auto motion

automotive engineering iav

IAV Customer Magazine | 03/2020

73 % say that AI is the most important future technology.

6 % are already using AI.

Dear readers,

Katja Ziegler
President, CFO
IAV GmbH

Dr. Ulrich Eichhorn
President, CEO
IAV GmbH

Dr. Uwe Horn
President, CHRO
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Matthias Kratzsch
President, CTO
IAV GmbH

Where a lot of data is generated, the use of artificial intelligence is hardly imaginable without it.

For many companies, artificial intelligence (AI) is currently the most important future technology. Used in a correct and responsible way, it offers enormous potential for new products, services – and development methods.

Platforms such as Netflix, Spotify and Amazon, for example, invest a great deal of effort in optimizing their algorithms so that they recommend films, music albums or products with the highest possible hit rate. The simple equation: The more these platforms learn about our preferences, the more accurate and better the suggestions become. The quality is sometimes already astonishingly high.

However, while Netflix and Co can train their AI according to the principle of trial and error in the same way as a chess computer, vehicle development must choose more demanding routes. Two major differences are decisive for this. Firstly, monitoring: In a chess game, the rules and framework conditions are clear. Completely unexpected events like in road traffic can be excluded. Secondly, the extent of damage: The AI of a chess computer can make millions of mistakes and learn from them. The consequence is a lost game. AI in a vehicle does not allow any mistakes, because the safety of us all is at stake.

As vehicle and mobility developers, we bear a particularly great responsibility. And so safety and reliability are our top priority when using AI. In a safety-critical system like a vehicle, we cannot leave results and decisions to chance.

Despite the great challenges, AI has enormous potential, which is crucial for future market success. After all, most technologies and developments on the road to tomorrow's mobility are often only possible today thanks to AI. It is a key technology for automated driving and central to the smooth functioning of driver assistance systems. But it also helps vehicles find their way around in unknown or rapidly changing environments (page 26). And it is the basis for smart voice assistants. In this way, AI helps to make the driving experience safer and more convenient and to gain time for other things. And OEMs of course also benefit from this, as their vehicles become more attractive.

But AI not only enables new products and services, it also enables development methods of a new dimension (page 10). Thanks to digitalization and increased computing power, we can now use completely new development methods that offer completely new possibilities – for example, for predictive maintenance of vehicles and engines (page 14) or with regard to future function development for control units (page 16). But these methods also support our engineers: By combining expert knowledge with the possibilities offered by AI, they obtain better results faster (page 20) and can use data-driven development methods to carry out even more precise simulations and tests automatically, for example (page 18). And this in turn benefits our customers. Because the use of AI in engineering is a catalyst that increases quality, reliability and the speed of the development process.

All this requires a deep understanding of these technologies, basic research as well as networking and exchange with universities and research institutes – something we at IAV have been cultivating and expanding since our spin-off from the Technical University of Berlin (page 22). The speed of development in AI is enormous. Ongoing exchange, joint research and development in networks are crucial to keeping up with the latest technology.

Our great strength is to master the most demanding customer requirements and to reliably bring new solutions into series production. Together with our partners and customers, we often break new technological ground. One thing, however, does not fall by the wayside: the responsibility for the legal conformity of the engineering services we contribute to the product success of our customers. This is ensured by a state-of-the-art compliance management system in which we at IAV have invested massively. Our partners, customers and society as a whole can rely on this.

We hope you enjoy reading this report!

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Super Power AI

What can AI do? Who can do AI? A quick introduction to the topic – status quo in Germany and the world.

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"We Do Not Want to be Presented with the Finished Solution"

Dr. Matthias Neumann-Brosig, expert for Data Science at IAV, and Sebastian Trimpe, Professor for Data Science in Mechanical Engineering at RWTH Aachen University, talk about the necessity of research networks.

Editorial

Topic focus

Driving forces

Trends

Changing track

About IAV

Green Power for Sustainable Mobility

Increase efficiency to over 45 percent with biomethane.

New Emission Laboratory Can also Be Electric

A new IAV test bench offers state-of-the-art measuring technology for all gaseous standard emissions as well as for mass and number of particles. Hybrid and electric vehicles can also be tested.

Always Live – Thanks to IoT Platform and AI

In a research project with partners, IAV is investigating the flexibility potential of electric fleets and the possibilities of intelligent grid integration.

EMC as a Growth Market

New IAV test center for electromagnetic compatibility planned in Heimsheim.

"We can play our part in slowing down the spread of the virus."

Dr. Uwe Horn
President, CHRO, IAV GmbH

Rising case numbers, new restrictions in public life: The coronavirus pandemic still has a firm grip on both, society and the economy. Dr. Uwe Horn, Director of Labor Relations and Managing Director, explains how IAV as a company is dealing with the situation.

A brief review: How did IAV react in the initial phase of the coronavirus pandemic?

When the virus broke out in China, the alarm bells also rang in Germany. Since January, we have had an interdisciplinary Covid-19 task force under the direction of occupational safety and HR and with the support of the works council and communication.

In the initial phase, this team provided our colleagues at IAV in China in particular with advice and support. By the time coronavirus started to spread throughout Europe and Germany, we were well equipped and well organized.

What measures did the company take?

The effects of the coronavirus pandemic are manifold. Our measures are correspondingly broad-based. The safety and health of our employees is our top priority. At the same time, we want to maintain our ability to work in the best possible way. So far, we have succeeded in doing both very well: The incidence of infection at IAV was and is under control and at the same time we have enabled the majority of our employees to work remotely within a very short time. We have received much praise from our customers for this.

For months, we have had to comply with the regulations: Anyone who can work meaningfully from home should do so in close consultation with his or her superiors. Over the summer, we allowed for a bit more flexibility in close coordination in close coordination with our work team. However, when the number of cases in Germany started to rebound in the fall, we returned to the original rule that anyone who can work from home should do so when it makes sense.

How are you meeting the challenges that coronavirus will undoubtedly continue to present to all of us?

We must remain vigilant and keep a close eye on the further development of the pandemic. The number of cases in Germany and in many other places continues to be a cause for concern. It remains difficult to forecast the further development of the pandemic. But we can do our part to slow down the spread of the virus and thus protect our healthcare system. Our offer of remote working helps in this respect, as does the close-meshed information we provide to our employees or the coronavirus testing capacities we have built up at IAV.

"IAV is financially sound. We are using the coronavirus era as an opportunity to move up a gear in terms of digitalization and efficiency of our own processes."

Katja Ziegler
President, CFO, IAV GmbH

"We at IAV are there for our customers and ready for action – before, during and after coronavirus."

Matthias Kratzsch
President, CTO, IAV GmbH

"Like any other crisis, coronavirus acts as a catalyst for change. We as an industry must seize the opportunity to shape this change together."

Dr. Ulrich Eichhorn
President, CEO, IAV GmbH

Artificial Intelligence

The engine of the future

AI – desire and reality

73% <> 6%

of the company are of the opinion that AI is the most important future technology.

have been using AI themselves so far.

Source: https://www.bitkom.org/Presse/Presseinformation/Companies-find-Artificial-Intelligence-difficult-to-handle

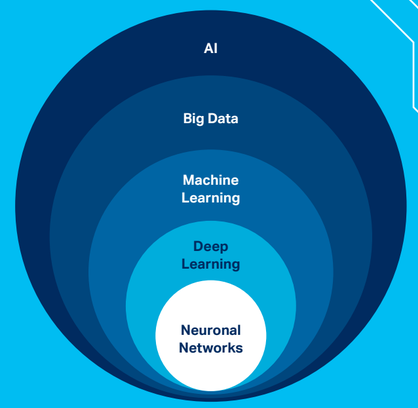
In order for AI to function smoothly, an optimal interaction of hardware and software is required. At IAV, the AI and IT specialist is taking over together with Germany's No. 1 provider of engineering cloud services: IAV subsidiary CPU 24/7.

The currently fastest computers in the world:

1. **Supercomputer Fugaku (Japan)** 415.5 PetaFLOPS
2. **Summit (USA)** 148.6 PetaFLOPS
3. **Sierra (USA)** 94.6 PetaFLOPS
4. **Sunway TaihuLight (China)** 93 PetaFLOPS
5. **Tianhe-2A (China):** 61.4 PetaFLOPS
13. **SuperMUC-NG (Germany):** 19.4 PetaFLOPS

Date: June 2020; considered value: Rmax (PFLOP/s)
Source: https://www.top500.org/lists/top500/list/2020/06/

AI – here's what it involved



AI: technical automation of intelligent behavior

Big Data: modern techniques for processing and evaluating huge volumes of data

Machine Learning: Algorithms for data analysis, pattern recognition and derivation of forecasts and decisions

Deep Learning: Method of information processing for decision-making based on large neural networks

Neural networks: multi-layered networks for data analysis based on the functioning of the human brain

AI makes the economy grow (forecast until 2030)

Germany:
509 billion US dollars
11.3% growth

Northern Europe:
1.8 trillion US dollars
9.9% growth

North America:
3.7 trillion US dollars
14.5% growth

China:
7 trillion US dollars
26.1% growth

Global ecomony:
15.7 trillion US dollars

Economic growth in the countries/continents triggered by AI in relation to the total economic volume of 2018.

Source: https://www.pwc.de/de/digitale-transformation/business-analytics/kuenstliche-intelligenz-sorgt-fuer-wachstumsschub.html

AI strategy of the German government:

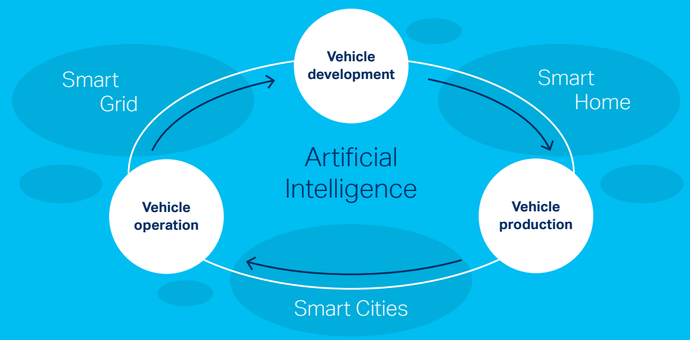
1. **Germany as a leading location** for AI technologies
2. **Responsible development** and use of AI
3. **Ethical, legal, cultural and institutional embedding** of AI in society

Five competence centers and the German Research Center for Artificial Intelligence (DFKI) strengthen Germany as a location for AI.

In addition, a large number of universities, institutes, research facilities and centers of excellence with a strong AI focus are establishing themselves – many of them in close cooperation with IAV.

Source: https://www.bmbf.de/de/kuenstliche-intelligenz-5965.html

The special quality: overcoming system limits with AI



AI tools

The basis for customized solutions are powerful AI tools.

< PyTorch /> < MLflow /
> < Python /> < pandas /
> < NumPy /> < SciPy /
> < scikit-learn /> < TensorFlow /
> < Kubernetes /> < Microsoft Azure /> < Keras /> < spaCy />

Those who invests stand to win

In the past five years, there has already been a lot of investment in future technologies. The top 3 in international comparison:

- **1st place:** USA 92 billion US dollars
- **2nd place:** China 22 billion US dollars
- **3rd place:** UK 6 billion US dollars

Source: https://venturebeat.com/2020/03/16/tech-nation-u-s-companies-raised-56-of-global-ai-investment-since-2015-followed-by-china-and-u-k/

"Digitalization Enables Development Methods of a Completely New Dimension"

Digital change is pushing the automotive industry at a rapid pace: Artificial intelligence (AI), Machine Learning and Big Data are finding their way into companies. In an interview, Chief Digital Officer Matthias Schultalbers explains the potential of these technologies and what customers can already expect from IAV today.

You're Chief Digital Officer at IAV – what path did you take to get here?

My interest in automation goes back a long time, not least because I studied automation and control engineering. I have been working intensively with digitalization for around six years now. At IAV, I want to lead the way in digital change and bring the latest research findings to series development. To lay the foundations for this, I founded the Research Center at IAV. In early 2018, a joint research lab was set up in Kaiserslautern in collaboration with the German Research Center for Artificial Intelligence (DFKI). One year later, I was given responsibility for our Digital Lab. About a year ago I was appointed CDO.

What happens in the Digital Lab at IAV?

In the Digital Lab, we take care of the transfer of know-how. We are a node and network for key technologies of digitalization and new ways of working. The Digital Lab works for the whole of IAV and drives the company's digitalization forward. Our aim is to combine knowledge from the various disciplines – from autonomous systems to the use of the latest AI technologies – with know-how from the various fields. This is where domain meets technology. This mission is driven forward by our innovation process that involves all IAV colleagues and enables cross-divisional networking. Through innovation campaigns and subsequent pitch sessions, colleagues can submit and implement their own ideas. A jury from the technical areas decides on which topics will be worked on further. In test sprints, our employees then develop minimum viable products (MVP) and simple demonstrators in a very short time. This results in products and services that we develop further with our customers, and strategies that continually improve our processes. Our colleagues then take the newly acquired knowledge from the Digital Lab back to their specialist departments – a constant cycle of know-how transfer.

Another important component is the exchange with our research network, such as the Research Lab, which we operate together with DFKI, and Cyber Valley in southern Germany, of which we are a founding member. It is one of our core competencies to reliably develop new solutions to production maturity. By bridging the gap to basic research, we ensure that new technologies and methods find their way quickly and efficiently from research, development and the first prototypes into production vehicles.

> **In the future, IAV intends to distinguish itself even more as a tech provider. Customers should turn to us with all questions relating to digitalization and the use of new technologies.**
>
> Matthias Schultalbers, Chief Digital Officer at IAV

In which digitalization technologies do you see the greatest potential for the automotive industry?

An extremely large amount of data is generated in the automotive sector. There is a lot of potential there, but the systematic evaluation of this data is a major challenge. We must focus on smart information gathering. Here, it is a case of generating the maximum information content from the existing data so that we can permanently reduce redundant measurements.

I also see a big lever in virtualization: The Digital Twin, for example, opens up undreamt-of possibilities for better safeguarding of systems compared to testing. In the field of predictive health monitoring, methods for detecting anomalies in measurement series from different control units have become established. This enables us to react to errors at an early stage. On the one hand, we can minimize the time needed for error correction and on the other hand we can reconfigure the system based on the quantitative estimation of the error. This way, the system behavior remains in the optimum despite an error. I also see many opportunities in the use of reinforcement learning, which allows models to be developed that independently find an optimal solution for the respective task within a target system. Even the system reaction flows into the optimization process and the model adapts itself until it reaches the desired behavior.

In addition, technologies such as Safety Supervisor help to secure neural networks in control units. Only those who also know and master the weaknesses of the AI are able to exploit the potential.

Every day, we deal with increasingly complex systems, higher quality requirements, increasingly documentation effort and shorter development times. Digitalization helps everyone in the industry to meet and master these challenges effectively.

How digital is IAV already positioned?

We have come a long way, but for us it is always a matter of finding new or even better solutions. As a leading development partner, we cannot accept standstill and have therefore worked successfully on core technologies in the past. For instance, we are excellently positioned in the field of predictive maintenance, in safeguarding neural networks (Safety Supervisor) and in control and regulation with AI (Reinforcement Learning). The task now is to deploy these technologies across the board at IAV from administration to engineering. To achieve this, we need to extend our mindset, expand knowledge management and create tools that all employees can use – not just individual specialists. Our customers will also benefit enormously from this.

Where do you want to move the company in the coming years?

It is important to me that IAV is digitalized as a whole – from technology (i.e. our divisions that work directly for our customers) through IT to administration. We are also working on adding new business models to our portfolio: In the future, IAV is to distinguish itself even more as a tech provider without losing our position in terms of implementation expertise. We want to continue to bring the latest developments from research into series production. However, customers should turn to us with all questions relating to digitalization and the use of new technologies. To this end, we want to offer a broad range of modules from which we develop individually tailored technical solutions for every problem and every domain.

How do you see the future?

With a high degree of optimism! We can rely on excellent employees in all areas. They have the know-how to drive digitalization forward. At the same time, we have the best development methods and customers who entrust us with their most demanding and success-critical topics and projects. There can be no better basis for us as a development partner. And this trust ensures that our expertise is increasingly appreciated and in demand beyond the automotive industry. And this is not an end in itself, because in a digital and networked world we need universal, cross-system solutions – solutions that know no industrial sector boundaries. And that is what we already offer our customers today.

