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auto motion

A question of compatibility

Interview

Dirk Hilgenberg and Matthias Kratzsch talk about the software-defined vehicle.

Second Life

What is important in the development of vehicle batteries to make them reuse as an energy storage?

Smart use

New approaches to heat flow control.

Dear Readers,

OEMs need to pick up speed on electromobility, self-driving cars and connectivity to guarantee their sustainability. An essential prerequisite for these future topics is electromagnetic compatibility (EMC). With our new EMC test center in Heimsheim, we are demonstrating – IAV lives the future and is fully embracing technological change in the automotive industry (page 24 to 29).

We offer smart solutions, such as a high-voltage battery in sustainable ECO design (page 46) or a modular and mobile test bench concept (page 48).

Software is becoming increasingly important for OEMs. The integration of advanced software services opens up new business areas for manufacturers.

Tesla is leading the way, for example with its own vehicle insurance policies, which are now also available in Germany. With the help of AI, driving behavior is analyzed – those who drive carefully pay less, according to the provider's model.

Volkswagen wants to catch up with Tesla in this regard with its software subsidiary Cariad. IAV CEO Matthias Kratzsch discusses the challenges still awaiting the pioneers with Cariad CEO Dirk Hilgenberg (page 7).

But it is not just Tesla that is pushing the pace in automotive software. Groups such as Amazon and Apple are also entering the market and moving more confidently in the digital ecosystem than most car manufacturers, emphasizes Jürgen Müller in an interview (page 16).

We also venture a look into the future beyond corporate strategies. A vehicle that predicts the driving maneuvers of the person at the steering wheel could proactively avoid accidents. You can read about how cars acquire these clairvoyant abilities on page 21.

We wish you a very interesting read!

Dr. Uwe Horn
President, CHRO

Matthias Kratzsch
President, CEO

Katja Ziegler
President, CFO

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This control unit has a lot going for it: It ensures that components and peripheral devices of a test bench work together. And all of this is mobile and individually adaptable.

Promotion[14]

IAV Awards Grants for Young Talent

The collaboration between business and science has been an integral part of IAV's DNA ever since its spin-off from the Technical University of Berlin in 1983. Both, universities and students as well as the tech solution provider benefit from innovation potential, synergies and top-class partnerships. To expediently promote talent, IAV has launched a 12-month IT scholarship with its partner IT-Talents.

Initially planned to be a single grant, the program was expanded to include 14 grants after reviewing around 200 applications. But the selected students are to receive more than just money. Because in addition to the financial grant, the focus also lies on establishing a professional dialog. This is facilitated by means of a regular exchange and face-to-face events to provide the grant beneficiaries with an exclusive insight. Tailored to each participant's requirements, we also offer active involvement, for example in the form of a working student role at IAV or a final thesis.

But IAV is always on the lookout for young and inquisitive talents beyond the scope of the grant program. For all job offers for working students and much more besides, please visit iav.com/en/careers.

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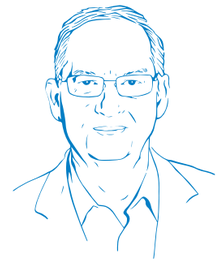
"We are redefining German engineering"

Our cars are evolving from mobile commodities into digital multi-talents. They know who is taking a seat in the vehicle and which seat setting the occupants prefer, know the shortest route to thesupermarket they trust and can pay for the electricity at the charging station independently. At the same time, the road to the software-defined vehicle poses numerous challenges for the automotive industry – both, OEMs and development service providers. We asked Cariad CEO Dirk Hilgenberg and IAV CEO Matthias Kratzsch about the latest developments in software, autonomous driving functions and cyber security.

Matthias Kratzsch
CEO IAV



Dirk Hilgenberg
CEO Cariad

What strategies are manufacturers adopting in order to make the leap to software-defined vehicles as soon as possible?

Dirk Hilgenberg: All of us in the industry have realized that our customers have new demands on us. They will continue to change in the coming years – for instance when we think about autonomous driving functions. Our primary goal is, of course, to meet and exceed the demands of our customers. In the Volkswagen Group, we have decided that this change can only be sustained in the future if we develop a large share of the software ourselves, always with the aim of being able to offer the customers of our brands functions in the vehicles that set them apart from the competition.

Matthias Kratzsch: However, the manufacturers' efforts to set up their own organizational units and drive the development of software solutions in-house also involve huge investments. They have realized that it is no longer sufficient to be "automakers" alone. To master software as a key technology and tap into the new business areas, it is essential for OEMs to create their own digital portfolios and optimally link their vehicles to these services. At the moment, we see that many manufacturers are looking for individual technological and also organizational solutions for this, which increases the development and integration effort. If the manufacturers find the right development partners, the tasks ahead can be mastered collaboratively and the high investment volume can be managed together.

To what extent does the development of an OEM.OS make any sense at all for the individual OEMs?

Hilgenberg: Of course, you could decide to buy in solutions from external suppliers. This would save time and effort in in-house development. But in the next step, you would then be inextricably bound to this external system, with all the often underestimated integration efforts that this entails. At Cariad and the Volkswagen Group, we have chosen to retain sovereignty over central, strategic control points, from our own software platform and electronics architecture to the cloud. We are redefining German Engineering – through German software engineering. We determine what we develop ourselves and what we embed. Already in areas such as over-the-air updates, security, diagnostics, monitoring and logging, an end-to-end software solution is needed – instead of implementing these functions redundantly in different versions.

Examples of such standards are UN R155/R156 and ISO 21434/24089. What solution strategies do you see and what role do software update management systems play for you here?

Hilgenberg: The UN regulations R155 and R156 provide important impetus for the entire automotive industry to implement standards for the security aspects – similar to the safety regulations. However, our understanding of sustainable security goes beyond the important basis of UNECE and ISO. To this end, we strongly follow the developments in the IT security sector, such as endpoint detection and response tools. We develop products for our vehicle architectures which, in addition to detecting anomalies, also enable us to carry out corresponding analyses and reactions. Our focus lies on protecting drivers from attacks in the best possible way. Software update management is a helpful tool for us to close vulnerabilities that enable attacks on the entire vehicle fleet much faster than before.

Kratzsch: The security monitoring already mentioned here will in future become a legal obligation over the entire lifecycle of the vehicle. That is why we at IAV have developed the Automotive Cyber Defense Center (ACDC), which detects anomalies and attacks on individual vehicles, the route infrastructure or cloud services at an early stage and can take countermeasures. This solution can be used for instance for small series, fleet operators and island mobility structures. This way, they meet the legal requirements and can benefit from the expertise we have gained through our OEM solutions.

What influence does the emergence of OEM.OS have on IAV's strategy?

Kratzsch: For IAV, it is strategically important that we participate in the development of OEM.OS, to co-develop and deliver the technology. Over the next few years, technical progress will bring about new standards, also across OEMs, for example in the area of cyber security. This means more complexity. As a tech solution provider, IAV makes this complexity manageable. We offer holistic software solutions, from the initial concept to the development stage ready for series production. Our responsibility by no means ends with the market launch but goes far beyond that – for instance with the topic of digital lifecycle management in the form of over-the-air updates. We will develop and deliver our own solutions in and around the OEM.OS, so that mobility projects are easier to integrate and to get off the ground. Real tests and prototypes are another cost factor, in this respect, we are already outsourcing prototypes and hedging to the cloud. Another point in favor of our services is our expertise regarding the comprehensive and partly market-specific standards of such solutions. Here, we can inform, coordinate and accelerate the exchange with the relevant authorities.

Since we are already talking about future requirements, where do you see the industry in the areas of OEM.OS, autonomous driving functions and cyber security in 2030?

Hilgenberg: Mobility is set to change fundamentally over the next decade. Individually used vehicles will remain the leading means of transportation in 2030. Many of them will already be automated, at least in defined areas, and some will also be autonomous. It is therefore crucial that vehicles are well connected with each other. At Cariad alone, we expect up to 40 million vehicles to be connected to the Volkswagen Automotive Cloud by 2030. Vehicle software and its safety will therefore play a central role in 2030, even more so than they already do today. They will become a completely new value driver for the automotive industry.

Kratzsch: The speed of development and technological progress, as we can see already today, is immense – and higher than ever. I expect to see a market consolidation due to the increasing cost pressure in vehicle development and production and for securing market share. Several mobility providers will use common systems for highly automated driving or OS solutions/platforms, as we are already seeing with mobile phone OS and mobile phone marketplaces. For this process, a coordinating player is needed who fully penetrates the topic technically and understands the interplay between the various technologies and players. IAV will assume this role. We are very well positioned to face these challenges and have been successfully developing engineering solutions in both fields (autonomous driving systems and security) for more than 15 years.

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How IAV vaccinates vehicles against cyber viruses

Cyber security is the subject of tomorrow's mobility: Autonomous driving and the networking of vehicles are increasingly targeted by hackers and must be reliably protected from attacks. Together with easycore GmbH and the Hamburg University of Applied Sciences (HAW), IAV has developed a concept that secures networked vehicles.

IT security as a pre-requisite for innovation

This research protects human lives: “Every new online interface that is integrated into the vehicle is a door for hackers who want to attack data and programs,” explains Professor Falk Langer, Team Manager Connected Systems Technology at IAV and Endowed Professor for Connectivity and Services Automotive Software at the Mittweida University of Applied Sciences. The defense against cyber attacks on vehicles is not only about possible economic damage that can arise from extortion, recalls or image loss. IT-Security is a key requirement for successful innovations in smart mobility.

That is why the project partners in 2018 launched the “SecVI: Security for vehicle information” research project by which vehicles can detect attacks early and prevent them from being robust – without having to change all existing vehicle components. This makes driving with networked cars safer. “Vehicles are now rolling computers, all of which are connected to each other,” says Langer. “They are constantly online, communicating with each other and with the backend.”

As in martial arts: Recognize and block attack

The partners of the research project – IAV, easycore and the HAW – have developed intelligent methods for the control, monitoring and reconfiguration of networks in vehicles in order to protect our increasingly interconnected vehicles. The IAV-initiated Automotive Cyber Defense Center (ACDC) coordinates these procedures and monitors the flow of messages between the car and infrastructure, as well as between control units, software components and services (e.g. navigation devices) on three levels. The first two levels always transmit abnormalities to the ACDC.

