auto motion

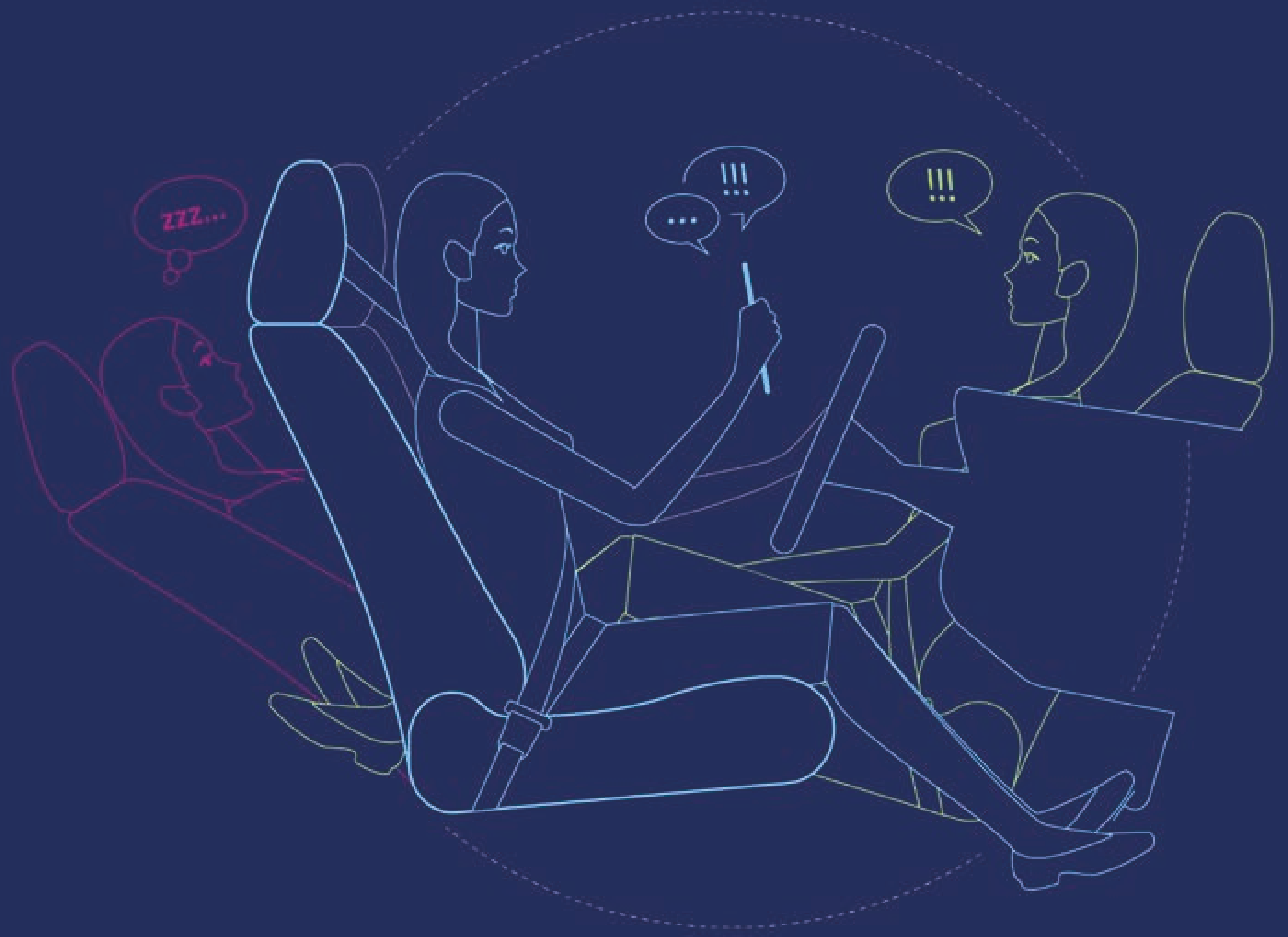
automotive engineering iav

IAV Customer Magazine | 03/2019

Next Level

Automated Driving at IAV

There are five levels to the self-driving vehicle. We explain what they mean.



Level 1
DRIVER ASSISTANCE
Assist systems such as adaptive cruise control (ACC) help the driver deal with road traffic. But the driver retains responsibility and control.

Level 2
PARTIAL AUTOMATION
The car performs individual tasks for the driver, such as unassisted parking, keeping in lane or braking and accelerating in traffic congestion. The driver monitors the car and is responsible.

Level 3
CONDITIONAL AUTOMATION
The driver can delegate simple, defined tasks completely to the vehicle for a longer period of time. The car can tell the driver to take back control again at short notice. Here again, the driver is responsible for everything that happens.

Level 4
HIGH AUTOMATION
The vehicle can cope with highly complex driving situations and drives on its own. The driver becomes a passenger, who can but does not have to take the steering wheel. When dangerous situations occur, the vehicle warns the passengers. If the passengers do not react, the vehicle achieves a safe status on its own, by stopping, for example. At the moment, there is no legal clarity as to who assumes responsibility for any damage when the car is driving on its own.

Level 5
FULL AUTOMATION
With or without passengers, from now on the vehicle drives from A to B completely on its own. It no longer has a steering wheel. Passengers are not liable for damage. However, up to now it has not been clarified who will then be liable for any damages.

Dear Reader

For a while now, the HEAT is on in Hamburg! But this is not because of an unusual heat wave. Instead, an autonomous electric shuttle is becoming the center of attention in Hamburg's HafenCity.

HEAT (Hamburg Electric Autonomous Transportation) was developed by IAV in cooperation with partners such as Hamburger Hochbahn AG, Hamburg's Departmental Authority for Economic Affairs, Transport and Innovation (BWVI), Siemens Mobility GmbH, the Institute for Climate Protection, Energy and Mobility (IKEM) and the German Aerospace Center (DLR). The project wants to prove that autonomous minibuses can be fully integrated in the road traffic and local public transport service of a big city. A three-week test phase in August was a great success. The next step will be following already in February 2020, with HEAT running autonomously through the HafenCity at maximum speeds of up to 25 kilometers per hour. You can find out more about the project in this issue of automotion from page 8 as part of our topic focus "Automated Driving".

Safety is one of the greatest challenges for autonomous vehicles such as HEAT. IAV's safety concept works with a functional multilayer architecture that divides the system into a comfort layer and an active safety layer. Please turn to the report on page 12 for more details.

Climate protection is currently one of the dominating topics of political debate. One thing is quite sure: the mobility sector also has to make a contribution to reducing CO_2 emissions. But the best way of doing this should remain an open issue for discussion in each specific application. For example, the use of hydrogen and synthetic fuels must be given due consideration as another interesting option alongside battery electric vehicles. Dr. Joachim Damasky from the VDA and Matthias Kratzsch, President and CTO at IAV, discuss these topics in the automotion interview from page 24.

Other topics in this issue: failure analysis of mechanical parts (page 30), new strategies to prevent cyber attacks on vehicles (page 32), strategic planning for electric distribution grids (page 38) and putting AI methods into practice (page 40).

We wish you some interesting reading.

Dr. Ulrich Eichhorn
President, CEO
IAV GmbH

Matthias Kratzsch
President, CTO
IAV GmbH

Katja Ziegler
President, CFO
IAV GmbH

Kai-Stefan Linnenkohl
President, CHRO
IAV GmbH

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"Now's the time to take decisions"

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IAV has a solution to support the strategic planning of distribution grids which fulfill all the demands made of a modern energy supply system

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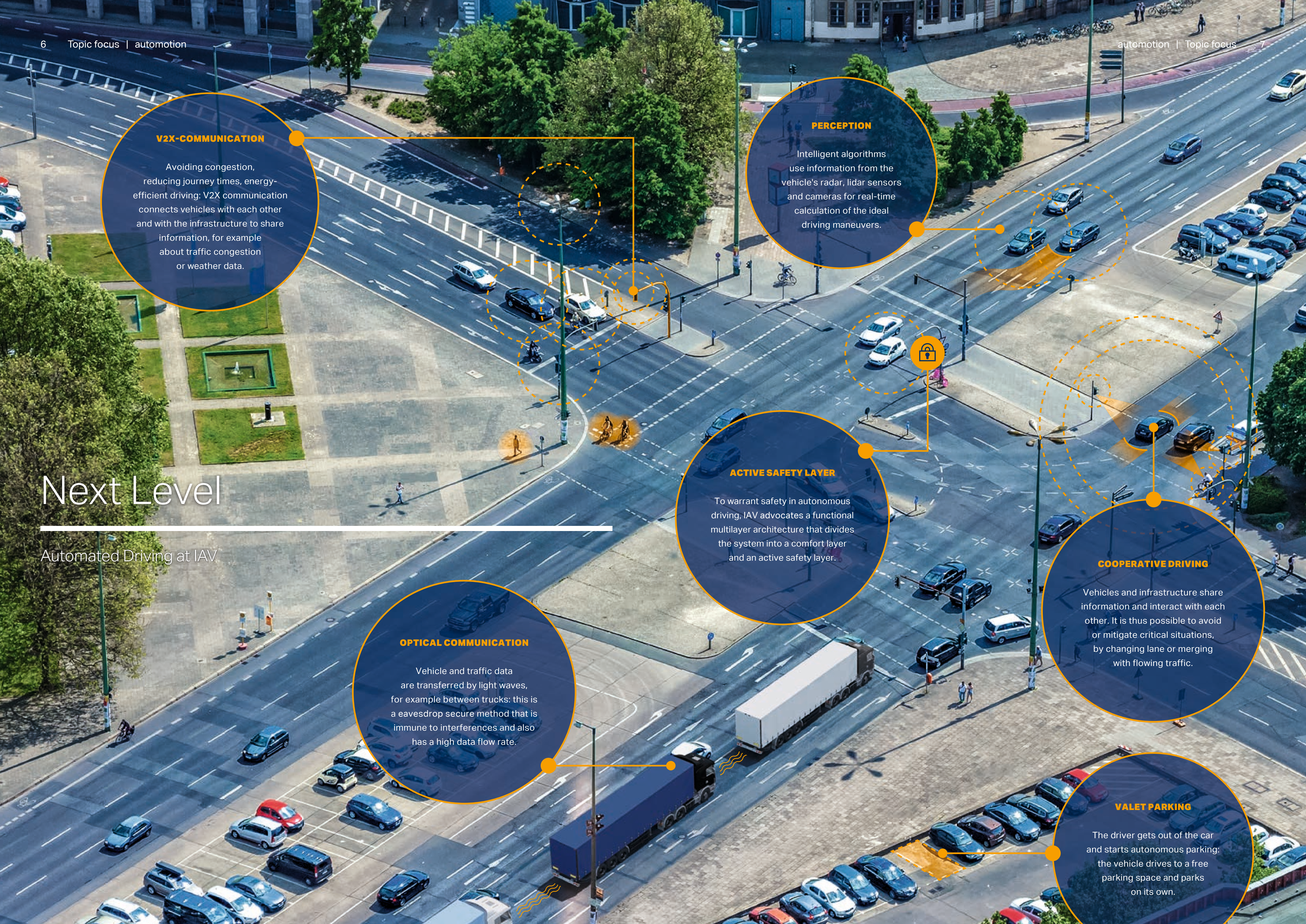
Equal partners

DEKRA and IAV cooperate on automotive EMC testing



Next Level

Automated Driving at IAV

V2X-COMMUNICATION

Avoiding congestion, reducing journey times, energy-efficient driving: V2X communication connects vehicles with each other and with the infrastructure to share information, for example about traffic congestion or weather data.

