOW) GmbH, which coordinates funding programs for sustainable

"There will be no getting around the need to introduce hydrogen as an energy carrier and the products based on it to the market much more quickly in the next few years if we want to gradually achieve the climate targets."

STEFAN SIEGEMUND,
Head of Sustainable Mobility and Alternative Energy Sources at the German Energy Agency (dena)

mobility on behalf of federal ministries, is therefore supporting suppliers, for example, in the development of more cost-effective and lighter pressure tanks for H_2 storage – the much more expensive and heavier pressure tanks have so far been an obstacle to market ramp-up.

"We are focusing on areas that we can influence," explains Elena Hof, Team Manager of the National Hydrogen and Fuel Cell Technology Innovation Program (NIP) at NOW. "This is about promoting development, but also about networking within the industry so that manufacturers can start projects together."

Whether rail, bus or passenger car – the demand for H_2 deployment options in transport and

"We focus on areas we can influence, for example strengthening the supplier industry."

ELENA HOF,
Team Manager at the National Organization Hydrogen and Fuel Cell Technology (NOW) GmbH

government funding is increasing everywhere, according to NOW. Heavy-duty transport promises the greatest rates of increase in the use of hydrogen, partly because batteries are not yet designed for the weight and long distances of commercial vehicles and there is a lack of sufficient charging points.

"The topic is currently very prominent, and the political will is great to do a lot there," Hof says, predicting wider use of hydrogen in trucks from 2025.

The world's largest car market, China, also has a complex funding landscape for H_2-mobility. In its new 15-year plan, the central government aims, among other things, to create an infrastructure for fuel cell vehicles and promote the development of H_2-powered buses and trucks.

INTERNATIONAL H_2 COOPERATION

In addition to funding, German policymakers are also focusing on partnerships with countries that, thanks to their geographical location, can produce hydrogen efficiently and thus also supply Germany. At the end of 2020, 22 EU states including Germany and Norway declared their intention to support the development of a European value chain for green hydrogen in particular. Similarly, the German government is funding a project to further develop electrolysis components in Saudi Arabia as part of the NWS.

CRITICISM FROM INDUSTRY

For the business community, the policy plans do not go far enough. In order to leverage the potential of hydrogen for climate protection and jobs, companies are pushing above all for a higher statutory minimum share of renewable energies in final energy consumption for transport and thus for more ambitious implementation of the EU requirements. For example, the planned electrolysis capacity of 5 gigawatts by 2030 could already be achieved by the middle of the decade, says the German Engineering Federation (VDMA), whose members are among the leading suppliers of electrolysis and H_2 processing plants.

"Politicians must generate a demand market for hydrogen so that it is worth investing in this technology," says Peter Müller-Baum, Managing Director of the Power-to-X for Applications AG at VDMA. "The path taken is right, but the pace is too slow."

In addition, the burden of the EEG levy on green electricity for hydrogen production must be eliminated and, if necessary, other levies must be reduced in order to achieve an attractive hydrogen price.

H_2 PIONEER JAPAN

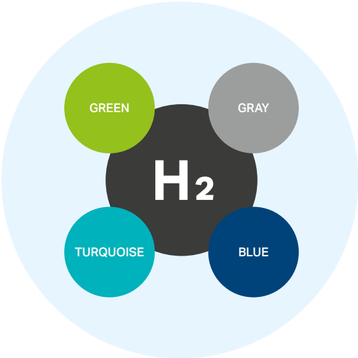
The example of Japan shows how this can be done. The island nation propagated the path to a hydrogen society years ago and is pursuing this change with vigor. The domestic market for fuel cell vehicles is to be massively expanded by 2030 to include trucks, buses and forklifts. Analogously, the use of H_2 via fuel cells is increasing in the heating and power supply of homes. In addition, the country is taking a more pragmatic look at the use of different H_2 variants depending on their origin, prioritizing security of supply and market incentives.

GREEN HYDROGEN IS THE TRUMP CARD

For the German government and industry, Japan's path could be exemplary in some areas, argues Siegemund of the energy agency dena. "The use of blue hydrogen may have advantages for long-term market development if there are also firmly defined targets for green hydrogen," Siegemund said. The NWS is clearly committed to green hydrogen, which is produced CO_2-free from renewables, but also allows for transitional use of blue hydrogen, which is produced through CO_2 capture and storage and is considered CO_2-neutral.

One thing is clear: The foundation for entry into a modern hydrogen economy has been laid with the unequivocal commitments made by politicians and industry. H_2 fuel cell technology is absolutely ready for the market and demand is also broad-based. "Now we need to ramp up production and distribution of hydrogen to generate cost advantages and make the technology competitive," Hof says. "I believe that in ten years, we will actually already be living in a different world," predicts VDMA representative Müller-Baum. "We are in the middle of the development towards a defossilized world."

SMALL H_2 COLOR GAGE



GREEN HYDROGEN
is produced from renewable energies and is completely CO_2-free. Electrolysis uses renewably generated electricity to break down water into its components hydrogen and oxygen. The federal government's strategy is to make green hydrogen marketable and enable its industrial production, transportability and usability.

BLUE HYDROGEN
is gray hydrogen whose CO_2 is captured during production and stored, for example, by "carbon and capture storage" (CCS). The CO_2 generated during hydrogen production thus does not enter the atmosphere and hydrogen production can be considered CO_2-neutral.

TURQUOISE HYDROGEN
is produced via the thermal cracking (pyrolysis) of methane. Instead of CO_2, solid carbon is produced. Prerequisites for the CO_2-neutrality of the process are the heat supply of the high-temperature reactor from renewable energies and the permanent bonding of the carbon. In addition, turquoise hydrogen has the potential to be CO_2-negative if biomethane and renewable energies are used for hydrogen production instead of fossil methane.

GRAY HYDROGEN
is generated from fossil fuels. Usually, natural gas is converted into hydrogen and CO_2 by steam reforming during production. The CO_2 is subsequently released unused into the atmosphere, thus reinforcing the global greenhouse effect.

Source: German Federal Ministry of Education and Research (www.bmbf.de)

Politics has not yet reached its goal

Hydrogen economy Germany

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"To make rapid progress on climate protection in Germany, it is essential to use all available instruments. The German government must set a regulatory framework that creates incentives to invest in this technology."

PETER MÜLLER-BAUM,
Managing Director AG Power-to-X for Applications,
German Engineering Federation (VDMA)

There are signs of euphoria in the energy industry: Against the backdrop of the Paris climate targets, companies are working on industrial restructuring and surprising with innovations – with the goal of CO_2 neutrality in 2050 always firmly in sight. The reason for the upbeat mood is hydrogen, a versatile energy carrier and storage medium and a central element in the Energiewende plans being pushed by the European Commission and the German government.

The transformation to a hydrogen economy offers Germany a major industrial policy opportunity with the prospect of countless jobs and extremely great potential for sectors such as the steel and chemical industries as well as mechanical and plant engineering, without whose technologies in the field of H_2 and power-to-X products this mammoth task would be impossible to implement.

But for hydrogen to actually begin its triumphal march, a new course must be set. Because as long as fossil fuels are cheaper than "green molecules," hydrogen produced from renewable energies can hardly be competitive. As part of its National Hydrogen Strategy (NWS), the German government is spending large sums of money – a total of 7 billion euros to promote H_2 technologies – to move the issue forward. However, with its target of 5 gigawatts of planned electrolysis capacity by 2030, the NWS falls short of the capabilities of plant manufacturers.

The real Achilles' heel of the NWS, however, is its lack of effective measures to stimulate a necessary demand market for hydrogen applications in Germany. Without market-oriented stimuli, policymakers run the risk that financial support will fizzle out without effect. Suitable levers for artificially increasing the price of fossil products would be a significant CO_2 price or – as long as CO_2 prices are not high enough – a legal constraint such as Green energy quotas.

The European Renewable Energy Directive (RED II), in which the EU determines the minimum amounts of renewable energy for the transport sector, offers a great opportunity to bring hydrogen or hydrogen derivatives to the market. Unfortunately, efforts on the part of policymakers to implement RED II have been woefully inadequate to date. However, if we want to achieve an economically driven market ramp-up of hydrogen and CO_2 savings in transport, then a quota for hydrogen and synthetic fuels is urgently needed.

Only with an ambitious implementation of RED II and the use of synthetic fuels is a transport turnaround and the achievement of the EU climate targets possible. And for the existing vehicle fleet with internal combustion engines, a rapidly effective CO_2 reduction can only be achieved with the use of so-called e-fuels. In order to make rapid progress on climate protection in Germany, all available instruments must be used, including by policymakers. The federal government must set a regulatory framework that creates incentives to invest in the relevant technologies. Unfortunately, however, we are often too slow and always try to discuss the best possible solution before taking action. Unlike here in Germany, where the issue of hydrogen has only really taken hold since last summer, Japan, for example, was quick to focus on a H_2 society and is systematically pushing ahead with its implementation.

It is clear that in the 2030s, the world will look technologically different than it does today. I am convinced that the production of hydrogen will then have been introduced on a large industrial scale worldwide. Thanks to hydrogen, we will see an intelligent linking of sectors such as electricity, industry and transport. Hydrogen will then be used in many industrial processes and will largely replace fossil fuels.

Complex preparation of a simple molecule: the hydrogen infrastructure

In order to achieve the goal of climate neutrality in 2050, greater use of renewable energies is necessary. Hydrogen as a versatile energy carrier and storage medium can form the basis for the necessary sector coupling. For this to succeed, the entire H_2 infrastructure must be considered and potentials leveraged.

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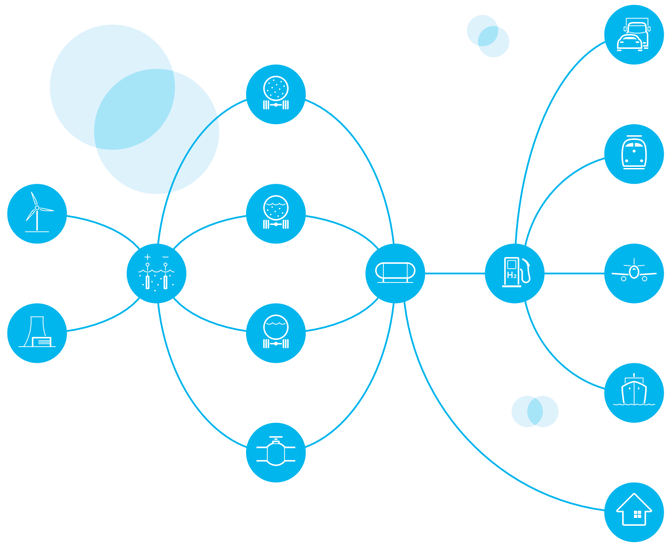

Hydrogen will play a central role in future energy systems and promises a wide range of potential applications, including in transportation and industry. "Within this context, the intelligent expansion of the hydrogen infrastructure is the decisive basis for, among other things, the expansion of hydrogen mobility," says Ralf Wascheck, Head of Department for Fuel Cell and Hydrogen Mobility at IAV. The high complexity of hydrogen generation, transport and consumption requires project-specific planning.

"And one of the roles the IAV Group plays here is that of a market enabler by providing consulting services in the early phases in order to strengthen our core business, engineering, at a later stage," explains Dr Sebastian Kahlbau, Head of Technology Strategy at IAV's consulting subsidiary Consulting4Drive (C4D). The following section uses practical examples to show which improvements and further developments are possible along the value chain by IAV in close cooperation with C4D.

ELECTROLYSIS FOR SUSTAINABLE MOBILITY

Electrolyzers that generate the energy-rich gas from electricity and water are available in many performance classes: Central plants with electrical input powers in the 100-megawatt range supply industry, feed into the gas grid and form the basis for the production of so-called e-fuels. In contrast, there are locally available electrolyzers in the power range of less than 1 MW. IAV has worked with partners to demonstrate such a decentralized and compact plant and has further developed the central components such as the pressurized electrolysis module and the system control. Ralf Wascheck explains the technical concept: "Thanks to the modular design, the performance class can be increased cost-effectively, which is why this electrolysis concept is ideally suited for supplying filling stations in the future – for example, for public spaces or for logistics companies' own operations as well as for local public transport. The concept combines the dynamics of PEM electrolysis with the robustness of alkaline technology."

EFFICIENT LOGISTICS CHAIN

Depending on the existing infrastructure and the quantities to be transported, hydrogen is mainly transported either in gas pipelines or – again in gaseous or liquid form at -253°C – by tanker truck. The legal requirements for the conversion of existing natural gas pipelines have not yet been clarified; liquefaction, on the other hand, requires an immense amount of energy.

There are no patent solutions for the choice of storage technology and the design of the logistics chain. IAV uses its own optimization tools to enable H_2 consumers to reduce costs nevertheless. Taking acquisition costs and other factors into account, suitable technologies can be selected, necessary subsystems dimensioned and delivery intervals determined, for example.