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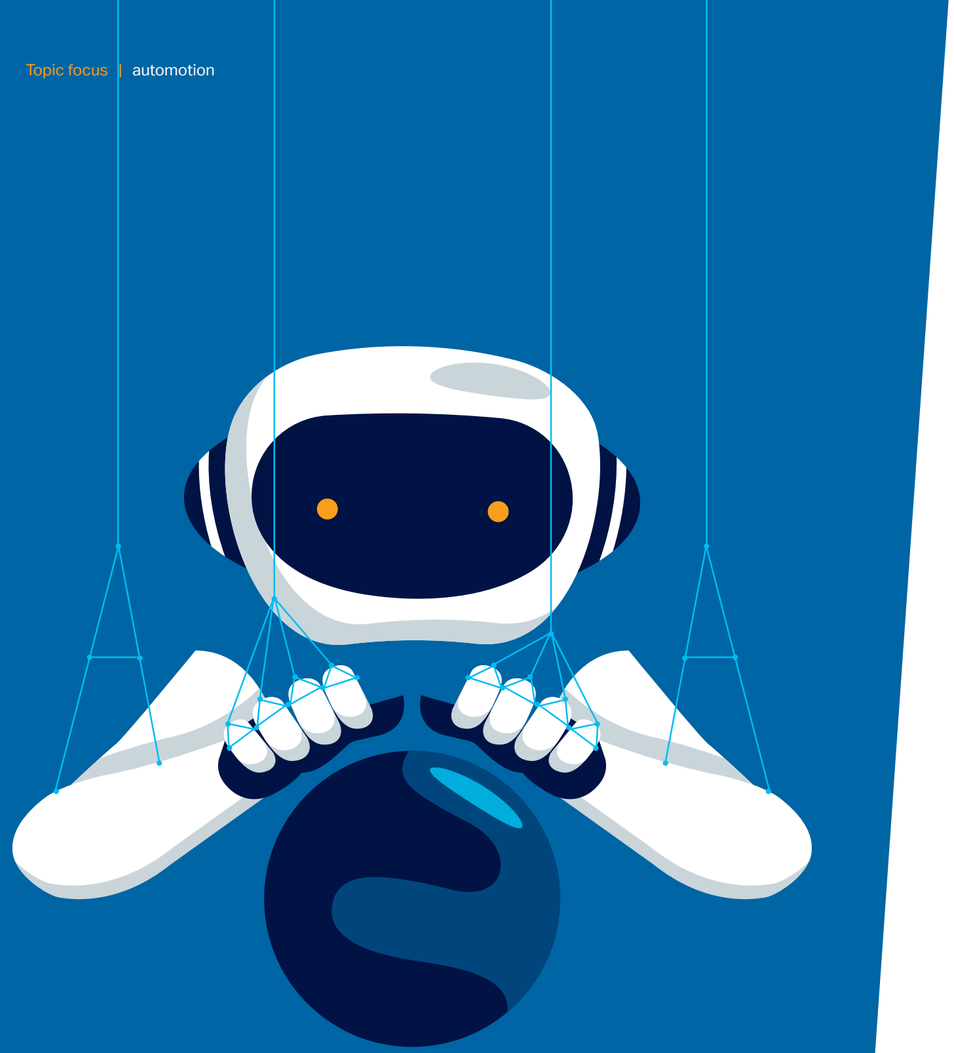

No Need to Look into a Crystal Ball

Predictive maintenance

How and in what time period does the position of a camshaft change? Under what conditions and how quickly do valves coke? When does a component need to be replaced before it gives up the ghost? Such forecasts do not require a glimpse into the crystal ball, but rather predictive maintenance. IAV is one of the technology leaders in predictive maintenance in the automotive sector.

"We use artificial intelligence (AI) to recognize patterns in sensor data and thus predict future behavior," explains Dr. Christian Nabert, specialist in Predictive Health Monitoring at IAV. Technologies such as Machine Learning and the Internet of Things (IoT) as a communication and data network are part of the toolkit. For predictive maintenance, Nabert and his colleagues are developing a construction kit with the latest methods, applying them in customer projects and linking the knowledge of the automotive industry with data science. They also cooperate with the German Research Center for Artificial Intelligence (DFKI) and the Fraunhofer Institutes.

Acting instead of reacting

Predictive maintenance means acting instead of reacting: Sensors record parameters such as vibrations or temperatures. Algorithms analyze the measured data in real time and provide information on whether and when maintenance or repair is required. "With AI, we expand the possibilities of predictive maintenance. For example, self-learning algorithms detect hidden patterns in the data streams and recognize complex cause-and-effect relationships," says Nabert. The advantages: Even before damage impairs the function of a machine, it can be repaired in a targeted manner, thereby minimizing downtime. Preventive maintenance at fixed intervals is also no longer necessary, which reduces costs.

These methods enable more than just maintenance: "They also enable us to determine, predict and optimize the current state of a system – whether vehicles, engines, test benches or other machines. We call this predictive health monitoring," says Nabert. That means: With the help of calculations during operation, the systems can work optimally.

Neural networks and algorithms

Nabert and his colleagues use sensor data for the models, for example on pressure, temperature, power consumption or structure-borne sound. The more data that is made available in good quality, the better. This is used to develop models such as artificial neural networks – such as feedforward networks, convolutional neural networks (CNN), networks with LSTM (Long Short-Term Memory) – or algorithms based on decision trees. In addition, experts use physical information such as thermodynamic relationships and circuit diagrams. Nabert: "For the quality of the models, it makes sense to integrate as much knowledge as possible. That is why we also use hybrid approaches to integrate physical information into data-based models."

Predictive status models are used to predict errors and system failures as well as to improve system performance. System monitoring makes it possible to maintain vehicles, test benches and other machines in line with requirements by forecasting changes in individual components – for example due to wear and tear. In addition, the methods and information from the engine control units can be used to monitor essential vehicle parameters. "We develop functions to ensure that a vehicle is always in optimum condition so that, for example, the requirements for emissions, durability and performance are met with maximum reliability at the same time," reports Nabert. IAV uses these methods extensively from combustion engines to electrified drives, as well as for data plausibility checks and monitoring of test benches.

Prognosis of valve coking

IAV has been gathering experience in predictive maintenance and predictive health monitoring for years. In one application, artificial neural networks (auto-encoders) and counterfactual analysis were used to detect errors in the environment of engine control units and to precisely estimate the size of the error, for example in the trimming of the camshaft. IAV used the methods for robust monitoring of component wear and its prediction for valve coking, for example.

It is not only the automotive industry that relies on Predictive Health Monitoring: Christian Nabert's IAV team is working on machine monitoring with IoT for an electrical wholesaler in southern Germany. "The dealer wants to know when to offer their customers which spare parts, for example for a cable cutting machine," says the specialist, outlining the task. To do this, sensors were attached to the machines and corresponding models were developed. This enables the wholesaler to recommend spare parts to their customers in good time and score points with additional service. They also optimize their warehousing and save costs.

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IAV uses data collection and assessment also for commercial vehicles:
Find out more about the use of Artificial Intelligence for prediction and health monitoring in this video.

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The Reward Principle

Reinforcement learning as function development 4.0

Thanks to reinforcement learning, neural networks can intervene autonomously and with foresight and support controllers in maintaining setpoints even under disturbing influences. IAV brings the methodology of "reinforcement learning" to automotive development and has applied it to projects such as boost pressure control – with the aim of making the concept of neural networks fit for series production.

Artificial Intelligence (AI) that plays Atari games independently and successfully – such messages regularly make it through the media. This is made possible by reinforcement learning. In reinforcement learning, a software agent independently learns a strategy through the principle of reward. It is a bit like conditioning: The right decision is rewarded – in the world of AI: provided with a positive feedback – and therefore aimed at in the future. In this way, AI improves its experience and thus its performance by trial and error. This holds enormous potential, especially for development in the automotive sector. "At IAV, we see reinforcement learning as a key component of future functional developments," says Dr. Christian Kruschel, Manager Data Science. "It can be used to solve problems for which there has not yet been a satisfactory answer."

Neural networks to supplement existing controllers

IAV has already successfully applied the method for customers and has supplemented existing controllers in external and internal projects with neural networks and significantly improved performance. In one project, for example, a neural network trained with reinforcement learning was able to optimize boost pressure control and ensure that the desired setpoint values were achieved quickly and without overshooting the boost pressure. The result is not only visible to the developer; the driver can feel it in the behavior of their car. "Especially in dynamic situations where the controllers used have poor performance, neural networks can be used as a supplementary variable," says Dr. Dennis Schmidt, Data Scientist at IAV. Through reinforcement learning, they learn how the controller needs to be amplified or attenuated in order to achieve the optimum at the current point in time and with foresight in the future. "The concept of supplementing controllers in critical situations is not new – but often current models do not have the flexibility to react adequately to complex, dynamic situations."

Active instead of reactive

Systems trained by reinforcement learning have a great advantage: They recognize that an error could occur in the future and actively intervene to prevent it. "Many of the controllers used, on the other hand, can only react to the control deviation between the actual value and the target value and thus only readjust," says Schmidt. But using neural networks alone as controllers is still a pipe dream. "As long as the quality criteria that apply to conventional controllers are not guaranteed for neural networks, we will not rely on this procedure alone," says Kruschel. "That would not be compatible with our high quality standards." In addition, he says, you have to weigh up anew in every system which methodology you use. "A neural network is only one of many possibilities, even if it is currently trending," says Kruschel. In principle, the approach can be transferred to similar use cases.

Fit for the series

Thanks to a safeguarding strategy, IAV makes neural networks fit for use in series production – even though, unlike conventional methods, their decision-making processes are not transparent and are therefore difficult to safeguard. "Put simply, we cannot predict how they will react in unknown situations," explains Kruschel. To solve this problem, IAV and research partners have developed a concept called Safety Supervisor specifically for ECU-related applications. It is a monitoring system to which the neural network reports the results it calculates. The Safety Supervisor decides for itself whether it can trust the result or has to switch on a substitute system to play it safe.

Optimized data processing process

Another challenge: The neural network is developed and trained on a high-performance cluster; the computing resources exceed the conditions prevailing on a control unit. Not only does the memory limit the size of the neural network, but also the execution time in the control unit must be less than one millisecond. The solution is called Neural Network Compression: It enables neural networks to be reduced in size so that they require fewer resources but still deliver the same performance. "We can process data quickly, train a neural network efficiently through our high-performance cluster and bring it into the ECU just as quickly," says Kruschel. "The entire data processing process is optimized at our company." IAV uses a fully automated workflow for this – and also relies on its domain knowledge. "We combine comprehensive know-how in the automotive sector and in the latest methods of artificial intelligence, develop our methods in-house and bring the solutions safely to production maturity – in short: At IAV, we can offer everything from a single source."

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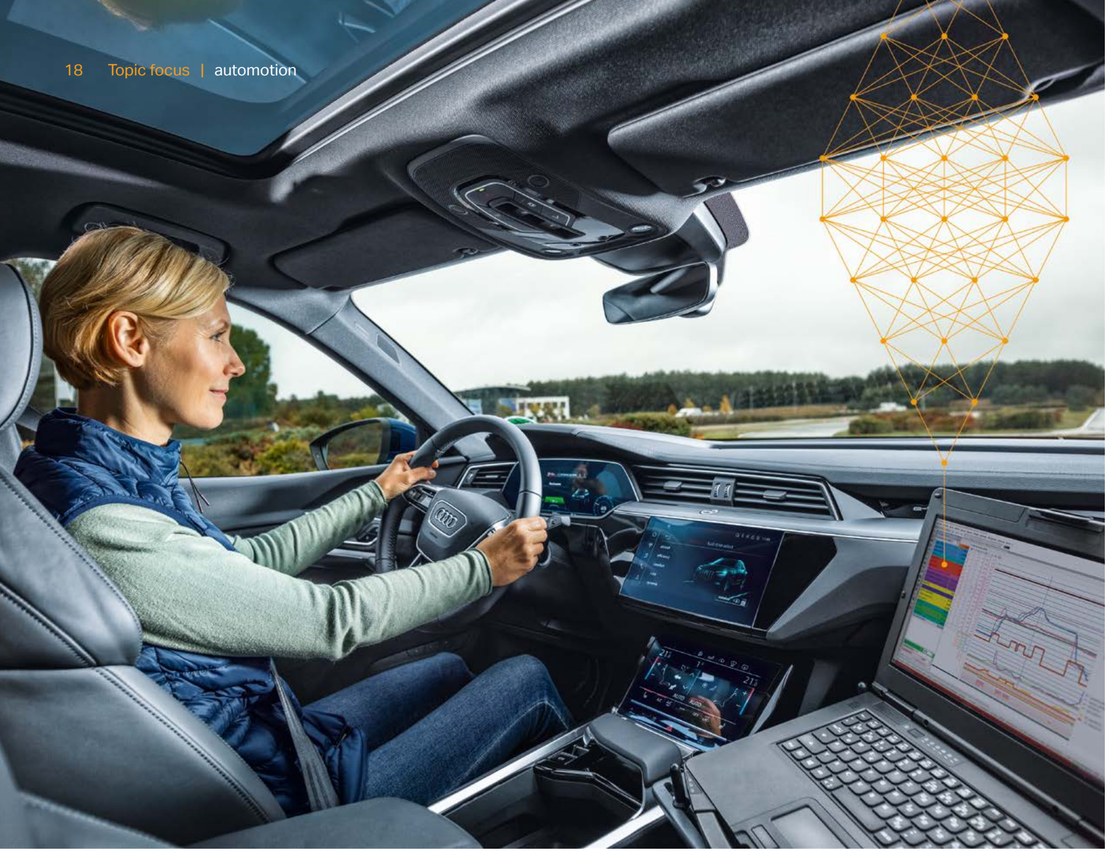
"With reinforcement learning, problems to which there has not yet been a satisfactory answer can be solved."

Dr. Christian Kruschel,
Team Manager Data Science at IAV



Transfer Learning Takes Digital Development to a New Level

Vehicle components are becoming more and more complex, cars more and more personalized and at the same time more intelligent. One of the biggest drivers: the steadily growing number of driver assistance systems. As the number of systems, models and combinations increases, so too does the amount of work involved in vehicle development. This is why IAV is conducting intensive research into a promising solution approach known as transfer learning.

An average passenger car today consists of around 10,000 individual components. All these components have to fit together. The coordination process, however, is costly and time-consuming. What tolerances do individual components, systems or elements of the powertrain have? How do they behave when operating under full load? At what mileage do they have to be replaced? In order to answer questions like these, vehicle design and development requires a vast amount of data, some of which must be collected at great expense.

10 to 100 times data reduction by means of transfer learning

Classifying millions of images to train an artificial intelligence (AI) for assistance systems is one of the rather simple tasks. It becomes more expensive and more complex as soon as the developers have to rely on trained specialists for each new data collection or even the destruction of the examined parts to determine load limits and fatigue strength. "The customer naturally does not like it if the test vehicle is damaged several times," is how Tilman Krokotsch, Deep Learning expert at IAV, describes the dilemma. "This pushes up the project costs. This is why we use AI to transfer findings from completed projects to new applications."

This is made possible by transfer learning, a solution to reduce data-driven development effort in the future. In the first step, the engineers look for a similar "problem" for which labeled data are already available – the so-called source problem.

"With transfer learning, we can transfer an AI model that has already been trained on the source problem to a new target problem. This means that much less data is required to train the AI for the new problem than if we start from scratch," explains Krokotsch.

An example of this transfer is already known turbochargers that are to be integrated into a new engine. "Transfer learning can be quite simple here," says the doctoral student. "At IAV, an AI for this component and its life expectancy in combination with the already known engine would already have learned a rough wear model of the component, and that would only have to be adapted to the new operating conditions of the new engine with a few additional data points."

Transfer learning in practice saves time and money

By successively transferring the transfer learning approach from theory to practice, several specialist areas can benefit, such as predictive maintenance, in which measurement data provides real-time information on whether and when maintenance or repair is required. The more projects and the more data, the better. "The basic idea behind transfer learning is that although individual projects may not have enough data to solve a problem in a data-driven way, the projects as a whole do," explains Krokotsch.

Transfer learning also offers added value for the programming and design of assistance systems. At the beginning of the development phase, assistance systems run through simulations. Due to the increasing connectivity of different assistance systems and components, this training is a labor-intensive process, but simulation is a reliable and cost-effective data source. As the process progresses, practical tests of the new assistance systems are required. By means of transfer learning, the leap from simulation to the road can be made with relatively little additional data.

"All in all, data-driven development gives us tools to work even more efficiently and with increased agility," Krokotsch is sure. "We save our customers time and money in development, because pushing a digital engine beyond its limits is easier and more resource-efficient than doing so with a real engine from an OEM."

Complete potential not yet exhausted

In the step-by-step application of transfer learning, IAV benefits from cross-industry experience, as in the energy sector, and can transfer the method to a wide range of use cases. "We are working on several levels to integrate this concept into our processes and develop it further," says Krokotsch. At present, existing AI models are mostly retrained on the initial problem of very similar target problems, since this transfer requires less additional data. In addition, the risk of a "negative transfer," i.e. a logical error of the AI due to the transfer from the source problem to the target problem, is lower.

Up to now, homogeneous transfer learning is almost exclusively applied, where the input data contains the same metrics. Such input data can be for example RGB images, which are composed of the three primary colors red, green and blue. If we want to transfer such a three-channel RGB image to a single-channel near-infrared (NIR), we refer to heterogeneous transfer learning. This is also the case when an already developed model is transferred from a source motor to a new target motor that has different sensors. As soon as a sufficiently high process reliability is available for heterogeneous transfer learning, the optimization potential associated with the method increases further.

However, transfer learning cannot and should not replace the results from practical tests with real models and the experience of engineers and applicators. "Only with the expertise and input of the applicator can we fully exploit the full potential of transfer learning. It tells us what the system is doing or how it can be designed," Krokotsch explains. "It's all about empowerment – with the transfer learning method, we want to give our colleagues new tools to continuously improve our engineering services for our customers."

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Hybrid AI

Less data, better models

Two keywords are currently on everyone's lips: Artificial Intelligence (AI) and the idea of the hybrid, which unites different things. Bringing the two together describes a hitherto largely unknown field of research: Hybrid AI. It helps to find answers to questions for which solutions have been difficult to find so far. IAV combines physical systems with artificial neural networks (KNN) and achieves outstanding results – not only in the automotive sector.

Christian Kruschel still remembers well an experiment, a model, without training in systems knowledge: "We fed a neural network with all the data we had – in the end, the cylinder pressure was to be simulated." The Data Science Team Manager at IAV laughs. "The result was very good but not usable in the application: The measured variables that the neural network prioritized were not convincing. Now there is an optimized AI procedure that does not do that anymore: hybrid AI.

Christian Kruschel and their colleagues at IAV usually work with the AI procedures from Deep Learning: Machine Learning (ML) using artificial neural networks (KNN). Explained in simplified form: KNNs consist of data nodes ("neurons"), which are linked together on different levels (Input, Hidden Layers, Output). As in the human brain, changes in neurone structure occur during AI training: Neurons are added or become irrelevant, weightings (the connections between neurons) are changed. The input information flows through the hidden layers to the output layer. A learning algorithm determines all parameters from the input and the expected output values by iterative and recursive procedures – this way, KNNs learn complex relationships, and manual programming of algorithms is no longer necessary.

Better to generalize

"AI has the core problem, however, that data can only represent reality under certain conditions," explains Kruschel. "As a result, the data situation is often not sufficient to generalize well." Generalize means that the network receives completely new data from the same application area, but that describes a different scenario. Hybrid AI provides a solution for this. The term "hybrid" means "crossed, mixed." More specifically, this means: "We enrich our models with expert knowledge," explains Ferdinand Küsters, Research Engineer at IAV-Lab and DFKI. "In this way, we achieve better models with the same amount of data or very good models with less data." If the network can access structural information or, in other words, physics-based data preprocessing, the model also performs better on new data.