Easycore provides a firewall for the Controller Area Network (CAN) for the first level, which protects the vehicle and its control units and blocks faulty communication at an early stage. For the second step, the HAW has developed software that can protect the vehicle network thanks to intelligent building blocks. These building blocks enable communication flows only if they comply with the previously defined network access control rules. A self-learning anomaly detection completes the protection on a third level: Thus, attacks can be identified and prevented. The concepts of the SecVI project were evaluated in a demonstration vehicle.

How does the ACDC work?

Autonomous driving is only possible if driver assistance systems use a variety of information from different sources. The data from the immediate environment of the vehicle must be processed with information from the Internet (weather, traffic, etc.) in the operating control of the car. This requires different security levels – in the control unit, in the vehicle and beyond.

IAV integrates the findings developed in the SecVI project into current developments on cyber security monitoring and incident response, i.e. reactions to threat situations. The resulting products and services can be used by OEMs, smaller vehicle specialist equipment or also in agriculture. The ACDC is to be offered as a service: The data from the vehicle or the vehicle fleet are first recorded and analyzed. When a threat is detected, the response is made to ensure the safety of the individual vehicle as well as the safety of entire fleets.

Security specialist Langer describes possible scenarios: If a car is attacked, the virus can spread to other vehicles through networking. Because the vehicle is connected to the ACDC, safety algorithms detect the anomaly. But drivers don't have to rely on technology alone. "Our staff will then take the necessary countermeasures and put the car into which the virus has penetrated into a quasi-quarantine. This prevents transmission to other vehicles," Langer describes the functioning of the ACDC. In short: Algorithms take over basic monitoring, recognize the threat situation and human personnel take action in the event of an emergency. The security engineers must then carry out a forensic analysis based on the development of an update that can be corrected.

However, because the development of safety updates can take between a few days and many months depending on the problem, the vehicles must be protected differently in the meantime. "Certain services, such as the traffic information of the navigation systems, or even control unit functions, can be temporarily disabled. Individual online functionalities are then not available until the update is available," explains Langer. "The services that are absolutely necessary for the basic functionality of the vehicle are transferred to other computers by means of reconfiguration and continue to function." With limited functionality, the safe operation of the vehicle is thus ensured. With the ACDC, IAV is paving the way for a secure and autonomous mobility of the future.

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Saxony absolutely flashed

The own car, for many city-dwellers it is an indispensable luxury. Public transport and the increasingly diverse range of alternative mobility offers are replacing private cars for an increasing number of people. It is more difficult in the urban peripheral areas and in the countryside. In Saxony, IAV is involved in several innovation projects with the aim of making shared mobility even more convenient, smart and autonomous.

Absolut The aim of the research project "Absolut" is to bring autonomous shuttles onto the roads in Leipzig. On the test track between the Messe S-Bahn station and the BMW plant, the shuttles will not only run autonomously but also at the usual local speed - with the aim of establishing demand-oriented flexible mobility offers – integrated into the offerings of the Leipzig Transport Authority (LVB). In addition, the consortium around LVB is aiming for approval for a maximum speed of up to 70 km/h.

In the project, IAV is responsible for part of the technical development of the automated driving functions, the integration into the vehicle as well as the technical testing. The first passengers are to be transported this year.

Erzmobil The small town of Zwönitz in the Erzgebirge wants to guarantee an attractive accessibility to all districts with its Smart City project. The Erzmobil project was launched in March 2020 to supplement public transport with an economically sustainable and environmentally friendly mobility solution. For this purpose, an electric shuttle serves a total of 28 entry and exit points, depending on current requirements and without a fixed schedule.

This is made possible by the IAV mobility platform, which coordinates the shuttle's on-demand system. In addition to the back-end service, it essentially consists of two apps: The booking service for the users and the information service for the person at the wheel. From a perspective, the Erzmobil could also be on its own.

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Flash In the district of North-Saxony, IAV is upgrading a midi bus to a fully automated shuttle to integrate it into regular public transport. For this purpose, an engineering team has equipped the vehicle with a self-developed self-driving system (laser scanners, radars, cameras and automation software). Thanks to the hybrid control concept, the heavily modified basic vehicle can be driven both fully automatically and with one person at the steering wheel. Flash's terrain is the route between Rackwitz Station and Schladitzer Bucht, where the shuttle will be in automated mode. At the same time, the vehicle can also be used on other routes as a regular bus.

The test operation started in the summer of 2021, the next step in 2022 is a pilot phase with passenger transport.

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“OEMs’ business model is moving into the digital ecosystem”

Software and the automobile are now more than just two inseparable terms. For a long time, the biggest transformations in the change of model series have been taking place under the metal. Topics such as software architecture, networked customer functions, digital service portfolio and cyber security have become relevant factors that can determine the success or failure of a new model. In an interview with us, Jürgen Müller, Executive Vice President Software Systems & Connectivity at IAV, talks about the latest developments and players on the market, as well as the current challenges in the automotive software cosmos.

“Adhering to perfection costs speed, which is enormously important against the backdrop of shortening development times.”

The relevance of software in the automotive sector has been steadily increasing for years. In your opinion, are the manufacturers prepared for this pressure for innovation?
Jürgen Müller: Manufacturers have to adapt their thinking patterns to the topic of software and say goodbye to perfectionist demands. In the networked world, it is no longer possible to completely predict a result and define a solution down to the last detail. Everything is in a constant state of flux, and by the time a result is achieved, new basic requirements are already in place.

We have to learn to live with incompleteness in our own solutions, something we have not been used to in the past with hardware components in vehicle development. Software is never completely finished and constantly requires further development and optimization even after market launch. Holding on to perfection costs speed, which is crucial against the backdrop of shortening development times.

How can car manufacturers achieve the necessary speed in development?
High and intelligently applied degrees of automation help to increase efficiency and speed and enable rapid iteration. However, this form of process optimization alone is not enough to meet the software challenge. The manufacturers’ business model is moving into the digital ecosystem. When it comes to the topic of vehicles, the term “smartphone on wheels” often comes up. That is not entirely appropriate, because up to now the essential functions have not been comparable to a smartphone. But through networking, the car is now also becoming a window into the online service world of the user.

Strategically, it is not enough to integrate familiar services into a vehicle. For manufacturers, it is necessary to rethink their business models from the ground up, away from vehicle-driven developments towards offers from the so-called information space to become mobility providers. Thus, the vehicle themes must subordinate themselves to the digital space to establish an attractive platform for new digital business models on the market.

Furthermore, the better my adaptability for new things and impulses, the better my result will be and the more competitive I will be.

How can manufacturers build up this attractiveness?
The turnaround I have outlined can only work through successful partnering or acquisition of companies. There are companies that operate in the digital eco system already much more successfully than the classic manufacturers, for example Amazon or Apple. I am sure that Apple will continue to show standards for digital immersion.

However, I am convinced that the manufacturers still have a big advantage. That is their strong brand, which is associated with emotionality. They need to carry this strength into the digital ecosystem. For this, it seems advisable to look for the right partners instead of a catch-up programme. If, on the other hand, carmakers do not shift their activities to the information space and drive them forward there, they risk, in perspective, being subsumed into the value creation of others.

“For us, this is not just about developing software, but about the ability to live software.”

How can IAV as a partner support manufacturers on their way into the digital ecosystem?
We want to act as a connector between the information space and the physical world and build a bridge. As a long-standing development partner of manufacturers and as a tech solution provider, we can use our wide-ranging know-how to think ahead, develop solutions at an early stage, incorporate them into our projects and make them available to our customers.

The bridge to be built is based on a holistic approach, which we in the software sector call “Mastering Software”. For us, this is not just about developing software, but about the ability to live software. “Mastering Software” arises from the combination of end-to-end software architecture, automotive software engineering and digital lifecycle management.

This will enable us to provide solutions for connected mobility offers in the future and to take on more responsibility. In this way, we make it easier for manufacturers to jump in at the deep end and can help them to break away a little more easily from a demand for perfection.

What solutions are you already introducing?
One concrete topic for us is the Automotive Cyber Defense Center (ACDC). This is a solution for a cyber security monitor that we have preconceived. The system keeps an eye on entire vehicle fleets and the road infrastructure detects potential

> “The pace of innovation in the field of software is not Europe-centred but is currently set in the U.S. and China.”

threat scenarios, analyses them and can initiate countermeasures. Another highlight is a solution from the field of cloud engineering. With the project Erzmobil in Saxony, we have succeeded in establishing a line-demand transport service for rural areas via a digital mobility platform.

In the future, we will also focus on the topic of high-performance vehicle software. More and more functionalities in the vehicle are being implemented on processors and it is necessary to open up different platforms and operating systems and flank them with modern cyber security systems. With our broad range of offers, we want to establish ourselves on the market as a tech solution provider for software.

What does your path to become a software tech solution provider look like in concrete detail?
We can already offer solutions for software and tool chains that move in the car, in IT systems and on mobile end devices. We are already very good on the vehicle side. However, we still have to improve on the topics of connectivity and the cloud. It is important for the further development of our know-how to look beyond our own horizons.

The pace of innovation in software is not Europe-centred but is currently set in the U.S. and China. We don’t have to be the fastest everywhere, but an international footprint and intensive exchange is certainly also a point that makes us more attractive for younger employees.

We need young and creative minds to achieve our goal of becoming a tech solution provider for software. At IAV, we offer these young talents a wide range of creative opportunities. Not only do we benefit from their ideas and innovations, but so do our clients.

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Five seconds ahead of time

People and their behavior are sometimes unpredictable. This can lead to unexpected and risky situations, especially in road traffic. Looking into the very near future could prevent this. You don’t need a crystal ball or the third eye for that. Cameras, algorithms and neuronal networks are the ingredients for more safety in road traffic.

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Finally, the parking space at the side of the road is found, a quick look at the mobile and quickly out of the car. As the door is opened, a cyclist almost crashes into the vehicle. Many people are familiar with moments of shock like this: A little inattention almost caused an accident.

But what if the car could recognize potentially dangerous situations at an early stage and warn road users? A research project at IAV is looking into a neural network-based technology that can prevent situations of this kind: Optical Flow allows a glimpse into the future.