PERCEPTION

Intelligent algorithms use information from the vehicle's radar, lidar sensors and cameras for real-time calculation of the ideal driving maneuvers.

ACTIVE SAFETY LAYER

To warrant safety in autonomous driving, IAV advocates a functional multilayer architecture that divides the system into a comfort layer and an active safety layer.

COOPERATIVE DRIVING

Vehicles and infrastructure share information and interact with each other. It is thus possible to avoid or mitigate critical situations, by changing lane or merging with flowing traffic.

OPTICAL COMMUNICATION

Vehicle and traffic data are transferred by light waves, for example between trucks: this is a eavesdrop secure method that is immune to interferences and also has a high data flow rate.

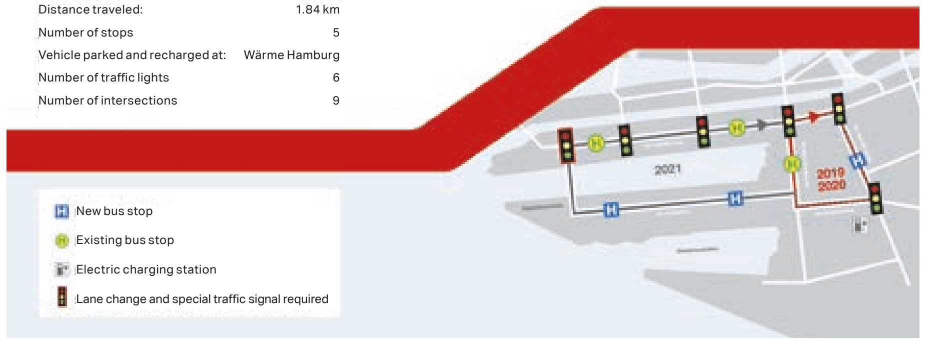
VALET PARKING

The driver gets out of the car and starts autonomous parking: the vehicle drives to a free parking space and parks on its own.

The HEAT is on

Successful first test run for the autonomous minibus HEAT in Hamburg's HafenCity

During a three-week test period, the autonomous minibus built by IAV and partners that goes by the project name of HEAT (Hamburg Electric Autonomous Transportation) was put through its paces on public roads in the city of Hamburg. All expectations in terms of performance and safety were fulfilled in the course of the test. At the moment, the vehicle is being prepared for the next stage: in February, it is to operate in a larger area at higher speed.



During the first three weeks of August, HEAT was put through its paces in Hamburg's HafenCity at speeds of up to max. 15 kilometers per hour. "We had to comply with a defined small circuit round a block of houses as we have to apply for a permit for autonomous driving on specific route sections", reports Veit Lemke, Executive Project Manager at IAV and HEAT project leader. The minibus receives data not only from its own onboard sensors but also from the surrounding infrastructure: radar and lidar sensors had been fitted to roadside masts by project partner Siemens for wireless transmission of the measured values to the vehicle. "This gave HEAT a better idea of what to expect at upcoming junctions, in order to adapt the driving strategy accordingly", explains Lemke.

A vehicle attendant was on board at all times during this early test phase and could have triggered an emergency stop at any time to bring the vehicle to a standstill. HEAT's passengers consisted of development engineers from IAV, tasked with monitoring the technical systems as well as drawing conclusions from how the vehicle performed for subsequent journeys and for the next development stage. "All those on the demonstration journeys were surprised at how unusual it is to ride in an autonomous vehicle, and were also amazed at all the meticulous care that had gone into the entire development", reports Stefan Schmidt, Executive Vice President of the Project Management Office at IAV. "But we all felt completely safe after next-to-no time, and all the more determined to make the project a success."

Many lessons learned in a dynamic setting

The experiences gained will also have a contribution to make. "The test has taught us a great deal in a highly dynamic setting", says Lemke. "Apart from the fact that this was a densely built-up area, other challenges included the many road users who didn't always abide by the rules of the road, including fast, flexible e-scooters." The minibus was fitted with video cameras to register as many of these traffic situations as possible. The recordings are now being used in simulations for further improvements to HEAT's autonomous driving functions. All personal data such as registration plates and faces are rendered unrecognizable for privacy reasons. Autonomous driving depends on precise positioning of the vehicle. "We need accuracy of 10 centimeters, so that GPS alone is not adequate", explains Lemke. "During the three-week test, we recorded a high-resolution map of the area to include the position of landmarks such as road signs or hard shoulders."

At the moment, IAV is preparing the HEAT minibus for the next test phase. In February 2020 the plan is for it to operate in a larger area at speeds of up to maximum 25 kilometers per hour. In addition to the necessary software updates, new components will also be added for this purpose: "For example, an improved joystick by our partner Schaeffler Paravan Technologies (SPT) will be fitted for manual driving", says Lemke. "Up to now, we had no possibility of manually evading a hazard situation and had to revert to an emergency stop. In future, the vehicle attendant can intervene in the steering even in automated mode." Specially trained passengers will be taken on board HEAT for the first time during the next test phase. Every time the vehicle is upgraded, it has to be inspected again by the technical inspection company Dekra, with renewed approval necessary from the authorities. Only then is HEAT allowed back on the roads, fitted with a regular registration plate.

Proven solution for drive-by-wire

One of IAV's partners on the HEAT project is Schaeffler Paravan Technologies (SPT). The world market leader for car solutions equipped for the disabled produced the triple redundant drive-by-wire technology that controls the minibus's brakes and steering. "This is a validated technology that has been tried and tested on the roads for many years now"; says Dr. Manfred Kraus, Head of Product Development for Chassis Systems at Schaeffler Paravan Technologies. "We can make reference to the systems operating for many millions of kilometers, an important factor in the homologation process." The company's contribution to the next HEAT generation comprises a new rolling chassis including the drive, steering, brake, shock absorbers and wheel suspension. This will be available from the second quarter of 2020, allowing the minibus to turn its wheels through 90 degrees and also turn on the spot. "The whole project is extremely exciting for us because we're creating something completely new", says Dr. Kraus. "Up to now, no-one else has managed to drive an automated minibus with Level 4 SAE on public roads at speeds of up to 50 kilometers per hour. What we're doing here is clearly pointing the way forward."

"We are a group of partners working towards a shared aim: to operate an automated minibus in urban traffic for the first time", says Schmidt. "As far as future mobility is concerned, solutions like this are particularly interesting for the last mile". The HEAT project also provides valuable insights into the mobility value chain, with IAV acquiring the expertise to develop autonomous vehicles and also to operate them if necessary. HEAT will be making a grand appearance at the ITS World Congress in October 2021: the intention is for it to run through the HafenCity in automated mode at speeds of up to 50 kilometers per hour.

Contact:
veit.lemke@iav.de
stefan.schmidt@iav.de

First Autonomous Shuttle Bus in Hamburg

The HEAT research project aims to integrate the vehicle in regular road traffic

We say welcome to HEAT (Hamburg Electric Autonomous Transportation), the new minibus at the heart of a unique R&D project in Germany! It measures five meters in length, weighs 4.5 tons, has an electric drive with practically zero emissions and should start operating in Hamburg's HafenCity with space for up to ten passengers as from mid 2020. The youngest member of the HOCHBAHN fleet should run in automated mode. Information provided by the roadside infrastructure and the control center ensures the shuttle finds it way safely on the test route. At the same time, the shuttle also transmits information to the control center.

The HEAT research and development project is breaking absolutely new ground with an ambitious target: the intention is to ascertain and verify that autonomous minibuses can be fully integrated in a big city's road traffic and local public transport service. The HEAT vehicle is being tested under real-life conditions on public roads, with the aim of achieving speeds of up to 50 kilometers per hour driving autonomously.

On presenting the vehicle, Michael Westhagemann, Hamburg's Senator for Economic Affairs, Transport and Innovation, emphasized: "HEAT offers the city a chance to pursue research into every single facet of automated and connected driving. Our absolute priority is safety! A key factor for future use of autonomous vehicles is that people have to accept them. The cross-manufacturer test route for automated driving and the autonomous shuttle clearly demonstrate that we in Hamburg want to explore new mobility concepts, offering ideal conditions for industrial experts and scientists to put their ideas to the test. At the ITS World Congress 2021, we will use HEAT and many other projects to show the world that Hamburg is a pioneer for innovative mobility solutions."

One key feature of the HEAT project is the gradual approach. The first phase consisted of tests without passengers on a defined test route, with a professional vehicle attendant on board to intervene immediately if needed. The first passengers should then be taken on board from mid 2020, together with the vehicle attendant who will still be present at that point. Completely autonomous operation (without vehicle attendant) should then be implemented pursuant to SAE Level 4 by the time the ITS World Congress takes place in October 2021.

The minibus developed by IAV has currently been approved for ten passengers. It has two benches with four seats each together with a folding bench with two seats. It also has a ramp for disabled access. The batteries for the electric powertrain are recharged by Vattenfall in the HafenCity.

In addition to the specially developed vehicle itself, the research project will be focusing above all on issues of traffic and IT infrastructure, digital control technology and the technical interfaces. The intention is for the vehicle to be integrated in real road traffic so that it has to be able to travel at speeds of up to maximum 50 km/h. To this end, it has to be fitted with cameras, radar and lidar, while the additional smart roadside infrastructure consists among others of sensor elements and digital communication systems.

The HOCHBAHN control center monitors actual operation and gives the vehicle commands and instructions, depending on the prevailing traffic situation; in any critical situation, control center staff can trigger an emergency stop and communicate with the passengers. The control center also sends the timetable and the currently planned route to the shuttle.

Before test operations could begin, approval had to be obtained to put a totally new vehicle on the road, equipped with completely new components and managing entirely without many conventional elements such as steering wheel and outside mirrors. A gradual approach also applies to the homologation side of the project, with permits and approvals being obtained step by step throughout the project. Permission for the August tests was received mid July.

The necessary legal support for the HEAT project comes from the IKEM (Institute for Climate Protection, Energy and Mobility) which is also dealing with the resulting requirements for the vehicle and the infrastructure, and for regular operation with passengers. The special aspect of autonomous driving is that the technology in the vehicle has to perform all the driver's tasks in terms of complying with the traffic rules.

The test route in Hamburg's HafenCity will be altogether 1.8 kilometers long. In contrast to the initial plans, the route had to be shortened to take account of major construction work being carried out in the HafenCity, but this has no impact on the research and development results of the project. The minibus will serve altogether five bus stops, including three regular bus stops used by HVV vehicles and two new bus stops set up specially for HEAT.

The gradual approach has also been deliberately chosen for the route itself to gain experience during the individual phases, in order to proceed with a subsequent step-by-step increase in route length, automation level and vehicle speed. The scope and gradual development of the tests will be geared to warrant maximum safety at all times, as stipulated in the homologation process.

The main focus of the HEAT project is on the human aspect, looking at the needs of the people for whom the new option of an autonomous bus has been devised. It should make it as easy and pleasant as possible for them to use the vehicle, in combination with a high feeling of safety. The DLR (German Aerospace Center) is the project partner responsible for accompanying research which includes analyzing user requirements to obtain input about the design of the vehicles and the transport service they provide. Other aspects of accompanying research include evaluating passenger acceptance and examining interaction between the system and other road users in the test area of Hamburg's HafenCity.