Best of both worlds: Control engineering and Artificial Intelligence

A pre-selection of input variables is the easiest way to integrate expert knowledge into a model. This procedure has long been standard in data-based modeling. The hybrid AI approach goes beyond this: Here, physical models are integrated directly into the data-driven model and adapted with AI support. This allows new components to be developed quickly, for example for the Digital Twin. In controller design, IAV combines neural networks and differential equations in a multi-stage process – with the result that the controllers designed with it generalize better than classical neural networks. Such an approach is also helpful, for example, in computationally complex flow simulations. Küsters explains: "The problem was solved with NeuralODEs, a quite new form of neural networks, which internally use differential equations for modeling." Therefore they are well suited for physical processes.

With hybrid AI, IAV specialists are finding the best solutions to problems in almost all areas ever more quickly, as Kruschel explains. Küsters describes it in more detail: "If, for example, you bring in the structure of a robot, i.e. information about its rough design, you can achieve greater accuracy more quickly." Of course, this also applies to the automotive sector, where IAV's core expertise lies: The problem with predicted cylinder pressure mentioned at the beginning has long since been solved – thanks to hybrid AI.

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Bundled AI Expertise at IAV

Expert network AI circle

Artificial intelligence and data science are developing at breakneck speed and increasing complexity. IAV has set up the AI circle to keep abreast of the latest developments and pool its in-house expertise. It brings together AI experts from various fields – and the company's concentrated expertise in customer projects.

A network of experts instead of an army of lone fighters: That is the idea behind the AI circle. With it, IAV links and promotes the expertise of the colleagues in the company who work with Artificial Intelligence (AI). "This technology is so universal and at the same time so complex that it is not bundled in a single department but rather colleagues from all over the company deal with it," says Dr. Mathis Börner, Data Scientist in IAV's Digital Lab, who is actively involved in shaping the AI circle as the person responsible for methods in data science and AI. Events and digital platforms are intended to promote the exchange between these employees. "In the AI circle, colleagues learn from each other and benefit from each other's knowledge. They can also address their questions to an entire network of experts. We also hope that this will lead to an additional acceleration in projects and developments," says Börner.

Digital lab as incubator

The project is driven by the in-house Digital Lab, which acts as a catalyst for digital projects as part of the company's digitalization strategy. One of its most important instruments is the so-called innovation process. Selected ideas submitted by employees are given a jump start here: The lab with its permanent and more than 20 student employees takes over an initial start-up development; only then are the projects are handed over to a division. "We start with the idea in the employee's head and see ourselves as an incubator. The AI circle should also function in this sense and also generate new projects that are suitable for the innovation process," says Börner. The idea of an AI network within the company is not entirely new: A forerunner, the AI community, laid the foundations, and with the new AI circle concept, the idea of networking is now entering a new round – with a sharper profile. "We have now deliberately positioned ourselves even more technically and in terms of content."

Learning with and from each other

For this purpose, the "Brown Bag Sessions" during the lunch break include internal topics related to AI on the agenda – projects, problems, experiences and questions. "Here, it is not about presenting oneself, but really about entering into a professional exchange, learning from and with each other," says Börner. In the second format, the "AI Talks," experts from renowned institutions such as the Fraunhofer Institute, DFKI or RWTH Aachen University regularly speak. Topics include the certification and safeguarding of neural networks, natural language processing, reinforcement learning or the question of how Machine Learning for time series can be successful – ergo: in addition to topics that are intended to provide food for thought, above all those that are relevant to the work and customers of IAV.

The customer benefits

After all, it is the customers who benefit most from the AI circle. It is not only an instrument to stay on the ball in a rapidly growing field, but also an important building block to be able to offer the customer state-of-the-art technology at all times. "With the AI circle, we bring out the maximum of AI competence that IAV with its more than 8,000 employees has to offer for our customers. We bundle this expertise, make it broad-based and ensure that it filters back into customer projects," says Börner. "When a customer works with one of our teams, they can be sure that they will have access to an IAV-spanning network of AI expertise."

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"We Do Not Want to be Presented with the Finished Solution"

AI research and IAV

Knowledge transfer and joint research belongs together for IAV. Dr. Matthias Neumann-Brosig works at IAV in the Research Data Science department. Sebastian Trimpe is Professor of Data Science in Mechanical Engineering at RWTH Aachen University and Research Group Leader at the Max Planck Institute for Intelligent Systems. The two met in Cyber Valley and have been working together for years. In the automotion interview, they talk about the challenges and potential of collaboration – and why this leads to faster results.

What was your first project together?

Trimpe: Our collaboration began in 2016 with a throttle control project. Traditionally, parameters must be set manually. IAV used a Machine Learning algorithm that we helped to develop and which enables us to find these parameters automatically.

Neumann-Brosig: We have been supervising a joint doctoral student ever since. He works on learning processes in control engineering such as the synthesis of stochastic controllers on the basis of experimental data.

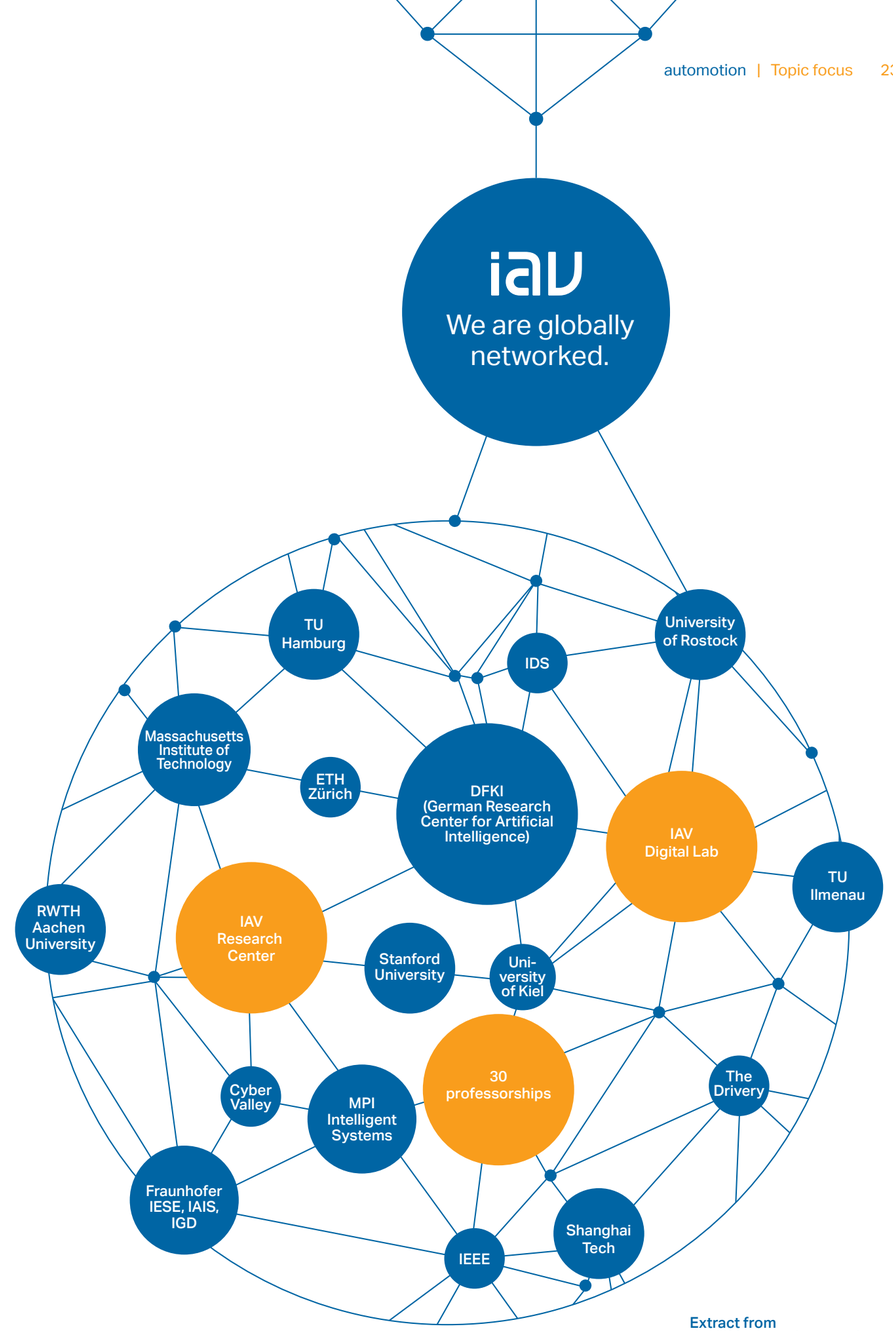
What are the advantages of such collaboration?

Trimpe: At the interface of control engineering and AI, there is great potential through new sensor and data technologies and the resulting availability of data. In particular, approaches that combine data with classical control engineering are very promising. This is where we start with basic research. We develop new methods and algorithms and want to implement them in specific applications – often together with industrial partners.

Neumann-Brosig: As an industrial partner, we don't want to be presented with the finished solution, but rather know how it is created. In this way, we sharpen our methodological competence, because it is a central competitive advantage. This is why IAV has also become involved as a founding partner in Cyber Valley, Europe's largest AI research consortium. Sebastian Trimpe is active there through his research group at the Max Planck Institute. We also work very closely with the German Research Center for Artificial Intelligence in Kaiserslautern. In early 2018, we founded a joint research laboratory for this purpose.

In which fields is cooperation particularly useful?

Trimpe: For example, in the area of safety. It poses special challenges for Machine Learning. AI success stories in which a computer wins against a human in complex games like chess are impressive. But they cannot simply be transferred to technical or physical systems because of the safety requirements. The computer, which learns to play chess, can easily try out any behavior a million times over. In the worst case, it loses. A robot or a vehicle, on the other hand, can cause damage to itself or others and cannot keep hitting walls. And in contrast to chess, the conditions in the real world change constantly. Therefore fundamental research questions must be solved, so that we can apply AI to robots, technical systems or cars in a way that it works safely. And we also have to ask how to stimulate the systems in a way that we get meaningful data, while at the same time operating safely.



Extract from the IAV research network

"When different approaches and points of view come together, this can be very fruitful for the project and can give rise to completely new approaches."

Dr. Matthias Neumann-Brosig
specialist at IAV in the Data Science Research Division.

What does collaboration offer in terms of this challenge?

Trimpe: It enables a fast transfer. With the throttle valve, less than a year and a half passed from the initial idea to implementation. We can only achieve this speed, which is so important in AI, if we combine basic research directly with applications. I am glad that in our collaboration with IAV it was understood from the outset that although we do basic research, we can accelerate its transfer to practice if we combine it with applied research.

Neumann-Brosig: IAV emerged from a university spin-off; for us, it is part of our DNA to maintain the close link between science and research. In the field of AI, we are networked with the world's leading institutes and universities. This keeps us close to the latest research findings. At the same time, our series competence makes us a strong partner who can bring research into industrial applications. This benefits both sides and we all profit from the fact that knowledge transfer is not a one-way street.

How important are such collaborations for Germany as a business location?

Trimpe: Finding answers to the research questions associated with engineering applications of AI offers huge potential for companies in Germany and Europe. Research networks help to keep up with the pace. If we can move quickly here and find new, more open forms of collaboration, this can become a locational advantage.

What requirements do partners have to meet for this cooperation?

Trimpe: Openness and understanding for basic research. Plus the ability to get involved with each other, an interest in applications and the willingness to deal with the uncertainty that is part of research.

And what challenges does it pose?

Neumann-Brosig: An important and at the same time very exciting challenge is to bring the different worlds together. Depending on the project, representatives of different disciplines come together – for example, control engineers, computer scientists and statisticians. Sometimes it is an art to find a common language. At the same time, however, there is also great potential here. When different approaches and perspectives come together, the project can be very fruitful and completely new approaches can emerge. For me personally, this is always an enriching and motivating experience.

How does IAV always find the best people for such demanding tasks?

Neumann-Brosig: For one thing, we work very closely with a large number of universities and research institutes on various projects. On the other hand, many students gain their first practical experience with us and then want to stay. What's more, some of our employees later return to the universities as doctoral students or professors and advertise for us. As a result, IAV has been extremely closely networked with research for many years now and is well established as a top address for researchers and developers.

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"Research networks help to keep up with the pace. If we can move quickly here and find new, more open forms of collaboration, this can become a locational advantage."

Prof. Dr. Sebastian Trimpe heads the Institute for Data Science in Mechanical Engineering at the RWTH Aachen and is research group leader at the Max Planck Institute for Intelligent Systems.

Centimeter-accurate Localization and Real-time Mapping

Visual Simultaneous Localization and Mapping (vSLAM) opens up a promising opportunity to bring intelligent environmental perception into series products in a cost-effective and scalable way. It can also supplement or even replace lidar systems of highly automated vehicles. IAV has developed its own algorithm for this purpose, with a focus on applications in the mobility sector.

The so-called vSLAM technology has already proven its worth in numerous applications. For example, it is used for the navigation of autonomous drones or for suction robots to help them find their way around the home. Unlike lidar-based systems, which use laser beams to measure the distance to walls and objects, vSLAM relies on information from a camera installed on the robot – similar to the spatial perception of the environment by the human eye. With the help of this information, software constructs an always up-to-date three-dimensional map of the room, within which a robot can determine its exact position and react to changing conditions.

vSLAM offers many more promising applications for intelligent environmental perception: High-precision localization is a cornerstone of intelligent environmental perception. Image recognition technologies and AI algorithms can often only show their full strength if they know where an object is in relation to a vehicle or robot. With vSLAM, applications such as trained parking or AR navigation can be made available to a broad mass.

The necessary camera hardware is already installed in most production vehicles. vSLAM is therefore a pure software solution and can be a low-cost and at the same time extremely effective supplement or alternative to lidar, radar or ultrasonic sensors. The potential is therefore high, because: For the applications in automated or autonomous driving, vehicles need perfect knowledge of their location and orientation to function reliably and to find their way around their deployed environment.

The vSLAM algorithm developed by IAV uses the camera's live images for this purpose. By repeatedly finding feature points again, a three-dimensional map of the environment is created in real time. At the same time, the vehicle can determine its own position within this environment. Common localization solutions are based on GPS data. In cases of a lack of signal – for example in car parks or in less developed areas – the accuracy of the positioning fluctuates, in the worst case the system comes to a standstill. However, this is precisely what IAV's vSLAM solution prevents, and it is precisely the interaction of vSLAM with existing sensors that creates a robust localization solution with a wide range of applications.

IAV offers the software solution to vehicle manufacturers during series and pre-development. But many other fields also benefit from the technology. Manufacturers of navigation systems, for example, have high-resolution 3D cards at their disposal which, in conjunction with vSLAM, enable high-precision navigation over long distances. Autonomous drones can use vSLAM to navigate through unmanned terrain and return safely to their launch site. Would you like to learn more about the technology and the possible applications? Please contact us!

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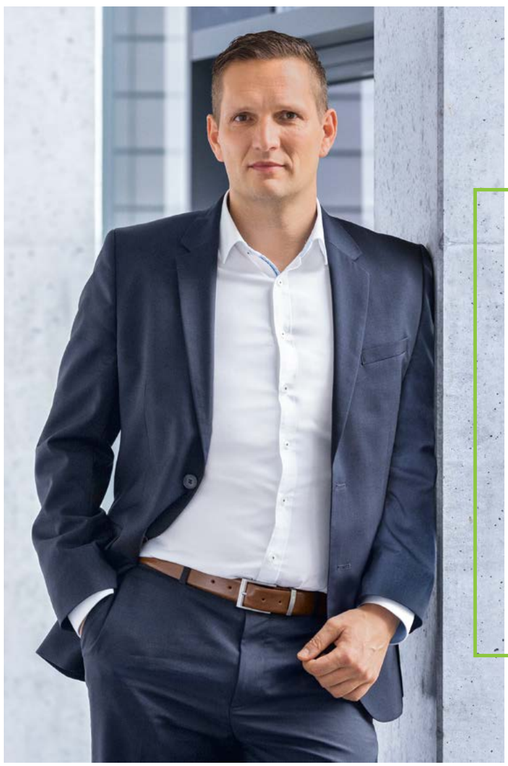
"IAV Unites the IT and Automotive Worlds"

How data analyses from IAV are changing vehicle development



"Our analyses are high performance, efficient and customizable. We thus offer an all-round package."

Jens Schulze,
Head of the Data Analytics and Fleet Validation Department at IAV

Whether electric mobility, autonomous driving or the trend towards "automotive devices" – the development of modern vehicles is highly complex and is changing rapidly. As a software partner, IAV offers vehicle manufacturers comprehensive support. Targeted data analyses can be used to detect errors in vehicle development at an early stage or to test new innovations. Jens Schulze, Head of Data Analytics and Fleet Validation, explains how data analyses work and why IAV is one of the market leaders in this field.

In recent years, the importance of big data analytics in vehicle development has grown considerably. What exactly does IAV do in this field?

Schulze: We provide support in vehicle development, particularly in the release of vehicle functions and the entire vehicle. This is an area in which we have been active for over 20 years and for which we have developed a special service – the IAV Measurement Data Platform. At its core, it deals with the storage, analysis and visualization of vehicle data.

What exactly is this data and at what stage of vehicle development does this work take place?

Schulze: Our work takes place in the field of fleet validation. This means that we work on prototypes, pre-series or end-customer vehicles that already have most of the planned vehicle functions and are tested again for functionality before they are released. First, we collect the raw data from the vehicle and store it in a specially equipped data center. There, we have the necessary technical prerequisites to keep the data as efficient as possible and to analyze it with regard to certain functionalities.

What makes IAV stand out when it comes to analyzing vehicle data and what added value does it offer customers?