Our brain is the computer that calculates our movements

Currently, Optical Flow allows us to jump five seconds into the future. Not enough for Warda Khan, Technical Consultant AI for Software Solutions at IAV: "Twenty seconds would be ideal. That would give enough time to change decisions for an action in traffic." But the research is not there yet. That's why Khan is looking for investors to support IAV's research – or pilot customers to bring the process to series maturity.

But what is Optical Flow? And how can it help make road traffic safer? First of all, Optical Flow is a daily computing power of our brain that enables us to move purposefully. With every movement, an image of our surroundings is created on the retina of the eye, relative to our movements. These patterns of movement – the Optical Flow – within our field of vision help our brain calculate the following: Am I moving or are the objects around me moving? What distance exists between the objects and me and when do I reach them? How do I avoid a collision?

The images of the objects move across the retina at different speeds. Optical Flow enables us to make course corrections – and avoid obstacles. In road traffic, this means that people recognize the movements of other road users out of the corner of their eye and unconsciously take them into account when deciding on their own course of movement.

This computing power can be simulated and transferred, for example, to navigate autonomously driving cars – to understand the movement trajectory of objects outside the vehicle. Optical flow carries the time dependency information along with the presence of an object. Currently, IAV's solution is based on camera feed from inside as well as from outside the car, this makes it easily integrable without additional equipment expenses.

Cameras recognize intention to act in real time

The basic idea for IAV's Optical Flow project is to track in real time where drivers focus their attention. "We combine this information with images of the vehicle's surroundings captured by cameras and GPS data. This allows us to see if the person behind the wheel is intending to turn right or left, or if they want to go straight," Khan explains. "If he or she is about to make an unfavorable decision, we could give a warning signal – for example, if she is steering left, where she would collide with oncoming traffic."

At the base of this solution, it contains real time gaze estimation of the driver. A neural network is trained to recognize whether the person being filmed is looking down, left, right or up by means of fixed orientation points in the eye. Integrating this information with intention prediction network gives a probability of where the person's eyeball is likely to move in which direction within the following five seconds.

"When we combine both pieces of information, we end up with the direction of the gesture," Khan concludes. This in turn reveals the intention of the person behind the wheel, who can be warned against making wrong decisions. A driver assistance system based on this method may save many potential accidents resulting from human error.

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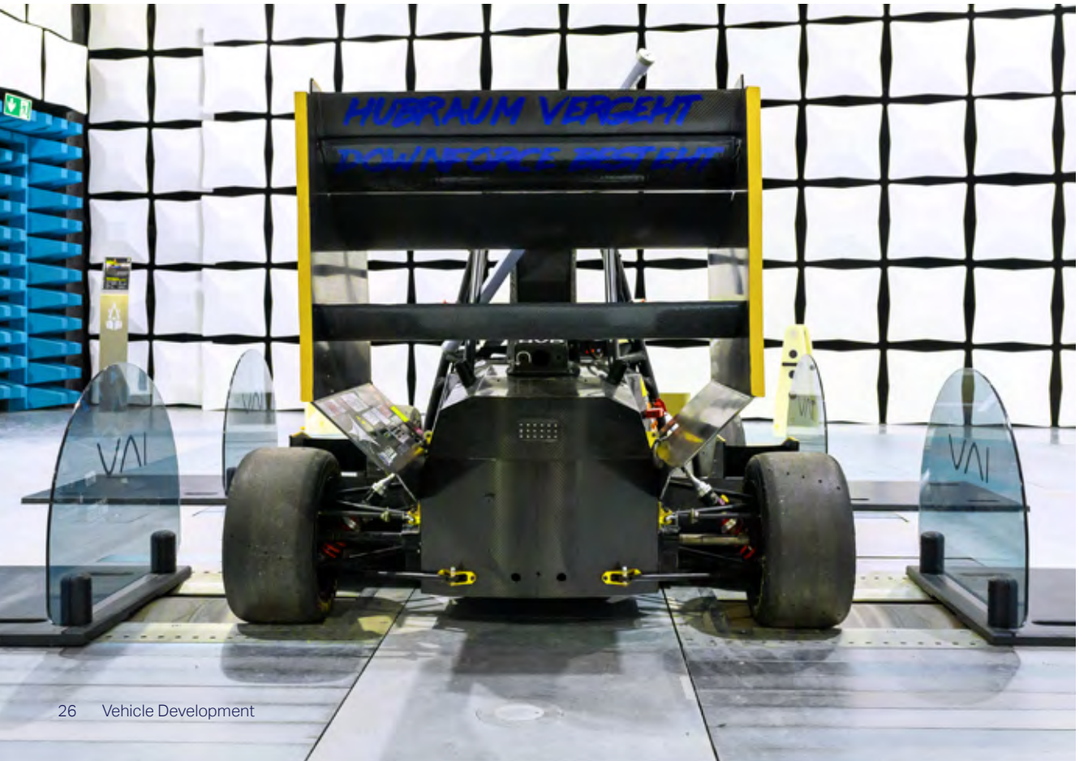
Invisible precision work

Ensuring electromagnetic compatibility (EMC) is becoming increasingly important in vehicle development. Three technological changes are driving up the measurement effort in the field of EMC: Automated and autonomous driving functions, the increasing electrification of originally mechanical or hydraulic systems, additional functional conditions such as charging. Hence, IAV has set up a new EMC test center in Heimsheim, near Stuttgart, to meet the growing test requirements of manufacturers.

During the construction of the EMC test center were no crazy designer inside, but a team of experts for the vehicle and component measurement.



Nothing remains hidden to modern measurement technology.

EMC measurements without interruption in multi-shift operation

On the electro emission-free roller test bench everything, from bicycle to the racing cars, finds place.

EMC testing of individual vehicle components as well as the entire vehicle is an essential milestone in the development process. Without corresponding proof of EMC, there is no type approval. The measurements on which this evidence is based must show that the function of the assemblies is not impaired by external and vehicle-internal disturbances, nor are other sensitive assemblies disturbed by them. The minimum requirement is defined in the UN ECE R10, but the manufacturers go far beyond these requirements in their internal tests to ensure comfort systems and to represent the state of the art.

"Electric mobility is becoming more and more important, including at Porsche. We are happy that we now have appropriate EMC testing capabilities on the doorstep of Weissach."

Dr. Markus Gräf, Managing Director, Chief Operating Officer Cellforce Group

EMC test center in Heimsheim meets increasing test requirements

In recent years, the amount of testing required in the field of EMC has increased considerably. Vehicle conditions that were irrelevant for EMC in conventionally driven cars, as only mechanical or hydraulic systems were active, are gaining in importance, such as electric driving or recuperation. All new conditions such as charging are added. Two “standards worlds” also meet here, as the vehicle is connected to the public charging infrastructure and must therefore meet the same requirements as other large electrical consumers. To make matters worse, there are many different charging scenarios worldwide, all of which need to be reviewed.

The definition of the function is also becoming more and more complex in both KI-based systems and automated driving functions. This means that the monitoring of the necessary parameters, which then guarantee a statement about the perfect function, is becoming more and more complex.

The new test center is equipped for all the already known and new challenges in the field of EMC and covers the complete range of EMC engineering.

Modern measuring environment for driving to loading

The new test center features two halls for immunity and emission tests in the context of EMC, one for complete vehicles, the second for vehicle components such as electric axles or batteries. A special highlight here is the emission-free roller dynamometer for the simulation of all relevant vehicle conditions. This can be rotated by 360 degrees, which allows the position of the test object to be changed in relation to the measuring antennas within a very short time. It is also compatible with a wide range of vehicles, whether bicycle, motorcycle, small car, or light commercial vehicle.

Another technical treat of the test portfolio is the specially developed load infrastructure. With it, the on-site engineering team checks whether the loading processes of the test vehicles are functioning properly. The test object must not introduce any interfering effects into the public network in order not to impair the operation of other equipment via the network. At the same time, a check is carried out to determine whether the predefined operating states are being adhered to: For example, the truck must not suddenly start the engine, activate the alarm system, or abort the charging process prematurely. The plant in Heimsheim has an output of up to 500 kilowatts. This range of performance allows conducting tests for all current standards and globally established on-board networks.

> “We are fully involved in the transformation of the automotive industry with our test center.”
>
> Matthias Kratzsch, CEO IAV

Focus on future requirements

Regardless of what the customer’s individual order looks like, EMC measurements are always precision work in which invisible quantities are precisely determined. An end to the trend of increasing requirements and relevant test scenarios in the field of EMC is currently not in sight. At Heimsheim, people are up to date and already today are thinking about tomorrow’s challenges.

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Listen to the rattling

Unfamiliar noises while dri
uncertainty and concern
gers. Is everything in the
should, or might a serious
tially be brewing?

ving often cause
among passen-
car working as it
problem poten-

A system that can distinguish between normal and questionable operating noises would not only help prevent unnecessary consequential damage, but also reduce the number of avoidable workshop visits. That is why IAV has joined forces with the Technical University of Braunschweig to investigate the advances that artificial intelligence (AI) can make in detecting and classifying such noises.

Noise can provide valuable information on the general condition of individual components or the vehicle as a whole. Various optimizations of the acoustics during operation are already carried out during vehicle design and development to ensure that as few disturbing noises as possible penetrate into the interior. After production and delivery of a vehicle, operating noises become interesting for service and quality assurance. Possible wear of individual components can be identified at an early stage based on noises, meaning the affected parts can be replaced in good time and any potential consequential damage can be avoided. The challenge, however, lies in reliably detecting and correctly classifying the noises.

Complex noise world

The high diversity of conventional operating noises turns the search for anomalous sounds into the proverbial search for the needle in a haystack. Normal noises include the engine and transmission, but also rolling noise, which can vary depending on the surface, as well as weather-dependent noises (e.g. rain or hail) or noise from other road users or construction sites. In addition, the vehicle's own noise varies depending on the model, age and mileage. "The classic methods of noise detection cannot do justice to the wide variability of normal and abnormal acoustic sources," says Dr. Alexander Roy, Senior Technical Consultant for Advanced Diagnostics at IAV. "With the help of neural networks, we can track down critical sounds with surprisingly good detection rates."