The installation of electrolyzers and hydrogen filling stations requires extensive knowledge of a legal situation that is undergoing considerable change. In addition to designing the systems and developing efficient operating strategies, IAV therefore provides project planning support – both when converting existing systems and when installing new ones, taking into account applicable standards and directives.

OPTIMIZING THE CONSUMPTION SIDE

At the end of the value chain are possible consumption sectors such as transport, buildings, industry as well as power generation. IAV offers a wide range of services here, especially in the field of transportation with concepts for hydrogen combustion engines, for example, as well as fuel cells for a variety of applications.

Suitable filling stations are needed for the various applications of hydrogen in mobility. IAV provides support here in mechanical, electrical and thermal integration and has detailed thermodynamic simulation models of all relevant components. In addition to the automotive and aviation sectors, activities are being extended to the maritime and rail sectors.

In addition, IAV is looking at stationary consumers, for example the building sector. In future quarters, energy in the form of electricity, natural gas, heat and hydrogen can be purchased at prices that fluctuate over time. Specified load profiles for electricity and heat, for example, can be implemented in a cost-optimizing manner. Depending on the scenario, hydrogen can be converted back into electricity with fuel cells, burned in combined heat and power plants or thermal baths, fed into the gas grid or used to supply a connected filling station. Efficiency losses from the electrolyzer and fuel cell can be stored in the form of heat and used specifically for heating.

However, conventional control strategies do not do justice to the more complex infrastructure. IAV is therefore developing open- and closed-loop control systems that optimize the mode of operation, taking into account forecast electricity prices and load profiles. "While the algorithms remain largely unchanged, the respective adjustment is made via defined model parameters such as the output of the electrolyzer or the size of the hydrogen storage tank. Scalability is ensured by transferring the one-time high development effort to numerous systems," explains Michael Nöding, development engineer in the Hydrogen Infrastructure and Electrolysis team at IAV.

Step on the gas: blueprint for H_2 engines

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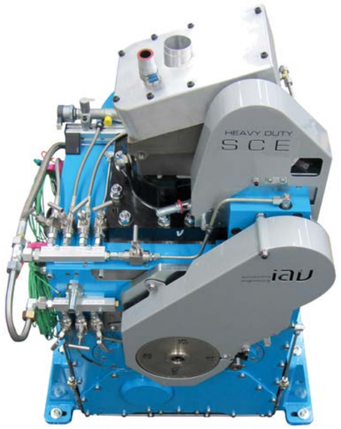

The single-cylinder research engine with a displacement of two liters is an important component of IAV's hydrogen activities. It enables realistic investigations of typical heavy-duty usage scenarios.

Hydrogen combustion engines are climate-friendly and theoretically ideally suited for commercial vehicle applications, but also for use in agricultural and construction machinery and passenger cars. IAV is conducting extensive research into the H_2 combustion process with the aim of making hydrogen-powered "zero emission" vehicles ready for series production by 2025 .

The European Union has significantly increased the pressure on commercial vehicle manufacturers: As early as 2025, their fleets must emit a full 15 percent less CO_2 than in 2019, and another 15 percent five years later. One thing is clear: The EU's climate targets cannot be achieved with highly efficient diesel engines alone. The EU also expects a minimum proportion of zero-emission vehicles, i.e. models with battery electric drive (BEV) or fuel cell (FCEV) or a hydrogen combustion engine (H_2-ICE).

The EU's CO_2 targets are giving new impetus to hydrogen mobility. It can be applied where battery electric drives have system-related disadvantages – for example in long-distance heavy goods traffic. Technically, the hydrogen combustion engine will be ready for series production in commercial vehicles in the near future, and the hydrogen fuel cell is already being tested in the first near-series truck fleets. And in terms of operating costs, parity with diesel should also be established in a few years.

EASIER TO INTEGRATE INTO COMMERCIAL VEHICLES

In certain cases, the hydrogen combustion engine can show its advantages. This makes it a readily available candidate for CO_2-neutral commercial vehicle applications. "With the fuel cell, there are still questions to be answered, such as cost, durability and package," says Dr. Christoph Bertram, Senior Vice President Commercial Vehicle Powertrain at IAV. "The hydrogen combustion engine on the other hand, is easier to integrate into commercial vehicles, plus existing production capacity at OEMs can be further utilized." Hydrogen consumption with a highly efficient engine for long-haul trucks with a large proportion of highway traffic is very good and competitive with the fuel cell, simulation results show.

IAV therefore stepped up its H_2 combustion engine activities three years ago, focusing in particular on applications in heavy commercial vehicles and mobile machinery. An important component of IAV's hydrogen activities is a single-cylinder research engine with a displacement of two liters, which enables realistic investigations of typical heavy-duty usage scenarios. "We want to use it, for example, to better understand internal and external mixture formation and optimize the parameters for subsequent series production use," explains Marc Sens, Senior Vice President of Powertrain Advanced Development at IAV. "The focus of our investigations is the question of how to achieve the required power density and range with a hydrogen combustion engine."

CHALLENGING COMBUSTION

In particular, it is important to get to grips with combustion. This is because hydrogen has a high laminar burning velocity, tends to burn irregularly and also loads the engine with high pressures. The research engine is ideally suited for investigating measures against preignition. It can also be used to determine the nitrogen oxide and particulate raw emissions and compare different solutions for injecting the fuel – intake manifold injection, for example, leads to more homogeneous mixtures in the combustion chamber than direct injection. Direct injection, in turn, offers advantages in terms of achievable power density and in avoiding backfire events. This is why IAV favors direct injection of hydrogen in future series developments.

The performance and environmental friendliness of H_2 combustion engines also depend on the tank system and exhaust aftertreatment system used. "We are therefore looking at various storage options in addition to the engine, for example gaseous or liquid," Bertram reports. "In terms of exhaust aftertreatment, it's a question of which components are really needed in terms of product costs, such as a urea SCR catalyst, possibly in combination with an H_2-DeNOx catalyst for the nitrogen oxides and a filter for oil-based particulates."

INTEGRATED, MODEL-BASED DEVELOPMENT METHODOLOGY

The aim of IAV's experts is to be able to offer their customers ready-made concepts with series-production capability for combustion processes, exhaust gas aftertreatment and tank systems – always optimally tailored to the desired application scenario. "From our tests with the research engine, we have derived generally valid models that predictively describe the combustion process or knocking, for example," says Sens. "This flows into our development methodology from conception to the model-based application for series development. A transfer to different engine classes is a given and important because hydrogen burners are also interesting for heavy SUVs, light commercial vehicles and even passenger cars."

IAV customers also benefit from extensive test resources for hydrogen powertrains – after all, it is often a matter of converting a compression ignition engine into a spark ignition engine. As early as 2008, IAV had developed an initial H_2-combustion engine right up to the pre-series stage. "That's why we could now move very quickly from a research engine to a full engine," says Sens.

"There is no right or wrong. There is only suitable."

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Truck buyers have a choice of different climate-friendly energy sources for their powertrains, such as hydrogen or e-fuels. But which of these technologies fits the particular application scenario? And how does low-emission mobility affect the total cost of ownership for customers? IAV has developed a methodology that helps OEMs such as freight hauler, public transport operators, fleet operators and start-ups alike to develop market-ready deployment scenarios.

"Our customers are faced with the big question of which powertrain technology they should use in the future," explains Florian Brandau, Head Business Development Commercial Vehicles E-Mobility at IAV. On the one hand, there are the vehicle manufacturers who have CO_2 fleet targets to meet and have to offer their products on the market at an attractive price, says Brandau. "On the other side are fleet operators, logistics companies, freight forwarders or public transport operators. For them, the total cost of ownership (TCO) of a vehicle is what matters in the end." IAV can develop cost and technology scenarios for both, OEM and operators.

A cost calculation alone hardly offers the customer any added value. Rather, it is the combination of technology and profitability considerations that helps them make the right decision for them. After all, in addition to technological hurdles and questions such as the maturity of the technology in the field, other factors are important – such as the purchase price of the vehicle, system efficiency and fuel/energy cost, tax and toll charges, and resale value in a volatile market environment.

LOOKING TO THE FUTURE

In addition, corporate strategies often play a role in the decision for an alternative drive system, such as favoring certain technologies like batteries, fuel cells or hydrogen combustion engines. "Very different scenarios exist," says Tom George, Head Business Development Commercial Vehicles at IAV. "For example, depending on where I get the electricity from, whether it's from public charging stations or even from my own production, there's a different price. Based on these parameters, a technology in the TCO may or may not work for a customer."

Through discussion with customers, coupled with a sound database and tailored presentation method, IAV can develop an objective basis for decision-making: "We can use our methodology to very clearly present common premises and specifications and compare them with those of our customers and users," says George. "There is no right or wrong. There is only a fit for our customer." It is important, however, to assess the trend for the future. "We can't just map the status quo, which is literally what I can experience on the road," Brandau explains. "But also, based on our technology expertise, how the market will develop in the next five to ten years."

JOINT SEARCH FOR PARTNERS

That's why the work doesn't end with advice on which technology suits the customer. IAV also helps – as the following example shows – in the search for cooperation partners for joint project implementation: A logistics company wanted to convert its fleet to hydrogen, but was unsure whether sufficient H_2 refueling stations would be available within the next five years. "We involved the company where it wouldn't break a confidentiality agreement, in our discussions with vehicle manufacturers or in our own projects," George says. "And together, we've been looking for someone who can build him a hydrogen fueling station." In the meantime, the two are looking for other partners for vehicle production. "Of course, we can't promise that there will be refueling stations or that hydrogen will be available cost competitive in the end," George emphasizes. "But we can support our customers with a detailed analysis and sound technology advice, helping to lower the barriers to market entry for them." And even after consulting has ended, IAV remains involved in projects and contributes towards their further development.

Green & affordable: new drive concept for sustainable mobility

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In heavy-duty transport, there are good reasons for using the hydrogen-powered fuel cell: It offers long ranges without CO_2 emissions. By contrast, European passenger car manufacturers are almost unanimously relying on purely electric cars. IAV has developed a functional powertrain with a fuel cell that brings the breakthrough of this environmentally-friendly technology a step closer in passenger car transportation as well.

Vehicles powered by fuel cells do not produce any emissions that are harmful to the climate or to health if hydrogen is produced using regenerative energy. They also offer longer ranges than purely electric cars, with shorter refueling times. Nevertheless, the market has not been gaining momentum for years: Only a few manufacturers offer models powered by H_2 fuel cells, they are expensive to produce and the filling station network is sparse.

"Current fuel cell vehicles rely on large fuel cell systems with high total output covering all operating points," says Dr. Dennis Backofen, Team Manager for Fuel Cell Model-based Development at IAV. "This brings with it various disadvantages, for example high costs, high weight and large space requirements, a high level of effort during application and, under certain circumstances, can lead to a short service life for the fuel cells."

NEW FUEL CELL CONCEPT: ONLY THREE LOAD POINTS

With the so-called LEAN fuel cell powertrain, IAV has developed an antonym – the full name "Low cost, Efficiency optimized, Attractive range and Non-complex" describes the basic idea: Instead of combining a large fuel cell with a small battery, IAV engineers are taking the opposite approach. "We use a small fuel cell with 40 kilowatts of power – in contrast, about 100 kilowatts are common in current fuel cell vehicles," Backofen said. "Another energy source in the LEAN concept is a battery with a capacity of 22 kilowatt hours. In currently available models, values of two kilowatt-hours are more common."

Through this approach, in addition to the costs as well as package, two other advantages can be generated: a significant reduction in the application effort and the aging of the fuel cell. Thanks to the large battery – which covers the dynamic requirements while driving – the fuel cell can be operated in only three operating points (close to idle with 4 kW, medium load with approx. 13 kW, full power with 40 kW). "This significantly simplifies the application and greatly reduces the dynamic load on the fuel cell – which significantly extends its service life," says Backofen.

DRIVE CONCEPT FOR THE COMPACT CLASS

IAV examined the performance of the new approach using a specific example. The starting point was a vehicle from the compact class weighing 1.6 tons, with a top speed of 160 kilometers per hour and a range of 700 kilometers in WLTP. The electrical energy storage system used is a so-called EMBATT battery with a storage density of 270 watt hours per liter – developed in a research project by IAV and partners with the aim of increasing the energy density of lithium-ion batteries to such an extent that purely electrical ranges of 1,000 kilometers are possible.

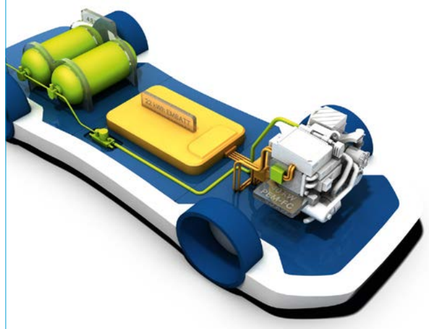
The optimized fuel cell is based on a current stack from mass production for which the developers assume various technical improvements by 2025, for example the reduction of activation, concentration and ohmic losses. The vehicle's tank can hold 4.8 kilograms of hydrogen at 700 bar pressure.