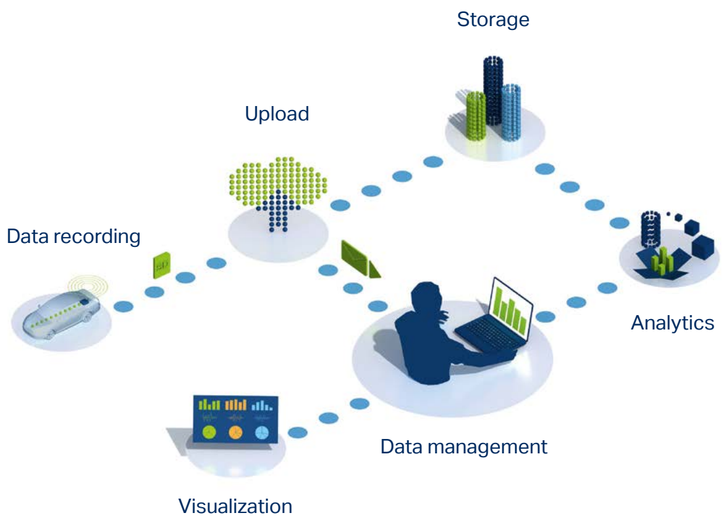
Schulze: Data analyses in the automotive sector require very detailed vehicle and IT knowledge. This is because the interconnectivity of vehicle electronics has become increasingly complex in recent years. Communication between the electronic participants is handled via so-called services, which require a great deal of computing power when the system is heavily utilized. If this computing power is not available, errors in the information flow can occur. Finding these errors is not so easy due to the enormous amount and complexity of data. However, since we have a very precise knowledge of automotive engineering and the IT world, we are one of the market leaders in this field. Our analyses are high performance, efficient and customizable. This enables us to offer the customer an all-round package.

You use a special IT architecture for this. How exactly is this structured?

Schulze: Before we start a project, we first record the customer's requirements and objectives as well as all processes and use cases. In the meantime, we have developed a very extensive range of algorithms and models that cover almost all analyses in the automotive sector. Then we decide which components are needed and build the appropriate IT architecture according to the requirements. There is a choice of various infrastructure and connectivity concepts, virtualization approaches and application layers as well as analytics framework. In the case of infrastructure and connectivity, for example, the question is whether a private, public or hybrid cloud is used. For virtualization, we choose between container technologies, virtual machines or serverless models. The analytics framework are based either on GPU or CPU processors and the architecture is based on a streaming, batch or lambda approach.

What analyses can be used by customers within the framework of the IAV Measurement Data Platform?

Schulze: The platform's IT architecture and analysis models were developed specifically for use in the automotive sector and are technically state-of-the-art. They enable us to map everything that is currently possible. This includes above all vital and real-time data from the vehicle, but also the mapping of specific forecasts and use cases from endurance testing. The results of these analyses can be visualized in different ways. We have a very comprehensive, modular system that allows customers to configure their own dashboard. The dashboard gives them a simple overview of all errors and anomalies and helps them to improve vehicle functions and ECUs.



Can you give a specific example from your everyday work?

Schulze: A classic case would be pattern recognition in case of a communication error of the ECUs. Let's say that after all software components have been integrated, the brake light no longer works under certain conditions. In daily operation, it would be very costly for a manufacturer to detect this error themself. But with our analysis models it is no problem, because they know the software architecture of the vehicle very well and the customer can access it via a web-based measurement data management system. Thus, the error can be found within a very short time via a simple search function and displayed in the desired form. Very similar to a Google search.

What sets IAV apart from classic IT companies?

Schulze: In addition to our IT know-how, we have many years of experience in the automotive industry, which opens up enormous potential for vehicle development. Especially by using artificial intelligence, machine learning and cloud technologies, we can evaluate very large and complex data volumes. So our unique selling point is that we combine the IT and automotive worlds. We are experts in our field and show customers how to evaluate very large and complex data volumes in accordance with their objectives.

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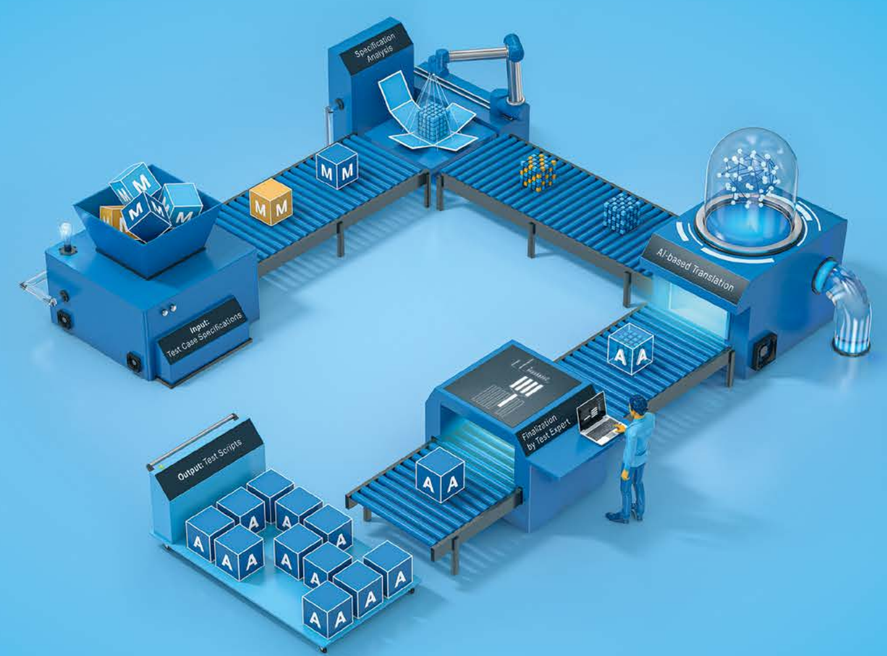
Automate Software Tests Faster with Artificial Intelligence

New IAV tool creates test scripts largely independently



Software tests are complex and are therefore increasingly automated. An AI-based solution from IAV accelerates this process: It creates test scripts from the manual test descriptions and achieves a high degree of accuracy in the selection of automation components. As part of a modular toolkit of tools, it is designed to make the work of test experts much more efficient in the future.

Test automation is becoming increasingly important: Many companies rely on machine assistance for software quality assurance because it increases efficiency and allows them to run tests independently overnight, for example. Compared to manual processing, this saves valuable time and reduces costs, especially for repeated tests. The automation of software tests is not a trivial task, however: "As a rule, you need a great deal of expert knowledge and sound programming skills to do this," explains Dr. Remo Lachmann, Team Manager Software Test Automation & Data Quality at IAV.

What's more, there is always a need to make adjustments to the tests as the project progresses. For example, the automated test sequences can be disrupted by changes in the software. Particularly in black-box tests, where the tester does not know the source code of the software, such problems further increase the effort required for automation. "We have therefore set ourselves the goal of noticeably accelerating the implementation of test automation with the help of artificial intelligence," says Lachmann.

The IAV solution learns from known test case descriptions and the corresponding test scripts how it can later select the appropriate components for automatic testing from a text it does not know. For example, a simple test execution can consist of starting a web application, entering the user name and password and then pressing the login button. The individual steps "Start application," "Enter user name," "Enter password" and "Press login button" correspond to predefined components of an automation script. The IAV tool displays the automatically predicted components in an easy-to-use editor.

High hit rate through Machine Learning

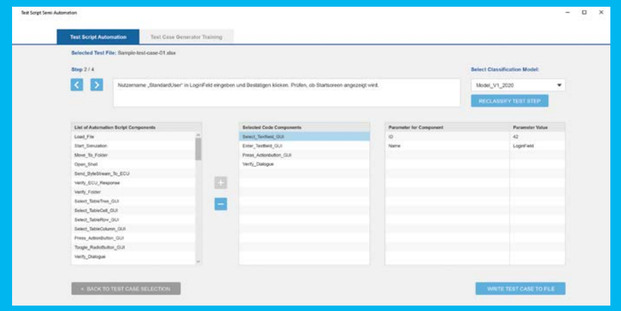
Until now, a human expert had to manually select these components from a library of dozens of components and assemble them correctly. In initial tests, the new IAV solution has managed to determine the required script components correctly and independently for around half of all test cases through supervised learning. For the other half, the AI was already close to the desired result, so only minimal manual rework by the experts was necessary.

"This is a very good result because we are dealing with a particularly difficult task for Machine Learning when it comes to the automatic generation of test automation," explains Lachmann. "On the one hand, different testers use different terms for the same steps, and typing errors make life difficult for us. Natural Language Processing – i.e. the automatic preparation of texts – can only help us to a limited extent with such difficulties. On the other hand, one step in testing can correspond to any number of script components – so we are not dealing with a 1:1 relationship, but with a multi-label problem."

Customer projects sought for further development of the tool

The new solution promises to significantly speed up the testing process in the future. "Employees with little experience in particular save a lot of time when searching for the right components and can therefore work quickly and very effectively," says Lachmann. "In the next step, we want to automatically generate test cases directly from the customer's written requirements, which will accelerate the test creation process even more."

In order to further advance test automation, Lachmann and his colleagues are currently looking for customers who are interested in joint pilot projects. "Everyone has different requirements and boundary conditions," the IAV expert explains. "The more practical examples we can take into account when developing our new tool, the more precisely we will be able to improve the quality of our solution."



The intelligent test case editor accelerates test script creation through Machine Learning.

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From the Simulation Environment to the Vehicle in the Shortest Time

IAV's integrated development process enables software to be extensively tested in simulation environments and then quickly brought into the vehicle as executable code. This "rapid control prototyping" is an important part of the holistic tool chain at IAV.

The development of software for interconnected, highly automated or fully autonomous driving functions is very complex and at the same time must be realized in ever shorter development times. Especially when using agile development methods, the testing of each software version ("builds") is therefore of great importance. Tests of the code quality as well as the software functionality ensure that the delivered software versions have a high degree of maturity. As part of its holistic tool chain, IAV focuses on automating all tests as far as possible. The tests are triggered automatically once a build is complete.

The actual development process follows the process known as "V-Model" (see illustration). This model depicts the individual process steps over time and makes it clear that the level of detail from the first requirement to the architecture concept to the solution concept and implementation is constantly increasing. In the classic development process, the left branch is run through first until a compiled controller status is available. This is followed by an ascent to the right branch of the V-Model, where tests are typically performed. The final step is the integration into the vehicle and the final overall functional test.

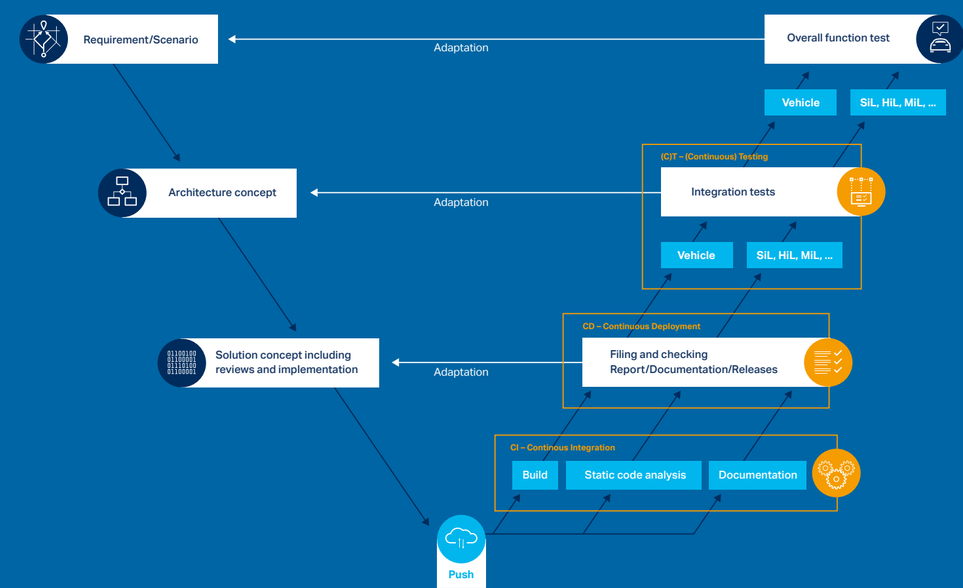
IAV's integrated development process for rapid control development makes it possible to perform horizontal iteration loops in the V-Model. This allows problems to be identified very quickly. For example, a controller in the design tool can be tested directly on available models of other components or subsystems even if the target hardware or vehicle is not yet available. This integrated development process for rapid control development is called "rapid control prototyping." Key process steps in the integrated development process at IAV are "continuous integration," "continuous deployment" and "continuous testing."

Automatic testing of code quality

The "continuous integration" step focuses on non-functional tests. The term describes how the various components of an application are continuously merged into executable software. Within the context of a "static code analysis," aspects are examined like the structure of the algorithms or conventions for the optimal readability of the software codes. The analysis also evaluates whether guidelines are adhered to, which were defined by industry committees such as MAAB (MathWorks Automotive Advisory Board) or MISRA (Motor Industry Software Reliability Association).

If deviations are found during this analysis, the responsible programmers are directly notified of this result so that they can correct the detected errors. As in the following steps, the code analysis also includes automated documentation.

Dr. Rick Voßwinkel, IAV expert for motion planning, explains how this is done: "Once a software release has completed this first test step, "continuous deployment" takes place. In this process step, the new, verified code is automatically provided for all relevant development, test, integration and production environments. For example, the code and the script-based delivery documents are stored centrally in a cloud solution. This ensures that all developers have access to this latest version." The results of this automated delivery process include test logs from static code analysis and function documentation. If required, these documents can even be regenerated for earlier software versions.



Functional tests as part of the development workflow

Closely linked to the automated integration and delivery process is "continuous testing," which focuses on the functional tests. In this step, the tests are carried out automatically, for example as sub-functional, integration or quality tests. Depending on the planned test scope, the tests are carried out on the basis of different simulation concepts.

In order to be able to test vehicle-related vehicle dynamics control, IAV has developed various specific simulation models that run, for example, in Simulink modeling software provided by MathWorks. Dr. Voßwinkel emphasizes the practical advantage: "The rapid control prototyping we use enables us to generate executable software from the code in the simulation environment in a very short time, which we can then use directly in the vehicle in the next step. In this way, the developed functions can be experienced more quickly in the overall vehicle system."

In addition to the use of these simulation tools, real data is another important basis for efficient testing, says Voßwinkel. The basis for this can be recorded real test data as well as previously generated simulation results. The fact that the developed software is modular in structure also favors efficient testing at module level. For example, internal module interfaces can be used as the basis for a comprehensive test catalog.

The advantages of "rapid control prototyping" have already been proven in customer projects as well as in internal development and research scenarios. IAV is continuously developing its customized tool chain for automated software testing and is thus ideally equipped to meet the current and future requirements of the automotive industry.

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Methodological Toolkit for Evaluating Future Driving Functions

Modern vehicles already offer a high number of driver assistance systems (DAS). In addition, manufacturers (OEMs) are able to connect individual vehicle systems with each other more and more intelligently. But which new driving function offers specific added value for the end customer and is compatible with the respective brand values? consulting4drive (C4D) and IAV offer a methodological toolkit for evaluating the added value of automated driving functions, even in the early stages of development.

With a methodological toolkit for the early real-world testing of ideas for automated driving functions, the management and strategy consultancy consulting4drive and IAV support manufacturers in the further development of their vehicles. In this way, automated driving functions can be prototypically adapted to the desired customer requirements during testing and their actual added value for the respective target group can be verified prior to series development. This enables OEMs to compete in the intra-industry race for new driver assistance systems while at the same time reducing the risk of costly developments that do not match the brand or customer needs.

Re-prioritizing customer needs through design thinking

At the beginning, it is necessary to analyze the manufacturer's goals: How can the best possible customer added value be generated? OEMs must find answers to this question – the experts from IAV and consulting4drive provide support with the help of relevant market studies, analyses of target markets, customer preferences and legal regulations in order to specify the scope of validation and uncover relevant customer requirements.

In the subsequent operationalization, a functional matrix is created: What can the individual driving functions and sensors already do today and what should they do in the future? The resulting matrix supplements the market view with the OEM potential of the driving functions. "We combine function modules of the system, for example trigger conditions and function calls for anticipated customer added value, especially for the focal points of comfort and safety. We then check the actual benefit of the new functionality in suitable test situations with test persons and expand the V-model to include the customer experience," says Dr. Sebastian Kahlbau, Manager Technology Strategy at consulting4drive.

The function matrix is used to check which new combinations are technically feasible for the objective in relevant use cases. "Here, for example, we examine a combination of individual functions such as emergency brake, lane departure warning system and cloud functions. We implement the resulting use cases in existing vehicle architectures at short notice," says Paul Prescher, Team Manager Active Safety at IAV.

> **"With this method kit, C4D and IAV create a symbiosis that dovetails the focal points of strategy and management consulting with engineering expertise."**
>
> Michael Junger, President, consulting4drive

Testing new driving functions on the test track

In order to test the added value in practice without risk, each individual use case can be tested in several countries with different target groups on one test site. While the test persons drive their cars over the test track, an augmented reality system (vehicle-in-the-loop) projects the previously defined scenarios into the vehicle. The newly combined automated driving functions behave as if the simulated objects and vehicles were present in the immediate vicinity of the test car. The test persons' impressions in the vehicle are evaluated qualitatively and quantitatively by consulting4drive and IAV. "Vehicle-in-the-loop offers the possibility of experiencing any complex and risky driving situations directly, reproducibly and safely by the driver," says Roland Kallweit, Head of AD Functions & Simulation at IAV.

These results are used as the basis for validating or falsifying the tests and reflecting them in the OEM's strategic planning. "With this method kit, C4D and IAV create a symbiosis that dovetails the focal points of strategy and management consulting with engineering expertise: Design Thinking in concept development and the validation of new, interconnected functions as well as a fast implementation in the prototype, for example as a Minimal Valuable Product, is very agile and successful," emphasizes Michael Junger, President of consulting4drive.