Neural networks listen in closely

After preprocessing the data to be used for acoustic diagnosis, the signals are processed by a mel-filterbank and converted into a format that can be used by the neural networks. During the learning process, different layers of the neural network record different information. The folded layer primarily captures information about the frequency structure of the sound, while the recurrent layer detects temporal relationships.

For this analysis process, a large data set with driving recordings from different vehicles in diverse driving situations and with a wide variety of environmental and vehicle-specific noises is used. To obtain a measurable indication of the accuracy and reliability of the process, synthetically anomalous noises at different volumes are mixed in. "We divide the data set into three sections. The first section is used to train the neural network, the second section is used to check the function, and we then use the other material to measure the performance and accuracy with which the network detects anomalous sounds," says Roy.

To increase the precision of the diagnostic system, anomaly detection is useful in parallel with the neural network. The anomaly detection system is only aware of normal operating noises and filters out anomalous noises from its perspective, without, however, being able to categorize them more precisely. If both the neural network and the anomaly detection system sound an alarm, the probability of a need for action on the vehicle is quite high.

Watch now: Video on acoustic diagnostics in vehicles.

Acoustic diagnosis interesting for many use cases

It is possible to customize how proactively the AI sends alerts for possible anomalous sounds based on specific customer requirements. "However, one hundred percent precision can never be achieved with AI; there can always be cases where anomalous noises are not detected, or are predicted but none are present." says Roy, summarizing the fundamental characteristic of all AI approaches.

Integration of the system into modern vehicles is possible, for example, via the infotainment system. The AI can record live acoustic data via the on-board microphones, for example, and transmit it via cloud computing services for further analysis. In this way, automatic acoustic diagnosis can be implemented for many end devices without installing additional hardware.

In addition, the intelligent system is also of interest outside the automotive world and could be used, for example, in wind turbines, machines in production or aircraft. Wherever machines cause noise, the system can add value in early fault detection and relieve human ears.

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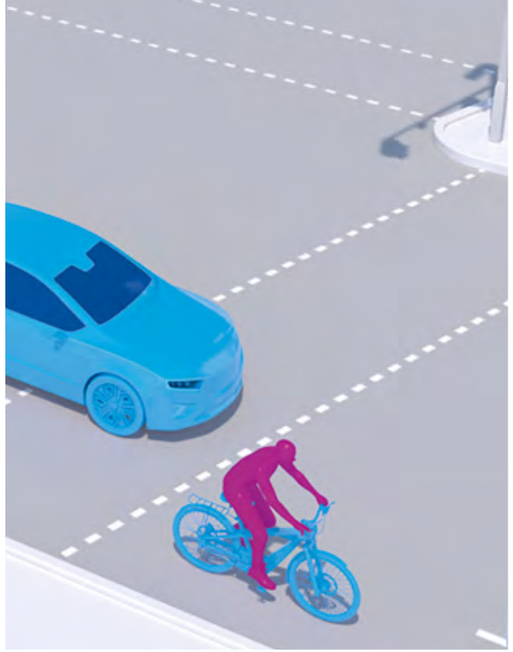

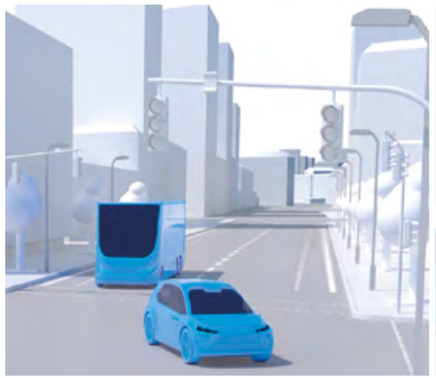

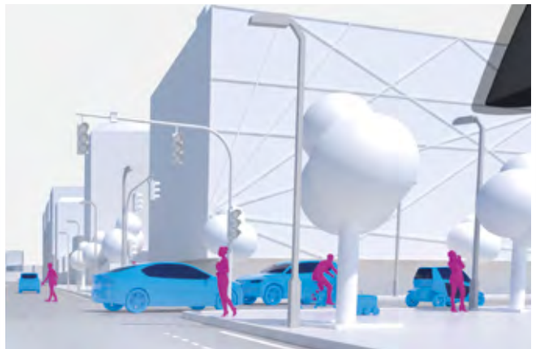

Remedy for testiritis

Test drives, functional tests, stress tests, endurance tests, load tests: Before a new vehicle model is approved, it has to endure a flood of test runs. For a long time now, the focus has not only been on the engine, chassis, steering and body. In 1937, the W30 prototypes of the Volkswagen Beetle, with around 2.4 million test kilometers, probably eclipsed all known test volumes for new vehicles up to that time. Today, vehicle developers can only smile about this, since assistance systems, software, services and safety functions in networked vehicles have to be tested for bits and bytes just as much as the classic sheet metal has to be tested for stability – not to mention ever more comprehensive safety standards.

IAV develops smart tool chains and automations for test sequences so that manufacturers can implement the increasing scope of tests against the backdrop of shortening development times and not succumb to testiritis. This allows costs to be cut and new functions to be reliably designed and virtually tested so that prototypes can be turned into production vehicles more quickly.

How engineers test today

Test Case Automation (TCA) from IAV makes measurements more efficient and less prone to error – thus advancing digitalization in the core business. The tool chain ensures reliability and high quality of the data generated. Furthermore, testing is possible remotely, as the engineering specialist does not need to be on site directly.

Fast, consistent and error-free: With Test Case Automation (TCA), IAV has developed a tool chain that significantly simplifies the execution of test cases on the vehicle with the INCA application system. Until now, such tests have involved a great deal of effort, with IAV carrying out around 10,000 of them every year. Until now, a specialist has had to prepare, perform and evaluate each individual measurement manually. Errors occur sporadically in all manual processes. With the help of the TCA tool chain, repetitive tasks in the creation of test environments are automated so that test cases can be processed easily and efficiently. In this way, the tool chain significantly reduces the risk of errors. In addition, TCA makes it easier to perform testing remotely, as engineers do not have to be in the vehicle themselves for the test, but can hand over the task to test drivers, as all essential steps can also be automated during execution.

How does TCA work?

TCA is a tool chain for automated test case validation that uses the INCA software as an application system. In practice, it looks like this: The specialist plans the test case using the “Testcase Manager” tool. From this planning, an INCA database with the required data is automatically generated. Each test case is linked to an INCA-FLOW process for the automation of the execution. Subsequently, correctly named measurement data and metadata are automatically stored in a folder.

For the test itself, the presence of specialist personnel is not necessary, which significantly simplifies trials abroad in particular in terms of personnel requirements. The test drivers only have to save the folder with the test environment on a measurement computer and can then start the “Testcase Executor”. This starts the linked INCA-FLOW process with the stored test configuration at the push of a button and automatically establishes a connection to the measurement hardware in the vehicle. In pop-up windows, the person at the steering wheel receives additional instructions that are necessary for the execution of the specific test case, for example on the driving profile or on manual actions such as an ignition change. Extensive technical knowledge is not required to perform the test. With another click, the test case starts: Through TCA, the measurement runs automatically, while the driver can fully concentrate on the INCA-FLOW-guided execution of the test case. Finally, the measurement can also be terminated at the push of a button. As a result, all data is stored automatically and with the correct naming convention. The exact and transparent filing makes the measurements reproducible at any time and thus simplifies the obligation to provide evidence. The result is test case-based assurance documentation, which is necessary to meet high quality requirements (e.g. A-Spice).

What further developments of TCA are planned?

TCA was developed for engine control unit applications in the automotive sector but can be used flexibly wherever engineers perform tests in connection with an application system. Conceivable applications include the engine test bench or the hardware-in-the-loop (HiL) system as well as integration in tool chains, for example in vehicle networking. In the future, IAV intends to offer the creation and provision of the test environment and the add-on as a service for customers. To this end, two application systems have already been adapted for INCA-FLOW, and the integration of the CANape software is in preparation.

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Test drive in the virtual interior

What at first looks like the latest version of the Car Driving Simulator is in fact the modern test environment for the development of new safety functions in cars. In this simulated environment, IAV uses synthetic sensor data from the computer – and tools from game development. Photorealistic renderings are used instead of real people and test vehicles.

Now that vehicles have a firm grasp on their external surroundings, the interior is now increasingly being equipped with sensors too. They enable new safety functions such as adaptive restraint systems or the monitoring of vital functions to find their way into the vehicle, permitting for instance a call to the emergency services to be automatically placed in case of an emergency. One of these innovations, "Child Present Detection," is likely to be NCAP-relevant in the future: The function is intended to enable the vehicle to determine whether a child has been left behind in the passenger compartment and is now in potential danger of death – due to heat exposure in summer, for instance.

Cameras and radar sensors thus become the "eyes" in the passenger compartment and provide the data for the new safety functions. The algorithms behind this are based on machine learning, which makes safeguarding a challenge. "We need very large amounts of data for this process, which is impossible to generate exclusively through real test drives with real people," says Maximilian Brenneis from IAV Fahrzeugsicherheit GmbH. "That's why we resort to synthetic sensor data, which we generate relatively easily and in great variety on the computer. This allows us to develop and safeguard safety functions for our customers quickly and reliably."

Tool from game development

The technical basis for these photorealistic simulations is the Unreal Engine from U.S. manufacturer Epic Games, which is normally used to produce computer games and Hollywood films. IAV's experts use the Unreal Engine to create vehicle interiors and people in high quality and detail. Variations in the interior are just as easy to customize as the deceptively real representation of people of all ethnicities, ages and genders.

Moreover, the digital occupants from the computer are not static pillars of salt: They move during the simulated journey (for example, when accelerating or making a sharp turn) and change their facial expressions – just like real passengers. Light and shadow also permanently change the reflections in the interior and thus provide the algorithms with extremely realistic training data. The synthetic sensor values have another appealing feature: They are already perfectly segmented, so there is no need to manually assign individual pixels to different body parts, which speeds up the entire process enormously.

End-to-end tool chain for the entire development process

"The safeguarding of functions in the interior is becoming increasingly important," says Brenneis. "This applies to all future vehicles, but especially to self-driving cabs. If we were to leave out the person behind the wheel, the technology must be able to keep an eye on the interior and its occupants."