Supported by:
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
based on a decision of the German Bundestag

Erneuerbar mobil

www.hochbahn.de/heat

Project partners and their tasks

- City of Hamburg – BWVI: Traffic planning by the LSBG (State Office for Roads, Bridges and Waterways), implementation and operation of necessary infrastructure systems by HHVA (Hamburg Transport Facilities), with the Department for the Interior and Sport (State Transport Authority) safeguarding the legal prerequisites.
- HOCHBAHN: Consortium leader for the project, administrative and functional leadership and coordination of the whole project (supported by hySOLUTIONS), operational concept and practical operation of the autonomous buses
- IAV GmbH: Vehicle development and implementation; vehicle-related development of the technology involved in autonomous driving
- Siemens Mobility GmbH: Concept and on-going development of the roadside infrastructure for the necessary control center
- IKEM – Institute for Climate Protection, Energy and Mobility: Study of new operator and business models, legal support for the permission and homologation processes
- DLR (German Aerospace Center): Accompanying research

Making Autonomous Driving Safe

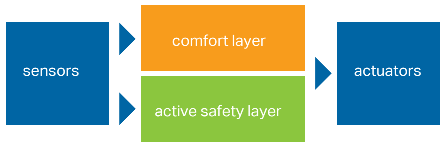
New software architecture addresses the challenges in making autonomous driving safe

In an abrupt danger situation, the right decision to prevent an accident has to be taken in no more than a fraction of a second. People do this intuitively on the basis of their experience. Autonomous vehicles will have to do the same thing just as well.

There are many diverse challenges involved in developing autonomous systems. On the one hand, the systems must guarantee safety and accident-free driving. On the other hand, the development process for increasingly complex functions up to validation has to remain manageable, despite the high safety requirements. "Safety and accident-free driving are among the biggest tasks in the development of our systems. We have designed a comprehensive safety concept working in cross-divisional projects", explains Dr. Ulrich Bauer, development engineer for predictive safety at IAV.

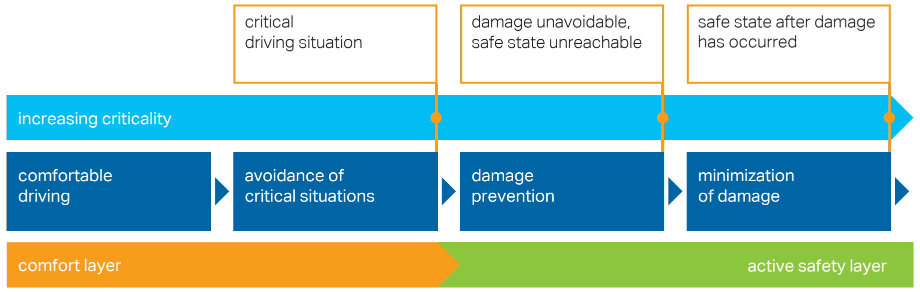
IAV's safety concept

To warrant the safety of autonomous driving, IAV relies on a multilayer architecture that divides the system into a comfort layer and an active safety layer.



The comfort layer ensures convenient execution of the respective automated driving task, from passing through an urban junction to driving on the motorway. By contrast, the active safety layer intervenes in cases of acute emergency and reacts appropriately to the particular hazard by heavily reducing the comfort requirements.

In normal operation, the system is in the state of comfortable driving, with the comfort layer in control of the system. In a critical traffic situation, the active safety layer takes control of the vehicle and brings it back to a safe state, for example with a braking or avoidance maneuver. Once the situation has been mitigated, the system can switch back to comfortable driving.



The behavior of the active safety layer depends on the specific situation. An avoidance maneuver can make sense when traveling at high speed on the motorway. In this case, it is important to check whether this is possible by using a free adjacent lane or even by remaining in the current lane. If an autonomous shuttle in urban traffic is considered, an emergency break is in many cases better in mitigating complex scenarios, because there is often insufficient space for other maneuvers. Such complex scenarios can involve different road users and also embarking and disembarking passengers.

Multilayer architecture allows differentiated development

"The multilayer architecture helps to fulfill the high demands placed on automated driving functions while limiting the development effort to a reasonable level", says Dr. Roland Kallweit, Head of the Predictive Safety Department at IAV. The different layers make it possible to focus on the individual development: critical scenarios have no longer to be regarded for the comfort layer, while comfort requirements need not be taken into account in the active safety layer. All in all, this simplifies matters with two leaner development processes that integrate the appropriate development methods in each case.

"Among others, we rely on innovative development methods such as Vehicle-in-the-Loop to take the complex, safety-critical scenarios for the active safety layer into account", explains Paul Prescher, Team Leader for predictive safety at IAV.

The distinct approaches can also result in different process models for the comfort and the active safety layer. The active safety layer uses the waterfall model to take account of the high safety requirements in terms of design and implementation. By contrast, the comfort layer can be developed with agile methods for a swifter response to trends and customer requests and to make functional enhancements observable more quickly.

"New development methods and adequate design patterns will become increasingly important for autonomous driving in order to cope with the huge complexity involved. Our task in research and development is to give the right answers", says Dr. Matthias Butenuth, Senior Vice President for Automated Driving Systems at IAV.

Vehicle-in-the-Loop

Real-world driving situations combined with virtual scenes

The Vehicle-in-the-Loop method (ViL) combines simulations with the real vehicle for designing and validating functions. A physical vehicle drives in a real test environment, which is enhanced by virtual objects. Augmented reality in the vehicle makes the virtual objects visible for the test driver.

The method is ideal particularly for scenarios that are too complex or too dangerous for testing with real road users. These can include situations with high speeds or oncoming traffic. ViL thus allows for reproducible and resource-saving testing of risky scenarios without any danger.

Contact:
ulrich.bauer@iav.de
matthias.butenuth@iav.de
roland.kallweit@iav.de
paul.prescher@iav.de

Automation Pioneers

Simulation-based algorithm development and validation for autonomous driving as integrated process

The autonomous minibus named HEAT has started to go through testing in Hamburg's HafenCity. The aim of the ambitious project is to transport passengers at speeds of up to 50 km/h on public roads without a driver. The research and development project by IAV and other partners is one of the first in the world to test autonomous driving on public roads. The development of connected autonomous vehicles such as HEAT presents the engineers with new, high demands.

"We notice that projects like HEAT need a new approach before complex functions such as those needed for autonomous driving can make the transition from research to volume production. We're breaking new ground; the automotive world hasn't had to deal with this before. Established conventional methods are simply no longer enough" says Dr. Matthias Butenuth, Senior Vice President for Automated Driving Systems at IAV.

Autonomous driving systems have to fulfill stringent requirements in terms of safety, reliability, robustness and availability. The development scopes and the necessary test mileage would result in unrealistically long development times and costs.

Integrative overall development process

The best way of keeping the workload within reasonable limits is to use different virtual methods throughout the entire development process, from specifying the functions through to validating their implementation.

"We need methods and processes to obtain insights in a virtual space which can then be used in every phase. One key question is how can the results of the various methods be made transferable? We've still got a good way to go, but autonomous driving systems will never reach the level of manufacturing readiness without this kind of process", explains Thorsten Scheibe, Head of the Simulation & Validation Department at IAV. The only way to reduce the real mileage and the share of complex methods, keeping the engineering workload altogether on a realistic scale, is if the results can be transferred between development steps and methods, and incorporated in the overall development.

HEAT as process prototype

For HEAT, IAV has developed a corresponding concept that continues to be defined and implemented in the course of the project. The IAV concept builds on various modules:

- simulation-based methods,
- scene-based development and validation, and
- virtual models.

These modules must be put together intelligently and integrated holistically in the overall development process. For this to happen, interfaces and workflows must be defined and standards observed.

Methodical diversity

Virtual methods are involved in every phase: more abstract methods are used for validating and narrowing down large parameter spaces, and more complex methods for assessing corner cases. In the early development stage, simulation-based validation methods such as Concept-in-the-Loop or Vehicle-in-the-Loop help to define valid requirements and the processes for safe deign of Safety of the Intended Function (SOTIF) and functional safety. Model-in-the-Loop helps with algorithm development based on rapid prototyping and early validation of the technical solutions.

Scene-based development and validation

Appropriate use of virtual methods throughout the whole process with the generation of compatible results depends on defining scenarios and models in advance that can be used in all development phases. Examples here include overtaking another vehicle or turning right at traffic lights when there is a cycling lane. The set of relevant scenarios and corresponding parameters continues to be specified throughout the course of the development process, thus achieving a very high level of maturity. The scenarios are kept in a special scenario database that is accessible to the various virtual methods.

Virtual models

Real-world circumstances are emulated in simulations by abstracting them in models, such as models of sensors to visualize their function and system behavior or road user behavior models. Model complexity can be adapted to the goals of the development phase and to the method being used in each case. The model is readjusted during the development process on the basis of specific performance indicators and statistical methods.

The models are also kept in a central model database in an abstract description form and can be used with various simulation tools. "Our aim is to automate the entire development process, including final validation. No standard exists for this up to now. The HEAT project offers us the great opportunity to define and test the concept, which makes us pioneers", says Butenuth.

Contact:
matthias.butenuth@iav.de
thorsten.scheibe@iav.de

Researching, Promoting and Conne cting

Research projects help to build up know-how and foster cross-sectoral networks

What are the major questions, challenges and problems of our time? Which disciplines and specialist fields are relevant? Which partnerships and collaborations are promising? Together with partners from science and industry, IAV develops solutions that will shape the world of tomorrow and the day after.

Research and development projects that bring together partners from different disciplines and sectors often generate new findings about important or particularly topical issues. "For IAV, participating in research projects makes an important contribution to sustainable further development of pioneering topics", says Michael Aengenheister, coordinator for R&D projects at IAV. "The know-how generated during research projects works to our benefit in orders for our customers; new sectors profit from our engineering and technology know-how with solutions for the entire mobility ecosystem", says Aengenheister. IAV is currently involved in more than 40 R&D projects.

Automated driving is one of the big topics of current research and development. IAV is working with various partners in the framework the following state-funded projects.

AULA
AUTONOMES
SCHNELLLADEN

AULA

Autonomous electric vehicles with automatic charging technology

Over the next few years, we can expect to see driverless cars and minibuses being used as taxis in a number of cities throughout the world. For environmental and sustainability reasons, these vehicles are to be driven by purely electric powertrains. One particular challenge to be addressed for fully automated operation of these e-taxis entails completely automatic recharging of the battery without someone having to intervene manually.

The AULA project intends to achieve significant technical progress in the core aspects of automatic driving functions, quick charging systems and automated recharging of vehicles, resulting in products ready for volume production and the official homologation process for the participating project partners.

The overall aim of AULA is to develop a fully automatic electric passenger car with functionally reliable and fully automatic quick charging in the semi-public environment without user intervention, as well as developing near-production software and hardware components for the vehicle, the contact system and the related safety systems.

Partners: Fraunhofer Institute for Transportation and Infrastructure Systems, IAV GmbH

Funded by:
SAB Sächsische AufbauBank
(Development Bank of Saxony)

Project duration:
October 2016 to October 2019
https://www.synchrone-mobilitaet.de/

HarmonizeDD
AUTOMATISIERT UND VERNETZT
IM URBANEN MISCHVERKEHR

HarmonizeDD

Automation and connectivity in mixed urban traffic

The HarmonizeDD project aims to address the diverse reciprocal disruptions in mixed urban traffic with novel functions and services for automated and conventional vehicles. Widespread basic services are provided by a cellular telephony and edge cloud solution. Additional cloud solutions in roadside units are used for an extended range of functions on certain corridors. The vehicles themselves are equipped with new interaction mechanisms that make it possible for these services to be used in both automated and non-automated vehicles. The solutions have been tested in experiments at the Dresden digital test site (Saxony).