HIGHWAY TEST: GREATER RANGE THAN BEV

In a calculation, the developers compared the range and driving time of a Tesla Model 3 with the fuel cell vehicle. The result: At a speed of 130 km/h, the distance from Flensburg to Oberstdorf (983 km) can be covered with hydrogen in about eight hours and requires three refueling stops. If, on the other hand, the vehicle is purely battery-electric, the journey takes just under two hours longer with a total of four refueling stops. In addition to the faster refueling, the main reason for this is the greater range of the LEAN-FC-Powertrain vehicle at the stated speed compared with the battery vehicle.

The fuel cell variant also comes out ahead in terms of cost. Internal estimates of the prices for batteries, fuel cells and tank systems show that substituting the LEAN powertrain for the all-electric powertrain noticeably saves costs. "With our concept for the C-segment, we remain recognizably below the forecast cost trend for fuel cells," says Ralf Wascheck, Senior Vice President Fuel Cell and Hydrogen Mobility at IAV. "For many customers, this would be a conceivable option, especially since a top speed of 160 km/h is marketable."

LEAN FUEL CELL POWERTRAIN



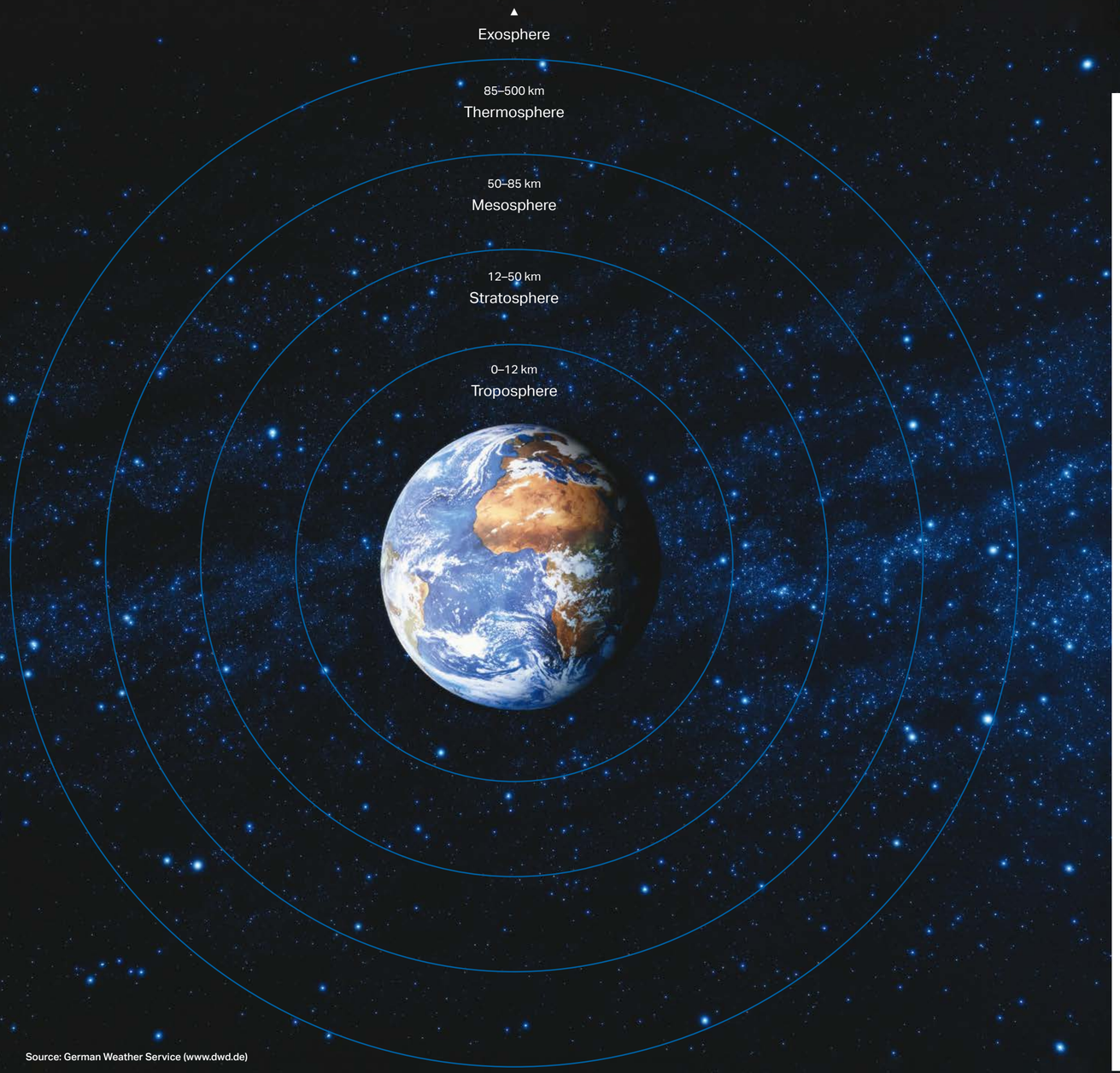
Fuel cell system	40 kW, PEM fuel cell
Battery	IAV EMBATT, 22 kWh, 270 Wh/l
Tank size	4.8 kg, 700 bar
Hybrid strategy	3-point operation with constant load, battery recharging

VEHICLE PERFORMANCE
(C-Class vehicle 1.6 t)

Hydrogen consumption (WLTP)	0.8 kg/100 km
Max. range (WLTP)	762 km
Max. speed	160 km/h
Acceleration (0-100 km/h)	7.6 s

EMBATT TECHNOLOGY

Powerful batteries for e-vehicles and alternative applications: As part of a research project, IAV is working with the Fraunhofer-Gesellschaft and industrial partners to develop a battery system that can be integrated directly into the vehicle chassis as well as processes for manufacturing the bipolar electrodes. Thanks to large-area electrodes in a stacked structure and efficient storage materials, EMBATT technology enables all-electric ranges of up to 1,000 km. The OEMs' goal is to increase volumetric energy density to 500 Wh/l and significantly reduce manufacturing costs. EMBATT can contribute to this – as well as to the industry's efforts to further reduce modules and complexity. There are already initial entrepreneurial approaches to the commercial further use of the technology.



Source: German Weather Service (www.dwd.de)

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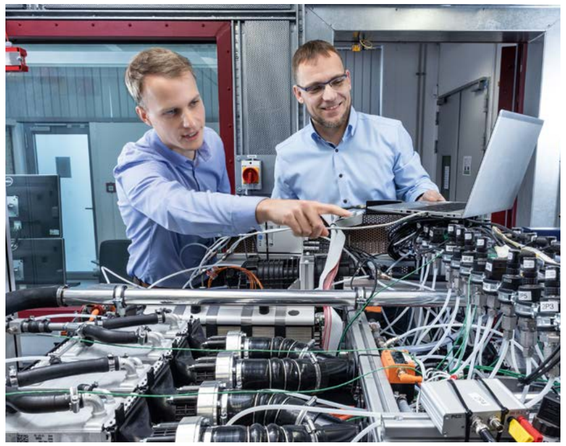
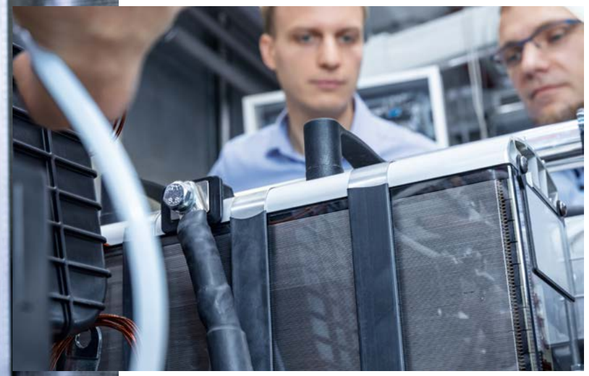
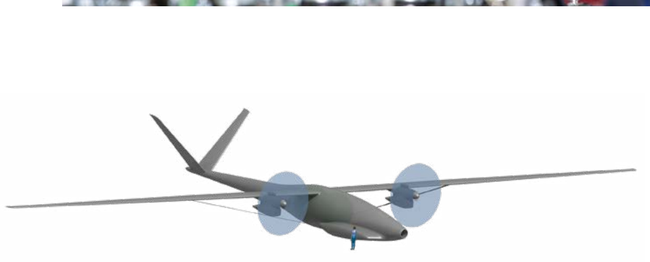


Rocket science: the fuel cell system demonstrator developed by IAV for use in the stratosphere.





KATHARINA SCHÜTTE,
Team Manager Fuel Cell
Systems Development

A tricky task: Powered by energy from fuel cells, an unmanned platform from the stratosphere is designed to close radio holes on the ground. However, a fuel cell system that is operational in the environmental conditions of the stratosphere does not exist. Actually. A brief history of how IAV solved the problem.

"I'll get back to you later, my reception is bad right now." A typical everyday sentence. Because whether on the train or on the highway, the danger of radio silence lurks above all where the next village or the next radio mast is out of range. According to a survey from October 2018, Germany alone counted 240 blackspots. But it is not always possible to erect radio masts – whether for economic or infrastructural reasons.

So why not simply solve the problem from the air? This thought brought the British start-up Stratospheric Platforms Limited (SPL) onto the scene. The idea: an unmanned platform that supplies regions with poor network coverage with cellular reception and high-speed internet from the stratosphere. Sounds like science fiction? But it is not. From an altitude of 18 kilometers, the unmanned flying object is supposed to eliminate blackspots on the ground. Since there is no air traffic in the stratosphere, the object could fly undisturbed over areas where there are only a few cell towers. And its antennas would provide excellent reception there.

In order not to harm the environment, the drone should be able to travel for as long as possible and also have an environmentally friendly propulsion system – a fuel cell system fulfills precisely these requirements. This should enable the platform to fly emission-free for nine days at a stretch. An ideal solution – if it weren't for the extreme environmental conditions at altitude: For fuel cells to work optimally, they need overpressure and a cooling water temperature of around 70 degrees Celsius. In the stratosphere, however, the air pressure is extremely low and the temperature is -60 degrees Celsius or less. And, of course, the drone's climb and descent into the stratosphere must also go smoothly.

To get the idea off the ground and first develop the concept for the fuel cell system and then get proof of function, SPL turned to IAV. "That was quite a challenge for us, also in light of the extreme operating environment," says Katharina Schütte, Team Manager Fuel Cell Systems Development, who was in charge of the project. It took a year and a half to design the system – with the support of IAV's fuel cell system simulation – and then set up the demonstrator. "From the idea, through assembly, to commissioning and functional verification, we handled the entire project at IAV – every engineer's dream," says Schütte, laughing. For the functional verification on the ground, components from the automotive industry were mainly used, as they had already proven their worth.

Katharina Schütte's team worked closely with IAV's networked software experts on the project. In addition, an external partner, Pankl Turbosystems GmbH, was on board to develop a multistage compressor for the project. This complex system was commissioned together with the partner at the IAV fuel cell test station. The multistage compressor made it possible to generate overpressure when air enters the fuel cell stack. "The compressor makes the fuel cell work as if it was on the ground. The low atmospheric pressure in the stratosphere is compensated by the system," says Schütte. What was challenging in the development of the system layout and control was the requirement that the fuel cell system must also provide the required power during climb and descent. The system thus has to function just as well at 1 bar ambient pressure as at 70 mbar in the stratosphere.

IAV's interconnected software experts also developed the control system for the system and implemented it on the basis of the Dragoon control unit, one of IAV's own developments. On the test station, the colleagues were then challenged once again – because in order to simulate the conditions in the stratosphere at the air inlet of the fuel cell system, some modifications had to be made to the test station. "Everything turned out very well. And in the end, we showed that the demonstrator is functional on the ground under simulated stratospheric conditions," Schütte says. According to SPL, the first unmanned platforms are expected to make their way into the stratosphere in 2024. The end of blackspots is not far off.

Small and fleeting: navigating the hydrogen storage universe

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Gaseous, liquid or material-based – hydrogen can be stored in different ways. IAV supports its customers in selecting the best option, the respective components and development up to series production maturity. In doing so, the experts always keep an eye on the legal requirements of the key markets.

Hydrogen is the future – it will play a key role in making mobility more sustainable. However, no one yet knows exactly where the journey is headed. "New CO_2 limitations have set the market in motion," says Philipp Rolke, Head of the Product Engineering and Validation Department at IAV. "At the moment, the focus is on fuel cells and hydrogen combustion engines as propulsion systems, while the fueling and supply system tends to be neglected in the discussion."