Methodological toolbox for the targeted innovation of driving functions

These short tests of the use cases provide OEMs with a well-founded opinion about the actual customer added value of new automated driving functions. "By quickly deciding on the right innovation features, a much more efficient use of existing development resources can be ensured. We use the methodology to check relevant topics from the function matrix in fast motion for added value for the customer and the influence on the strategic OEM core brand values," explains Björn Siemon, Senior Consultant, Technology Strategy at consulting4drive. With the new methodology, the two partners consulting4drive and IAV can accelerate the rapid real validation of new automated driving functions and reduce the risk of handing over a feature that is only useful in theory to series development without customer benefit.

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consulting4drive
powered by IAV

Agile and Secure

When developing vehicle software, it is important to build a bridge between modern, agile development methods and the high safety and documentation requirements of the automotive environment. IAV meets this challenge with an agile project landscape developed in-house.

Agile methods have established themselves in software development for good reasons: They help to ensure that rapidly changing requirements are optimally incorporated into projects. At the same time, regular checks of iterations through tests ensure higher quality and greater transparency. Last but not least, errors and wrong directional decisions in the development process can be avoided. However, this type of software development partly contradicts the classic plan-driven specifications of the automotive industry. After all, the development of software for vehicles is subject to process models such as the document-heavy Automotive SPICE (Software Process Improvement and Capability Determination), which is standardized as ISO/IEC 15504, or the V-Model, which divides the development process into clearly defined sub-steps. In addition, many other requirements must be observed in the automotive environment, such as the UNECE (United Nations Economic Commission for Europe) safety regulations for cyber security management systems with the specific application of ISO 21434 or the functional safety specifications defined in the ISO 26262 standard. At the same time, however, general conditions such as increasing cost pressure and shorter development periods make the use of agile methods practically indispensable.

IAV resolves this area of conflict with an agile project landscape developed in-house. It bridges the gap between agile working and the process standards and specifications of the automotive industry. "Our agile project landscape is based on a series of tools and process steps – which complement each other optimally and flexibly," explains Carsten Elvers, Team Manager in charge of Functional Software in the Embedded Security department at IAV. "We also provide our software specialists with the necessary structural and cultural environment."

Features come into being during three-week sprints

The development process is based on the Scrum method, where the implementation is organized in three-week sprints. The content of such sprints usually involves features, i.e. specifically defined vehicle functions – this is also known as "feature-driven development." In order to quickly achieve testable results, not all constraints or possible errors are taken into account in the early stages of development – refinement, optimization and hardening follow later.

A feature is always processed by "Pair Programming," i.e. by two programmers according to the dual control principle. The team of two supervises its development content through all project phases, from architecture definition, fine design and coding to testing. The concept of "test-driven development" is also frequently used in this process: "Whether it's a digital vehicle key or an assistance function – if we look at features from the user's point of view, a suitable functional test can be defined even before the actual software," explains team manager Carsten Elvers. In such cases, the test is created first and only then the software code. In the course of project development, more and more individual tested aspects then switch from "red" to "green." The team of two is also responsible for the functional tests that verify and validate the result of each iteration. The goal is always to provide regular, quality-assured deliveries.

Modern project management tools automatically keep logs

This approach is supported by the use of modern development and project management tools. The documentation and communication platform Confluence as well as the administration and reporting software Jira play a central role. In addition, specific tools such as Bitbucket, a web-based service for managing version statuses, are used. "Tools like Confluence and Jira offer the great advantage in project management that they generate metrics and reports automatically. This relieves the programmers of routine work, while at the same time the entire team has an overview of the project status at all times. And the important requirement of traceability is fully met," explains Carsten Elvers. According to the team manager, this leads to a real win-win situation: The programming teams can work independently and expediently. And IAV can deliver quality-assured, even faster results of the highest standard to its customers.

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Product by IAV

Testing of Infotainment Systems Made Easy

More and more features like phone, navigation, apps or mobile internet access must be developed, integrated and tested. And this long before real test vehicles are available. No easy task for software developers and testers, because the complexity of test setups is constantly increasing. IAV Umba provides a remedy.

The new IAV product is a test rack for infotainment control units that enables software developers and testers to create professional test setups without the help of hardware experts. In addition to the electrical architecture for the respective vehicle platform, IAV Umba also provides all the interfaces for diagnostics, a residual bus simulation and the power supply. This keeps the desk tidy and all tests clearly comprehensible – because IAV Umba was developed together with testers for testers. The highly integrated design incorporates 20 years of practical engineering experience.

What's special about IAV Umba: The test rack is manufactured in series quality by certified companies and can even be supplied in large quantities at short notice. Professionally manufactured cable harnesses and connectors guarantee trouble-free operation. And the integration of all components in a single housing considerably reduces spatial requirements and maintenance effort.

The test rack is currently available for the VW architectures MQB, 37w and MEB and is constantly being further developed to be compatible with all future products of the VW group brands. Upon request, IAV experts can integrate all components into IAV Umba and put the system into operation. This also includes online connection to the relevant cloud structure so that testers can start work immediately. This creates ideal conditions for developing modern infotainment systems.

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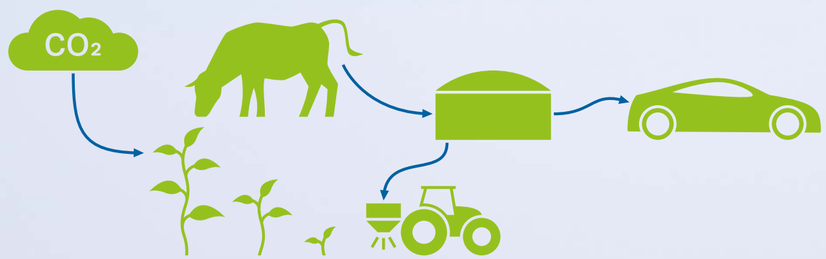
Green Power for Sustainable Mobility

Increase efficiency to over 45 percent with biomethane



Climate-friendly driving is not only possible with batteries, but also with gaseous fuels. More precisely with biomethane (CH4), which is obtained from organic waste and agricultural residues and offers a promising complement to the advancing e-mobility. The use of biomethane in the combustion engine reduces both CO_2 emissions and the primary energy demand very significantly over the entire life cycle. An in-house development by IAV shows how a vehicle powered purely by methane can achieve a range of more than 900 km. The concept makes it possible to increase the efficiency of a biomethane-powered gasoline engine in a hybrid powertrain to over 45 percent while at the same time achieving the lowest possible pollutant and greenhouse gas emissions. IAV presented the study at the Aachen Colloquium 2020 on Sustainable Mobility.

Achieving the Paris climate protection targets is and will remain difficult as most sectors of the economy still predominantly use fossil fuels and emit environmentally harmful greenhouse gases. What is needed are not only innovative drive and mobility concepts, but also climate-friendly substitutes for oil and coal. One option is biomass as an important source of renewable energy.

Resource-saving biomethane is produced by fermenting animal manure as well as waste and residual materials from household, forestry and agriculture. Its combustion as a fuel in a vehicle releases only as much CO_2 as the processed plants have bound during their growth.

Biomethane: Fraunhofer sees great potential in the transport sector

The application potential in the transport sector is considerable. If half of the previously unused but mobilizable substrates were used, 2.4 to 4.8 million mid-range cars in Germany, which corresponds to about 5 to 10 percent of the nationwide car population, could be powered by biomethane, according to a study by the Fraunhofer Institute for Systems and Innovation Research ISI in September 2019.

But there are still some technical hurdles. In internal combustion engines, methane is one of the fuels with the lowest raw emissions of pollutants, but is itself a harmful greenhouse gas. In order to also reduce this greenhouse gas in the best possible way throughout the entire engine map range, higher exhaust gas temperatures are required. In addition, the range of current methane-powered vehicles is only about 450 km due to the unfavorable package of gas tanks. Today's vehicles still rely on an additional small gas tank.

However, biomethane has an important advantage over the two best known renewable energy sources, wind power and the sun: It is available all year round, even when the winds are calm and it is overcast, and can be distributed using the existing network of natural gas pipelines and storage facilities. So what could be more obvious than to develop a drive concept in which biomethane can make an immediate contribution towards CO_2-neutral and sustainable mobility?

Use of biomethane in the combustion engine

IAV has been developing technology solutions for forward-looking drive concepts for decades. This time IAV has designed a highly efficient hybrid with stoichiometrically driven combustion engine (ICE) for the use of methane. Among other technologies, the IAV "Metamax" study uses pre-chamber ignition as well as cooled low-pressure exhaust gas recirculation, which makes it possible to increase the effective efficiency of the gasoline engine at its best from 39 percent currently in series production to more than 45 percent.

At low ICE power demand, the electric motor is intended to power the vehicle, since the exhaust gas temperature in this operating range does not reach the required 550°C. However, this is absolutely necessary to enable a safe catalytic conversion of methane as well. At cold temperatures, the catalytic converter is electrically preheated before the ICE is started, so that it can convert from the first second on. In the serial/parallel hybrid system, the torque requirements on the ICE are reduced during strong acceleration. As a result, the ICE can be designed for higher efficiency right from the start and always run close to its sweet spot while running.

"Methane in itself already enables the very low raw emissions of pollutants in the ICE However, previous concepts still run on a small gasoline fear tank," says Dr. Emanuel Binder, development engineer in IAV's Advanced Powertrain Development department. "We wanted to develop a vehicle concept suitable for everyday use that has a long range and requires methane only."

Lowest CO_2 emissions over life cycle, low primary energy requirement

The biomethane is stored in special tanks in the rear of the vehicle at a pressure of 200 bar. The range of 920 km is mainly achieved by the 168-liter tank volume and the high system efficiency of ICE and hybrid components. Low-pressure port injection is also beneficial to the range.

As part of the study, IAV compared the biomethane drive concept with selected technologies such as battery-electric vehicle (BEV), plug-in hybrid electric vehicle (PHEV), hydrogen fuel cell (FCEV) and synthetic fuels (PtL) and examined them in terms of energy efficiency in the life cycle (cradle-to-grave). The result: From a life cycle perspective, a biomethane-fueled ICE on the road shows the best combination of low CO_2 and low primary energy demand, because especially in the production of biomethane only a small number of conversion steps are required and the combustion properties of the green gas have a positive effecton ICE efficiency.

One thing is clear: no single drive type can serve all applications, markets and requirements, especially not when it comes to the amount of fuel or energy required. What is needed is an interplay of smart technologies and measures to make transport more sustainable – combustion engines remain an important part of this. When developing drive concepts, IAV not only focuses on the components but on the overall picture. Life-cycle considerations are therefore not at the end of the development process, but at the very beginning.

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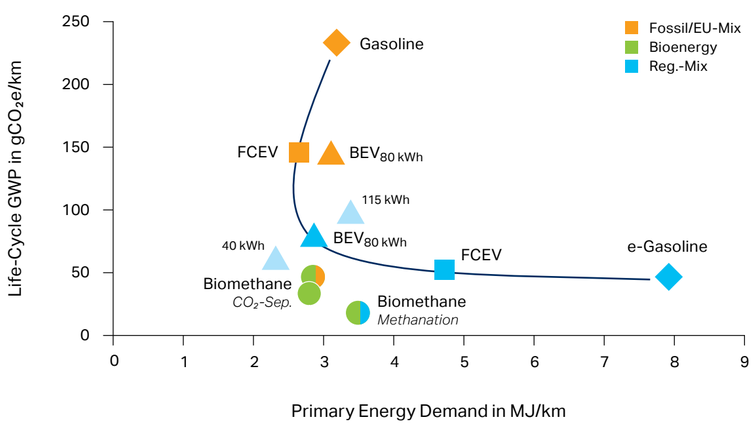

New Emission Laboratory Can also Be Electric

Ever stricter emission regulations, new measurement parameters and country-specific test cases: As the complexity of modern powertrains increases, so do the demands on measuring and testing systems. A new test rig from IAV in Berlin offers state-of-the-art measuring technology for all gaseous standard emissions as well as for mass and number of particles. Hybrid and electric vehicles can also be tested.

Building on its many years of expertise in testing and measuring procedures, IAV has created an infrastructure comprising state-of-the-art measuring equipment and facilities for complete vehicles, systems and components.

With the "Emission Roller Test Bench 4," which went into operation in October, IAV has added a very potent test facility to its range of services for its customers. In addition to passenger cars, it can also be used to test medium-heavy commercial vehicles up to a total weight of 4,770 kg as well as electrified vehicles. The all-wheel drive roller test facility delivers a system output of 150 kW per axle and enables precise, reproducible test results.

Broader test spectrum, more driving cycles

Beyond the WLTP test procedure, it is also possible to run internal, more demanding test profiles in addition to the legally prescribed driving cycles. In addition to the legally required CVS emission measurement, the new test laboratory also offers continuous measurement procedures and is therefore also the right tool for development support.

"By expanding capacity with a facility that can do more than just map the legal standard, we are offering our customers real added value," says Bernd Poytinger, Head of the Roller Chassis Dynamometer Department at IAV.

To ensure maximum reproducibility of measurements and realistic mapping of road driving scenarios, our new test facility also includes the use of driving robots in combination with our proven simulation environment.

In order to achieve our customers' SOP targets, this facility can also run in multi-shift operation.

Fast loading column as anchor point for e-vehicle measurements

IAV has integrated the various sections of the plant in the best possible way, thus enhancing the efficiency of the entire facility.

For hybrid and purely electric vehicles, IAV will have a 300 kW DC rapid charging column in the test chamber by early 2021 at the latest. It will be able to carry out range measurements and, with the aid of special measuring technology, to examine the energy flows of batteries in a differentiated manner, for example during charging and recuperation.

Efficient battery management and a thorough check of the battery storage are essential prerequisites for guaranteeing the safety of electric cars and achieving the longest possible range.

With the new facility, another piece of high-tech has moved into our listed former bus depot dating from 1927. As a result, IAV now has four ultra-modern roller test rigs in Berlin alone with state-of-the-art emission measurement technology, including a high-altitude climatic roller that allows temperatures ranging from minus 30°C to plus 40°C to be set across the entire pressure spectrum from 1,000 to 500 mbar.

"With the new test bench, we not only offer our customers forward-looking complete solutions for emission testing, but also support the testing and development of electrical drive systems," says Andreas Geistert, Head of the Test Field Department at IAV.

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With Atomic Precision

High-performance technology for the development

Whether in biological research, medical diagnostics or for material testing in engineering: The fields of application of radioactive nuclides are extremely diverse. In the automotive industry, radionuclide technology (RNT) is used by engine developers, among others, as a central tool for wear analysis in important components such as piston rings or connecting rod bearings. IAV already uses the RNT method for measurements on internal combustion engines – but it can also be used in the field of e-mobility, for example for e-components and transmissions.

The future technologies such as e-mobility, autonomous driving and interconnectivity show that the pace of innovation in the automotive industry is continuing to accelerate rapidly. Product development must keep pace and is also gaining momentum through progressive digitalization and the use of predictive simulation software and artificial intelligence.

With increasingly virtual development processes, it is becoming increasingly important to gain early insights into contact friction between solid bodies at certain operating points and the resulting material removal. Here, so-called online wear measurements with radioactive nuclides provide measured values in the nano range, this allows to check and optimize the quality of the simulations tools.

Where forces of motor-driven locomotion are acting, relative movement between solid bodies occurs. The resulting friction is both ecologically and economically disadvantageous. On the one hand, it slows down the movement between bodies and thus leads to higher fuel consumption and increasing CO_2 emissions. On the other hand, progressive wear causes additional costs for repair and spare parts. Developers therefore rely on the precise and efficient RNT method to keep friction and wear to a minimum. Almost all wear-relevant engine parts and materials can be activated, examined and evaluated.

Synergy effects in development

The shortening of product cycles has an impact on the development processes. Endurance tests of up to 1,000 hours for car engines, which provide insufficient information at high costs, are now considered unprofitable. Based on RNT measurement results, release and production start can be significantly accelerated and the associated costs noticeably reduced, says Dr. Hubert Schultheiß from the Simulation and Validation Department at IAV.

"The measured values provide a key basis for quickly evaluating wear processes in the development and testing process and noticeably improving predictive calculation methods," says Schultheiß. "In addition, we determine wear rates in real time and can thus precisely optimize wear-relevant components for their service life requirements."

Wear analysis in real time

At the RNT method, the component under investigation is first bombarded with protons, deuterons, alpha particles or neutrons at a particle accelerator (cyclotron). The reactions of these particles with the atomic nuclei of the evaluating components produce a thin radioactive layer on its surface, which emits a readily measurable gamma radiation during radioactive decay. The abrasion-based wear generates tiny activated particles which are introduced into the lubricant and whose gamma radiation can be detected in the oil circuit. In addition, the wear rate of the components in question can be monitored online continuously and with high precision during operation on the test rig.

IAV has a special permit from the Free State of Saxony to use the RNT measuring method at its Chemnitz/Stollberg site as handling radioactive materials is subject to the Radiation Protection Act, among other things. IAV also works with its Belgian partner Delta Services Industriels (DSI), a specialist in the development and use of radioactive marker techniques.

In IAV's own application of the RNT method, up to five components can be examined simultaneously thanks to the use of ultra-pure germanium detectors for gamma rays. These so-called HPGE detectors are much more efficient than sodium iodide (NaI) detectors, which can only analyze up to two elements simultaneously.

Sights set on new areas of application

From the RNT measured values, the data preparation tool IAV Teslin generates detailed overviews of all measuring processes per component. Developers and component managers on the customer side benefit from much greater efficiency and better evaluation options during and after endurance tests.

Thanks to our in-depth expertise in the field of inspection and testing equipment, we have been involved in RNT wear measurement for many years. In doing so, we also test new areas of application with a view to the essential future technologies, for example in the field of lubricating oils for electric drives. Here, too, the RNT method allows valuable conclusions to be drawn, for example, about the wear behavior of different materials or coatings with a constant reference lubricant. For example, the qualities of different gear oils in electric drives can be compared with each other with regard to the wear behavior of specific components such as gears and bearings.

"Radionuclide technology offers great potential for the entire powertrain," says Philipp Zumpf, Head of the Simulation and Validation Department at IAV. "It is an effective instrument for improving the resource utilization of the complete powertrain system."