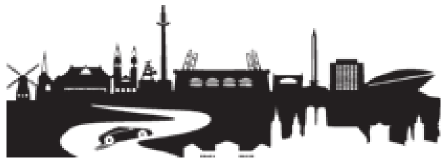
IAV has developed new vehicle functions for cooperative automated driving in mixed urban traffic. One particular focus comprises decision mechanisms for interacting with road users on differing automation and connectivity levels, using among others the mobile and roadside unit cloud services. The resulting functional sample parts have been integrated in test vehicles in order to test and evaluate them together with the other partners during test drives in real road traffic.

The project is embedded in Saxony's initiative called "Synchronous mobility 2023: Intelligent transport systems in Saxony".

Partners: BMW AG, Fraunhofer-Gesellschaft e.V., Institute for Connected Mobility (IVM), MUGLER AG, Noritel Mobile Kommunikation GmbH, Preh Car Connect GmbH, Chemnitz University of Technology, Dresden University of Technology, Vodafone GmbH

Funded by:
Federal Ministry of Transport and Digital Infrastructure (BMVI)

Project duration:
April 2017 to October 2019
https://www.synchrone-mobilitaet.de/



OPA^{3}L

Optimally assisted, highly automated, autonomous and cooperative vehicle navigation and localization

OPA3L focuses on transferring aerospace know-how to the field of highly automated driving so that this can be used for Mobility 4.0 in Germany. The key contents consisting of autonomous planning and navigation as well as trajectory optimization and control form the basis for application in autonomous vehicles. OPA3L builds on the previous funded project "AO Car" with IAV participation, extending the research questions to real-life application scenarios with the involvement of partners from industry. The necessary navigation system includes, in particular, the important aspects of localization, ideal routing and active control.

The aim of the project is to automate recurrent journeys in known areas and, in particular, to present solutions for cooperative maneuvers in such areas. To this end, the project partners are working at implementation in an application-oriented test site. The overriding goals of the project for implementation in real-world vehicles include:

- Creating standard software frameworks for the varying requirements of highly automated driving
- Transferring know-how and algorithms from aerospace to highly automated driving, as well as defining the requirements for modern satellite navigation
- Developing efficient AI algorithms for highly automated driving.

IAV has assumed project responsibility for decision-making, (model-based) movement planning and (model-based) driving dynamics control.

Partners:
University of Bremen, Bundeswehr University Munich, ANavS GmbH, IAV GmbH

Funded by:
Federal Ministry for Economic Affairs and Energy (BMWi)

Project duration:
March 2019 to February 2023

PAVE

Potential of automated traffic systems

Significant changes in mobility behavior, mobility organization and traffic organization must be expected in the new future. This will result in new business models and new challenges in both individual traffic and in freight transport. Referring to today's mobility behavior and urban transport tasks, the research project PAVE (Potential of automated traffic systems) aims:

- to develop visions for future forms of behavior and organization based on autonomous vehicles
- to derive requirements for the vehicles
- to discover new forms of organization and services
- to estimate and assess their impact in terms of the traffic system, environment and safety.

A market model is used to analyze what kind of performance will be possible in a system for automated connected driving, which needs and demands will arise and which kinds of systems, services and vehicles are likely to meet with the broadest levels of acceptance.

IAV's task in the PAVE project is to provide content-related and methodical support in elaborating future visions of automated driving, and to support the development of requirements for vehicles and systems.

Partners:
International Academy Berlin for Innovative Pedagogy (INA), Psychology and Economics, Robert Bosch GmbH, Berlin University of Technology, Otto von Guericke University Magdeburg

Funded by:
Federal Ministry of Transport and Digital Infrastructure (BMVI)

Project duration:
October 2018 to December 2020
https://www.bmvi.de/SharedDocs/DE/Artikel/DG/AVF-projekte/pave.html

REMAS

Resource management system for highly automated urban transport

When it comes to the automotive sector, traffic engineering, information and communication technology as well as information science, a large number of highly complex requirements have to be met. The development activities of many players from all these areas have to be combined, with joint simulation and testing of the resulting solutions.

The resources involved have to be adequately pooled and managed in the interests of an interdisciplinary combination of such development activities as well as resulting validation measures in test corridors. The REMAS project addresses this challenge, creating the scientific basis in the context of highly automated urban traffic. This includes methods for integrating such resources with a new simulation middleware, for the support and real-time coordination of test drives and driving maneuvers as well as monitoring critical system attributes. An innovative information model is the core of a cooperation platform that is connected up to the real-world traffic system, as well as the tools, vehicles and components involved in the development process.

Technology analyses revealed that further progress is necessary above all in the field of intelligent transport systems. Technological advantages can be achieved by integrating resource management systems, driver assist functions and system development.

Partners:
Fraunhofer Institute for Transportation and Infrastructure Systems (IVI), NXP Semiconductors Germany GmbH, MUGLER AG, Institute for Connected Mobility (IVM), TechniSat Digital GmbH, dresden elektronik verkehrstechnik gmbh, FSD Fahrzeugsystemdaten GmbH, Chemnitz University of Technology, Professorship for Communications Engineering, Dresden University of Technology, Chair of Vehicle Mechatronics and Chair of Transport Systems Information Technology, IAV GmbH

Funded by:
SAB Sächsische AufbauBank
(Development Bank of Saxony)

Project duration:
September 2015 to August 2019
https://www.synchrone-mobilitaet.de/

SAFARI

Safe automated and connected driving with self-updating maps at the test site in Berlin Reinickendorf

The objective of this project consists in the development and practical validation of how automated and connected vehicles interact with a cooperative infrastructure. The focus is on high-precision and self-updating digital maps, with input from the vehicles and smartphones.

The central approach of SAFARI presumes that most errors are systematic and can be experienced, learnt and predicted by automated and connected vehicles. Changes in the street setting, such as roadworks or cars parked on the road, are detected immediately and forwarded to all connected vehicles in the area. The connected vehicles should also provide information about free on-street parking spaces and recognize certain objects such as streetlamps or road signs, updating their position where appropriate.

In this project, IAV was responsible for communication between vehicles and backend and for backend updating of the maps. Other focal aspects of IAV's work included V2X communication for sharing hazard warnings and infrastructure communication between vehicle and traffic lights using 802.11p technology (Wi-Fi).

Partners: Berlin's Senate Department for Environment, Transportation and Climate Protection, Hella Aglaia Mobile Vision GmbH, IAV GmbH, Daimler Center for Automotive Information Technology Innovations (DCAITI), Fraunhofer Institute for Open Communication Systems (FOKUS), Free University of Berlin, Senate Department for Economic Affairs, Energy and Business, Reinickendorf District Administration, Deutsche Telekom

Funded by:
Federal Ministry of Transport and Digital Infrastructure (BMVI)

Project duration:
June 2017 to June 2019
www.testfeld-berlin.de

SecVI

Security for Vehicular Information – security architecture for vehicle networks

For autonomous driving, innovative driver assist systems have to be provided with all the necessary information. The increasing connectivity of vehicles and infrastructure opens up new attack scenarios for unauthorized access to data and programs. Security solutions are therefore constantly competing with attack technologies. Averting such attacks is key for protecting the vehicles, their systems, the gathered data and also for protecting all road users.

The project partners want to develop a robust, low-complexity network architecture for monitoring the security of the information flow in the control areas of the vehicle on various levels and to protect against attacks. The new network architecture should be harmonized with the existing communication technologies in the vehicle. Even if the robust network architecture eliminates many attack patterns, it is still necessary to detect attacks and threats as soon as possible and to react swiftly with corresponding security updates. To this end, new add-on functions are developed, building on the basis of the existing vehicle-specific components. The new functions are also supplemented by the cloud infrastructure of the vehicle manufacturer for prompt importing of updates for a whole vehicle fleet.

Working on the basis of real-life application data, the project develops procedures and evaluates them in a demonstration vehicle to make autonomous driving much safer.

Partners:
Hamburg University of Applied Sciences (HAW), easycore GmbH, IAV GmbH

Funded by:
Federal Ministry of Education and Research (BMBF)

Project duration:
April 2018 to March 2021
http://secvi.inet.haw-hamburg.de/

SYNCAR

Automated Urban Driving

The aim of the SYNCAR project is to develop new solutions for predictive, automated driving in cooperative communication with other road users and traffic light systems. Among others, this has resulted in a new way of optimizing traffic flow by providing specific targeted maneuver recommendations for certain vehicle groups or also individual vehicles.

Besides leading the consortium project, IAV has also been involved in developing new functions for highly automated driving, including methods for predictive driving, cooperative communication of driving behavior with the environment and consideration of maneuver recommendations.

Partners:
dresden elektronik verkehrstechnik gmbh, Fraunhofer Institute for Transportation and Infrastructure Systems, FSD Fahrzeugsystemdaten GmbH, FusionSystems GmbH, Preh Car Connect GmbH, Chemnitz University of Technology, Dresden University of Technology, IAV GmbH

Funded by:
SAB Sächsische AufbauBank
(Development Bank of Saxony)

Project duration:
September 2016 to August 2019
https://www.synchrone-mobilitaet.de/de/projekte/syncar.html

Keeping an Eye on the Eyes

Put through their paces: IAV tests the functions of new infotainment systems according to the stipulations made by NHTSA and JAMA

Many serious accidents are caused by inattentive drivers. The American National Highway Traffic Safety Administration (NHTSA) and the Japanese Automobile Manufacturers Association (JAMA) therefore make precise stipulations for the functions of infotainment systems regarding the extent to which they are allowed to distract users while driving. The UX Lab in Gifhorn has a simulator where the IAV experts check that all requirements have been met.

IAV's UX Lab in Gifhorn is equipped with a driving simulator that observes precisely what the driver sees. Test persons at the simulator make a contribution to improving road safety. To be more precise, a life-size vehicle test model enables the engineers to see whether operating the infotainment system proves to be too much of a distraction for the driver who thus pays inadequate attention to what's happening on the road. These tests are prescribed by the American National Highway Traffic Safety Administration (NHTSA), because more than 3,166 people in the USA were killed by inattentive car drivers in 2017 alone.

New infotainment systems therefore have to pass the NHTSA test before they can be launched on the USA market. To this end, the IAV experts at the Gifhorn simulator recreate a cockpit based on the manufacturer's CAD data, which corresponds in ergonomic terms to the later production vehicle. On the screen in front of them, the test persons see an American road scene including the lane markings and road signs used in the USA. They wear an eye-tracking device with two cameras to record their eye movements and another camera to film their field of vision. "This shows us exactly how long the driver looks where in various use cases, such as entering a phone number while driving", says Daniel Nause, engineering psychologist at IAV. "Other typical test cases include changing the scale of the map, entering the destination or scrolling through the contacts list on the display."

Precisely defined maximum permitted distraction

An infotainment system will have passed the test if at least 21 of 24 test persons took their eyes from the road for less than twelve seconds during the whole process. Furthermore, the individual distraction must last less than two seconds on average. And finally, no more than 15 percent of their glances away may have lasted for longer than two seconds. All this can be recorded precisely with the eye-tracking device. If a function fails the test, it will have to be disabled in the production vehicle.

Occlusion testing is another test method that does not need the simulator. Instead of an eye-tracking device, in this case the test persons wear a headset that has a liquid crystal display for either opening or blocking the field of vision. For the NHTSA test, it is set to transparent for intervals of 1.5 seconds. These are the time slots in which the test persons have to operate the functions of the infotainment system. Here again, the system has passed the test if at least 21 of 24 test persons manage to do this in maximum twelve seconds "open time" (in addition to the closed intervals).