IAV is meeting the increasing need for testing that this entails with a hybrid safeguard: The bulk of the data comes from the computer. Real test drives are only scheduled at the end of the process. This means that new interiors and derivatives can also be tested without any great effort. Moreover, the innovative approach is not limited to safeguarding: "The synthetic sensor data is also suitable for designing the functions," explains Brenneis. This enables IAV to offer its customers an end-to-end tool chain for the entire development process. The virtual interior is available for simulated test drives at any time.

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Know before what happens

A new IAV tool predicts the probability of component failure. This enables manufacturers to decide what makes more sense: a repair or an upgrade. The development was inspired by medicine.

No vehicle component lasts forever because wear and tear limits any lifespan. And sometimes problems occur more often and sooner than the manufacturer expects. “It can happen, for example, that a high-pressure pump fails after just 60,000 kilometers,” reports Kristina Luermann, development engineer in the Diesel Engine Application division at IAV. “This is not normal, so the manufacturer has to respond – by changing the pump or having it serviced in the service center.”

In this situation, it would be helpful to be able to calculate a component’s future probability of failure – because it and the number of units produced determine the future need for spare parts as well as the costs associated with the problem. And that’s not all: if a vehicle manufacturer knows the cost of a repair, it can also decide whether it’s worth making improvements to the affected component. If these investments would be significantly higher than the financial outlay for service center visits, it would be better to leave the technology as it is. Otherwise, an improvement measure would make sense.

Forecasts based on existing data

IAV has developed a model and implemented it as software that can support such decisions. Based on existing service center data for the current model series and corresponding values from previous model series, the tool calculates the probability of failure of components such as high-pressure pumps, exhaust gas temperature or NOx sensors. “A vehicle manufacturer does not need to collect new information for this,” explains Luermann, who developed and programmed the tool. “We use service center data that OEMs have anyway.” The forecasts can also be made for individual markets to capture regional specifics.

IAV’s in-house development started in December 2021 and was tested on a series from a German OEM. The data basis was formed by reports assigned to specific damage codes in the engine area. In the future, the script is to be further developed into a tool, including a user-friendly user interface. Luermann was inspired by work in epidemiology, where similar models are used to estimate how many people will develop cancer in the future. She has applied this proven “survival analysis” to vehicle components.

The method is intended to help vehicle manufacturers make more intelligent decisions in the future. “Today, OEMs wait until costs accumulate. That’s very expensive because you don’t react until very late,” says Malte Freymann, head of the Diesel Engine Application team at IAV. “We therefore want to provide manufacturers with better radar.” So that OEMs have potential problems and their consequences on their radar as early as possible.

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Use waste heat intelligently

Thermal management often leads a shadowy existence during vehicle development. Wrongfully so: the intelligent control of the heat flows leads to noticeable improvements in the efficiency of powertrains and extends the lifetime of components. At the Vienna Motor Symposium, IAV presented new technological and methodological approaches.

Whether hydrogen, hybrid or electric vehicles: Heat is the inevitable companion of motion. Sometimes it disturbs, but in many cases, it can also be used intelligently. “In any case, it is crucial that the unique features of the various powertrain technologies are taken into account,” says Marc Sens, Head of Powertrain Research and Technology at IAV. For the Vienna Motor Symposium, IAV therefore investigated how the thermal management of vehicles with battery electric, fuel cell and hydrogen combustion engine powertrains can be optimized.

Over the past decades, developers have naturally gained the most experience in this field with internal combustion engines. A lot of waste heat is available here, which can be used, for example, for heating the vehicle cabin. At the same time, however, it must also be ensured that sufficient thermal energy is available for the operation of the exhaust aftertreatment system.

In Vienna, IAV presented a solution that combines waste heat recovery with a phase change cooling system. “This enables us to extract waste heat from both the exhaust gas and the cooling system,” says Dr. Alexander Fandakov, project engineer in the Powertrain Research and Technology team at IAV. “We have thus achieved an optimum balance between engine efficiency and exhaust gas temperature levels – and thus also ensured the zero-emission conformity of the powertrain.” This is the only way to keep the hydrogen combustion engine on par with its two competitors – the battery electric and fuel cell powertrains – which by definition are emission-free.

Inspired by the bees – Thermal management in the powertrain

In comparison: Heat regulation in the hive

Beehive heating in winter

- Air sealing: Bees seal cracks and gaps in the hive with propolis.
- Clustering: Reducing the body surface area of bees exposed to cold air. Closure of the ventilation air channels of the hive.
- Endothermic heating: muscle contractions combined with wing fanning for ventilation of the heated air.

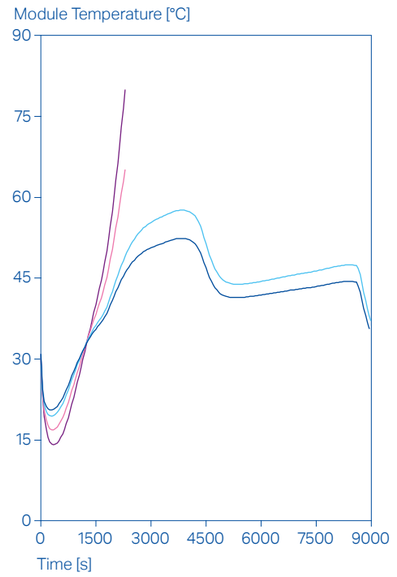
Beehive cooling in summer

- Ventilation: wing fanning.
- Heat shield: Bees absorb heat with their bodies and dissipate the stored heat in well-cooled areas of the hive.
- Evaporative cooling and humidity control: bees carry water in their bodies, spew it in the beehive and ensure the circulation of cool, moist air thanks to wing fanning .

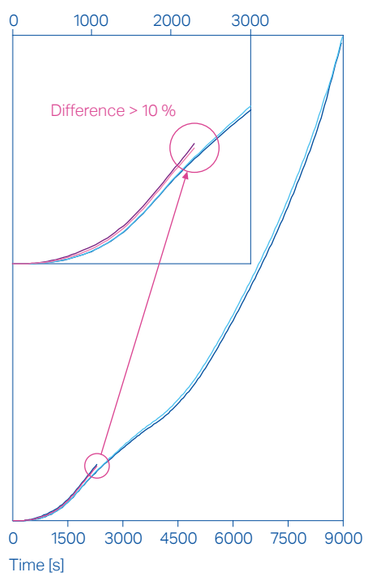
Extended battery lifetime

Battery module temperature and aging reduction during high-power charging with dedicated cooling system optimization.

500 kW Charging @ 800 V

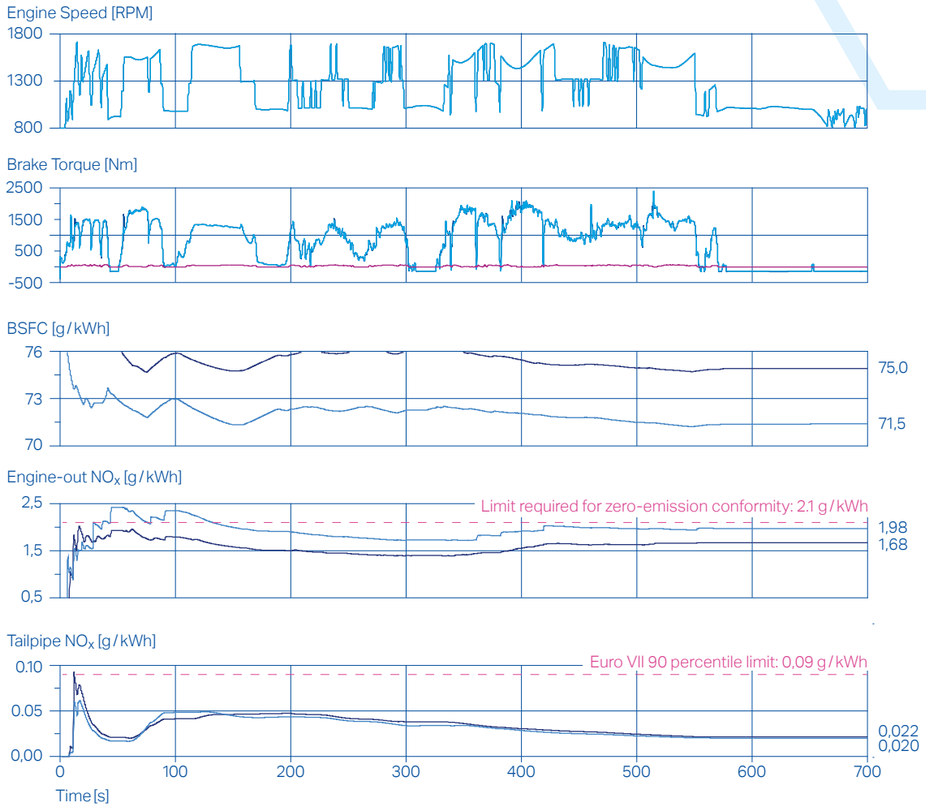


Ageing



Efficient hydrogen engines

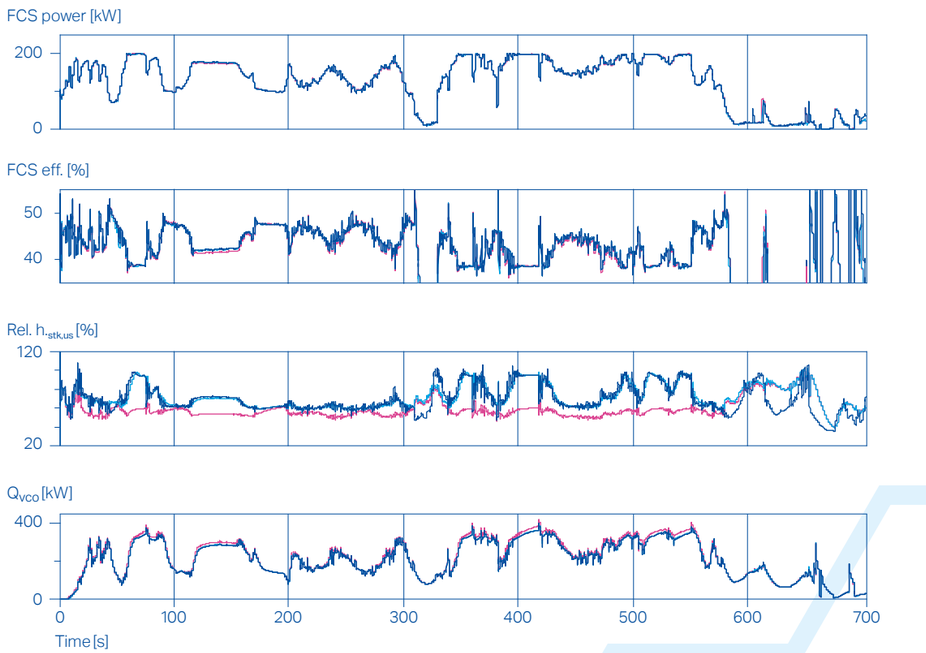
Increased efficiency and future pollutant emission legislation conformity for zero-emission HD H_2 ICEs with phase change cooling and waste heat recovery.