If you have always wanted to know how your friction partners behave and how they can be optimized, then contact us. IAV's RNT test capacities are ready and able to effectively improve many systems and components.

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"We Have a Healthy Respect for the Task"

Today, IAV is one of the top 3 development partners to the automotive industry worldwide. With over 35 years of experience in the industry, the company has built up outstanding engineering expertise – and recognized the potential for other sectors as well: robotics, as well as energy, water and agriculture. In an interview, Sebastian Sinning, Head of Business Development at IAV, talks about key IAV core competencies and how they are used to master key challenges in these markets.

Mr Sinning, automotive engineering is and will remain IAV's core business. Why robotics, energy, water and agriculture in particular?

Sinning: Digitalization is leading to far-reaching upheaval in practically every sector. This entails risks for the established players but also huge opportunities for innovative solutions. The door is wide open for creative companies with appropriate intelligent solutions. The basis for this can be recorded real test data as well as previously generated simulation results. And this know-how is in demand not only in our traditional industry, but also in other areas. We have therefore analyzed various industries and their challenges. Our guiding question was: Can we solve the challenges of this industry with our expertise from the automotive sector? The strategic fit was best in the four industries mentioned – of which robotics is strictly speaking a technology.

What other criteria played a role in the selection?

Sinning: In addition to the question of how well our know-how can be transferred to other business areas, another decisive factor was of course how well our premium claim fits the respective industry. In our core automotive business, which will remain in focus in the future, we are the first choice for our customers – especially for projects critical to success. Why? Because we bring innovative technologies to the road on time, at the highest level and with the highest safety standards. And in such a way that they prove their worth millions of times around the world every day. Of course, the economic framework conditions and business cases must be right for this premium claim. And that naturally also applies to the new industries. The added value that customers buy with it must pay off – and we see this potential more and more often.

What specific IAV competencies do you intend to use to convince customers in these non-automotive sectors?

Sinning: Through our decades of automotive engineering, we have acquired extensive know-how in control engineering, automation, mechatronics, hardware development and lightweight construction. In recent years, we have built up extensive expertise in the fields of AI and data science and are one of the most innovative engineering partners in this field. In the new industries, we rely on some of these competencies, such as AI and Data Science, depending on the requirements. Often we bring together a large number of these competencies because this is the only way to create added value, for example in the development of intelligent and independently operating service robots.

IAV is known above all for its engineering skills in the service provider role. Own products are less the core business. Will this change in the new industries?

Sinning: Our focus remains on engineering on behalf of customers. That is what we master perfectly. But we want to take on an even stronger role as a system integrator for some developments. To this end, we are bundling our forces with partners who take on sub-projects which we then transfer into the overall product. In the agricultural sector, we have even been successfully doing this for many years. We develop and supply the CEBIS display and control system for the Claas company – production is handled by a partner commissioned by us. Or an example from the water industry: Using our AI and data management know-how, we have developed an intelligent coronavirus early warning system which uses the evaluation of publicly available data and analysis results of wastewater samples from the sewerage system to derive information on the spread of Covid-19. This enables a much earlier detection and more precise localization of infection foci. In this project we are working together with the Technical University of Berlin and ORI Abwassertechnik GmbH, a leading manufacturer of automated samplers with remote data transmission for sewer systems. The TU Berlin is responsible for the sampling and analysis of the samples, while ORI GmbH supplies the samplers and measurement technology. We provide the IT environment, are responsible for data analysis and evaluation and ensure that the project as a whole works successfully.

Established structures, established industry players and competition from the start-up universe: Aren't you taking on too much with your focus on industries that were previously foreign to IAV?

Sinning: Entering a new industry is without doubt a challenge. We have a healthy respect for the task at hand but also the courage to take this step. We have done our homework, carefully analyzed the markets and worked out our potential. We are able to bring highly complex technologies into series production and have over 35 years of experience in this field. If we then combine this experience with innovative ideas, such as in our software product IAV Optera, with which we support electricity network operators in optimizing existing networks and planning new networks, we will attract attention in new industries. And then the road to an initial acquisition meeting is not far off. At the same time, we see that industry boundaries are becoming increasingly blurred. With our work for the energy sector, for example, we end up working for our core business again and help e-mobility achieve a breakthrough.

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Always Live – Thanks to IoT Platform and AI

In a research project involving more than 60 Work XL street scooters from Deutsche Post DHL, IAV is examining the flexibility potential of electric fleets and the possibilities of intelligent network integration.

Electric mobility is becoming increasingly popular. According to Statista, 63,000 purely electric vehicles were registered in Germany in 2019. In 2020, the number of registrations has already exceeded 77,000 (as of August). Growing model diversity, greater ranges and government subsidies are encouraging more and more customers to switch to an emission-free e-drive. To ensure that these vehicles can also be charged, the demand for electricity is growing. And this should, at best, come from renewable energies for the ecobalance of the e-vehicles.

Predictively avoiding grid bottlenecks

This is particularly tricky when entire fleets of vehicles have to be charged simultaneously overnight, for example by delivery services. This poses a growing challenge for distribution grid operators. Because if an unexpectedly large number of vehicles are connected to the grid, this can lead to grid bottlenecks in the supply. Especially since sun and wind are also not constantly available to meet the regenerative power demand. The danger: Without intelligent planning, the supply and demand of energy can become unbalanced at peak times – and the vehicle fleet might not be fully charged come the following morning.

To prevent this, IAV, the Reiner Lemoine Institute and E.DIS Netz have joined forces in the "Intelligent grid integration of electrified logistics" research project (Netz_eLOG). At the Deutsche Post DHL distribution center (DPDHL) in Kleinmachnow, Brandenburg, the consortium is investigating the flexibility potential of an electric fleet and the possibilities of grid integration. Specifically, the aim is to develop a procedure for automated load and charge management so that the entire vehicle fleet can be operated in a grid-compatible manner and thus make its own contribution towards grid stabilization. For the first time, data from both the grid operator and the fleet operator will flow together in one system. In the practical test, 63 Work XL street scooters from DPDHL will be used. The idea is to use targeted, time-controlled load shifts to predictively avoid possible grid bottlenecks on the one hand and thus ensure that the fleet is charged, and on the other hand to compensate for the peaks in the feed-in of renewable energies into the grid. These interventions for grid stabilization are achieved by ad-hoc control and regulation and a high data transparency between distribution grid and loading fleet.

Optimal grid load thanks to AI

An important prerequisite is therefore that the demand for electricity is intelligently linked to the generation of electricity from renewable energies. "The big challenge is to integrate the logistical criteria of the fleet operator and the requirements of the grid operator into the control of the charging processes. These are two completely different worlds that we are linking together for the first time," says Robert Frase, Head of Department of the Thermodynamics and Power Systems division at IAV. In the Netz_eLOG project, IAV is developing an interoperable IoT platform that compares and evaluates the data fed in by the network and fleet operators. An AI-based load control system based on this platform ensures an optimum grid load and ensures that the fleet is charged in line with demand. The aim is that grid operators will be able to use this software solution to predict future demand and take it into account in grid planning. This is possible both during "normal" operation and at peak times, such as during the Christmas period, when vehicles travel longer routes and also need to be charged in between.

"For this project, our experience in automotive development is playing into our hands," adds Robert Frase. "In addition to its expertise in the development of electric vehicles and their technical features, IAV covers the range from communication from the vehicle to the charging station, an underlying back-end and the effects on the power grid."

The development and use of data platforms is also a key element within this context. Robert Frase: "We think in systems – whether in vehicle development or in the energy industry. And we rely on synergies: We want to use our experience in automotive development for the topics of "digitalization" and "automation."

For IAV, there are many parallels between the two areas: There is hardly any difference between control engineering and data record management in vehicles and energy industry plants.

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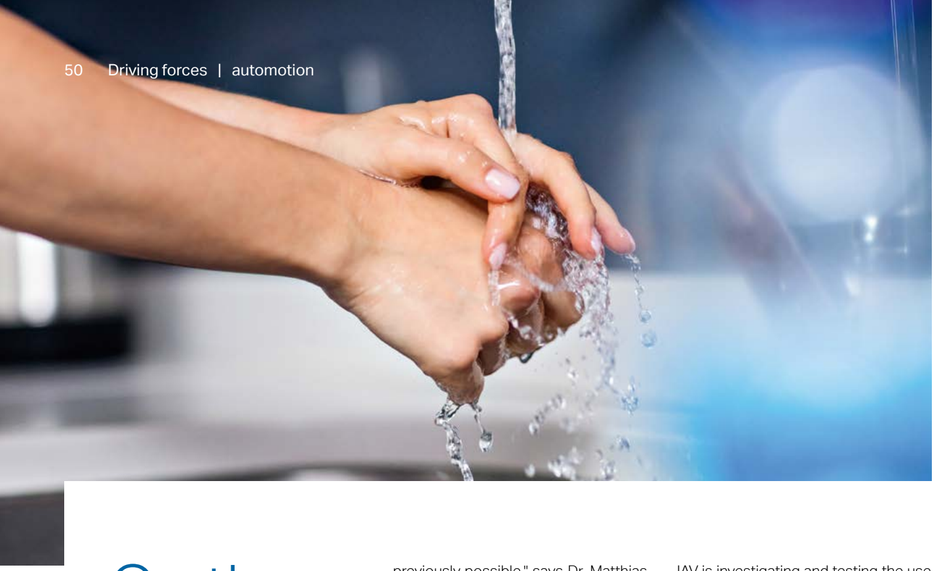
Network_eLOG" Project ("Intelligent grid integration of electrified logistics")

www.netz-elog.de

Partner: Reiner Lemoine Institut gGmbH (consortium leader), IAV GmbH, E.DIS Netz GmbH, DHL Kleinmachnow (associated partner).

Netz_eLOG is funded within the framework of the "Erneuerbar mobil" funding program of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). The project management agency is VDI/VDE-IT.



On the Trail of the Virus

IAV has developed a methodology for deriving information on the spread of Covid-19 through intelligent evaluation of wastewater data. This enables a much earlier detection and more precise localization of infection foci.

Until an effective vaccine against Covid-19 is available, the early identification of outbreaks of infection remains one of the major challenges to prevent the further spread of the virus. Time is of the essence. The problem: Several weeks can easily elapse between an infection, the appearance of the first symptoms, a smear sample, the availability of a test result and the notification of the responsible authorities. In the meantime, the virus can spread unnoticed.

However, the RNA pathogen (ribonucleic acid) is directly detectable in wastewater. "If we merge data from wastewater samples with public test and infection data and evaluate it in an integrated manner, we can detect a wave of infection earlier and localize it more precisely than was previously possible," says Dr. Matthias Pätsch, responsible for Business Development Water Management at IAV. The early warning system created by him and his team is based on two developments: an intelligent, cloud-based IoT platform for data synthesis and evaluation that has already been tried and tested in practice and an AI-based method for the intelligent positioning of devices in the sewerage system that can take samples automatically (so-called samplers).

In this project, IAV is cooperating with the Technical University of Berlin (Institute for Urban Water Management) and ORI Abwassertechnik GmbH, a leading manufacturer of automated samplers with remote data transmission for sewer systems. The TU Berlin is responsible for the sampling and analysis of the samples, while ORI GmbH supplies the samplers and measurement technology. IAV in turn provides the IT environment, is responsible for data analysis and evaluation and thus forms the bracket of the entire project.

The IoT Platform from IAV records – in strict compliance with legal data protection regulations – the publicly available health data of government offices and other public institutions as well as the data of connected samplers, evaluates these in real time and displays the results on a topographical and individually scalable map.

To identify where the samplers should be positioned in the sewerage system, IAV is investigating and testing the use of artificial intelligence based on a so-called Bayesian network. "With the help of initial sampling in the sewage treatment plant and sewer system, historical data on previous infection spreads and data on infection foci from human tests, the probability of positive samples at a specific point in the sewer system can be calculated," says Pätsch. The aim is to take further samples in the sewer system, which is filled with thousands of inflows and outflows, at precisely those nodes that promise a high hit rate – and thus have a particularly high significance for the localization of an infection event.

"With our AI-supported method, we are able to achieve a meaningful result more quickly. This saves valuable time in the detection and localization of an emerging focus of infection," Pätsch sums up.

The concept of the early detection system is currently in the implementation phase. The next step is the test deployment in a pilot project with individual cities or districts.

IAV is also setting up an early detection system at its Gifhorn site. IAV's own PCR (polymerase chain reaction) test equipment is being used in this cross-divisional project. The rapid tests are already being used to carry out initial tests to determine corona RNA in the company's wastewater system.

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Harvest Time

IAV drives Farming 4.0 forward with an AI-controlled harvesting aid

Getting the harvest quickly and safely at the right time to secure the work of an entire year. Farmers face this challenge when preparing for harvest time and it is not always possible to find enough helpers for their fields in time. Although some agricultural products can be harvested by machine on a large scale, a sure instinct is required for many crops. Only for products without crop damage do farmers achieve good prices. To support them, IAV is developing a robotic arm that provides targeted and efficient support for harvesting work.

24/7: Robotic arm is fast, precise – and smart

Each arm functions as an autonomous unit and has control technology, cutting tools and its own camera to recognize and harvest the crop. During operation, the harvesting robot focuses on the stalk of the fruit. It then picks it up and cuts it off in one go. This enables harvesting free of damage and bruises.

To ensure safety in the field, several of these robot arms are mounted on the long sides of a vehicle facing inwards. They receive their electricity from the vehicle's on-board power supply. They then place the harvested fruit on a conveyor belt in the middle of the vehicle.

"Alongside precision, speed is the most important factor in our robotic arms," says Dr. Jürgen Pannek, Senior Technical Consultant for Robotics at IAV. "After all, there is usually only a very short time window available for harvesting crops."

Perfect symbiosis of bionics and artificial intelligence

In order for the harvesting robot to recognize the fruits as such, they are first photographed in detail. With the help of these pictures, the robot is first taught to recognize not only the fruit, but also its stem and degree of ripeness. Using standard artificial intelligence (AI) methods, a hit rate of 20 percent can be achieved with just eight images. "Our goal, however, was to achieve a hit rate of over 95 percent. This requires several hundred shots under real conditions, i.e. in the field and in all weather," says Pannek. Ergo: The AI has to be trained intensively and extensively in order to achieve the necessary performance. Advantage: Only comparatively simple computer hardware is needed to retrieve these images during the actual harvest. In addition, the procedure is independent of whether the crop is strawberries, cucumbers or peppers.

And the harvesting robot is also a generalist in lightweight construction in terms of its design concept: Thanks to its modular concept for the gripper and kinematics, it can be converted to different fruits in just a few steps. When developing the harvesting robot, IAV engineers benefit from their automotive expertise – particularly in the areas of autonomous systems, mechatronics and operability.

Future prospects for vertical farming

In the future, the robotic arm will be used not only in the field, but also at lofty heights. In vertical farming, i.e. the cultivation of different fruits on several levels, a track system puts the harvesting robots on the right track. In addition, in the future the arms could not only assist in harvesting but also in looking after the crops by detecting and removing weeds, pinching out or detecting pests.

"No matter whether vertical or horizontal: Our robotic arm is flexible and supports the farmer with its precision and speed – even in time-critical situations," promises Pannek.

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The Perfect Symbiosis

E-cars as power storage devices at home

The idea is simple and forward-looking: Why not use parked electric cars as a storage facility for excess green electricity and thus compensate for fluctuations in the power grid? Efficient storage technologies for solar and wind energy are still rare. However, with the continuously growing number of e-vehicles, a large number of batteries are coming into circulation – a great potential for energy management in the home, for example, if this storage capacity can be used intelligently. With bidirectional charging technology, electricity can flow in both directions between home and car. IAV is developing the communications software relevant to this – thus creating an important lever for the success of the change in energy policy.

When switching to renewable energy sources, a key objective is to ensure a balance between energy demand and availability at all times. Intelligent storage systems and networks are needed to effectively distribute or store solar or wind energy from peak periods. Battery storage systems for electric vehicles can contribute towards the temporary supply of electricity to homes, especially at peak loads when electricity from the grid is expensive, during bottlenecks such as when winds are calm or at night when the home's own photovoltaic system is not generating electricity. Charging takes place either during the day via a PV system or from the grid at favorable electricity prices, for example by using wind power at night.

With the introduction of e-mobility, vehicles with battery capacities of more than 25 kWh on average are becoming increasingly available on the market. According to the German Federal Association of Energy and Water Industries (BDEW), the average consumption of a 3-person household in Germany in 2019 was about 3,500 kWh per year, i.e. about 10 kWh per day.

In this way, e-cars can not only be used for environmentally friendly transportation. By using the storage capacity provided by the high-voltage batteries, e-vehicles become a central component of the so-called "smart home system." In this way, they stabilize not only the energy management in the connected private home, but also the energy grids as a whole. Intelligent interconnectivity is necessary for this to work in practice. Most smart home concepts are based on the Internet of Things, whereby electrical devices such as the PV system, heating and consumers are integrated into the "Home Energy Management System" (HEMS) by means of intelligent control. The aim of the system is to use an analysis of the energy flows induced by the consumer to store the solar power generated at home as efficiently as possible and to use it for personal consumption via an intelligent distribution system.

Battery electric vehicles can also be integrated into the HEMS, the key technology here being bidirectional charging: This not only enables electric cars to draw power from the grid at times when general electricity demand is lower, but also to feed it back into the grid via a charging point during phases of particularly high demand for electrical energy. Intelligent software enables the automated control of charging and discharging processes. The holistic integration of e-vehicles into the charging infrastructure and energy system is currently being researched in various projects, including by IAV, and the legal and regulatory framework is being evaluated.

As part of the "Bidirectional Charging Management – BDL" research project, companies and institutions from business and science are developing technology and system solutions in the field of energy and charging management at the Forschungsstelle für Energiewirtschaft e. V. in Munich and analyzing possible use cases. As a technology leader in future-relevant drive systems, IAV has a deep insight into the development of fully and partially electric vehicles and supports the joint project, which is scheduled to run for three years until April 2022 and is funded by the German government.