Set of test persons compiled by IAV

Selecting the test persons is strictly regulated: there must be twelve men and twelve women. In each case. The NHTSA demands three people each aged 18 to 24, 25 to 39, 40 to 54 and 55 years and older. All must be in good health, they must be active drivers (at least 3,000 miles per year), experienced in handling modern touch devices and, of course, not familiar with the new infotainment system. IAV uses external agencies to recruit the test persons as well as reverting to its own test person pool consisting of 584 employees and 464 external people (the number continues to grow).

They can also take part in the tests prescribed by the Japanese Automobile Manufacturers Association (JAMA), which IAV also conducts in Gifhorn. In this case, ten men and ten women are required aged between 20 and 49 years. These tests also address the issue of how displays in the car distract the driver. The JAMA tests only use the visual occlusion goggles. The limit values differ to those specified by the NHTSA: the headset opens the field of vision for 1.5 seconds and then blocks it again for one second. This pattern is constantly repeated and the test persons have to complete the task in maximum 7.5 seconds "open time". They then indicate on a scale of one to seven how stressed they felt during the whole process.

"The NHTSA and JAMA tests help us to make a contribution to improving road safety", says Nause who has been dealing with this issue for four years. "The tests can be carried out in Germany or in the target countries USA and Japan." No matter where the IAV simulator is being used, it keeps an eye on the test person's eyes.

Contact:
daniel.nause@iav.de

Ready2Test

Automotive technology is growing increasingly complex. What does the perfect combination of design, ergonomics, haptics and quality look like? How can mobility and communication grow together? What will future operating concepts look like? To answer these questions, the development process has to listen above all to car drivers and interested persons. That's why Ready2Test has been initiated by IAV.

Do I have to fulfill certain prerequisites to take part?

If you are willing to experiment and enjoy getting immersed in technological issues, then Ready2Test is just right for you. Anyone aged 18 years and over can take part, with or without a driving license.

How does it work?

If test persons are needed for a certain user test, IAV sends out an e-mail invitation to the people meeting the respective criteria. If you are selected, you will have to come on site to IAV for a few hours. You could be asked to do online tests or to answer a traditional survey, or to perform tests in the vehicle. It gets really exciting when we use virtual reality (VR) and augmented reality (AR). Here you can experience simulated driving situations or test a new head-up display. You will of course be remunerated for your efforts.

Register right now as a fun of driving tester!
www.ready2test.de

“Now‘s the Time to Take Decisions”

Interview with Dr. Joachim Damasky (VDA) und Matthias Kratzsch (IAV)

Matthias Kratzsch, President and CTO at IAV, and Dr. Joachim Damasky, Managing Director Technology at the German Association of the Automotive Industry (VDA)

At the beginning of December 2019, politics and industry exchanged views on the powertrains of the future at the Berlin Powertrain Symposium, a conference organized by IAV in cooperation with the VDA. Apart from the influence of legislative framework conditions and how to deal with complexity, another important issue is which energy carriers make sense alongside battery electric vehicles in order to achieve climate-neutral mobility by 2050. Please read below a dialogue between Dr. Joachim Damasky, Managing Director Technology at the German Association of the Automotive Industry (VDA), and Matthias Kratzsch, President and CTO at IAV.

Cars are currently the focus of discussions dealing above all with climate protection. How do you see this debate?

Kratzsch: It's good to have an intensive debate. But it is also important that after perusing a range of different opinions, in the end we manage to find a shared objective that reconciles the societal, political and industrial interests. Above all, it is important to avoid factually unfounded arguments. At the Berlin Powertrain Symposium, we encouraged an open and fruitful exchange between industry, science and politics.

Damasky: A consensus should be possible if we keep discussions on a factual level. The objectives are clear: the automotive industry subscribes to the German government's climate targets. It's now a case of making sure that the necessary prerequisites are put in place quickly.

Kratzsch: In terms of climate protection, it is crucial to limit the absolute CO_2 level in the atmosphere by 2050. And the way that we achieve this is just as important as the actual target. In a best-case scenario, we need a range of measures that will cut CO_2 emissions at very short notice. Bearing in mind that the average car on German roads is meanwhile nearly ten years old, all crucial technologies will have to reach manufacturing readiness at the latest in 2040 if we want climate-neutral fleet consumption by 2050. This also means that now is the time to take the necessary decisions about the corresponding infrastructure.

Which infrastructure decisions need to be taken?

Damasky: Hydrogen is a central element in CO_2-neutral energy supply and will play an important role in the transport sector from 2030, particularly for heavy duty vehicles. The German government is currently preparing a hydrogen master plan and is in close contact with the industry which will have to provide the powertrains.

Kratzsch: We need carbon-neutral hydrogen made from eco-electricity. Up to now, we use hydrogen made from natural gas; in Japan it's even made from coal. We've got to look at the entire energy chain and not just at what happens in the vehicle.

But current legislation only pays attention to vehicle emissions.

Kratzsch: Yes, that's right. Unfortunately, there are still no incentives for measures to reduce the carbon footprint on the fuel side. Changing the current tank-to-wheel approach will probably not be discussed on the European level until 2023 and possibly not come into effect until 2030. We need to take and implement decisions before then. We also need to know if we should then view emissions on the well-to-wheel basis or take the entire life cycle analysis.

Damasky: As far as life cycle analysis is concerned, we must make sure it does not counteract all our current efforts. Our aim is to ensure that the process for manufacturing batteries for electric cars is so climate-friendly that it no longer impacts on the life cycle analysis. Battery recycling also has a role to play here: we must implement a closed cycle of resources.

What are the arguments in favor of hydrogen as an energy carrier?

Kratzsch: Hydrogen or hydrogen-based methane could be the backbone for the future energy industry. With its possibilities for storing regenerative energy in the long term, this energy carrier can even compensate for periods without sunlight or wind.

Damasky: We need a chemical energy carrier other than batteries. Carbon-neutral hydrogen production is the basis every time, regardless of whether the hydrogen is being used directly or for subsequent production of e-fuels.

What role do synthetic fuels play in achieving the climate targets?

Damasky: In the last 20 years, the German automotive industry has reduced the fleet consumption of its new vehicles by 35 percent. Unfortunately, this has not generated a net reduction in the carbon footprint of road traffic, due to many effects. For example, the level of motorization in the base year 1990 (the year after the Berlin Wall came down) was far lower in eastern Germany. On the other hand, we face the target of reducing transport-related emissions by 40 to 42 percent by the year 2030. This cannot be achieved by fleet renewal alone. What else can we do? It simply won't be sufficient to expand public transport services, which are already overburdened in many cities. Admixing renewable fuels could be part of the answer.

Kratzsch: Admixing synthetic fuels could give us an immediate and significant CO_2 effect in the entire vehicle fleet. We wouldn't have to wait for electric vehicles to gradually take over a larger share. And while the fuels themselves are still in need of certain development, in principle the engines are actually ready.

Further market penetration of hybrid powertrains would also help to reach this target. Basically, they themselves are a kind of "admixture", in this case a direct admixture of electric energy.

Is Germany capable of producing sufficient quantities of hydrogen or synthetic fuels?

Damasky: If we want to remain an industrial country, we will continue to be dependent on energy imports in future. This is also due to the fact that our specific climate prevents continuous operation of large-scale plants. We will be well advised to start timely cooperation with countries that can offer what we need in this respect.

Kratzsch: Thinking of Germany as an industry location, it would be very interesting for us to develop technologies for the production of hydrogen and e-fuels. In turn, these technologies could be exported to other countries. This has always been the traditional German business model!

In future, Germany at least will be implementing a CO_2 pricing scheme in the transport sector. What impact is this going to have?

Damasky: We welcome cross-sectoral pricing based on a trading system as long as the proceeds are used to improve the traffic infrastructure. This is something we've been demanding for a long time. Basically, such a system can create a situation that puts the new technologies on an equal footing as far as life cycle costs are concerned.

Kratzsch: In the automotive industry, we will notice a clear impact not only from CO_2 pricing but above all as a result of CO_2 penalties from 2020. This has led to the current situation where there is great pressure to make further progress in developing battery electric vehicles. Another effect is that we will have to reassess those fuel-saving technologies that were hitherto deemed unprofitable for business reasons.

Damasky: We mustn't forget the commercial vehicles. We're really under pressure here. Improvements to conventional vehicles and powertrains may help to reduce consumption by a further 15 percent. But the target for 2030 is 30 percent. Electrification is a possible solution for light and medium trucks up to approx. 28 tons and also for heavy trucks deployed in daily shuttle services. But what about long-haul trucks? Some manufacturers are already investing in technologies that will remain viable until 2030 and beyond.

How optimistic are you that Germany will still have a flourishing automotive industry in 2040 while also achieving the Paris climate targets?

Damasky: Just two years ago, I'd have said that will be difficult. But when I see the great extent to which industry and politics are trying to meet halfway and that many of our member companies have meanwhile set themselves targets for CO_2 neutrality, that makes me very optimistic. What is still not clear is the extent to which consumers will be willing to go along with us. But if we can't manage that in Germany, who can?

Kratzsch: The scale of engineering challenges that we are currently facing is broader than ever before. This refers on the one hand to the diversity of powertrain technologies and energy carriers; on the other hand, we have new mobility concepts and connectivity between vehicles and backend systems and between one another. If we can manage to get society, politics and industry on board to face these challenges together, then I am convinced that in 2040 we will still be a high-tech country with a strong automotive industry.

Now it's up to us all to set the right course to achieve this. Our Berlin Powertrain Symposium has been a contribution to the exchenge in this respect.

Optimized for the Fleet, Customizable for Every Model

New electric drive unit from IAV – modular configuration reduces complexity

The future belongs to electric drives. Automobile manuacturers today want solutions which are, on the one hand, optimized for an entire fleet but, on the other, can also be customized for individual models without major input, for example in terms of performance, number of speeds or special comfort functions. IAV has developed a modular, scalable and highly integrated electric drive unit that meets these demands while also permitting short development cycles.

In order to meet their customers' wishes, engineers need to reconcile different aspects when developing an electric powertrain. What is called for here are low development costs and shorter development times with product costs kept to a minimum. In-house development work at IAV has shown that, for all intents and purposes, these different and challenging demands can be met with a smart design.

Modular configuration reduces complexity

The electric drive unit from IAV reduces complexity by using modular design and identical interfaces to all subsystems. At the same time, it is possible to customize drives for a particular vehicle class, for example in respect of gear speed number and transmission ratios. It can also be adapted to suit the various market segments and the costs that are acceptable in these segments by using different technologies. Parameters, such as engine power and torque, can also be varied for the same layout of electric motor. Depending on customer requirements, additional functions, such as a parking lock system or a shutdown system, can be provided, with the latter deactivating the electric motor if speed from the combustion engine is too high while the axle is being used in a P4 application. Although the number of speeds can be varied, higher efficiency and better performance are more likely to benefit relatively heavy vehicles. For lightweight models, one gear speed is usually sufficient. "Depending on comfort demands, for example, we can shift gear with or without traction interruption," reports René Kockisch, Team Manager for Transmission Mechanics at IAV. "Optional torque vectoring for sporty vehicles is also planned." Shifting torque between the wheels enhances driving dynamics and improves safety when cornering.