The fact that the entire topic is still in its infancy in terms of dissemination is also confirmed by a look at the filling station infrastructure. Around 120 filling stations in Germany will be offering mostly gaseous hydrogen by the end of 2020.

In addition to gaseous hydrogen storage under high pressure, approaches to liquid and material-based hydrogen storage are still the subject of intensive research. Anyone who wants to develop a hydrogen vehicle today and bring it to market is confronted with a number of complicated issues.

DEVELOPMENT, SERIES PRODUCTION AND APPROVAL FROM A SINGLE SOURCE

IAV is familiar with all aspects of hydrogen mobility from years of project work, including the requirements for mobile and stationary tank systems. "Precise knowledge of current tank systems is indispensable, because the right sensors, valves and heat exchangers are needed to feed the hydrogen to the fuel cell or combustion engine at the right pressure and temperature range," clarifies Frank Siefken, Project Manager at IAV. The developers also keep a constant eye on changes in global safety and approval regulations. This enables them to help customers into the saddle quickly and without complications, so that there are no nasty surprises later on when it comes to product liability.

If a customer decides to develop their own hydrogen vehicle, the experts can be on board from the first step in the component selection process. Safety is a key issue here. The high pressure rating of 700 bar in particular, combined with the volatile gas and extreme temperatures, places considerable demands on the material and requires intensive validation. "We can design the components, ensure their compatibility with the current tank systems and develop them to the point where they are ready for series production. The topics of manufacturing and a comprehensive test procedure for the vehicle system can also be commissioned through us," emphasizes Richard Trott, Technical Consultant for hydrogen and gas storage systems. This is a clear advantage for customers, as they can outsource the entire development process to a partner at Tier 1 level if required.

MISSION TO INCREASE EFFICIENCY

Currently, engineers in the industry around the world are working at full speed to design hydrogen tanks that are even more efficient – the aim is to increase storage capacity. "For the gaseous storage systems, high-pressure tanks are currently available in standardized pressure levels of 350 bar and 700 bar. In addition, there are considerations to introduce a further pressure stage with 500 bar in the future," reports Trott. Another solution is cryogenic storage. Storage densities could be increased by around 75 percent compared with gaseous hydrogen under 700 bar pressure.

Most recently, IAV experts have been working primarily on these cryogenic solutions. "We are registering that the market is currently heavily involved in the question of whether we will find predominantly compressed gaseous or cryogenic liquid hydrogen in vehicles in the future," says Siefken. "We can provide fully comprehensive advice in all areas of hydrogen storage and offer the most suitable solutions in each case." The experts have been able to prove this many times in projects with different types of vehicles, from passenger cars to heavy commercial vehicles.

For a long clutch life

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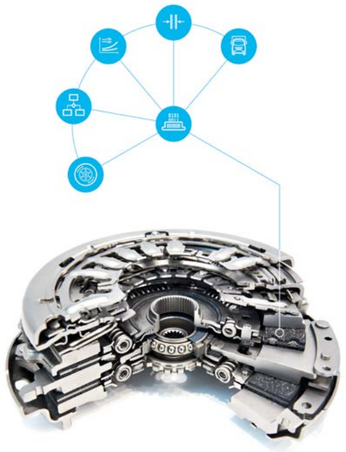
Unplanned breakdowns of commercial vehicles cost money – a problem especially for transport companies, which usually operate with low sales margins. One effective method of optimizing machine running times is predictive maintenance. To this end, IAV has developed an algorithm that determines the "state of health" of dry vehicle clutches in automated manual transmissions.



The clutch is the central link between the engine and the transmission – if it fails, trouble-free starting and gear changes are no longer possible. This makes it all the more important to surveil its condition continuously and precisely. To do this, an algorithm developed by IAV uses the standard speed sensors on the engine and transmission input side as well as the torque estimated by the engine control unit.

"With this information, we can determine the friction power per start-up process, which allows us to estimate the material removal and the change in the friction coefficient of the start-up clutch," explains Dr René Knoblich, Technical Consultant in the Transmission and Hybrid Systems department at IAV. "This allows us to predict when the vehicle needs to go to the workshop for maintenance, thus avoiding unexpected breakdowns."

And not only that: Because the current condition of the clutch is known, another algorithm developed by IAV can influence the starting behavior and in this way ensure that the component reaches a specified minimum service life. "Depending on driving style or payload, the clutch is subjected to different loads," says Dr Jörg Beilharz, Head of Department for Transmission and Hybrid Systems at IAV. "Our algorithm prevents particularly wear-intensive starting processes, for example. This reduces negative effects on the coefficient of friction and avoids increased material removal. "

The method is particularly suitable for small commercial vehicles that handle logistics on the "last mile" and where a particularly large number of start-up processes occur. An extension of the approach to wet start-up systems is planned.

READY FOR SERIES DEVELOPMENT

The physical model behind the new algorithm describes the wear processes and is based on numerous test bench measurements of different clutches that IAV has carried out together with TU Berlin. In the meantime, IAV's solution is so precise that nothing stands in the way of series development. The developers are also helped by the fact that the computing power of modern control units is now sufficient to permanently determine the condition of the clutch while the vehicle is in operation.

"At the moment, the estimation and control algorithms are still running on a prototype ECU," says Knoblich. "In the next step, we want to make the software fit for a production ECU." "Downtime and operating costs are important issues in the commercial vehicle sector," Beilharz concludes. "We are sure that demand for our new algorithm will increase strongly in the foreseeable future."

"IAV is not a commodity company, IAV is an original."

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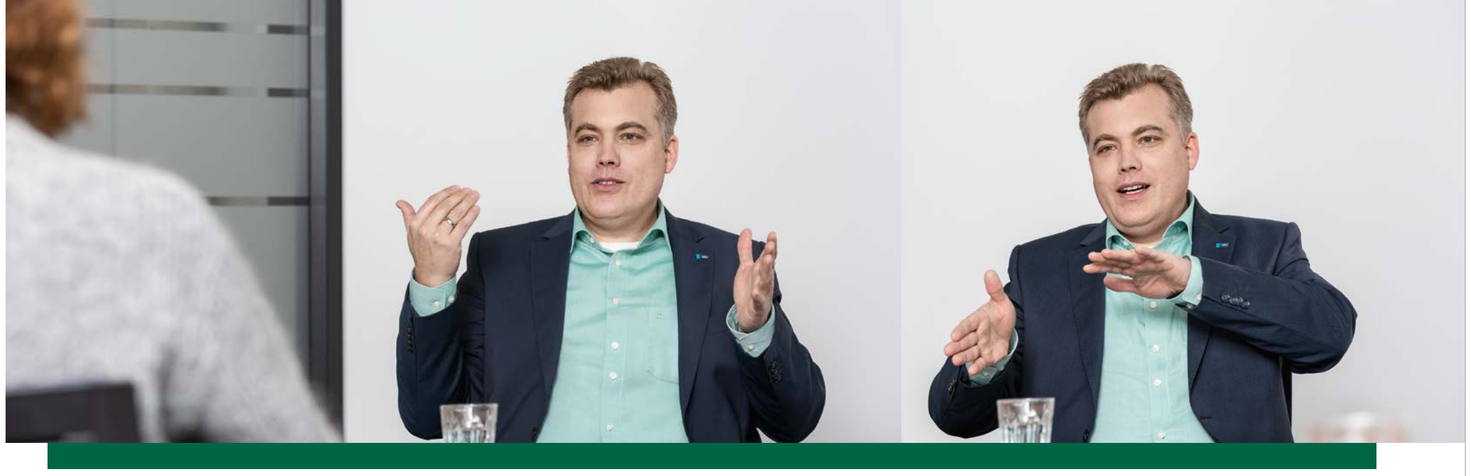
The race for digital pole position in the automotive sector is in full swing. The central role for tomorrow's mobility is played by the software. How to deal with the ever-increasing pace of innovation and players like Google or Amazon? Markus Blonn, Senior Vice President Network Software at IAV, on a market in motion, old rear-view cameras and the courage to take risks.

"Google, Amazon and Co. are taking a data center approach – the car is just the means to an end for them."



automotion: Mr Blonn, what is the state of software development in cars today?
Blonn: Modern cars today contain about 100 million lines of software code – about four times as much as fighter jets. In the past, we used embedded control systems that had a volume of 4 MB; now we're at about 40 GB. In addition, the state of the art is no longer static but dynamic 64-bit architectures, which allow software updates to be applied over-the-air. In comparison, software development for a rear-view camera system from ten years ago feels like programming in assembly language.

automotion: What changes has that brought to the market?
Blonn: Software has become the decisive factor in meeting customers' need for sustainable and connected mobility. At the same time, it remains invisible: For the customer, the software is good if the services it delivers work and the security is reliable. We no longer think of software only in terms of the vehicle, but in terms of an interconnected world. Tomorrow's mobility will be defined by scalable services. To ensure that such cloud or on-premise applications run smoothly, an IT infrastructure with appropriate computing and storage capacities is just as necessary as compliance with legal requirements for data protection and data security.

automotion: And how can IAV provide support in this regard?
Blonn: IAV is very good at translating complex physical problems into software solutions. In terms of content, with the implementation of the UNECE regulation for software updates and security, we are also well on the way to closing the distribution chain from requirements to testing and beyond. We have integrated Technical Compliance and meet Automotive SPICE Level 2 standards with qualified tool chains. As a result, when it comes to cyber security, we have fewer gateways for hacker attacks and system errors to worry about. As a result, we develop handcrafted, high-quality software for end-to-end functions. In vehicle access systems, we can combine our strength from the embedded and IT worlds.

automotion: It feels like every OEM now wants to develop their own software and operating system – what's in store for us?
Blonn: It's actually true: Whoever has the monopoly on technology retains sovereignty over all digital services and customer data. Nevertheless, not every corporation will develop its own operating system. I expect that we will see at least two operating systems from the USA. Android is one candidate. I expect a similar move in China, if only because the market follows different rules, for example in terms of privacy and security. And in Europe, too, I expect one or two operating systems to become established. The chances of this are good, not least because the pace of development has picked up considerably in this country.

automotion: Will a partner like IAV still be needed at all when OEMs become software houses?
Blonn: As far as our role is concerned, two points count for me. First, we are very good at developing functions, defining requirements together with customers, creating production-ready solutions and integrating them into the vehicle. We responded early to the changes in the automotive industry, so our solutions can launch on the market in a timely and reliable manner, whether it's connectivity issues, autonomous driving, modern powertrains, test procedures or safeguarding. Secondly, we have focused more on services and can, for example, offer software-as-a-service solutions for which we take responsibility. Here we can also confidently say: IAV is not a commodity company, IAV is an original. We must remain true to this and continue to adapt and develop our services in line with market needs in the future. As already mentioned, mobility services are currently changing more than ever before. Here, too, we are working with our customers to create appropriate services and solutions.

automotion: And where does IAV still need to step up its game?
Blonn: In terms of speed: We need to develop software even faster, without compromising on reliability and safety, of course. We can achieve this by further automating the development process and thinking more strongly in terms of networks in order to further increase our software expertise. We have an internal qualification program that is geared towards technology developments on the market and thus future-proofs the software. What also helps us are close ties to science. We are a member of the Softwarecampus of the German Federal Ministry of Education and Research and help to educate the next generation of leaders in software development. We also have some partner projects with universities. For example, with the Mittweida University of Applied Sciences, FAU Erlangen-Nuremberg on an open source project, and the University of Oldenburg on the topic of architectures. We are on the right track here.

automotion: Why is this exchange with the academic community so important?
Blonn: It provides us with IT and software expertise from outside. Bringing colleagues together with students, with spin-offs from TUs or start-ups that are implementing innovative topics, jointly launching new prototypes – that helps to further develop our own innovation culture. We have extensive expertise in series production and a high quality standard. However, the latter also means that it sometimes takes too long to bring concepts to market and develop them further with customers. Here, we can take a leaf out of Silicon Valley's business culture and dare to take more risks. Even if that means that you sometimes fail with an idea.

automotion: Keyword Silicon Valley: What do digital companies like Amazon or Google do differently than representatives of the traditional automotive sector?
Blonn: There are currently still two different approaches, Silicon Valley vs. Europe, or to put it another way: Data center vs. vehicle. Google, Amazon and Co. are pursuing a data center approach; for them, the car is only a means to an end. They develop software, the car lends itself to these companies as another sales platform, so they build the vehicle around the software, because the software is the focus.

We in Europe, on the other hand, still think vehicle-centric. But with the data center approach, the vehicle can be significantly widened as a digital bottleneck. Many computing processes can now be carried out independently of the car, and we expect 5G technology in particular to offer enormous potential in this area. Higher data rates can be transmitted via the interface in the vehicle, and new features can be executed in the back end, enabling us to achieve longer-lasting added value for the customer over the lifetime of the vehicle. Functions and services can thus be implemented, executed and updated more easily. An important advantage, because: The solutions are software, but the business model is service.