— Baseline
— PCC + WHR
— WHR contribution

Durable fuel cells

Increased humidity and improved fuel cell stack efficiency and durability with water injection.



— w/o PCC, w/ CAC, w/o H_2O (base)
— w/o PCC, w/ CAC, w/H_2O, opl
— w/o PCC, w/o CAC, w/H_2O, opl

Fuel cell: More efficient, longer lasting and smaller

For the first time, IAV has investigated the effects of water injection on the air intake side of fuel cell stacks. This allows the compressed air to be cooled without the need for a charge air cooler. “In addition, the intake air humidity is considerably higher, which prolongs the life of the fuel cell membrane and slightly improves the efficiency of the system,” reports Fandakov.

The cooling of the fuel cell stack has been optimized as well, as it must dissipate up to 60 percent of the total energy at full-load operation. The cooling water no longer flows through a classic radiator but dissipates its heat in a phase change-cooled heat exchanger. “Thanks to the phase change experienced by the coolant and the resulting improvement in heat transfer in the heat exchanger, the component can be much smaller than a traditional air cooler,” Fandakov says. “In this way, we have solved the existent packaging problems: In our study, we looked at a 40-ton long-haul vehicle, and thanks to the new approach the cooling system does not take up more space than in a conventional diesel truck, despite the increased amounts of waste heat a fuel cell cooling system has to dissipate at a similar power density.”

BEV: Higher efficiency and longer lifetime

Thermal management is particularly challenging in battery electric vehicles. On the one hand, very little waste heat is available here, however in the meantime the battery must be kept within a certain temperature window in addition to conditioning the passenger compartment. “That’s why we’ve been working very intensively on battery electric powertrains,” says Fandakov. “We wanted to demonstrate the potential of thermal management both in terms of efficiency and battery lifetime.”

For the first time, the IAV experts have coupled the simulation of battery cooling directly with the development of battery aging. A modification of the cooling system thus immediately resulted in a change in the battery lifetime. “The investigations revealed that intelligent cooling not only enables battery charging at 500 kilowatts – aging has been noticeably reduced as well,” says Fandakov. “In addition, we employed phase change cooling in the power components such as electric motor and inverter. Thanks to a higher temperature of the refrigerant of 80 instead of 60 degrees Celsius, we were able to store more waste heat in a storage component based on a phase change material (PCM).” This thermal energy in turn was employed for optimally preconditioning the battery already before the drive – which has improved the powertrain efficiency and extended the battery lifetime. Clearly, it pays off to think about thermal management early on.

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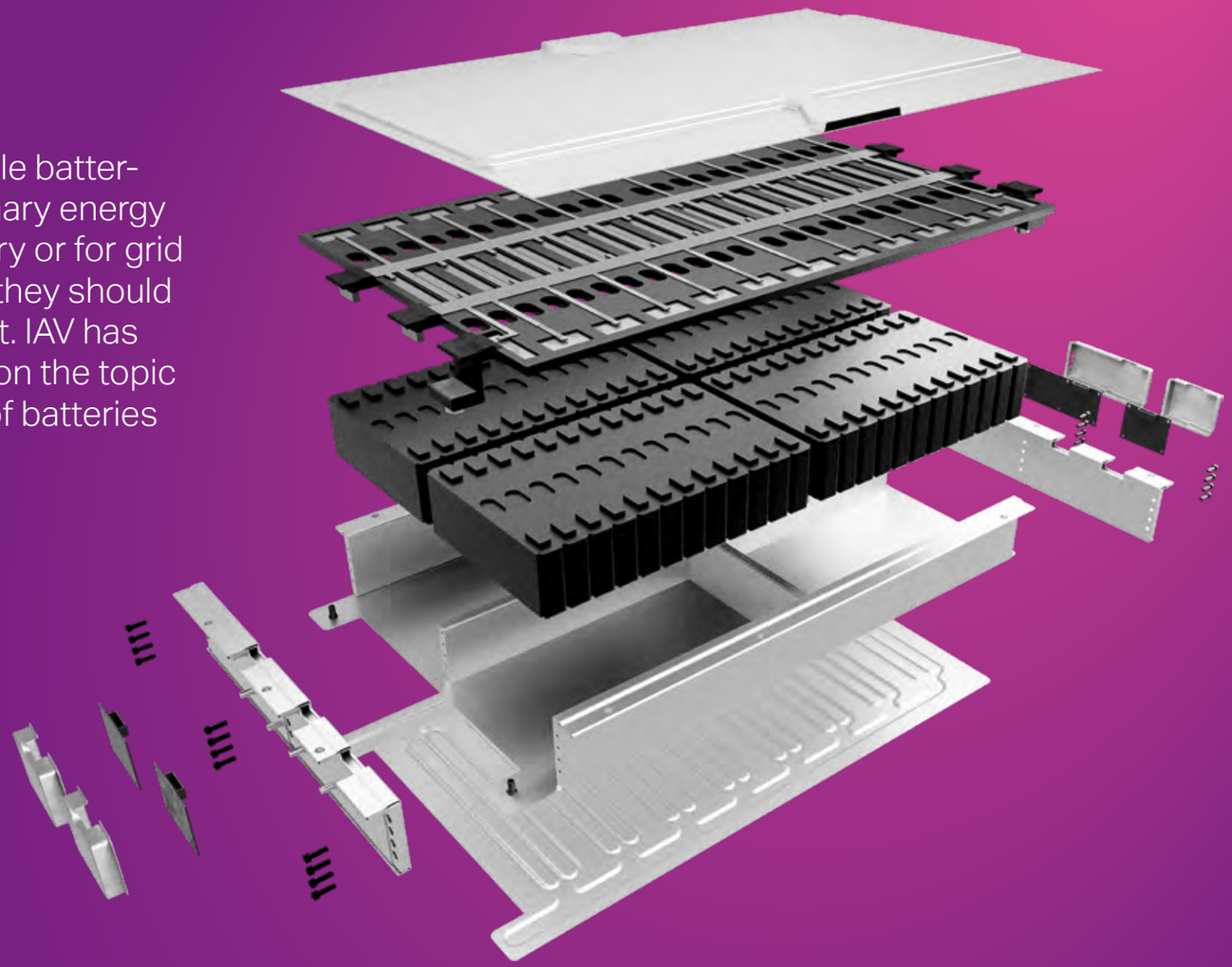
Fit for second life

After their use in electric cars, vehicle batteries can continue to serve as stationary energy storage devices in buildings, industry or for grid stabilization for years to come. But they should be designed for this from the outset. IAV has therefore been working intensively on the topic of “Second Life” and the recycling of batteries in the “Eco-Design 2.0” project.

When a vehicle battery has finished its first life, it is far from ready for recycling. “As a rule, the energy storage systems still have a residual capacity of 70 to 80 percent”, says Michael Clauß, Technical Consultant in battery systems at IAV. “These batteries can therefore be used as energy storage for many years to come – there is a wide variety of uses.” It is important, however, that in addition to the storage capacity, there is also sufficient cycle stability: During their “second life” batteries are charged 6.000 to 8.000 times, even if they are charged with a relatively low current load.

Energy storage systems can only start their second career in optimum condition if manufacturers consider stationary use in the essential aspects of development, such as design and connection technology. In addition, there are increasing requirements for recycling: While cathode materials such as cobalt and nickel and the anode’s current collector material – copper – are already being recovered today, the long-term aim is to recycle as many of the raw materials used as possible.

“At the moment, however, this is still a dream for the future”, Clauß says. “The next step will be to return anode material such as graphite and aluminum to the material cycle in addition to the cathode material.” Finally, CO_2 emissions during production and recycling are also to be reduced.



Eco-Design 2.0: Costs and CO_2 emissions are significantly reduced

So, what does a battery have to look like that is fit for a second life, is best suited for recycling and has the lowest possible carbon footprint? IAV has dealt with this question in the context of its own project “Eco-Design 2.0”. In order to meet the requirements of a “second life”, the IAV experts have divided a battery system with a storage capacity of 100 kilowatt hours into four separate cell-to-pack modules, each with a storage capacity of 25 kWh. “This is a little more expensive to produce for the first-time application, but it makes it easier to adapt later to the second life. In this way, we achieve a cost advantage of 31 percent for the housing components”, Clauß predicts. “At the same time, however, we do not compromise on safety while in the vehicle.”

To reduce the CO_2 footprint of the battery, IAV is using steel instead of aluminum. “The cooling plate, lid and battery structure can be made from this”, reports Clauß. “This significantly improves the ecological balance, because steel consumes significantly less energy both in production and in recycling.” Compared to a conventional battery, the carbon dioxide emissions of “Eco-Design 2.0” are reduced by 51 percent.

However, Clauß and his colleagues are not yet satisfied with the results of the current project. They are also currently working on further optimizing the chemistry of recycling processes. “The aim is to recycle more than 90 percent of the materials and thus to get a grip on the shortage of raw materials”, says Clauß. “That is why we are looking at recycling chemistry and are thinking about fundamentally new processes together with vehicle manufacturers.” However, it is important to find an optimum in terms of sustainability – in other words to clarify which degree of recycling still makes sense. But a solution will certainly be found soon.