Vehicle classification	A	C-Class	C-Class SUV	D-Class sedan mid	D-Class sedan high	D-Class SUV
Curb weight [kg]	**1,200**	**1,555**	**1,770**	**1,694**	**1,694**	**1,997**
Powered Axle	**FWD**	**RWD**	**RWD**	**RWD**	**RWD**	**RWD**
Powertrain requirements						
Acceleration time 0-100 km/h [s]	8.6	8.92	7.8	7.3	6.9	8.9
Max. Velocities [km/h]	180	180	180	198	215	190
Gradeability	> 30 % (all topologies)					
EV cruising range [km]	250	350	350	400	400	400
Energy consumption WLTP [kWh/100 km]	11.5	11.7	16.5	13.3	13.0	18.1
Powertrain configuration						
EM peak torque [Nm]	250	250	250	250	250	300
EM peak power [kW]	100	100	150	150	150	150
Number of speeds	1	1	1	1	2	2
Ratio 1. speed/2. speed	8.5	9.2	11.5	11.0	13.3/6.6	13.8/7.6
Vehicle sale shares (Germany)						
Specific sale share [%] ∑ =100 %	**24.9**	**25.5**	**21.2**	**12.6**	**5.5**	**5.1**

High performance with high efficiency

The electric drive unit has a power output of between 100 kW/250 Nm and 180 kW/300 Nm. Attainable output torque is between 2150 Nm and 4150 Nm. The electric drive unit's sophisticated thermal management system and demand-controlled transmission lubrication provide a high level of efficiency. An agreeable background noise is also guaranteed: "We optimized the casing in terms of NVH right from the outset," Kockisch says. "This began as early as the simulation model and continued through to optimizing topology for low weight and maximum strength.

By using many shared components and subsystems, IAV's developers were able to keep the costs of the modular electric drive unit low. In terms of the transmission alone, they are five to ten percent lower than for other solutions. The electric motor and power electronics allow further potential savings to be realized. Substantial additional savings can be achieved by reducing the number of drive units that need to be developed for the vehicle fleet.

Layout with proven IAV tools

The point of departure for the developers was IAV's Powertrain Synthesis tool which was used to match the modular electric drive unit to the requirements of an example fleet in respect of fuel consumption, performance, cruising range and costs. "In this initial step, we defined the framework for the modular system," Kockisch says. "IAV's Powertrain Synthesis then gave us suggestions for the key parameters needed for the drive unit, including the number of speeds and transmission ratios for the particular vehicle segment. Then we used IAV's E-Motor Synthesis and IAV Actuation Synthesis tools. They assisted the developers in finalizing the drive unit's detailed layout.

"With our modular electric drive unit, we have demonstrated that our customers' various demands can be met with tried and tested development tools and a smart design," Kockisch summarizes. "We benefited from our expertise and experience. They provided the key to overcoming all of the technical challenges and achieving a short development time." The modular IAV solution can be easily adapted to the requirements of other vehicle fleets and quickly turned into a production-ready solution.

Number of speeds:	2
Shifting:	Electromechanical/ electrohydraulic, shiftable at part load
Transmission:	i_1 = 14.04/i_2 = 7.22
Max. output:	180 kW
Max. torque:	300 Nm
Max. speedl:	14,000 rpm

Contact:
rene.kockisch@iav.de

Diagnostics for Components

IAV specialists scrutinize mechanical components in detailed failure analyses

There are many reasons why a component can wear out or fail after only a short time. IAV assists anyone wanting to get to the bottom of a problem. A specialist team uses state-of-the-art analytical methods, such as scanning electron microscopy and computer tomography, to uncover faults. On request, our experts will also work in a prophylactic capacity.

In a way, it is like going to see the doctor. When IAV's experts examine failed parts, they start with a detailed case history. "We really do look at the life cycle of components," reports Thomas Komischke, Head of the Industrialization, Product Development and Failure Analysis Department. "This covers everything from production to the conditions the parts were used under, i.e. the full biography. And, like a good physician, Komischke and his colleagues not only use their broad expertise but can also draw on the experience they have gathered over more than 20 years in designing, manufacturing and assembling vehicle components.

They specialize in mechanical damage of every kind, for example in engine components such as camshaft drives, fuel system injection components or electric plug connections. Usually, examination starts with a house call. IAV's experts travel to their customers and ask them for as much information as possible. How was the component used? What ambient conditions was it exposed to? Are there any reports from repair workshops that could be of help? At IAV, the parts – both new and failed specimens – then undergo thorough analysis. "This tells us whether something went wrong at the design stage or whether there are problems in production," says Frank Hohmann, team manager in Komischke's department.

Standard-compliant analyses

In carrying out their analyses, the specialists follow the VDI 3822 standard which defines all steps in detail – from recording, case history, analysis, result, identification of the root cause throught optimization to documentation. A comprehensive range of instruments is available for analysis, including stereo microscopes, 3D cameras and equipment for stress testing. The team also has access to particularly complex measurement technology. It can use a scanning electron microscope at the laboratory of Wolfsburg-based OHLF (Open Hybrid Lab Factory) and, if necessary, a computer tomograph from the Fraunhofer Institute for Production Systems and Design Technology in Berlin. "This gives us access to a wide range of facilities as and when we need them, which puts us in a position to always use the best analysis techniques," Komischke explains.

Examination culminates in a list of hypotheses on the cause of the problem. "In many cases, there is no single cause but the impact of several factors," Hohmann says. "Sometimes, for example, an engine component can be damaged by poor fuel quality in conjunction with driving short distances all the time. In the meantime, the team knows from experience which causes lead to problems particularly frequently.

Problems with fuel quality

Country-specific fuel qualities are an ongoing issue. Engines or injection systems can work perfectly well in Germany but quickly fail in countries, like India and Russia, or in South America because the quality of gasoline and diesel there does not meet Western European standards. Frequently, biodiesel and regenerative e-fuels also lead to more wear. But the materials used in production can also have an impact on service life, which is often noticeable when a second supplier enters the equation and the failure rate suddenly increases. This can also happen if a supplier relocates its production operations and has components made on another continent.

"Finally, we produce failure reports that give a detailed account of the course of damage and the reasons for component failure. Depending on the requirements, these can also take the form of expert opinions that can be used in a court," Komischke says. But IAV's experts do not leave it at that. They also give their customers suggestions on how to improve their components or enhance their production, for example in respect of coping with different fuel qualities or the new future e-fuels, as well as with the growing demands in on and off-road driving. Sometimes, IAV experts are called in as early as the concept phase to evaluate components and identify possibilites for optimizing prototypes.

Vast experience from design practice

These consulting services are based on the team's vast expertise in design matters as this is where the experts come from. They themselves have successfully seen through many projects, making them familiar with potential problems from years of practical work. "Initially, we started out by assisting customers in analyzing component failure, but then word got around and led to more and more inquiries," Komischke reports. Today, this service is very much in demand, just like the services of a good physician.

Contact:
thomas.komischke@iav.de

IAV Failure Analysis – Service Portfolio

- Drawing up Ishikawa cause-and-effect diagrams for the problem point
- Creating and facilitating FMEA
- Systematic handling to VDI 3822
- Drawing up failure hypotheses
- Analyzing tolerances

No Safety without Security

Joint research project with HAW Hamburg and easycore GmbH: detecting and fending off cyber attacks on vehicle fleets

As the number of vehicles connected to the internet increases, so do the security risks associated with attacks on IT. In a research project conducted in cooperation with Hamburg University of Applied Sciences (HAW Hamburg) and easycore GmbH in Erlangen (Germany), IAV is developing new strategies to prevent hacker attacks. The Automotive Cyber Defense Center plays a pivotal role in this regard as it constantly monitors vehicle fleets and sounds the alarm early on in the event of security-critical incidents.

If hackers succeed in gaining control of a vehicle through a security loophole, human lives can very quickly be at risk. As a result, the increasing level of connectivity between cars is presenting manufacturers with a major challenge: how can attacks be detected early and be successfully averted? The new domain controllers, with their numerous functions concentrated on a single control unit and the associated increase in the code base, make this matter even more urgent because this provides large potential targets that pose the threat of immense damage.

Permanent observation of fleets

"Loopholes in security quickly lead to safety deficits," warns Dr. Falk Langer, Team Manager for Vehicle Software Solutions at IAV. "Security is therefore becoming more and more a key requisite for safety. This presents vehicle manufacturers with an entirely new challenge. They permanently need to monitor fleets throughout their service life and take immediate action in the event of a cyber attack.

This calls for technical solutions that detect attempted attacks and report them to a monitoring center for analyzing data. Once a countermeasure has been found for the problem, the center responds with immediate counteraction to prevent infiltration. Since May 2018, the "SecVI: Security for Vehicular Information" research project has been examining exactly what this could look like. It is part of the "Self-determined and secure in the digital world" program funded by the German Federal Ministry of Education and Research.

IAV develops Automotive Cyber Defense Center

In various work packages, the project partners are examining where security can be improved – from the individual control unit and combination of several control units to vehicle connectivity with the cloud. "We look at the entire security architecture and will be testing new solutions both in the laboratory and in the vehicle," says Abdulvahap User, Head of the Vehicle Software Solutions Department at IAV. "Our work focuses on developing an Automotive Cyber Defense Center (ACDC) which monitors networks and can identify and repel attacks, in the same way as specialized departments do in companies.

In addition, the vehicles permanently report whether their firewalls and intrusion detection systems are detecting attacks. Among other aspects, the research project is examining which data is relevant to this and how it can be securely communicated to the ACDC. To limit the data volume of data, some evaluations are carried out in the vehicle – an approach that is known as edge computing and is also used in the area of the IoT. It is important for the ACDC to analyze the data from numerous vehicles. "Reports from a single vehicle are not enough because an incident identified could be a one-off occurrence," Langer says. "Only when a large quantity of such data is collected, we know that we are facing an attack on the entire fleet."

Reaching a secure state with countermeasures

Once an attempted attack is detected and analyzed, the ACDC can initiate countermeasures. Potential action includes disabling specific IP addresses, closing services in the vehicle or influencing data traffic by means of a software-defined network. In this regard, however, consideration must always be given to what these measures mean for driving. Would they completely immobilize the vehicle? Can the vehicle be put into a secure state? After all, it is not possible to simply shut everything down to be on the safe side, as you can with a computer. Besides the immediate action taken, the defects must be reported to the OEM who must then, of course, also prepare software updates. These must then be rolled out within a few days by means of an online update in order to guarantee safe and secure vehicle fleet operation in the long term, too.

The research project runs until 2021 by which time several demonstrators and a competition are planned. At HAW, hackers are to be invited to outsmart the newly developed security mechanisms and infiltrate a vehicle network. "We have gathered a good deal of experience with driver assist systems and highly automated driving – in research, advance engineering and volume production," Langer says. "IAV is hence ideally placed to be a pioneer in this field". In future, it was conceivable for IAV to operate an ACDC on behalf of OEMs and, in this way, help to improve security and safety.

Contact:
falk.langer@iav.de
fabian.schueppel@iav.de
abdulvahap.user@iav.de

SecVI Research Project

Security architecture for vehicle networks

The goal of SecVI is to develop a robust, low-complexity network architecture that shields internal components in tiered security domains and monitors both the syntax and semantics of message flows in the vehicle's control areas relevant to security.

In cooperation with partners HAW Hamburg (Hamburg University of Applied Sciences) and Erlangen-based easycore GmbH, it is planned to make the system self-protecting by centering the protection functions on selected gateways in such a way that, in the event of detected attacks, expired keys or maintenance intervals, the security-critical control systems are protected by blocking selected messages. This is accompanied by deactivating selected functions not critical to security.