MARKUS BLONN, Senior Vice President Network Software at IAV, advocates more agile processes in software development. Only those who have the courage to take risks and put developments on the market in good time can keep up with and help shape the dynamics of innovation.

The Car That Cares

The car becomes a guardian angel

As the average age of drivers rises, the likelihood of emergencies behind the wheel due to illness increases. At the same time, many people with pre-existing conditions are unable to use the car or can only do so to a limited extent. IAV has joined forces with the University of Oldenburg, OFFIS and the European Medical School Oldenburg-Groningen to develop a digital assistant. The assistant accurately observes and detects changes in the driver's health status and automatically initiates rescue measures in an emergency if it registers shortness of breath or even a heart attack, for example.

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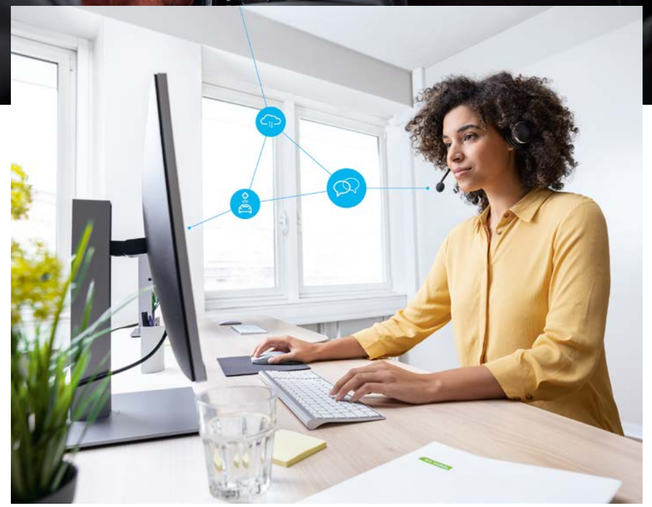


In an emergency, the car comes to a safe stop. Previously the health assistant registers shortness of breath or a possible heart attack. However, the AI can also be trained to detect other symptoms.

In an emergency, the vehicle independently makes an emergency call. This allows individual rescue measures to be initiated immediately if necessary.

Emergency braking and lane departure warning systems, blind spot assist and the eCall system, which has been mandatory for new models in Europe since the end of March 2018, are making driving safer and safer. More features are added with each new generation of vehicles. However, systems that are aware of the driver's health status and continuously monitor it in order to provide support in the event of an emergency with the help of automated driving functions still form a blind spot.

"Existing assistance systems such as fatigue or emergency assist programs know practically nothing about the health status of the person driving. As a result, they do not intervene or intervene too late in health emergencies," says Mark Busse, Head of the Connected Systems Integration Department at IAV. With the digital health assistant "The Car That Cares," IAV and its development partners want to change that.

COMBINED EXPERTISE FROM CLOUD COMPUTING, MACHINE LEARNING AND MEDICINE

The health assistant links the driver's driving behavior with their current health data and can thus detect deviations in breathing as well as heart rate and react accordingly. Jens Schulze, Head of Department Data Analytics and Fleet Validation at IAV, declares "In the event of slight respiratory distress, the assistant warns the driver via the infotainment system, activates the lane departure warning system as a supportive measure if necessary, and reduces the speed. In emergencies such as a heart attack or loss of consciousness, the vehicle comes to a safe stop at the side of the road and places an eCall." The driver has the option of stopping the initiated measures at any time. IAV has already successfully implemented an initial prototype of the system in a commercial vehicle.

IAV developed "The Car That Cares" together with the University of Oldenburg, OFFIS and the European Medical School Oldenburg, which provide support in sensor technology, the detection of medical emergencies and the evaluation of medical devices. The prototype assistant consists of several components integrated into the vehicle architecture: a chest strap from the medical field, AI-supported software installed in the vehicle, and a smart and secure cloud infrastructure.

The AI developed by IAV analyzes health and vehicle data in the cloud and creates a digital driver profile that serves as a reference for the software in the vehicle. As soon as the AI-powered software in the vehicle detects that the driver's data deviates from normal and may become safety-critical, it gradually activates the vehicle's assistance and automation functions. The trained software is able to register a variety of emergency situations – and react accordingly. "To train our self-learning algorithms, we analyzed different breathing and heart rate data. Subsequently, we defined with our project partners which ranges are considered normal states and what must be interpreted as irregularities or outliers," explains Schulze. These jointly defined guideline values are trained to the system's algorithm by the engineers.

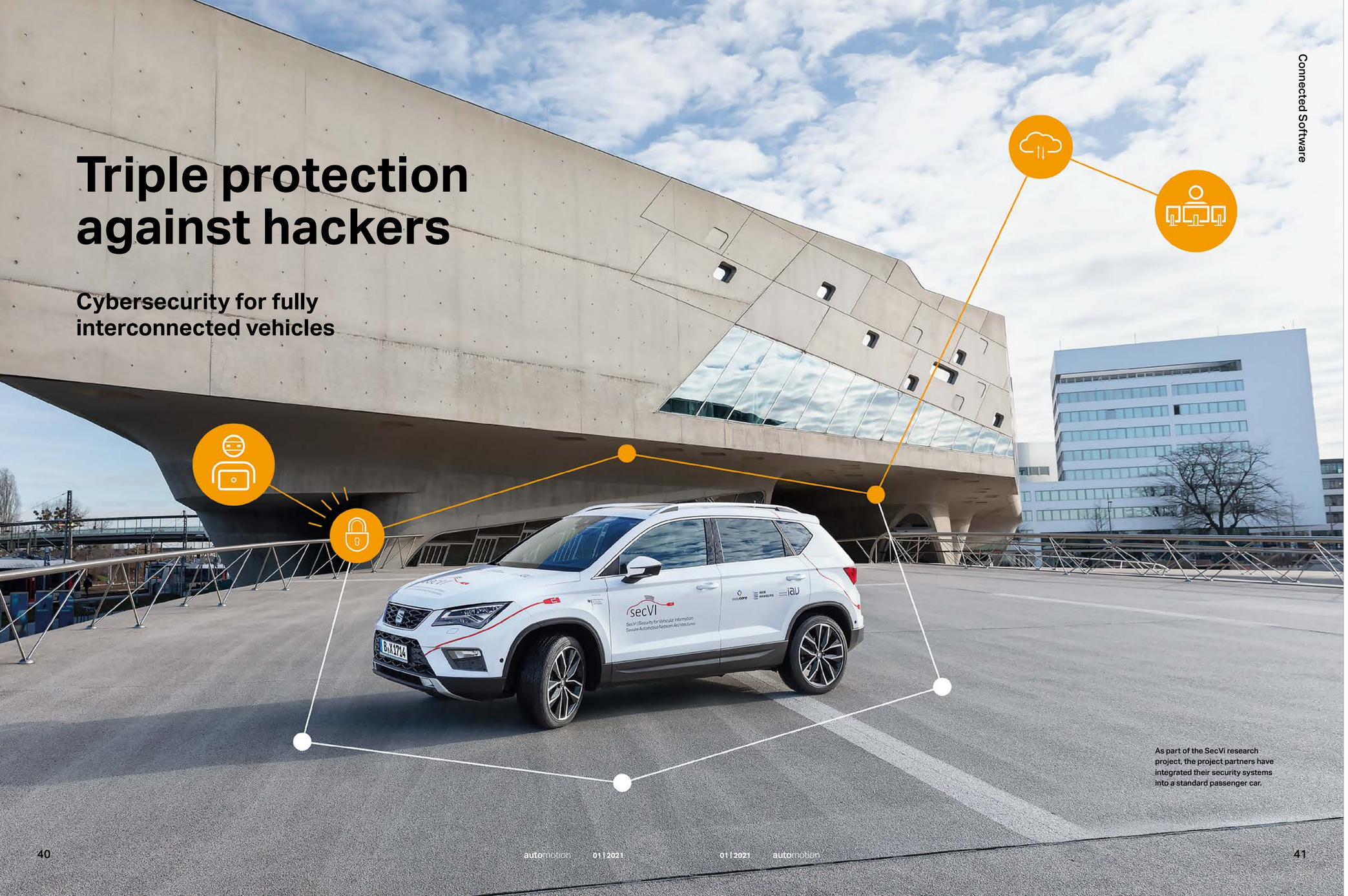
MODULAR DESIGN ENABLES INTEGRATION OF FURTHER MEDICAL DATA

"The health assistant can be incorporated into the existing software architecture of modern production vehicles as well as integrated during the development phase of new models," says Busse. Basically, the system uses the assistance and automation functions available from the manufacturer to independently stay in lane, slow down or pull over. In order for the system to provide this personalized and proactive support in an emergency, manufacturers' approval is required to control the VAS interfaces.

All road users would benefit from a digital guardian angel that prevents accidents in medical emergencies. It could warn not only in passenger cars but also in commercial vehicles such as trucks and buses in the event of critical changes and bring the vehicles, which weigh several tons, to a safe stop. Thanks to the modular design, other measuring systems and sensors can also be integrated, for example to determine oxygen saturation and sugar levels. The secure data infrastructure can be flexibly designed and adapted to different international data protection regulations – so that the guardian angel can watch over the driver anywhere in the world.

Triple protection against hackers

Cybersecurity for fully interconnected vehicles



As part of the SecVi research project, the project partners have integrated their security systems into a standard passenger car.

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It's a horror scenario: Hackers cripple a manufacturer's entire vehicle fleet through a cyberattack on its IT systems – with incalculable consequences for road safety. To prevent such situations from arising, IAV is working together with the University of Applied Sciences (HAW) in Hamburg and software service provider easycore GmbH from Erlangen on a new method for vehicle cyber security.

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Fully interconnected vehicles are the prerequisite for autonomous driving. However, new forms of mobility and innovative vehicle concepts also place new demands on cybersecurity. From 2022, therefore, specific requirements of the UN Economic Commission for Europe will apply to the cybersecurity of vehicles. This is because the more complex IT systems become, the more opportunities there are for attacks: Every new online interface that is integrated into the vehicle opens up a potential gateway for hackers.

If attackers actually succeed in taking control of a vehicle, human lives could be at risk. "If a website is hacked, then material damage occurs. But if a vehicle is attacked, personal injury is also possible. This is because IT security is closely linked to personnel safety," explains Professor Falk Langer, Team Manager, Connected Systems Technology at IAV. With the research project launched by IAV in 2018, "SecVi: Security for Vehicular Information" launched by IAV in 2018, vehicles are to be able to detect and fend off attacks at an early stage, thus ensuring the safety of passengers.

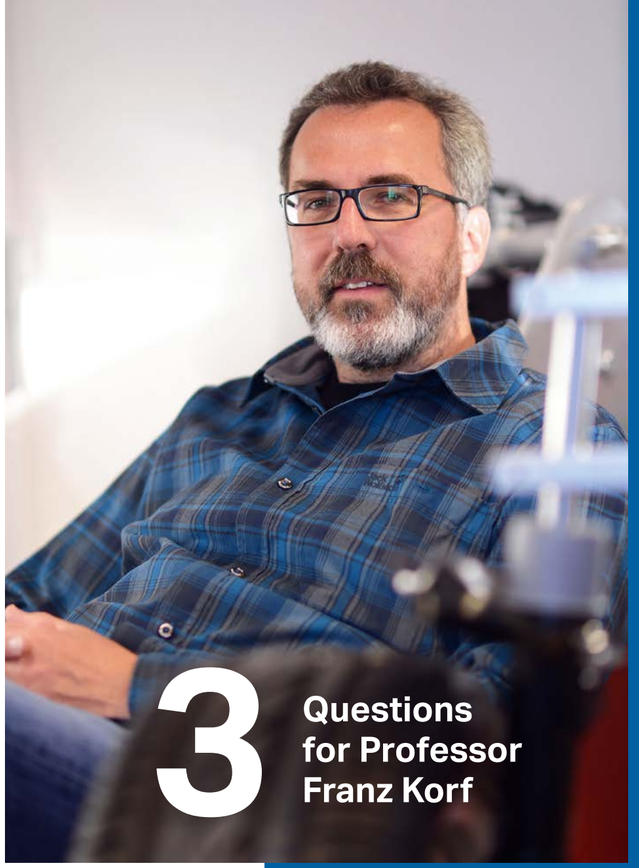
TRIPLE PROTECTION OF INTERCONNECTED VEHICLES

The research project focuses on intelligent procedures for controlling, monitoring and reconfiguring networks in vehicles, coordinated via an Automotive Cyber Defense Center. This is intended to raise cybersecurity to a new level. Together with easycore GmbH and HAW, IAV has developed a revolutionary concept that secures interconnected vehicles on three levels using the onion-skin principle. "The levels of the concept must interlock seamlessly to realize comprehensive monitoring and targeted incident response. This allows interconnected vehicles to be protected against cyber attacks in the best possible way," adds Jochen Decker, Managing Director of easycore GmbH.