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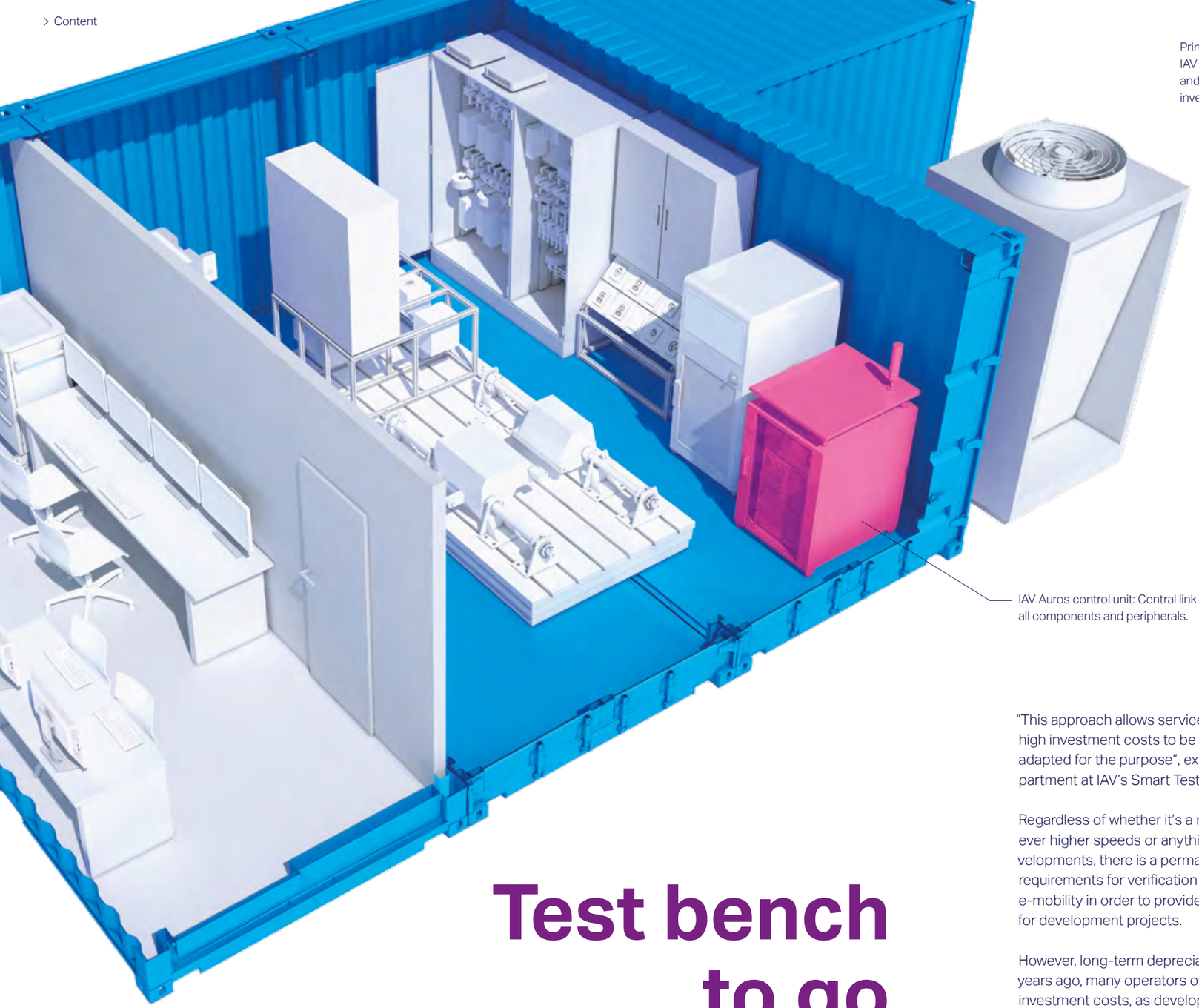

IAV Auros control unit: Central link between all components and peripherals.

Principle of mobile PST: The modular test bench concept developed by IAV allows measuring and testing equipment to be set up on free spaces and customized. The innovative model reduces service times, saves investment costs and helps to keep project plans in line with requirements.

Test bench to go

As automobility changes, so do the requirements and customer needs in the field of testing. One trend that is stabilizing is the leasing of measurement and testing technology in line with demand. IAV has developed a concept that makes test benches mobile and modular in use – wherever the customer needs them.

"This approach allows service times to be significantly reduced, high investment costs to be avoided and project plans to be adapted for the purpose", explains Sven Hönicke, Head of Department at IAV's Smart Test Factory Stollberg.

Regardless of whether it's a matter of increasing drive power, ever higher speeds or anything else – due to rapid technical developments, there is a permanent need to adapt to the changing requirements for verification and test equipment in the field of e-mobility in order to provide customers with targeted support for development projects.

However, long-term depreciation periods no longer exist. Unlike years ago, many operators of test centers today shy away from investment costs, as development projects rarely take longer than five years and requirements can change significantly depending on the project.

With the help of mobile test benches, customer requirements can be better met overall. Test facilities in specially converted transport containers can be set up flexibly at different locations and dismantled without effort once the tests have been completed. Rental is possible for a limited period ranging from a few months to several years.

Power connection and suitable floor space

"These testing capabilities can be deployed on site exactly where and when a need arises", says Jens Liebold, Business Model Engineer at IAV. "The infrastructure required is limited to a suitable floor space and a power connection."

A typical setup of a mobile test center ("test bench in the box as a service") from IAV shows three modular segments: the actual test chamber with measurement and control equipment, the control room respectively the operating room and the interfaces to the technical building equipment.

The central control unit of the mobile test bench is IAV Auros. Within the scope of a compact showcase, the unit provides all the elements required for testing high-voltage (HV) components, such as automation PC, safety equipment and power supply. IAV Auros is the central link between all parts and peripherals and can integrate other components into the test circuit.

Thanks to specially developed software, which is also used on IAV's own test benches, IAV Auros can be operated like a conventional test bench. The software allows all test parameters to be specified, can address systems such as control units, oil pump or fan and automates all test tasks.

Road-to-Rig: Making the most of development time and resources

In view of significantly shorter development cycles for vehicles – and especially for software – demand-driven and fast solutions are more necessary than ever. With an eye on development time and costs, OEMs are increasingly shifting testing tasks from the road back to the lab ("road-to-rig"). As a tech solution provider, IAV is responding to this development with new capacities.

"New test tasks, wide-ranging requirements in terms of number of channels, performance and automation of test sequences present everyday challenges", says Konrad-Fabian Wittwer, Product Manager Test and Measurement Systems at IAV. "The key to success is modularity and scalability in all dimensions."

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Photons in the E-drive

In the automotive industry, radionuclide technology (RNT) is a proven method for the wear analysis of materials and coatings – for example in combustion engine development. IAV now also uses the measuring method in the Chemnitz/Stollberg test center to investigate components in the electric drive.

"The transformation of the industry has also changed our development focus," explains Dr. Hubert Schultheiß, Technical Consultant in tribology driveline at IAV's Future Powertrain division."In the search for further applications of the RNT test method, we have come across a need for this technology, among other things, in the development of gearboxes and electric drives."

The friction between solid bodies causes energy losses and the associated wear causes high repair costs. Both parameters must be minimized from an ecological as well as an economic point of view. Early measured values for contact expulsions and the resulting material removal are extremely important, especially in the increasingly virtual development.

So-called online wear measurements with radioactive nuclides provide timely, high-precision results in the nano range, by which the quality of simulations can be checked and optimized. Therefore developers rely on the precise and efficient RNT method to keep friction and wear as low as possible.

The component to be examined is shot with particles on a particle accelerator (cyclotron). The reactions of these particles with the atomic nuclei of the component to be evaluated create a thin radioactive layer on its surface, which emits photons and thus a well measurable gamma radiation during radioactive decay. The abrasion-based wear produces the smallest radioactive particles whose radiation can be detected in the oil circuit.

Lube oil analysis based on RNT measurements

Oils have a significant influence on wear. The requirements for lubricants for gearboxes in electric cars are very high, especially because the gearboxes in electric powertrains are integrated with the electric machine in a drive unit and are lubricated and cooled with a common medium. Due to other wear mechanisms, wear rates are significantly lower than on combustion-engine components – precise measurement results are even more important here.

The RNT transmission measurements are used not only to identify critical components and operating points based on the wear level, but also to evaluate oil qualities. IAV had received an order from a renowned lubricant producer to develop new oils for applications in e-mobility. "The aim was to make a pre-selection of suitable oils," says Schultheiß. "RNT measurements are very useful here because you can get reliable wear values per oil type within a few days."

The high demands placed on measuring accuracy made it necessary to develop a suitable measuring structure and to optimize the entire measuring and evaluation process. For gearboxes without pressure circulation or injection lubrication, a system has been developed with a new type of magnetic detector that allows the oil to be removed from the oil sump of the gearbox, passed the detectors, and fed back to the gearbox at a non-critical point.

The IAV Teslin data processing tool generates detailed overviews of all measuring processes from the RNT measured values. During the tests, developers also benefit from automated analysis and test bench control, which shows that the desired quality of the measurement results has been achieved or that otherwise the measurement continues.

"RNT wear measurements offer considerable advantages over conventional endurance tests," says Schultheiß. "These include time and cost savings, higher accuracy and the determination of not only the total wear but also the operating point-related wear values. This technology also holds great potential in the field of electric power trains."