The project is funded by the German Federal Ministry of Education and Research (BMBF).

Project Kick-off with the Software Campus

Ambitious students are given an insight into application-oriented research projects

In the Software Campus, partners from industry and science have made it their task to train future IT specialists and executives. Since February, IAV has been participating in this network, which is aimed at outstanding master and PhD students in the field of computer science and related disciplines.

"As the 'Network Software' cross-function, one of our main objectives is to strengthen software expertise within IAV in the long term and to recruit highly qualified specialists for our company. That's why, at the start of the year, we became an industry partner to Software Campus, which aims to train the IT specialists and executives of the future," states Markus Blonn, Senior Vice President Network Software at IAV. "Thanks to cooperation with industry partners such as IAV, the students have the opportunity to work on application-oriented research projects."

At IAV, they will be working on the following software projects:

- AI-supported analysis of production process data in cooperation with the DFKI (German Research Center for Artificial Intelligence)
- Conception and development of a framework for migrating data processing applications to serverless environments in cooperation with TU Berlin
- AP-HMI: an Adaptive and Personalized Human-Machine Interface in the vehicle in cooperation with the DFKI
- Security and robustness of reinforcement learning algorithms in cooperation with the Technical University of Munich
- ARCA – Automated Requirement Change Analysis for the development of complex technical systems in cooperation with Paderborn University
- Reinforcement learning for controlling mechatronics processes with few insecure data in cooperation with the KIT

"The projects will be implemented in two years in teams that pick their own mentees," explains Andrej Lehmann, who is responsible for the program within the Human Resources Division. During this time, IAV will support the postgraduates with technical input and methodological competence.

The wealth of highly qualified candidates this year was received with great enthusiasm. "I wouldn't have expected this many outstanding applicants," reports Daniel Hess, head of department within the Software and Systems Division at IAV and responsible for one of the total of six projects.

Contact:
andrej.lehmann@iav.de
markus.blonn@iav.de
daniel.hess@iav.de

software campus

Hack Attack at IAV

IAV Security Hackathons for students

Two days, up to 40 ambitious programmers, and around ten tasks that have to be completed. These are the conditions of the IAV Security Hackathons which have been taking place regularly since 2018. Students from throughout Germany are invited to solve IT or automotive security tasks such as vulnerabilities in software, for instance. The tasks have different levels of difficulty so that both beginners and experienced students can take part.

Information about our hackathons is available at www.iav.com

Components in Permanent Stress

IAV experts use stress tests to examine the reliability of components

Vehicle components need to cope with a lot. On special test benches in Gifhorn, IAV's Robustness Validation and Environmental Testing Team investigates whether they are really robust enough for the intended service life. The testing portfolio covers the entire process chain from coordinating test plans to issuing component release recommendations.

300,000 kilometers of mileage, 8,000 operating hours and ten to fifteen years of reliable service: the demands on vehicle components are high. The best way to find out whether they really are up to all this is on a test bench, for example in a thermal cycling endurance test which the level sensor for the chassis is subjected to. "For this purpose, we are building a special mechanical system that simulates loading and unloading as well as the levels of stress and strain occurring on the road," explains Dr. Uwe Metzing, Head of the Body Electronics & Validation Department at IAV. "We then put them in a climate test chamber with a temperature range that varies between minus 40 and 125 degrees Celsius in line with a specified profile and humidity of

maximum 100 percent." In 1,900 hours on the test bench, it is possible to simulate the stress loads that will occur later on during the planned 8,000 hours of operation. After each endurance test run, a torque and function test is carried out to verify that the sensors will work properly and without flaws.

Similar conditions as in the wheelhouse

In the dirty water test, sensors and mechanical systems are placed in a tank containing a mixture of water, salt, Arizona dust, glass cleaner and dish-washing liquid. This mixture simulates the subsequent ambient conditions. "There are many sensors installed in the wheelhouse that come into contact with water, snow, salt and dust," Metzing reports. "We examine the effect this has on their reliability. In each endurance test run, they need to survive one million rotational movements across 120 degrees which takes around four days. All in all, testing covers 15 cycles of this type, after which a torque and function test is carried out to verify proper working order.

LV124/VW80000 etc.

The Robustness Validation Team can offer a wide range of tests. Besides climate, electrical and chemical tests in line with LV124/VW80000, analysis also covers the impact of vibrations and mechanical shocks on components. In most cases, these are accompanied by special tests taken from the component specification, such as sensing smooth operation of the rotating arms on the torque test bench.

Although our experts are specialized in examining sensors and control units, they can also test mechanical parts in addition to E/E components. They are usually called in as soon as initial samples are in hand from manual production and shortly before the start of production (SOP) when volume-produced components are available. "We can cover the entire process chain, from coordinating the test schedule with the customer to recommending final release for components," Metzing says. "What sets us apart from other providers is our system expertise. We are in close contact with the OEM and very familiar with the demands in the actual vehicle. On top of this, we benefit from expertise in component aging and failure causes."

This also applies to electric cars which are constantly gaining importance. Here, testing needs to be set up differently on account of the high voltages involved. In addition, operating times of up to 30,000 hours are also envisaged in this domain. And finally, components are not only exposed to strain from driving, but from charging too. This is why Uwe Metzing and his team will be building many more special test benches that will enable them to put components to the acid test.

Contact:
uwe.metzing@iav.de

Digital Ants as an Efficient Means of Improving Power Grids

IAV has a method that supports the strategic planning of distribution grids which fulfill all the demands made of a modern energy supply system

The energy transition changes everything. The ongoing expansion of renewable energy sources makes grid planning increasingly complex. IAV has developed a method for automated planning of distribution grids with a clearly structured comparison of different expansion scenarios.

The energy transition has been changing many aspects of Germany's power industry. Increasing numbers of local energy producers are feeding their fluctuating yield into the grids that have not been suitably prepared for this hitherto. This means that the grid operators have to invest in their existing infrastructure to bring it in line with the new challenges. The existing grid has to be made fit for the future with minimum investments in copper infrastructure and intelligent systems.

This is a typical optimization task and one that is also commonplace in automotive engineering. In recent years, IAV has used numerous optimization methods to handle complex issues with many parameters and is now in a position to transfer the resulting know-how to other industries. Power grid planning is one of these new areas that involves a particularly high level of complexity. "We're dealing with hundreds or thousands of grid nodes, as well as a comprehensive set of rules regarding structure topology", explains Dr. Michael Schollmeyer, Smart Grid Team Manager at IAV. "For example, certain electrical limit values have to be respected in order to prevent damage to the equipment that could cause power failures."

Avoiding misdirected investments and using synergies

When it comes to strategic grid planning, such as connecting both new wind turbines and new industrial estates to the grid, there are so many possible solutions that the grid operators can no longer cope without suitable tools. However, the high level of complexity in strategic target grid planning is not a problem for the IAV solution. "Our highly automated method autonomously devises and analyses thousands of different grid variants, helping distribution grid operators to avoid reactive grid planning, preventing misdirected investments and making specific use of synergies", summarizes Lukas Ruck, project manager at IAV.

The core element of the process consists of a variation on the ant colony optimization algorithm often used to devise efficient point-to-point connections for distribution tasks in logistics. Ants foraging for food act as the role model as they search for the shortest possible route between their anthill and a source of food. But IAV's engineers have made substantial additions to the traditional ant colony optimization algorithm to take account of the complexity involved in power distribution grids, as otherwise it could only plan ring and string lines.

In the IAV solution, the electrical attributes of the grid plan are imported and supplemented with geoinformation for every node. "For example, the grid operator can stipulate the permissible length of rings and branch lines or the maximum number of local grid stations per ring", says Schollmeyer. "Furthermore, our process is capable of modeling, transformer stations, substations and sectioning points. It can also model string lines to a string or ring starting from the substation or transformer station."

Every iteration results in an improved grid

Once all necessary information is available, the algorithm proceeds with iterative generation of multiple possible solutions for efficient connection of the individual points. In this case, "efficient" means a grid with lowest possible investment and operating costs that still fulfills all load flow and short-circuit requirements. A learning algorithm ensures that the resulting grid structures get better with every iteration. The result is an efficient grid with minimum overall costs that fulfills all demands in terms of high supply quality. "Our optimization process makes no concessions in terms of reliability or safety while achieving the required supply quality in all grid situations with less investment", says Ruck.

IAV offers strategic grid planning as a service. The algorithm has already proven its practical suitability in cooperation projects with several distribution grid operators. It was used in one of the projects to reduce the length of the power circuits in an existing grid to allow for targeted reductions in high-maintenance overhead power lines. At the same time, two new industrial estates were to be integrated into the target grid. Additionally, the resulting grid was supposed to be clearly arranged with regards to daily operation. IAV's target grid solved this task in less time at around 20 percent less investment costs than the grid planned manually by the project partner.

The project showed that the experience and technical expertise of the distribution grid operator can be well combined with the solutions proposed by the algorithm, resulting in numerous possible options for devising the target grid and its precise details in terms of routing, sectioning points and other important parameters which could then be discussed.

Contact:
michael.schollmeyer@iav.de
lukas.ruck@iav.de

Transferring AI Methods to Practice

Digitalization methods toolkit, joint learning and doctoral researchers: IAV and DFKI work closely together

In cooperation with the German Research Centerfor Artificial Intelligence (DFKI), IAV has been transfering new artificial intelligence (AI) methods to engineering since 2018. Among other things, the results are fed into a methods toolkit that is available to all developers.

In January 2018, IAV and DFKI opened the joint "Research Laboratory for Learning from Test Data" (Forschungslabor Lernen aus Prüfdaten – FLaP) in Kaiserslautern. At FLaP, researchers and engineers from IAV and DFKI are investigating which AI-based analysis methods are suitable for use in automotive development testing processes. The focus is on machine learning methods, such as deep learning and time-series analysis. "We transfer state-of-the-art AI technologies directly into our company", elucidates Matthias Schultalbers, responsible for digitalization at IAV. "Furthermore, we are interested in developing and testing new ideas and subjects for engineering applications."

IAV's Research Center located in Gifhorn channels the results obtained into advance engineering. In doing so, IAV pools innovative topics, such as control engineering, tool development, data science and process automation and development.

Methodical search for hyperparameters

The methodical search for the optimum hyperparameters of AI models is one of the current research topics in the cooperationproject between IAV and DFKI. In the case of neural networks, for instance, the structure and size of the network must be adapted to the particular task at hand. "There are new systematic approaches that DFKI is currently exploring," reports Dr. Peter Schichtel, researcher at IAV and part of the team in Kaiserslautern. "We are working on the subject with our colleagues in Gifhorn with the aim of finding the optimum AI solution for each problem by determining the hyperparameters using a methodical approach". The findings are quickly incorporated into all IAV projects and the digitalization methods toolkit which is available to all IAV engineers.

In the "ForGAN" project, the partners are investigating new ways of using generative adversarial networks (GANs) for probabilistic time-series prediction. "This involves, for example, predicting signals that are not equally distributed," says Schichtel. "GANs are not only capable of predicting the expected mean value but also model the variance of a process." This method could be used to predict the air volume required during combustion in the cylinder. Another project is examining ways of using anomaly detection methods effectively in the big data environment.

Doctoral researchers in current AI topics

In addition to two staff members from DFKI and IAV each, the team includes four doctoral researchers. Two of them are working on current issues for IAV. The first doctoral thesis focuses on GANs in general and aims to provide a better understanding of this highly topical AI method. The other doctoral researcher uses auto-encoders to examine physical processes in complex systems. In concrete terms, this is about extracting correlations from the compressed data representation of these special neural networks and then interpreting them.