A firewall for the Controller Area Network (CAN) from easycore protects the vehicle and its control units as a whole. If irregularities occur, the rules of the CAN firewall are adapted so that harmful communication is blocked at an early stage. On the second level, HAW uses Software Defined Network (SDN), a new technology for vehicles. The vehicle network protects itself by means of intelligent modules. This is because the building blocks enable communication flows only if they comply with predefined network access control rules. These rules can be adapted over the runtime. Together with self-learning anomaly detection, attacks can be identified and prevented.

If an anomaly is detected, specific services or even ECUs that have a vulnerability can be disabled. Services that are absolutely necessary for the vehicle's functionality are then shifted to other ECUs. Despite a restricted range of functions, safe operation can still be guaranteed. This is facilitated by the third level – IAV's Automotive Cyber Defense Center (ACDC). The first two levels always transmit abnormalities to the ACDC. "If a device reports anomalies and the ACDC detects an attack, the ACDC initiates countermeasures in the firewall or SDN and reconfigures the network," Langer said.

The ACDC collects information from the entire vehicle fleet. This makes it possible, on the one hand, to detect hidden attacks by correlating the fleet data and, on the other hand, to roll out preventive measures to protect the vehicles at an early stage.



3 Questions for Professor Franz Korf

For SecVi project coordinator Professor Franz Korf from HAW in Hamburg, it is clear that the increasing degree of vehicle connectivity will require multi-level security solutions in the future.

In the research project "SecVI: Security for Vehicular Information," teams from science and development are working closely together. automotion spoke with project coordinator Professor Franz Korf, who teaches at the Department of Computer Science at the University of Applied Sciences (HAW) in Hamburg.

automotion: Professor Korf, what requirements do cyber security systems have to meet today?

Korf: Many functions in the vehicle – including safety-critical ones – are based on software. This means there is also a potential risk of cyber attacks. To make matters worse, in the future attacks via the network could be directed not only against individual cars, but also against entire vehicle fleets. Cyber security systems, which consist of several interlocking subsystems, must therefore be able to detect attacks, evaluate them and initiate countermeasures as connectivity advances.

automotion: How do projects benefit when they are implemented in a partnership?

Korf: In the SecVI project, different IT security technologies intertwine, so that all project partners benefit from their complementary expertise. With IAV, easycore GmbH and HAW Hamburg with two research groups, three partners are coming together, each bringing a different background to the project. IAV has the necessary technological expertise to holistically map the security requirements in accordance with the UNECE specifications.

automotion: Why did you jointly decide on a three-stage approach?

Korf: In the SecVI project, we are integrating two different technologies into the Automotive Cyber Defense Center (ACDC): ECU (Electronic Control Unit) protection through firewall-based technologies and an SDN-based (Software-Defined Networking) attack-resistant network architecture. Since there is no one excellent security technology that can block all attacks, several technologies must mesh to protect a vehicle fleet. And that's exactly what we're doing in the SecVI project.

"Our joint solution forms the basis of a future security architecture for vehicle networks."

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Test platform ignites turbo for modern vehicle development

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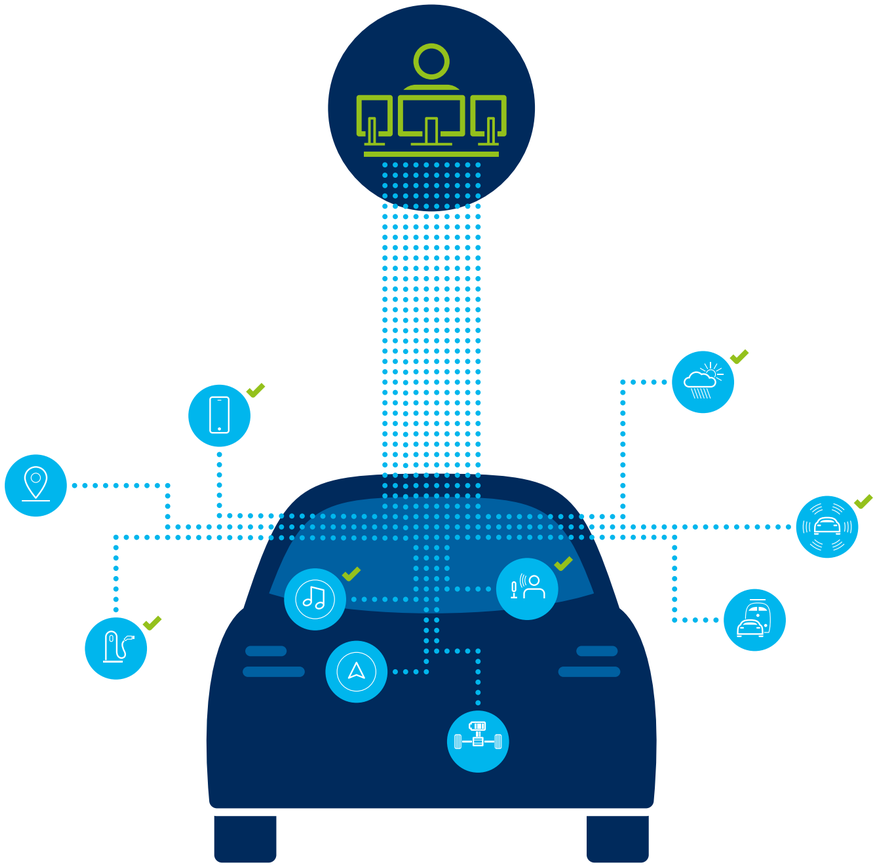


With each generation, cars are becoming more complex, more interconnected and more varied. As a result, the need for testing is also growing – an enormous challenge with ever shorter development cycles. IAV's answer is a test automation platform that not only makes the work of OEMs and suppliers easier, but also significantly shortens the development time for new automations.

More information on the infotainment screen, additional systems for voice control and voice recognition, plus more ECUs with radio interfaces – the diverse functions of modern vehicles also place new demands on test systems and test procedures. It is thus becoming increasingly complex to ensure that all information is transmitted and displayed correctly throughout the entire lifecycle of a vehicle. This includes digital services such as traffic information or data transfer from smartphone to car – and in a wide variety of markets. A new and specially developed test platform from IAV helps to master the complexity and produce results around the clock.

The platform contains all the essential modules such as tracing, hardware actuation, residual bus simulation, image and sound processing as well as user and resource management that are required for designing a test automation system. Even engineers who have never developed a test automation before can create automations with the support of the community.

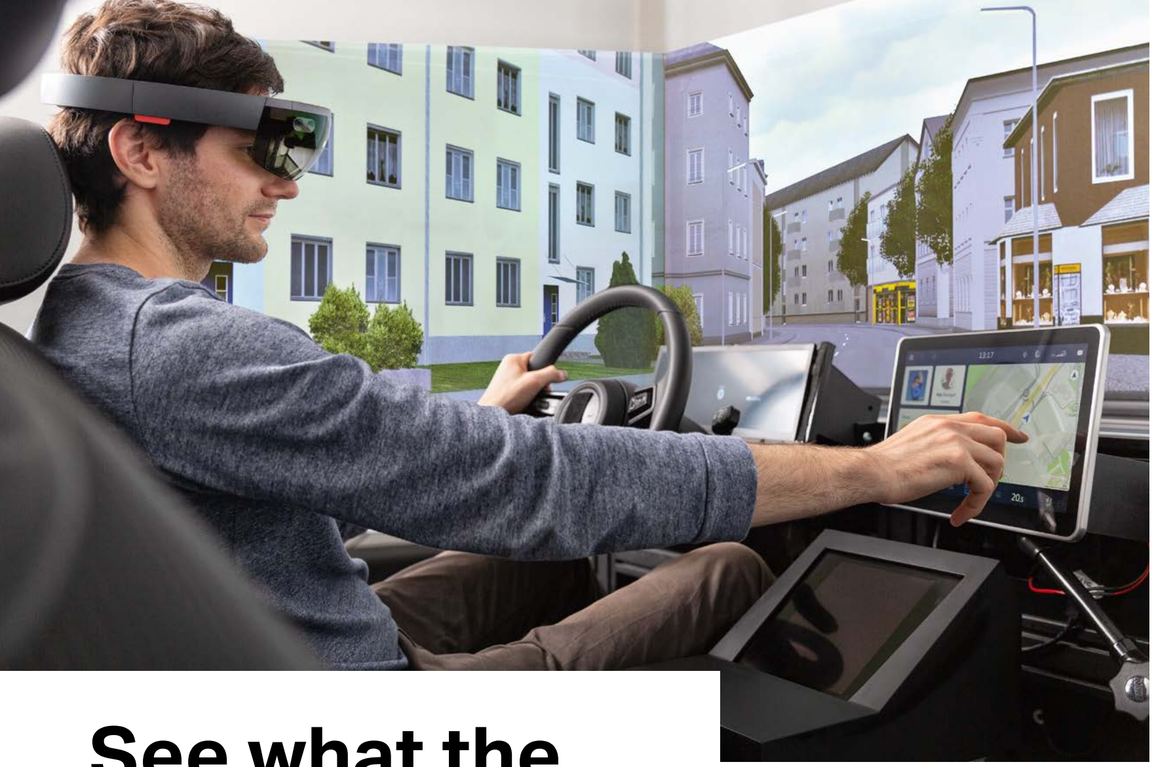
On the platform, IAV engineers make their developed test automations available to colleagues. These can be automations for voice and gesture recognition or smartphone control, for example. This allows the team to use existing automations from colleagues for new projects or to adapt them to their own requirements within a very short time. In this way, the test platform's toolbox grows automatically from project to project.

"In areas such as component development, data transmission, back-end functions and overall integration into the vehicle, we share test resources and automation tools with our platform," says Björn Steffen, Senior Vice President Connectivity & Analytics at IAV. "We are thus able to develop end-to-end solutions for our customers much faster than before and cut development time by quite a bit." Initial automations based on the IAV test platform are taking place in the areas of availability analysis of interconnected systems, navigation services or even app testing.

CUSTOMERS, PARTNERS AND THIRD-PARTY PROVIDERS BENEFIT

A particularly unique feature of the platform is the integration of the Remote Infotainment Lab (RIL). This allows manufacturers and suppliers as well as their app developers to access the test hardware released by IAV from anywhere in the world and test whether their newly programmed functions harmonize with the existing control units and software versions. The test platform is particularly suitable for developers who are unable to set up such a test environment. They conveniently receive the results of test automations and availability checks of services and controls via e-mail. "In addition to this, we provide our customers with a service that allows them to transfer log data with a log of the test process or trace data to their own systems and evaluate it virtually," says Daniel Danz, Senior Vice President Infotainment Functions and Systems.

And the platform holds even more potential: With each newly configured test automation or availability analysis, the know-how collected in it grows. The aim of IAV's developers is to make the platform accessible to as many interested parties and areas as possible. "In perspective, we also want to open up the platform to topics such as hardware-in-the-loop control or engine test bench control," says Steffen. "An extensive ecosystem is just emerging here, and we are far from having exhausted its potential."



See what the future holds

HMI concepts in AR and VR

What a vehicle will look like from the inside can be quickly checked these days with the help of 3D views. But how do you make a human machine interface (HMI) tangible long before the vehicle even enters pre-series development? IAV has created a development environment that uses virtual reality (VR) and augmented reality (AR) to configure user interfaces quickly and easily.

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Digitalization is opening up more and more new possibilities in the area of human-machine interfaces, such as operation via sensitive surfaces or augmenting the environment via a head-up display (HUD). This creates new design scope for the design of a vehicle HMI. The trend is clear: from simple operation to a holistic experience. And for car buyers, an intuitive HMI is increasingly becoming a purchasing criterion. Manufacturers are therefore faced with the challenge of bringing new HMI display/control elements to market as quickly as possible. To do this, they need to make them tangible as early as possible – while they are still in the prototype phase – so that the HMI can be tested on the end customer if possible. However, vehicle manufacturers not only need fast solutions, but also cost-effective ones: Instead of having to make physical prototypes of these elements – which is time-consuming and expensive – other options are needed for evaluation. IAV's user experience specialists led by Yves Tamborini, Team Manager UX Research & Concepts, have developed a virtual environment for this purpose: AR/VR scenarios bring the HMI to life virtually – even before pre-series production.

VIRTUALLY EVERYTHING IS POSSIBLE

Yves Tamborini explains: "We work with different test methods. In the area of VR, for example, we are rebuilding the entire interior of a vehicle using 3D software so that we can simulate displays there in different places – both on the vehicle displays and in the arrangement of other controls." Test subjects then wear VR goggles and a data glove to spatially experience and test the virtual interior.