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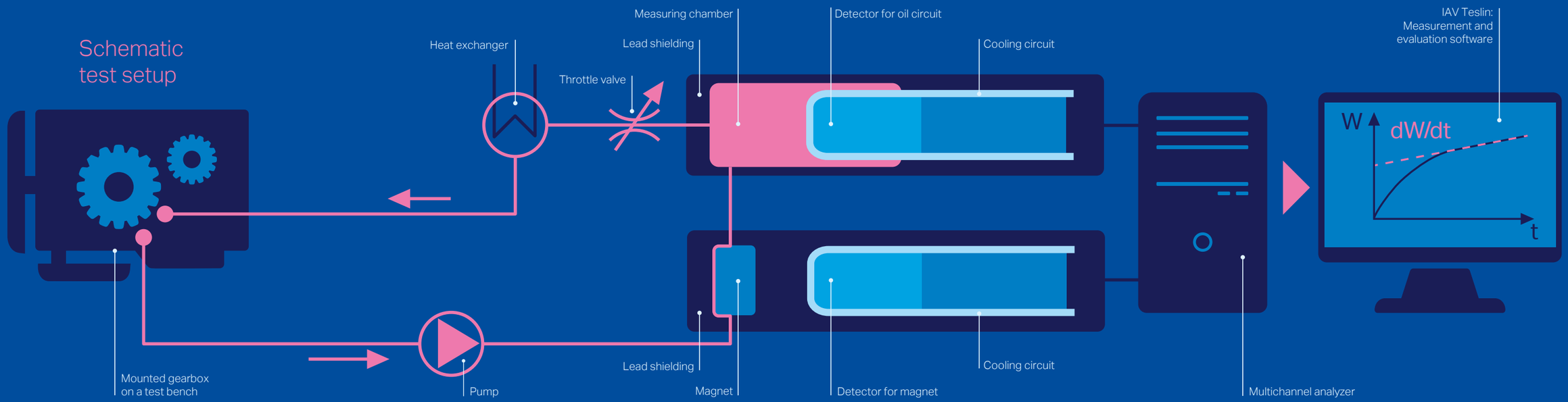

“From digital island solutions to virtual product development”

IAV is networking its tool and model landscape. With the new “Digital Twin Platform”, digital models can be interconnected via firmly defined interfaces and across all domains. In an interview, Dr. Mirko Leesch, Senior Vice President Powertrain Systems, Dr. Stephan Adelberg, Development Engineer in the Functions & Simulation department and Dr. Konrad Exner, Development Engineer in the Digital Lab, explain what lies behind the new approach.

Why did you start building the Digital Twin platform?
Dr. Mirko Leesch: New technologies are rapidly changing the automotive industry – and with it the market for development service providers like IAV. Vehicle manufacturers want to outsource ever more complex issues, so we are increasingly moving into the position of an OEM. If we want to be successful in the future and remain market leader in Germany, we have to master this complexity and handle corresponding projects efficiently.

What role do digital models play in this?
Dr. Stephan Adelberg: Digital models and individual model chains for the various vehicle domains are already accelerating development processes. For co-simulation, several subsystems can be linked via interfaces, with special simulation software being used for each component. In this way, for example, digital twins of transmissions can be coupled with models for the engine and exhaust gas aftertreatment. However, this approach still has its limits: Today, for example, it is only possible to a limited extent to implement the exchange of subsystems and models almost independently of simulation software and modeling approach efficiently and with little effort.

What will change with the Digital Twin Platform?
Leesch: Our models for the individual domains are coherent, consistent and tested. In the next step, we want to connect these islands respectively chains with each other. The goal is to be able to use digital twins across domains and throughout – from the initial concept to the start of production. In this way, we will move from isolated solutions to end-to-end, virtual product development. This is essential for our future, because only by networking our tool and model landscape will we be able to process complex projects quickly and efficiently.

Why does IAV develop its own solution and does not use commercially available products?
Dr. Konrad Exner: There are indeed ready-made solutions on the market that can be used to link models across domains. But they are not suitable as connecting platforms for IAV’s requirements. As a development service provider, we have to work with different tools and storage systems depending on the client and the project. Added to this are special legal conditions: we apply strict client segregation and work consistently according to the need-to-know principle.

Adelberg: Hence, we have started to develop our own digital twin platform. It consists of individual building blocks that generically describe certain development steps and to which digital models as well as meta-information such as title, use case, interface and contact are assigned. Their inputs and outputs are precisely defined so that the building blocks can be easily and consistently combined to form increasingly complex systems.

What does the Digital Twin Platform consist of?
Exner: Internally, it consists of four layers: The basis is access to databases and other information sources, followed by an integration layer for the individual data silos. Above this is the semantic layer, which describes the logical relationship between the data sets and contains the intelligence of the building block. The frontend for the user follows at the top level. The building blocks are separated from the model information, thus preserving the need-to-know principle. They are used repeatedly and are constantly optimized over time.

What do IAV customers get out of the new platform?
Leesch: They will benefit from greater speed and higher quality in the development phase, but also during the bidding phase, among other things. The feasibility of the new approach has already been proven conceptually by a requirements assessment and a mock-up. Now we are going full steam ahead with the next steps: to develop a proof of concept with a complex customer project. The interest is great: there are already other customers who would like to use our new platform in IAV projects.

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China – HMI Wonderland

Different country, different HMI system – manufacturers must adapt user interfaces to local conditions before launching them on the market. Especially in China, HMI solutions that are particularly unusual for Europeans are in demand. That's why IAV is significantly expanding its capacities in China and offering versatile tech solutions, from concept studies to series development.

中国 – 人机交互的理想王国

入乡随俗：用户界面进入新市场之前，必须要适应当地特色。欧洲人眼里不同寻常的人机交互方案，在中国却尤为热门。因此IAV正在中国扩大其业务领域，并提供从样件到批量开发的多功能技术解决方案。

In China for China – this briefly sums up the recipe for successful HMI development for the world's largest automotive market. "In China, we are not only dealing with different characters, but also different colors, country-specific online services and different criteria for approval," says Detlef Räth, Senior Vice President HMI & Performance Software Solutions at IAV. "And of course, Chinese customers also have their own unique needs. That's why an OEM can't simply adapt its existing HMI from Europe – an on-site development team is required."

客户至上

Putting on customer requirements at the center

IAV has been active in HMI development for the Chinese market for years, from concept studies to series development. The employees on site investigate the current needs on the market and cooperate with local research institutes and partners.

Customer needs are also the focus of concept development – together with Chinese design companies. "In order to be even closer to the end customers, we are currently transferring a lot of expertise from Germany to China," reports Erik Nieswand, Head of Department for HMI Software.

Among the peculiarities of the Chinese market are "intelligent co-pilots" – either taking the form of avatars on the infotainment system screen or special hardware on the dashboard. They greet the driver when they get into the car or recommend a break if the person behind the wheel seems tired. "Chinese customers also attach a great deal of importance to having several monitors in the vehicle," says Dr. Marcus Heinath, Head of UX & HMI Development. "These can then be used to play games when they get stuck in a traffic jam; something that is very much part of everyday life in Chinese cities. Instead of a controller, the steering wheel with its buttons can then be used as an input device." Another key factor for Chinese customers is the seamless integration of the smartphone into the vehicle: all profiles and apps must be directly available there. And finally, the market in China for intelligent voice control is growing, so voice operation of vehicle functions will also become much more relevant.

IAV has been developing series software for infotainment systems for the Chinese market for around four years now. Up to now, existing modules have primarily been adapted for the Chinese market – for instance in terms of design or with a view to additional features. Soon, however, this process will also be increasingly shifted over to China. "Here, it is important to note another peculiarity: Chinese OEMs do not use their own operating system or framework for their HMIs," according to Räth. "Instead, they use Android. So, we have been building upon our own expertise in this area too."

There are already many vehicles on the road in China with HMI software from IAV – including the latest versions of infotainment systems for electric vehicles from well-known OEMs. However, adaptation to local peculiarities need not remain a one-way street: In the future, HMI experts could also help Chinese OEMs gain a foothold in this country, thereby transforming the credo into "In Europe, for Europe".

"ObjectivO" 把关

On-site backup

This also applies to the last step of HMI development, the backup. It must be done locally with a dedicated team because test drives must take into account local traffic conditions and Chinese online services. When evaluating HMI systems, Räth and his team also rely on user tests in China and on the "ObjectivO" tool they developed themselves, which HMI experts can use to determine whether a solution complies with the current guidelines (e.g. regarding the potential for distraction for the person behind the wheel).

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心动不如行动，快来联系我们吧！

e-fuels in sight

For the transition to a CO_2-neutral world, entire industries must move away from fossil oil and gas. Besides fuels, this also applies in particular to the chemical industry. One solution is the so-called e-Fuels, the life-cycle assessment of which IAV is now investigating.

More and more OEMs are focusing development on the environmental impact of their vehicles with a view to the Paris climate goals. IAV is further expanding its expertise in this area, which already goes back 10 years.

Besides engineering and process know-how in the field of energy sources and power generation, this includes above all life cycle analysis (LCA). In addition, IAV is also working on solutions for increasing the acceptance and transparency of CO_2 footprints of products, for example using CO_2 blockchain technology.

"We started in the automotive sector, but we are also conducting the investigations for many other products", explains Emanuel Binder, test engineer at department Research and Technology at IAV.

The focus is on synthetic fuels (e-Fuels), such as synthetic gasoline / diesel, methanol, ammonia, methane and hydrogen, which can be produced at low cost at global sweetspots in South America, Africa, Australia and elsewhere thanks to rich renewable energy sources. The power-based fuels are not only suitable for use in mobility, from road transport to aviation and shipping, but also as a basic material for the chemical industry, where it can replace crude oil and natural gas, for example, for the production of plastics (e-Crude).

Life Cycle Engineering

What the LCA of a production plant for synthetic fuels looks like and how much CO_2 and other greenhouse gases can be saved compared to fossil fuels are two of the core questions that the Berlin-based tech solution provider is dealing with. IAV attaches particular importance to linking the LCA with the actual engineering ("Life Cycle Engineering") and to using its in-depth expertise for systems and components, such as electrolyzer, fuel cell or combustion engine processes.

"The entire technology system in the field of e-Fuels is similarly complex as the overall vehicle system", says Panagiotis Grigoriadis, team leader in the Organization Research and Technology. "With our expertise in system understanding and complexity control, we can certainly deliver added value here."

"We are convinced that LCA must be at the beginning of every product development and constantly accompany it", says Binder. "Together with our customers, we discover the actual pain points and ensure that we use our engineering expertise in the right places!"

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IAV dates for your diary: Shall we meet?

You will find the latest updates regarding upcoming dates for your diary on our website

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"The question is if it's still up to date that highly qualified people have to apply. We send our people to certain events with ready employment contracts. We don't need cover letters and no big formalities."

Dr. Uwe Horn, CHRO IAV