As an engineering specialist, IAV develops and tests the communication protocols between the electric car, charging infrastructure and power grid, thus creating the conditions for controlled charging. The individual needs of the consumers and the availability of electrical energy are coordinated with each other with the help of intelligent tariff offers and appropriate scheduling of the charging processes. Numerous current solutions for HEMS work with a proprietary communication system into which devices from other manufacturers often cannot be integrated. IAV develops communication modules for all international standards, thus creating the basis for competitive and future-proof solutions for so-called "smart charging."

In theory, e-vehicles could be connected not only to the HEMS but also to the public power grid and thus contribute to general supply security, says Ursel Willrett, Senior Technical Consultant for infrastructure systems in the field of e-mobility at IAV. Regulatory changes must therefore be made in parallel with technical implementation.

"E-cars have great potential to cover the two central use cases – mobility and stabilizing local load management in the home," says Willrett. "They are predestined to secure the electricity grid and provide meaningful support for the change in energy policy."

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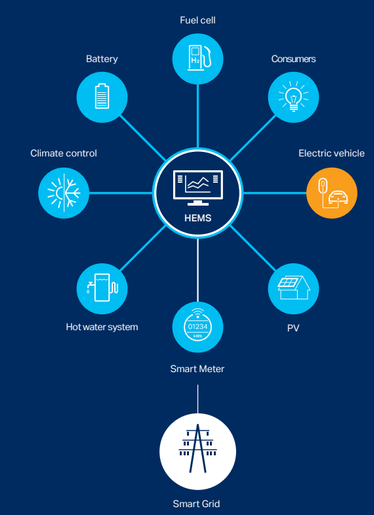

Live: New High-voltage Composite Test Bench

The electrification of fleets is progressing, and with the increasing diversity of e-models, the complexity of the various powertrains is growing too. This calls for a new generation of test equipment with a previously unattained range of performance and functions. IAV's new HV composite test bench in Chemnitz/Stollberg enables HV units to be tested individually and as part of a system in early stages of development.

The development and validation of high-performance electric powertrains requires comprehensive testing of all components. This is why IAV has set up extensive test facilities in which components can be tested not only individually but also in a system network. E-mobility can only reach its full potential if the central components for electric drives such as power electronics, battery, electric motor, charger and auxiliary units are optimally dimensioned and matched to each other.

The new HV composite test bench plays a pioneering role in the development process of the individual components and the e-drive system. IAV provides its customers with all the relevant test procedures and extensive testing know-how for testing their electrical, electronic and mechanical components as well as systems for the complete e-powertrain from a single source.

Unique in the industry

The basis of the IAV test facility, which is unique in the industry, is formed by four powerful electric machines with a braking power of 280 kW each (permanent, short-term up to 500 kW), a modular vehicle energy system (VES) with up to one megawatt output as well as a battery container and equipment for air-conditioned operation of the components between -40 and 150°C ambient temperature.

The heart of the test bench is the so-called HV-DC box; the central link for the entire electrical power flow. It can be used to test appropriate connections of the HV components and to analyze the reaction of individual components in the HV system, even in case of malfunctions or errors.

For the first time, the new test bench provides the opportunity to thoroughly examine subsystems even before they are integrated into the vehicle. This opens up far-reaching possibilities with regard to early development scopes on the overall system. For example, system function tests up to functional safety according to the ISO 26262 standard can be carried out in the entire HV system. In addition to the ideal behavior of components and systems, deviations from the desired functionality of the devices under test can also be investigated. Even without test runs with test vehicles, engineers thus gain valuable insights into the reactions of the HV system to operational disturbances such as short circuits, load shedding or inconsitencies in the supply grid during charging.

Reduce development time and costs

Long before a vehicle receives approval, relevant safety tests are also carried out in early development stages, for example, as part of safety and charging approvals. All in all, composite tests can accelerate relevant validations and functional approvals and reduce vehicle development time and costs by up to 50 percent.

The increasing complexity in the interaction of individual HV components also requires fully automated process control. IAV has developed and qualified the Afram automation software required for this, as it has done for the entire test bench.

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What Drives Our Customers in these Times

By Carsten Rinka,
Executive Vice President
of Sales at IAV

"More digitalization can make development more efficient – exactly what is needed in these cost-conscious times."

Even before coronavirus, three megatrends were particularly important with regard to future mobility: automation, electrification and connectivity/software. According to our observations, the pandemic is accelerating technological and structural change within the automotive industry.

Since the spring, the coronavirus crisis has put a massive brake on the automotive industry. And even at the end of this extraordinary year, OEMs, suppliers and EDLs are still struggling with uncertainties. Especially with regard to short-term costs, we are experiencing severe budget constraints on the part of our customers. Companies are prioritizing their projects. Issues that are close to series production and of particular strategic importance remain, while we are observing shifts in other areas. All in all, our customers are trying to implement their projects in a cost-driven manner with maximum quality.

Whereas our clients used to entrust us with individual projects in the development process, they are now increasingly asking us for overall technical solutions – naturally also for cost reasons. As a premium partner, we are increasingly taking on larger tasks, bringing in partners for our part and playing a coordinating role more frequently and to a greater extent.

In hardly any other industry in Germany is the value chain as closely interlocked and linked with modern IT as in the automotive industry. Coronavirus and cost pressure are driving up awareness of the necessity, but also the potential, of digitalization. I notice that very personally: As sales manager, I was on site with a customer three to four days a week before the pandemic broke out. Now I mostly use Skype. It works surprisingly well, although I'm really looking forward to when personal exchanges become more frequent again.

More digitalization can make development more efficient – exactly what is needed in these cost-conscious times. As EDL, whose hobby-horses are the most modern development methods, we can make a contribution here. And not only within the scope of specific development projects for our customers, where we apply these methods, but also by supporting manufacturers and suppliers in fundamentally realigning their own development with digital tools and processes.

Take for instance automated driving: To keep development times and costs within reasonable limits, a wide variety of virtual methods are used throughout the entire development process – from functional specification to validation of the implementation.

In the field of alternative drive technologies, especially e-mobility, development is progressing in light of the strict (and in the future probably even stricter) global CO_2 regulations. The development budgets for these issues are not being cut, but rather increased. By contrast, the budgets for the development of combustion engines come under even greater pressure in times of tight budgets (due to coronavirus).

In the area of software, a very decisive and increasingly important competitive factor, German OEMs are currently swiftly catching up by massively building up their own expertise and using special automotive operating systems or developing them themselves. Particularly when it comes to integrating IT into the vehicle, there is a great need for assistance from experts such as IAV, for example in coordinating the OEM experts' domain knowledge and the requirements arising from IT and connectivity structures.

In addition to the "classic" solutions based on specifications, our customers are increasingly looking to us to take responsibility for delivery performance beyond the SOP. For us at IAV, for example, the "Software as a Service" approach, which includes support and maintenance, offers a way of demonstrating that we are willing and able to assume greater responsibility.

There is also a growing demand for EDL services in the field of internal vehicle connectivity – here, the number of control units that manage key functions such as assistance systems and infotainment and bundle calculations for autonomous driving will continue to decline. Similarly, the remaining ECUs will become increasingly complex. IAV is well positioned both technically and methodically to play an even greater role in architecture as an integrator in these core OEM issues.

A further requirement that is currently being intensified by the pandemic is the issue of shifting development to so-called best-cost countries (BCC). The BCC approach also helps us at IAV to remain competitive on the cost side as well through complementary cooperation with partners abroad. As it is important for us that our partners match our premium standards, we pay particular attention to excellence in technologies and processes as well as recognized certifications.

One thing is clear: The megatrends from the times before the pandemic continue to determine the strategic and technological orientation of the automotive industry. Coronavirus acts as a catalyst here. My conviction is: Development partners who adapt to these trends in a timely and courageous manner and do not shy away from readjusting their own business model are more valuable to manufacturers than ever before – despite all the challenges that this transformation also poses for EDLs.

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IT in Transformation

From system operator to pioneer of digital value creation

Whether virtual development methods, data science or systems engineering – digital transformation has reached engineering and shifted the drawing board to the "cloud." To enable engineers to handle increasingly complex customer projects in the "new world," appropriate tools, IT technologies and methods are needed. Corporate IT is thus becoming a critical element for engineering success. IAV IT has taken up this challenge and introduced new processes that improve collaboration and focus even more strongly on the needs of engineers.

"We are converting no less than our entire operating model and integrating into our daily work the processes that have proved their worth in modern IT companies. Our collaboration model is based on SAFe, a framework for agile working across many teams. In keeping with the successful slogan "eat your own dogfood," we are setting an example of what our engineers increasingly need to be able to do in their day-to-day business," says Christian Müller-Bagehl, Executive Vice President of Information Technology & Services at IAV.

SAFe provides the framework for a structured, agile way of working for companies that have reached a certain size and thus complexity. Work results are mapped using the Jira tool and then merged again at organizational level. Using this process, all activities – from the strategic level to daily work – can be transparently displayed. In this way, IAV's IT not only creates a new, secure and transparent structure but also takes a close look at data as a critical and strategically important resource. The aim is to structure and connect it in compliance with the highest security standards so that products and services based on it can be flexibly adapted to customer and market requirements.

Joint implementation

The ways of thinking of engineers and IT experts traditionally diverge widely. The realigned IT at IAV therefore relies on a dialog between IT developers and users and a much greater service orientation geared towards the needs of engineers. The challenge here is to find a common basis for cooperation. (Please also read the interview with Christian Müller-Bagehl and Dr. Michael Reichel from CPU24/7 on page 60.) In regular coordination rounds – so-called process roundtables – executives and users come together with IT on specific topics and design IT products and services that offer IAV engineers the greatest added value. "The process is identical for all service and product clusters. This makes it possible to manage complexity across the board with an appropriate role concept. At the same time, isolated ways of working are avoided and immature IT solutions are not pursued further right from the start," says Müller-Bagehl. The decisions made together are always based on the added value that can be achieved. The vision: a value-led and customer-focused IT organization.

Value-creating orientation

In implementing the IT products and services designed in the Process Roundtables, IAV IT takes on the role of integrator, focusing on the interaction of data and interfaces and on faster recognition of system dependencies. To this end, Christian Müller-Bagehl and their team rely on the methods of enterprise architecture, i.e. on the interaction of business processes and IT within the company. They also provide IAV's engineers with a global group data management system that they can access at any time. Whenever possible, IT solutions are implemented on scalable platforms. A process-oriented and model-based approach ensures a high-performance, low-maintenance IT infrastructure. The goal is a data-focused IT for control, organization and value creation.

Excellent operation

After all, IAV's IT now ensures "end-to-end" secure and stable operation and provides IAV engineers with solutions that are as user-friendly as possible. Standard services are provided quickly and largely automatically. The IT experts implement the solutions developed jointly with the users on schedule using the so-called DevOps approach: IT developers and users work closely together on the development of the IT products, which in the end not only increases effectiveness – but also leads to faster and higher quality results.

Another feature of the new IT operating model at IAV is its ability to meet new requirements quickly and flexibly. This approach was put to the test during the rapid implementation of mobile work capability during the coronavirus pandemic. In just a few days, over 6,500 IAV employees were able to work from home – with comparable productivity.

The transformation of IT is a huge feat at IAV, but it is a necessary step. Christian Müller-Bagehl is confident: "We can make a decisive contribution towards making not only our developers and engineers, but also the company's customers more successful through digitalization. Ultimately, we can offer them even better engineering and thus help their products to be even more successful."

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From Clash of Cultures to the Best of Both Worlds

"It is important to provide engineering with the levers of the digital world."

Christian Müller-Bagehl,
President, CPU 24/7

The cooperation between engineers and IT experts is often challenging due to different ways of thinking – but it has great potential. IAV subsidiary CPU 24/7 develops engineering tools for a new generation of digital collaboration models. An interview with President Christian Müller-Bagehl and Dr. Michael Reichel, Head of Context Engineering at CPU 24/7

What is the role of CPU 24/7 within the IAV family?

Reichel: We are Germany's leading cloud provider for engineering. CPU 24/7 started out in 2006 as a high-performance computing service provider for computer-aided engineering. Today, we offer engineers in companies of various sizes a secure IT platform for all conceivable applications throughout the entire product development process.

Müller-Bagehl: We are increasingly working on a topic that we experience when we compare our development methods in engineering with what we see in our IT colleagues: The process models in the domains of IT and engineering sometimes diverge widely. Our goal is to intensify exchange and collaboration in such a way that we bring the best of both worlds together.

How do the differences between the two cultures manifest themselves?

Müller-Bagehl: Especially in the question of how they deal with complexity. In the "cloud world," new services are emerging daily, the number of IT components is growing and they are dynamically interconnected. Managing complexity here means orchestrating the interaction of services as they are offered. Engineering, on the other hand, masters tasks by breaking projects down into many subtasks, developing the building blocks task-specifically, reassembling them and bringing them to market. This fits well in a world where these building blocks and products can be touched, but in a highly connected world, this leads to problems: The complexity increases, but the perfected method of mastering it becomes inefficient. It is like trying to knock in a screw with a hammer. The IT world didn't have the time to devote to the perfection of mastering the building blocks – it had to learn quickly to master things outside its own sphere of influence in such a way that the added value reaches the customer quickly and noticeably. So some want to master complexity, others want to manage it.

So are there any commonalities?

Reichel: The same applies to both: Nothing ventured, nothing gained. However, the IT expert works specifically to keep the "turnaround time" – the time between parameterization or modification of the system and the gain in knowledge – as short as possible.

Müller-Bagehl: Both disciplines seek to quickly achieve good solutions with real added value for the customer. In the digital world, speed is very important, and it can only be achieved through collaboration and the latest digital methods. Engineering, on the other hand, thinks in terms of subject-specific pillars. We are convinced: It is important to provide engineering with the levers of the digital world.

How is this reflected in the CPU 24/7 strategy?

Müller-Bagehl: On the one hand, this IAV subsidiary is strong in providing managed HPC resources that can be used to reduce turnaround times for engineers' calculations without having to worry about hardware, connectivity or licenses. We are continuing to expand this expertise. On the other hand, we are setting up our Engineering Cloud. Here, we will place further services for engineers such as our Engineering Web Services, with which we provide applications based on a service catalog, container platforms and various collaboration and groupware solutions. We will increasingly offer services and tools in the area of context engineering to make methods of the IT world available to engineers.

"We offer our customers the platform to securely scale in a German cloud and the ability to deliver more than just a command line."

Michael Reichel,
Head of Context Engineering, CPU 24/7

What are the solution elements in such a toolbox?

Reichel: The core of the solution will be the so-called context map. It not only stores data points of different natures such as requirements, user stories, legal standards or architecture blocks, but also links them together in a meaningful way. In this way, for example, a solution architect can request contexts as a service: "Has this capability ever been developed in the overall system?," "Have any decisions been made about this open source component in the past?," "Who needs to be informed about the decisions?," "Who is affected by them? The contexts found in this way form the basis of a discussion and ground it. In essence, it is therefore necessary to set up evaluation services that provide such facts for a discussion between the trades. With an appealing user interface and fast enough in the substructure to keep up with meetings in real time as a context map. Our expertise in the cloud business will help us with the latter in particular. We are firmly convinced that our offering will bring the two worlds, engineering and IT, closer together and create solutions that ultimately benefit everyone involved.

So from the "clash of cultures" to the best of both worlds?

Müller-Bagehl: With our services, we create a meeting place for exchange. It is precisely the complementary cooperation of the two cultures that can create great added value.

Reichel: It is also important for us to invite companies that are themselves working on data-based solutions for engineering. We offer them the platform to scale securely in a German cloud and the opportunities to deliver "more than just a command line." We are in the unique position to dovetail the perspective of IT with the processes of our customers.

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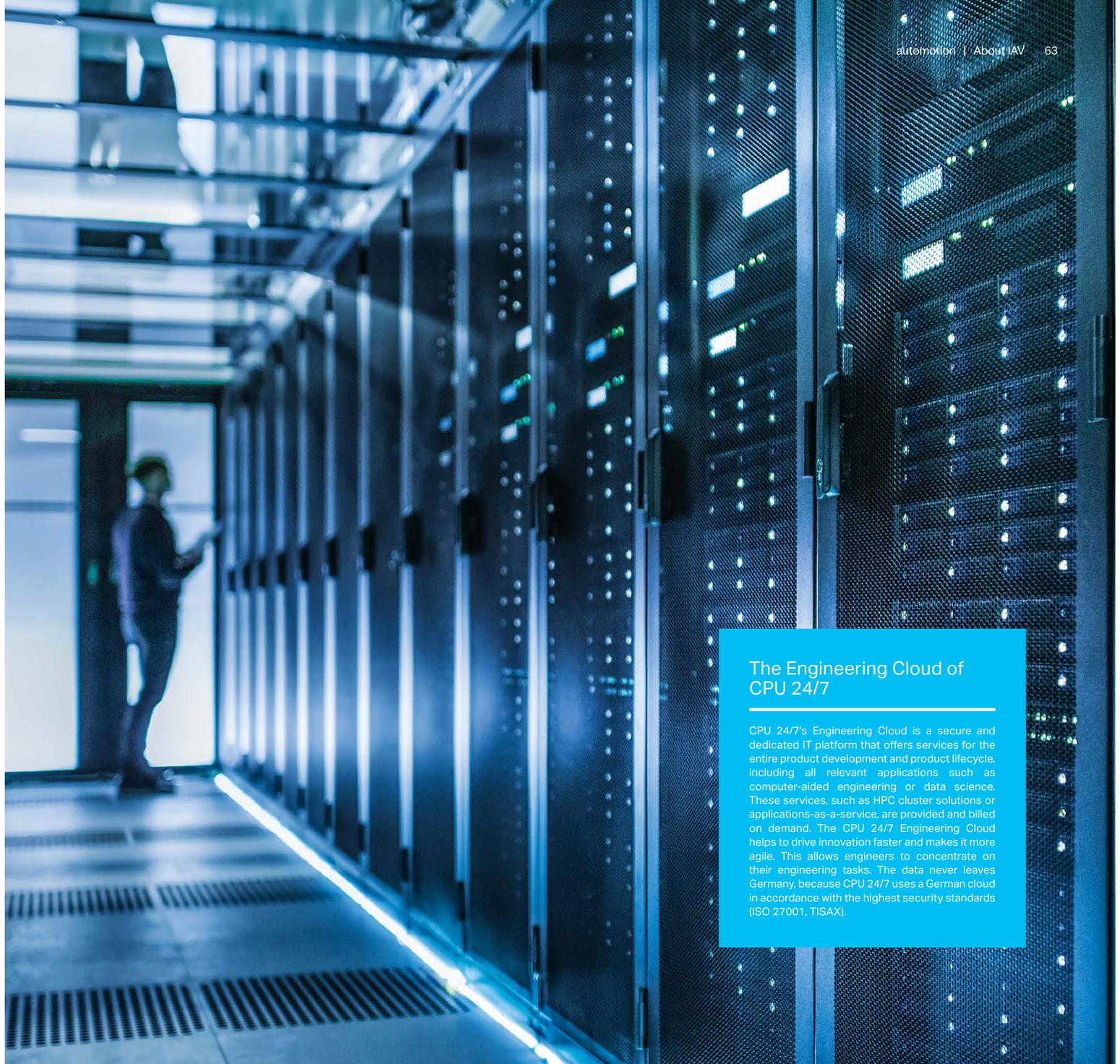

The Engineering Cloud of CPU 24/7

CPU 24/7's Engineering Cloud is a secure and dedicated IT platform that offers services for the entire product development and product lifecycle, including all relevant applications such as computer-aided engineering or data science. These services, such as HPC cluster solutions or applications-as-a-service, are provided and billed on demand. The CPU 24/7 Engineering Cloud helps to drive innovation faster and makes it more agile. This allows engineers to concentrate on their engineering tasks. The data never leaves Germany, because CPU 24/7 uses a German cloud in accordance with the highest security standards (ISO 27001, TISAX).