In the area of AR, the team is still in the experimental phase, but initial benefits are already emerging: Unlike VR, work can be done in a real environment – for example, in an existing vehicle or a seat box. AR scenarios can also be experienced by the test subject through a pair of glasses: "The test person sees their real environment, but with the help of the AR glasses, we can define certain components to be replaced or overlaid with 3D elements via AR," Tamborini explains. For example, a head-up display can be superimposed over the entire windshield. And other features such as data gloves even enable haptic feedback. Impulses in the fingertips give the test person an impression of switches, controllers and other elements.

THE HMI OF THE FUTURE

An important tool in handling the virtual HMI concept is the so-called IAV Fast & Easy AR/VR prototyping approach. "The HMI in the virtual vehicle is not static, but can be adapted in real time," explains Tamborini. A tablet can be used to quickly and easily assemble a wide variety of HMI elements using drag-and-drop or to load HMI configurations, which then appear on the virtual displays in the AR/VR scene in the vehicle.

Another plus point of the IAV Fast & Easy AR/VR prototyping approach: Designs and themes can be quickly exchanged or changed – this shortens development time. "So you no longer need to be an AR/VR expert to create HMI variants," says Tamborini. Such virtual test environments thus create flexibility as well as cost efficiency and also already map technical restrictions of the components. If physical display/operating elements are available at a later stage of development (e.g. displays, HUD, etc.), the HMI can also be displayed and operated there using the approach chosen by IAV.

Making the design and functions of the HMI tangible and, above all, evaluable at an early stage helps manufacturers in many ways. Here, too, IAV relies on virtual methods: Gaze duration and trajectories, type and number of interactions, errors, etc. can also be analyzed in virtual scenes. But not everything can be tested virtually: The National Highway Traffic Safety Administration (NHTSA) has defined stringent requirements for vehicles that are to be registered in the USA. "Manufacturers can have planned HMI systems evaluated in advance by our experts and tested using test subjects. This gives them certainty at a very early stage that all functions comply with the regulations and that nothing stands in the way of approval by the NHTSA," says Tamborini. HMI evaluations in the virtual world coupled with tests on real systems therefore create the best conditions for an intuitive and compliant user experience in the future vehicle – and show users today what the future holds.

Are they already completely sealed?

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Rain through an open window, a spilled drink in the interior, a drive through a deep puddle – carelessness that can damage the car and its components and really cost money. For this reason, engineers try to safeguard the vehicle against the unintentional ingress of liquids during the development process. Up to now, many expensive prototypes have been needed to check this. With a specially optimized simulation model, IAV is taking a faster and, above all, less expensive route.

MESHFREE

The CAD data of the vehicle was kindly provided by CareSoft kindly provided.

The simulation program covers many scenarios, including the path taken by water through activated windshield wipers. The results are also interesting for the design of the car body.

The simulated water passage not only provides insights into which components can be reached by liquids, but also into which path the water has taken in and on the vehicle.

The classic scenario is the open side window of a vehicle: In heavy rain, the water can get to the electronic components inside the door, leading to defects. Testing using prototypes and validating new systems with the aid of trials is time-consuming, expensive and often takes place very late in the development process.

That's why IAV is taking a different approach: With the help of the "Meshfree" software from the Fraunhofer Institute for Industrial Mathematics (ITWM), IAV engineers have developed simulation models of virtual water management. This enables them to simulate water flows even on geometrically complex and moving components and systems. This enables IAV to show not only which components could come into contact with liquids, but also which paths the water takes to get there and which design measures can be used to remedy the problem.

Compared to the previous test-based validation with real prototypes, simulation offers a major advantage: If a specific vehicle is driven through a pool of water, for example, it is possible to detect whether a sensitive component has been washed around with water. However, it is usually very difficult to determine how the water got to the respective component in a practical test.

Another advantage of simulation: Digital testing speeds up the development process enormously. "The development cycles of vehicle generations are following one another ever more quickly – especially in the case of electric vehicles," says Dr. Uwe Reinhardt, Senior Vice President Vehicle Testing & EMC at IAV. "Here, we have even less time for lengthy validation with an abundance of prototypes." Simulation in the early development phase helps engineers reduce the use of prototypes and thus shorten the development process.

For simulation, engineers use a vehicle's design data and have it drive virtually on the computer through a pool of water or through a rainstorm, for example. In recent years, IAV has continuously optimized its simulation methodology and compared it with tests. In the meantime, even complex damage patterns can be mapped – such as a defective axle boot that leaks oil, which then splashes onto other components as a result of the rotation.

Electric vehicles deserve special attention when it comes to protection against water damage. For example, while driving in the rain or through puddles, water can splash onto the vehicle's underbody and reach the high-voltage battery or power electronics. But the ingress of rainwater through the water tank below the windshield into the air intake of the air-conditioning system must also be avoided. In vehicles with internal combustion engines, on the other hand, the engine air intake is one of the most sensitive assemblies. If water gets into the combustion chamber, water hammer or a damaged engine is the possible consequence. In this simulation, the particular challenge lies in the coupling of air and water. But here, too, IAV engineers have found a solution. Simulation helps to identify such problem areas and develop protective measures at an early concept stage, well before the first prototype is built, and irrespective of the type of drive.

Connected out in the fields

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Highly automated, interconnected and compact agricultural machines that are flexibly deployed in the field in a swarm: what sounds like the distant future could become reality in just a few years. In the Feldschwarm (field swarm) research project, IAV and ten other partners from industry and science have joined forces to develop just such ideas and bring them to the field.

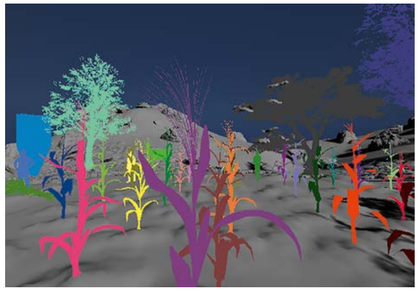

Image above: Photorealistic simulation with varying objects, scenes, weather conditions.
Image below: Automatic labeling of objects and generation of training data for neural networks

Digitalization has arrived on farms: Farmers are increasingly turning to cutting-edge technologies to use resources more efficiently, produce food sustainably and optimize farm workflows. According to a Bitkom study, more than 80 percent of farms are already using smart farming technologies. GPS-controlled agricultural machinery, agricultural apps for smartphone or tablet and the intelligent use of crop protection and fertilizers are among the most important technologies and applications.

The technological development of agricultural machinery has so far followed the motto: larger, more specialized and with more engine power – a development that is slowly but surely reaching its limits. This is because statutory road traffic requirements, increasing machine weight with the accompanying soil compaction or environmental protection aspects are setting limits to growth. "Increasing specialization, especially in the case of harvesting machines, is leading to ever higher acquisition and maintenance costs, while at the same time reducing the flexibility of work processes," says Markus Robert, an expert in perception and simulation at IAV. "This ultimately also increases the farmer's dependence on the machine being permanently operational. In the event of a machine failure, against the backdrop of ever shorter harvest windows, this means immediate financial losses for farmers." At the same time, the job of a farmer is becoming increasingly unattractive and is often accompanied by long, monotonous working days, making qualified personnel a scarce commodity.

Robert heads the Feldschwarm research project for IAV, which focuses on highly automated, compact and flexible machine swarms instead of a few large and specialized agricultural machines. Key advantages: Lower vehicle weight protects the soil, the failure of a vehicle can be compensated for more easily, and interchangeable working tools increase machine flexibility. At the same time, the swarms are operational around the clock, and the classic role of the driver is transformed into a system supervisor and manager responsible for the entire network.

"However, thanks to the high level of automation, the machines also contribute towards more resource-efficient and ecological practices in agriculture. Farmers can use the swarms in a more targeted way – for example, when using sprays or fertilizers," says Robert. The prerequisite for targeted use is that the agricultural machines not only separate the wheat from the chaff, but also actually recognize and distinguish whether the plants are healthy and the fruit is ripe, or whether objects or people are blocking the way, so that they can draw the right conclusions accordingly.

In the Feldschwarm project, IAV develops and is responsible for intelligent environment perception – the sense of sight for agricultural machinery. The agricultural field poses particular challenges for the engineers. "The classic methods for environment detection and collision avoidance from the automotive sector, such as simply recognizing objects, are not enough," says Robert. "Environment perception must work so precisely that it can not only recognize but accurately classify a wide variety of objects, objects and plants." To do this, Robert and his team first categorized objects into three groups: dynamic objects such as vehicles, people and animals; static ones such as utility poles or drainage ditches; and semi-static ones such as straw bales or briefly parked work equipment. Static and semi-static objects can be mapped permanently or briefly in the second step. "The machine can remember the position of the object and move around it without intervention," Robert says. "It gets difficult with dynamic objects, because they cannot be mapped and can only be reliably classified through intensive training of the environment recognition."

To do this, the IAV experts trained neural networks and fed them image material over and over again to increase the hit rate and the correct assignment of objects by the agricultural machine's sensors – lidars, radars and cameras. Robert and his team had to break new ground to do this, because in the agricultural sector, unlike for road traffic, there is hardly any freely available training data to date. "In addition to real data sets, we created numerous photorealistic simulation environments, with varying objects, scenes and weather conditions, to automatically generate training data for the networks. This allows us to teach the system what a corn plant is, for example, or what weeds look like, or which objects are trees. With this comprehensive set of virtual and real training data, we have prepared the neural networks for the first field trials in the real environment," Robert explains.

Those trials are now on the horizon. The test vehicle was set up during the winter months and expanded to include the components and sensors for environment perception. The agricultural technology of the future is moving one step closer.

FELDSCHWARM®

FELDSCHWARM® – AUTONOMOUS FIELD MODULES FOR RESOURCE-SAVING RESOURCE-CONSERVING AGRICULTURE
By July 2020, the seven companies and four research institutes in the Feldschwarm consortium have developed the basic technologies for autonomously operating attachments in agricultural technology. This technological shift in agriculture toward lightweight, flexible, highly automated, electrified equipment systems offers opportunities for central Germany's agricultural machinery sector to re-establish itself on the global market with high annual sales.

As a joint partner, IAV is responsible for the development of environmental sensor technology and sensor data fusion, taking into account the specific operating conditions of agricultural vehicles. In addition, adapted data maps as well as navigation components for route planning of the entire swarm are to be developed.

Project partners: Reichhardt Elektronik GmbH, Indikar Individual Karosseriebau GmbH, EIDAM Landtechnik GmbH, BITSz electronics GmbH, ILEAG e.V., Institute for Light Electric Drives and Generators, John Deere ETIC, Fraunhofer Institute for Transportation and Infrastructure Systems, Fraunhofer Institute for Machine Tools and Forming Technology, IAV GmbH, Raussendorf GmbH, TU Dresden

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Highly automated, compact and flexible to use: The agricultural machinery of the future is being developed in the Feldschwarm project.

Digital ants for better power grids

New solar plants and wind turbines, more charging stations for electric cars and heat pumps for homes – the Energiewende is picking up speed. Distribution system operators must adapt their grids. IAV Optera software now supports them in this complex task. The core comes from nature – an optimized variant of the ant algorithm.

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Network designs, load flows, route calculation – with IAV Optera's high-performance algorithms, distribution system operators can make their grids fit for the Energiewende. Conveniently as software-as-a-service – efficient, easy to use and in the shortest possible time.

Product by IAV

"Electricity network operators have so far been faced with the complex task of building and operating a powerful yet affordable power grid. The Energiewende is making this much more challenging: fluctuating generators and new types of consumers are increasingly pushing grids to their limits," says Dr. Michael Schollmeyer, who is responsible for the Business Unit Smart Grid at IAV. With IAV Optera, we have developed a powerful software that supports operators in planning, optimizes existing networks and thus significantly reduces investment costs – by up to 20 percent in tests."

Nature was the inspiration for IAV Optera: When searching for food, ants secrete scents that are used to orient their conspecifics. Shorter distances between the burrow and the food source enable the animals to reach their destination more quickly. This is why they travel along a path more often and leave behind more scents, so that other ants also choose this shorter route. The so-called ant algorithms exploit this concept.

IAV Optera is based on an optimized ant algorithm: The software designs, calculates and compares thousands of network variants for medium-voltage networks. The parameters – for example topology, voltage bands, costs – can be set in advance with just a few clicks. IAV Optera searches for efficient connections, performs load flow calculations, checks fault cases and finds suitable sectioning points in the network. The program also determines routes for underground line cable systems and optimizes the positions of cable fanouts. The highlight: this is all done completely automatically.

The digital ants learn to distinguish good connections from bad ones. Partial solutions that are found to be good are reinforced and incorporated into the next optimization cycle – the result is continuously improved. "Filtering out the best possible network variants from thousands is a typical optimization task that we solve in many areas of automotive engineering," says Schollmeyer. IAV has packed this know-how into its new software for the energy industry.

IAV Optera graphically displays the calculated variants. The network planner can compare them, modify them manually and thus design an optimum network structure. Initial tests in regular operation have already been successful at the partner LEW Verteilnetz GmbH (LVN) in Augsburg. Network planner Stephan Fettke: "By automating work steps and offering a high degree of flexibility in parameterization, IAV Optera software offers great potential for efficient and realistic target grid planning based on topographic maps. Our testing of the software shows that it is a very helpful tool in mastering our current planning tasks. At the same time, by testing IAV Optera, we are equipping ourselves to cope with increasing demands from the expansion of renewable energies and electromobility."

A case from practice: In a rural distribution grid with regional load centers and many solar installations, several lines are already reaching their limits; in addition, the operator forecasts a load increase due to electric vehicles. Ergo: some network areas will be overloaded in many switching states. The operator wants to take countermeasures.

For their target grid study, the planner used various optimization functions from IAV Optera in addition to the current grid analysis: This can be used, for example, to place branch-joint or increase cable cross-sections. Route optimization transforms network designs based on air-line distances into routes along roads. Based on geodata, highways, rivers, railroad lines and nature reserves are avoided or crossings are financially taken into account.

The obvious solution in the case of the rural distribution grid: replace 8.5 kilometers of overloaded lines with new cables and additionally reinforce the substation feeders. IAV Optera proposes an alternative: two new connections in the western service area and a short new line in the southeast. Thanks to IAV Optera, the grid operator thus gets by with only 6.9 kilometers of new lines – and saves 20 percent of the investment costs compared to the intuitive solution.

"The software does everything automatically, but it never replaces the network planner. On the contrary, its many years of expertise enhance IAV Optera's good results," emphasizes Schollmeyer. The planner not only defines the input parameters and selects the optimization functions; they also use an editing function to incorporate their detailed knowledge of the network characteristics into the study.

IAV Optera is offered as a software-as-a-service. This eliminates the need for installation and integration into the IT landscape at the distribution system operator. Planners operate the software via a web front end that communicates with the server via an encrypted connection. Its location in Germany and an IT security concept guarantee confidentiality and data security. IAV stores the network data only for the duration of the calculation. Full control over your own data and an optimized distribution grid – IAV Optera achieves both.

5 GOOD REASONS FOR IAV OPTERA

Meaningful relief for your employees

Efficient target grids in shortest possible time

High supply reliability and quality

Future-proof power grids with minimal costs

Objectification of your investment decisions

Our motivation. Our guard rails. Our promise.

The automotive sector is changing – it needs clear guard rails to navigate successfully through the changes. IAV has therefore taken a close look at its own purpose and values – the result is a compass for its employees – and a promise to its customers.

CONTACT **culture@iav.de**

Our purpose:
We move the world for the better through technology and engineering.

Excellence:
We are best in class.

Responsibility:
We take responsibility.

Focus on Customers:
We do it. For our customers.

"For us at IAV, purpose and values are much more than that, though. They are also a promise we make to ourselves and our customers."

Moving forward boldly or maintaining status, embracing change or preventing it: How a company deals with the changes the sector is currently experiencing is also shaped by its culture. And that culture lives very much from purpose and values – the guard rails that give employees orientation in their day-to-day work.

"But for us at IAV, purpose and values are much more than that. They are also a promise we make to ourselves and to our customers. In the summer of 2020, we set out to put this promise down on paper in crystal-clear terms so that we can be guided by it even better on a daily basis," says Dr. Uwe Horn, President and CHRO at IAV.

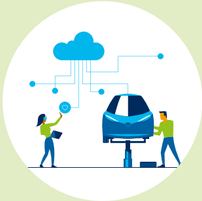
Along the way, there were countless talks, discussions and surveys – across all areas and hierarchical levels. The result was not a reinvention, but what has characterized IAV as a company since it was spun off from the Technical University of Berlin.

Keeping an eye on IAV's values and purpose: the Culture team in the People and Culture department. From left: Clemens Beer, Ines Protschka, Angela Zimmermann, Florian Methner, Stefanie Handlbauer

"This year, we are working intensively on visibly anchoring our purpose and our values in the company. To this end, there will be numerous workshops with our employees. The goal: Purpose and values should determine every action, every interaction with our customers or colleagues. They will thus have a significant influence on our attitude to work, the satisfaction of our employees and ultimately our entire corporate culture," adds Dr. Uwe Horn.

Partnership:
We win together.

Innovative Power:
We design and realize ideas.



Passion for Technology:
We love technology and engineering.

Personality:
We are all IAV.

Talent factory for automotive pioneers

Digitalization, automation, new drive technologies – these innovations are crucial for the future of the automobile. Today's vehicle pioneers need profound knowledge in precisely these areas. IAV is therefore funding two professorships at the Mittweida University of Applied Sciences – practical expertise for the skills of tomorrow, in keeping with the university's tradition.

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PROF. FALK LANGER,
Team Manager for Connected Systems Technology and Endowed Professor for Connectivity and Services Automotive Software at the Mittweida University of Applied Sciences

PROF. DANIEL KRIESTEN,
IAV Project Manager for Hardware and Software/ Security and Endowed Professor for Methods and Technologies Automotive Software at the Mittweida University of Applied Sciences

Three of the four Audi rings come from Mittweida. Through August Horch (Horch, Audi) and Jørgen Skafte Rasmussen (DKW), three of the four "Auto Union Rings" are linked to the Mittweida University of Applied Sciences, where the two engineers studied. Fritz Opel also studied at the "Technikum Mittweida." The training of mechanical engineers in the Saxon town was already internationally renowned for its practical orientation more than 100 years ago.

The tradition lives on: It is reflected in the cooperation with engineering partner IAV in the training and further education of specialists.

TARGETED QUALIFICATION IN KEY FUTURE TOPICS

In the master's degree program "Interconnected intelligent systems," students and professionals alike are trained in central future topics of tomorrow's mobility. There are currently 15 students in the first semester, including five IAV employees. Together with Professor Jan Thomanek from the Faculty of Engineering at the Mittweida University of Applied Sciences, IAV Foundation Professors Falk Langer and Daniel Kriesten have developed the field of study in the "Electrical engineering automation" master's degree program. Teaching focuses on topics such as software development, cybersecurity, artificial intelligence and connected and automated driving.

IDEAL DOVETAILING OF RESEARCH AND INDUSTRY

"Acquiring and processing data as well as high-level interconnectivity – these are the main tasks of technical development that make cars autonomous, safe, comfortable and environmentally friendly," says Kriesten, holder of the endowed professorship "Methods and Technologies Automotive Software." His colleague Falk Langer teaches "Connectivity & Services Automotive Software."

The students are enthusiastic about the new degree program. Wenhao Shen, for example, has already studied mechatronics in the bachelor's program in Mittweida. The 28-year-old particularly likes the fact that his professors show practical examples from industry. Engineer Stefan Rührdanz works at IAV in tactical decision planning for highly automated driving, where vehicles are programmed, among other things, to make autonomous decisions on lane changes, for example.

Above all, he values "keeping up with the state of the art, learning new things so that he can incorporate them into his daily work."

SUCCESSFUL BALANCING ACT BETWEEN JOB AND STUDIES

"Everything is very much in line with the working students," says a pleased Tom Schindler. The 25-year-old graduated with a bachelor's degree in mechatronics in February 2020 and now works in the special machine engineering department at automotive supplier Accomplast. Schindler: "Many professors record the lectures and seminars, so you can watch the videos for self-study."

Samuel Müller has already been working at IAV for four years in front radar software testing. "Vehicles are constantly evolving in the direction of computers. This course of study is ideal preparation for the new topics," the 28-year-old tells us. He invests two working days a week in his studies, and IAV gives him time off to do so. "The content is very practically oriented, and the professors are very considerate," he says, describing the balancing act between his job and further qualifications. In this way, he remains fully in line with the university's tradition – and can perhaps use the knowledge he has acquired to join the ranks of pioneering automotive engineers. Together with August Horch and Friedrich Opel.

FURTHER INFORMATION ON THE MASTER'S DEGREE PROGRAM
(only in German)
www.inw.hs-mittweida.de/studienangebote/elektrotechnik-automation-master/

Sharpened focus on Compliance

New content on iav.com

We have expanded our Compliance content on our website – because Compliance is important to us. Read more below about the background and how our customers benefit from our compliance structures.

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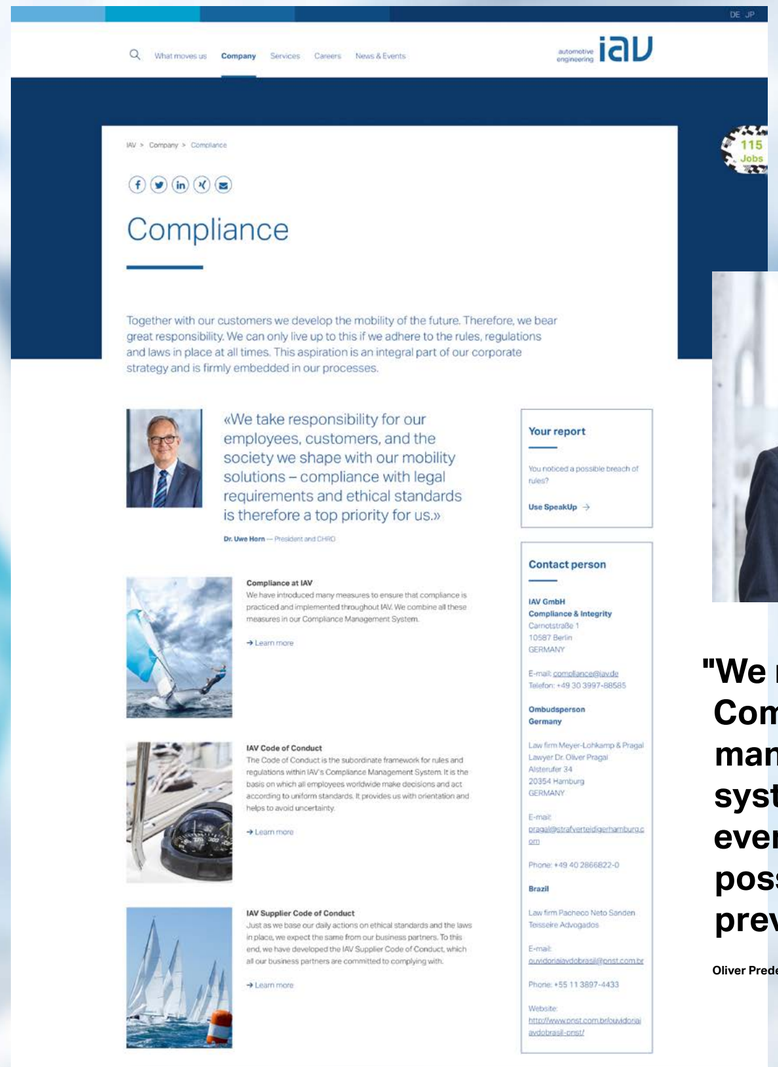
Compliance is a top priority for us. That's why we've devoted a lot of space to the topic of compliance on iav.com. Behind this are tangible enhancements to our monitoring systems. For example, we have set up dedicated monitoring processes for changes to laws and regulations, expanded our reporting channels for possible violations, and installed an international network for (technical) Compliance issues in all areas.

Our customers benefit from this: Even if in the end it is usually their logo and not ours that is visible on the products, with us they have a comrade-in-arms for the highest level of regulatory compliance at their side. Does this mean that IAV's services will become more expensive as a result of the enhanced Compliance management system? No. But it may mean that we have to take another look here and there and question the purposes and areas of application. After all, together with our customers, we want to ensure that our engineering services ultimately contribute towards a compliant end product. This also and especially applies to cases where we are entering new technological territory together and often no or no clear legal requirements exist yet.

Our sharpened focus on Compliance is reflected on iav.com. Here, we have added our content, explain our approach and describe our SpeakUp system, which can be used by internal and external users alike. Take a look for yourself at www.iav.com/en/company/compliance/



"We rely on our Compliance management system to do everything possible to prevent violations."

Oliver Predelli, Chief Compliance Officer

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IAV Customer magazine automotion
IAV GmbH
Ingenieurgesellschaft Auto und Verkehr

Publisher
IAV GmbH · Carnotstraße 1 · D-10587 Berlin, Germany
Tel. +49 30 3997-80
www.iav.com

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Collaboration
Christian Buck
fischerAppelt

Post production
Highlevel

Design
publicgarden GmbH
Ligalux GmbH

Frequency of publication
Three times a year

Picture credits
Bundesgesellschaft für Endlagerung (BGE), Christian Bierwagen, David Ausserhofer, dpa/Axel Heimken, getty images, Hoffotografen, H2 Mobility Deutschland, istockphotos, Max Lautenschläger, Now GmbH, Rimac Automobili, Sonja Hornung, Vivian Werk

Print
K+L PrintMedia GmbH

FSC www.fsc.org MIX Paper from responsible sources FSC® C106802