EMC as a Growth Market: New Test Center on the Way

The proportion of electronic components in vehicles continues to increase. It is becoming increasingly difficult for vehicle manufacturers to ensure that electromagnetic emissions do not cause interference and that vehicles themselves are not sensitive to electromagnetic fields. By building its own measuring equipment for testing electromagnetic compatibility (EMC), IAV is responding to the ongoing digitalization and electrification in the automotive industry and once again setting standards for comprehensive vehicle protection.

Regardless of whether it is e-mobility, autonomous driving, connectivity or innovative mobility services – in all key future fields, electromagnetic fields form the basis for data transmission. With the rapid development of new drive and vehicle technologies, the potential influence of electromagnetic interference is growing at the same time. In principle, this can be caused by any power-operated functional unit in the vehicle.

For this reason, all electrical components must meet the EMC requirements of the manufacturers with regard to interference emission and immunity. On the one hand, electromagnetic compatibility must ensure that the electronics integrated into the vehicle do not interfere with internal and external receiving systems. On the other hand, external interference immunity must be provided so that central functions and connectivity are not impaired by external electromagnetic fields. These basic ideas are an elementary part of the development work and are taken into account from the very beginning. Because nobody can afford to test the systems for electromagnetic compatibility only at the end of the development process.

Long-term cooperation agreed with German OEM

With the launch of a new EMC test center in Heimsheim near Stuttgart, IAV is responding to the unbroken demand for EMC testing capacity from manufacturers and suppliers despite the coronavirus pandemic. IAV has already entered into a long-term cooperation agreement with a German car manufacturer and will be assisting the latter in the future with both complete EMC vehicle development and EMC testing. Construction work on IAV's new test facility is scheduled to start in spring 2021, with the new facility scheduled to go into operation in early 2022.

"With our test center, we will be one of very few engineering partners in Europe that will be able to offer our customers the complete EMC development process, starting with the specifications, through support in EMC-optimized hardware development to integration into the entire vehicle with subsequent release recommendation, in-house and from a single source," says Matthias Kratzsch, Managing Director Technology. "We are thus underlining our claim to technological leadership in a growth market that is important for us."

The heart of the new test center is an EMC test laboratory with an emission-free dynanometer for vehicles. During the test process, IAV experts can map all test-relevant driving modes such as acceleration, braking or recuperation on the dyno. The laboratory is complemented by an EMC chamber for components in which components from parking sensors to high-voltage batteries can be measured.

New EMC test center can be used by other companies

With the new EMC test building, IAV is expanding its wide range of test facilities and laboratories for putting complete vehicles, systems and components through their paces. The extensive range of planned EMC test systems fits seamlessly into this high-tech area and will of course also be available to other vehicle manufacturers and suppliers.

"With our experts on site, we can support our customers in identifying and correcting electromagnetic incompatibilities in their vehicles and components at an early stage and thus avoid expensive multiple tests," says Kratzsch. "We are thus reaffirming our promise to our customers to master their most pressing challenges in the best possible way."

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Our Engineering

Cars and vans

Drive electronics

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

Powertrain concepts and integration

- Powertrain integration
- Powertrain concepts
- Energy management
- NVH powertrain
- Product data management
- Prototype construction
- Thermal management

Cockpit

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

E-traction

- Fuel cell systems
- E-fleet operation
- Electrification of the powertrain
- HV energy management
- HV energy storage
- HV safety

Exterior

- Attachments and glazing
- Front end and back end systems
- Body structure – doors, flaps and covers

Chassis/suspension

- Axis systems
- Brakes and slip control systems
- Chassis control systems
- Steering systems and steering assistance
- Wheels and tires
- Tank systems
- Testing and application

Vehicle electronics

- Design and integration of antennas
- Vehicle electrical system
- Electromagnetic compatibility
- Hard- and software development
- Body electrics and electronics
- Small series vehicles
- Light and vision

Vehicle functions

- E/E architecture integration
- Energy management
- Driver assistance
- Vehicle concepts
- Functional safety
- Complete vehicle validation
- Integral safety
- Air conditioning
- NVH vehicle
- Special vehicles
- Thermal management

Vehicle safety

- Full vehicle crash test
- Passenger protection, partner protection, restraint systems
- Safety electronics

Gas vehicles

- Expansion of gas vehicles (natural gas/ liquid gas)
- Dealer area
- Concepts

Transmissions

- Application of the transmission control
- Automatic transmission
- Calculation and simulation
- Dual clutch transmission
- Function and software development
- Geometric integration of the transmis-sion
- Hybrid systems
- Design
- Concept development
- Mechanical test and software test
- Continuously variable transmissions

Hybrid

- Energy management
- Integration
- Components

Interior

- Audio and language
- Insulation
- Interior/details
- Seating systems

Mobility

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

Product life cycle

- Aftersales
- eDiscovery
- Quality assurance
- Software and IT systems

Internal combustion engine

- Exhaust gas retreatment
- Exhaust gas recirculation (EGR)
- Charging
- Data supply engine functions
- Calculation and simulation
- Diesel engines: Thermodynamics and combustion processes
- Fuel and injection systems
- Gas engines
- Load exchange
- Mechanical testing and endurance testing
- Engine development and design
- Gasoline engines: Thermodynamics and combustion processes

Commercial vehicles and work machines

System integration

- Functional architecture
- Vehicle electrical systems
- ISO26262 & functional safety
- Safety
- Displays & HMI
- Drive electronics
- Calibration and diagnosis
- Exhaust gas retreatment
- Chassis
- Brakes & retarders

Electric commercial vehicles

- BEV
- Fuel cell
- HV power supply
- Charging system

CO_2 efficiency

- Fleet evaluation
- Aerodynamics
- Innovative engine concepts
- Hybrid solutions
- Transmissions
- ADAS & autonomous driving

Alternative fuels

- H_2 combustion
- Gas engines
- E-fuels
- Injection systems
- Tank systems

Transport & logistics

- Vehicle diagnostics
- Telematics and fleet management
- Apps

Power supply

- Autonomous energy supply
- Energy saving
- Power generation
- Energy storage
- Power distribution

Methods and testing facilities

Development methods

- Design of Experiments (DoE)
- Model-based application
- Test bench automation

Project management office

- Coaching and training
- Methods and processes
- Project management and control

Testing facilities and laboratories

- Complete vehicle
- Overall and subsystems
- Components

Quality management

Product solutions

- Electronic systems and components
- Development tools
- Vehicle conversions

Digitalization

- Competence development
- Business models
- Solutions
- Change management

We look forward to hearing from you!
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You can find out more about our unique range of competencies at: www.iav.com

Our Product Range

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IAV Cross

Injection analyzer

IAV Cross is a powerful system for hydraulic measurement of injection valves. It is used when differentiated consideration of injection processes is required.

IAV Primero

Fault simulation for lambda sensors

IAV Primero supports the entire OBD development process: Functional development, application and vehicle approval (OBD demo)

IAV Auros

Mobile test bench automation

IAV Auros is a mobile, effective and low-cost test system that contains everything you need for testing electric drives. The system transforms any room with a three-phase current socket (CEE socket 400V/63A) into a high-voltage test bench of direct voltage systems.

IAV Meru

Indexing system with knock detection

in the currently available generation as IAV KIS4

IAV KIS4 is a measuring instrument for calculating, displaying and evaluating thermodynamic and knock-specific variables of combustion engines.

IAV Meru

Indexing system

in the currently available generation as IAV Indicar

IAV Indicar is a measuring instrument for calculating, displaying and evaluating thermodynamic variables of combustion engines.

IAV Umba

Test rack for infotainment control units

IAV Umba is a test rack for infotainment control units that enables the software developer and tester to create professional test setups without the help of hardware experts.

INCA-FLOW

Guided application and automation

The application tool INCA-FLOW supports project managers, function developers, software developers and application engineers by accelerating and improving the development process in the application. Expert knowledge is made available company-wide.

IAV Kasai

Model-based application

in the currently available release as IAV EasyDoE

Design of Experiments (DoE) is a method that facilitates the efficient parameterization of engine control units. With the software, the user can perform a complete DoE as well as parameterization and optimization.

IAV Mara

Automated measurement data analysis

IAV Mara is used to search for and flexibly analyze measurement data. Complex analyses and visualizations can be configured according to individual requirements without any programming knowledge. Recurring tasks can be automated and calculated using distributed computing on cloud-based systems.

IAV Engine

Design and optimization of the engine mechanics

IAV Engine is an integrated tool for holistic design and optimization of mechanical drives in the powertrain.

IAV Macara

Editing, validation and visualization of application parameters

With IAV Macara, application data can be visualized, compared, merged and regenerated.

IAV Flexmore

List comparison, processing and analysis

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

IAV Teslin

Efficient and automated reporting

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

IAV White

Making connections in data tangible

IAV White visualizes large volumes of data in real time (BigData). This makes it possible to carry out evaluations intuitively and easily and to understand relationships.

IAV Barito

Application of battery models

The IAV Barito tool has been developed for the parameterization of battery models. It maps the entire workflow and is part of the tool chain developed by IAV for electric powertrains.

IAV Tronador

A look inside the control unit

IAV Tronador presents the most important information on an ECU directly in the function documentation. The presentation options range from simple display of static adjustment variables through to interactive analysis of measurement data.

Product by IAV

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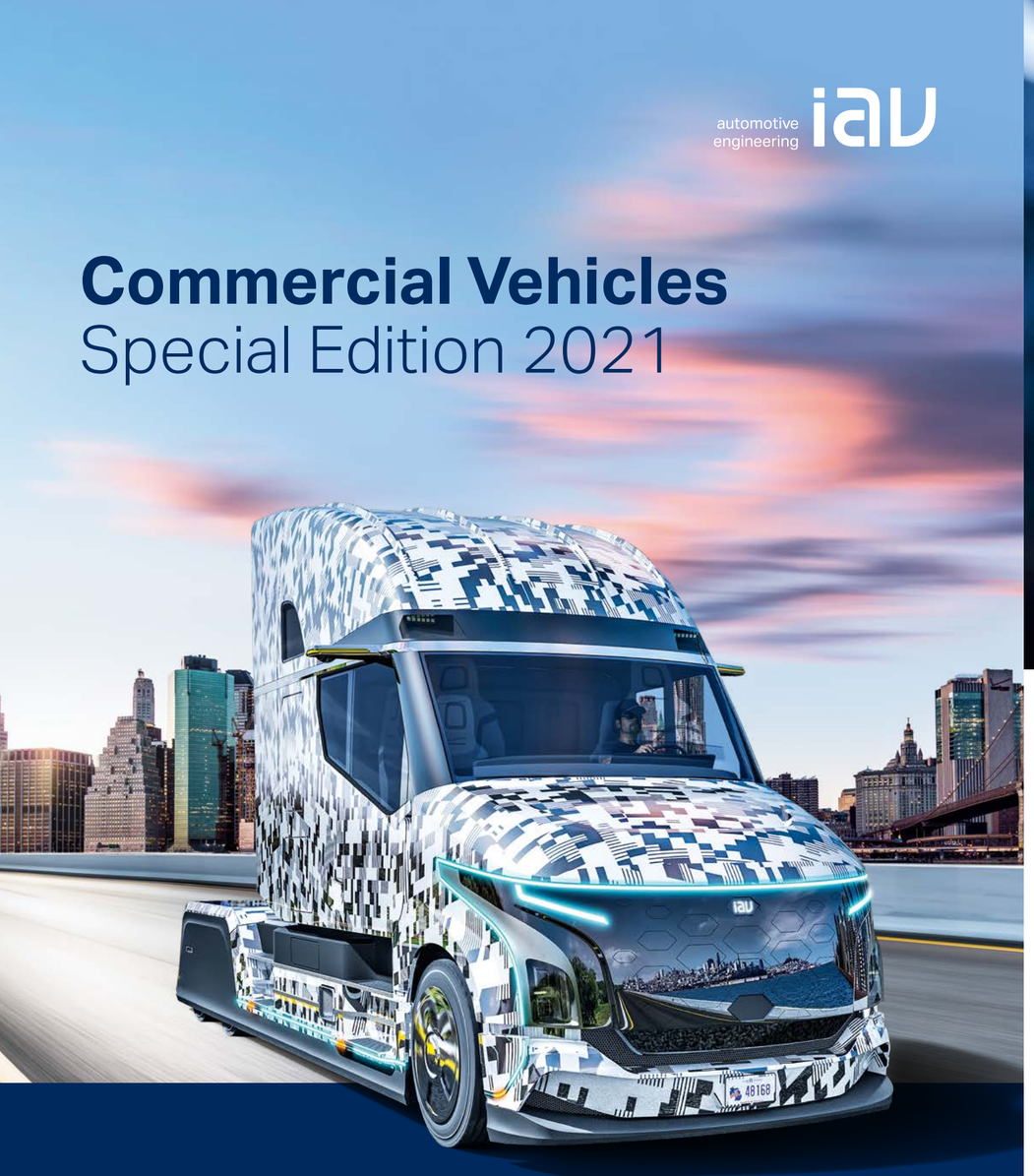
Commercial Vehicles
Special Edition 2021



Everything at a glance!

Our entire range of Commercial Vehicles topics is presented in a separate magazine – the CV Special. Issue 2021 focuses on the following topics: Changes in the market, CO_2 efficiency and the vehicle, digitalization, classic and innovative powertrains, as well as service and products.

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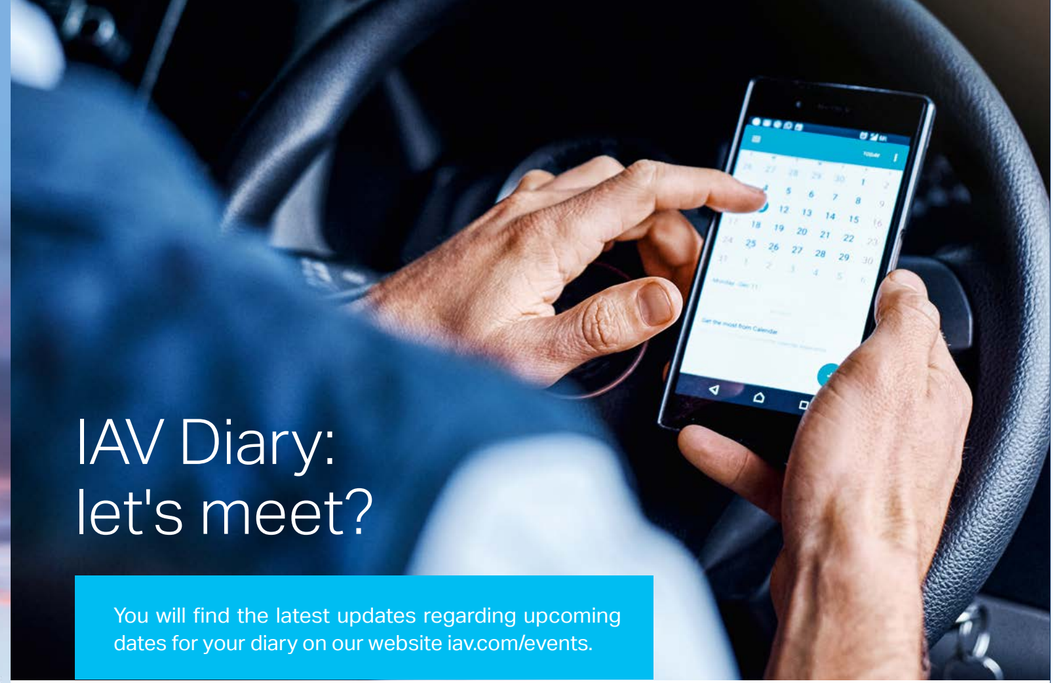

IAV Diary: let's meet?

You will find the latest updates regarding upcoming dates for your diary on our website iav.com/events.

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IAV GmbH · Carnotstraße 1 · D-10587 Berlin, Germany
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www.iav.com

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Post production
Highlevel

Design
publicgarden GmbH
ZITRUSBLAU GmbH Werbeagentur

Picture credits
Anette Cardinale
Christian Bierwagen
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istockphoto
Kathrin Heller
Lotte Ostermann
Manuela Steinemann
Sonja Hornung
Vivian Werk

Frequency of publication
Three times a year

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