In future, IAV will support the lectures of Prof. Dr. Andreas Dengel, Head of the Smart Data & Knowledge Services Research Department at DFKI in Kaiserslautern. "In 2020, lecturers from IAV will be giving parts of the lecture on AI applications,"

Contact:
matthias.schultalbers@iav.de
peter.schichtel@iav.de

The German Research Center for Artificial Intelligence (DFKI)

The German Research Center for Artificial Intelligence (Deutsches Forschungszentrum für Künstliche Intelligenz GmbH – DFKI) was founded in 1988 as a non-profit public-private partnership (PPP). It has operations in Kaiserslautern, Saarbrücken and Bremen, a project office in Berlin, a laboratory in Lower Saxony and a branch office in St. Wendel. DFKI is Germany's leading industry-focused research institute in the field of innovative software technologies based on methods of artificial intelligence. It is one of the most important "centers of excellence" in the international world of science.

DFKI projects address the entire spectrum from application-oriented primary research to the market-oriented and customer-focused development of product functions. Currently, approximately 1,100 members of staff from some 60 nations are researching innovative software solutions with a focus on smart data & knowledge services, cyber-physical systems, multilingual technologies, plan-based robot control, educational technologies, interactive textiles, robotics, innovative retail, business informatics, embedded intelligence, smart service engineering, intelligent analytics for mass data, intelligent networks, agents and simulated reality, augmented reality, speech technology, cognitive assistance systems, innovative factory systems, marine perception and smart enterprise engineering.

Its success: more than 130 professors from our own ranks and over 90 spin-off companies providing about 2,500 highly qualified jobs.

Frightened of Innovation?

Dr. Matthias Butenuth, Senior Vice President Automated Driving Systems: we must explain to people even better how autonomous driving improves their mobility

We are skeptical: only 17 percent of the respondents to a study in Germany would get into an autonomous vehicle in the foreseeable future, while worldwide it is 25 percent. In ten years' time, however, the figure could be as high as 61 percent in this country and 64 percent worldwide.[*1] In another study, some 70 percent also expressed concerns about the safety and security of vehicles and systems, and fear of manipulation, for example from cyber attacks. 65 percent of respondents don't trust the technology at all.[*1][*2]

Frightened of one of the tomorrow's big technologies, like autonomous driving?

In discussions about the most important innovations in the field of mobility, this is the catchphrase that is constantly heard: autonomous driving. This technology is seen as the key to making future mobility safe and sustainable. Even though we are still in the middle of the development process, there is one thing we have learned in recent years: the road to the driverless car is a long and winding one because the technology is complex and the investments are high. This is why new alliances are currently being forged to pool resources. It is still completely unclear as to who will make it outright and win the race at global level.

A current study shows that opinion is changing.[*2] From February 2018 to March 2019, consensus that automobile manufacturers should commit themselves to autonomous driving grew from only 28 percent to 41 percent among all respondents.

However, there is, in part, a lack of economic incentives for using the new technology in private transportation. This is also evident in a Prognos study carried out on behalf of ADAC, the German automobile association. Autonomous driving will only gain acceptance very slowly in the passenger car sector, and there will also be a long phase of mixed transport.[*3]

In contrast to this, there is definitely a business case in commercial and in public passenger transport. For this reason, the logistics sector is likely to be one of the first users of autonomous vehicles. Here, labour costs play such an important part that investment in new technologies may pay off more quickly.

In addition to the financial and technological hurdles, this future technology is also struggling with legal problems because there is still no binding legislative framework in place. Nobody currently knows which criteria will be used to homologate autonomous vehicles. New groups are forming here too, such as the International Alliance for Mobility Testing & Standardization (IAMTS) with the aim of testing, standardizing and certifying new mobility systems. Organizations, like the European New Car Assessment Programme (Euro NCAP) are working to establish what provides a uniform comparison basis for assessing the safety of vehicles from the perspective of European transport ministries, automobile clubs and insurance associations.

But what makes developing and validating autonomous driving so complex? People act intuitively to mitigate acute danger situations and prevent accidents. Their experience and perception of risks play a key part, above all in terms of permanently assessing the risks involved in the overall situation while taking into account all information from the context. This also includes inconclusive pieces of information, such as the movement of an unfamiliar object only perceived as a silhouette through a vehicle window. The central challenge is to get this human experience into mathematical models, for example by using methods of artificial intelligence.

But technology is only one facet of autonomous driving. Another important aspect is the question how autonomous driving benefits mobility? What does society expect from future mobility? How can autonomous driving meet these expectations?

Fewer accidents and greater safety are often mentioned in connection with autonomous driving. Even if it will not be possible to achieve complete safety, "Vision Zero" remains an important development driver. But that's not all. On top of this, we need to explain even better how autonomous driving can improve mobility. Current public debate and media attention, for example at the presentation of IAV's HEAT shuttle in Hamburg, demonstrate just how much interest there is. But they also highlight the questions and uncertainties that still prevail.

Autonomous shuttles offer better solutions for the societal question of tomorrow's mobility: if used and controlled intelligently, they can increase the range of mobility services while at the same time reducing the number of vehicles on the road, particularly in cities. Germany, as a center of business and industry, can also benefit: on the one hand, from the development in technology, on the other hand from its use, for example in the logistics sector.

Surveys also show further positive expectations, such as better fuel efficiency (73 percent), lower CO_2 emissions (71 percent) and time savings (50 percent) from autonomous driving.[*1] Benefits are also seen in greater mobility for people with physical impairments or disabilities (75 percent), lower levels of stress and a more relaxed style of driving (61 percent) and the ability to do other things while traveling (59 percent).[*2]

This is where action is needed. We must explain to people the opportunities and the huge potential autonomous driving can have for them personally! It is not enough to let matters rest at all the familiar catch phrases. On the contrary, ways must be created to try out and experience this future technology first hand. Only in this way will it be possible to spark positive emotions. Transparency in developing, explaining and experiencing autonomous mobility will make its acceptance grow in society. In a study, 45 percent of respondents stated they feel that manufacturers, associations, local authorities and the media on the whole provide adequate information on the subject, 53 percent feel there is too little information.[*2] This is a clear message, showing the automotive industry and mobility providers what needs to be done!

Contact:
matthias.butenuth@iav.de

Sources: *1 Capgemini Research Institute: The autonomous driving. A consumer perspective (effective: May 9, 2019): https://www.capgemini.com/de-de/news/begeisterung-autonomesfahren-waechst-trotz-sicherheitsbedenken/ [09/16/2019] *2 DHBW Ravensburg (Baden-Württemberg Cooperative State University), ZEK (Center for Empirical Communication Research): Die Akzeptanz für autonomes Fahren wächst (Acceptance of Autonomous Driving Is Growing) (effective: May 28, 2019): https://www.ravensburg. dhbw.de/dhbw-ravensburg/aktuelles/detail/2019/5/die-akzeptanz-fuer-autonomes-fahren-waechst.html (effective: 09/16/2019) *3 Prognos Research Institute: Einführung von Automatisierungsfunktionen in der Pkw-Flotte (Introducing Automation Functions in the Vehicle Fleet) (effective: August 1, 2018): https://www.adac.de/-/media/pdf/motorwelt/prognos_automatisierungsfunktionen.pdf [09/16/2019]

Three-Shift Day in the Berlin Himalayas

Huge demand for the IAV high-altitude climate roller dynamometer – realistic tests under laboratory conditions

For two years now, IAV has been operating a climate roller dynamometer for high-altitude testing in Berlin that can simulate driving in high mountain regions up to 5,300 meters – cost-effectively, efficiently and reproducibly. By intelligently linking test bench automation and simulation, the vehicle can be integrated into simulation on a "closed loop" basis.

Especially high up in mountains, vehicles need to cope with extreme levels of stress and load. The combination of low air pressure, high engine load and low speed pushes both drive system and cooling to their limits. Carrying out tests under such conditions used to mean traveling to far-away places for developers – to the Himalayas or Andes, for example. On top of high costs also come problems, such as unpredictable weather conditions and the influence of the seasons. Testing would be much easier to plan on a dynamometer that can reliably and reproducibly simulate these extreme ambient conditions.

It is precisely for this reason that, in 2017, IAV put its unique high-altitude climate roller dynamometer into operation at its Berlin site. It can be set to reach temperatures from minus 30 to 40 degrees Celsius across the entire pressure spectrum from 1,000 to 1,500 millibars. Air pressure can be lowered to just 500 millibars, i.e. conditions of the type prevailing in high mountains at 5,300 meters at 0 degrees Celsius. And, unlike hitherto familiar roller dynamometers, it is not only possible to simulate pre-defined speed-time profiles but also cornerin, such as driving over real-world mountain pass roads, or towing a trailer.

If required, the driving robot can take over

The structure and operation of the software are geared towards real-world test driving. The virtual routes are based on measured GPS or imported map data. Vehicle, route, driver and traffic can be varied at any time. A large monitor in front of the test vehicle shows the driver the road, enabling him or her to follow the course of the route driven. It is also possible to control the journey from an external cockpit in an operator room. If necessary, the driving robot can take over command in combination with a driver model. In particular, it can drive repetitive cycles with absolute precision, enhancing calibration efficiency. To optimize feedback in this test case between the vehicle on the roller dynamometer, the road model and the driver in the remote cockpit, a system is installed that enhances the virtual connection with sound shakers on the cockpit-seat frame.

The high-altitude climate roller dynamometer is big enough to examine vehicles ranging from mini-format (e.g. Smart) to maxi-format (e.g. delivery truck). "For the calibration, we can currently use three lines to measure engine-out exhaust gas", reports Bernd Poytinger, Head of the Roller Chassis Dynamometer Department at IAV. "Towards the end of the fourth quarter, we will also be able to measure the number of particles down to 23 nanometers with a particle counter." Combined with exhaust gas volumetric flow measurement, the emission results can then be converted from mass fraction (ppm) to concentration (mg/km).

"The virtual drive over mountain passes is safe, reproducible and highly efficient because the laboratory environment enables us to set whichever weather data our customers need. This provides an efficient basis for preparing or post-processing and, as the case may be, for substituting classic test drives at low temperatures and high altitudes," Poytinger says. "More and more customers are taking advantage of these benefit. The high level of demand means that the system is running five days a week, 24 hours a day in three shifts."

Stars and Carmaker are linked via Dyno Interface

A particular aspect of the high-altitude climate roller dynamometer is the conncection of the Stars software (Horiba) for test bench automation with the Carmaker simulation environment (IPG Automotive) for simulating environmental influences via the standardized Dyno Interface dynamometer interface. Through this synchronized real-time connection of roller dynamometer control, driving robot and simulation environment, the vehicle can be integrated into the simulation on a "closed loop" basis. "Connection to Carmaker enables us to offer our customers realistic road scenarios," Poytinger explains, "in which longitudinal, lateral and vertical dynamics as well as random traffic are simulated."

The vehicle, road and environmental parameters can be adjusted at the click of a mouse, even in the middle of a test, for example by activating and deactivating a towing dynamometer or increasing vehicle mass as well as by adding gradients or altering weather data. "You can run the cycle through over and over – a mouse click is all it takes to re-start at the foot of the mountain and drive over the pass again," Poytinger says. It wouldn't be as easy as this in the Himalayas or the Andes.

Contact:
bernd.poytinger@iav.de

Possible types of use/automation

- Manual driving in the vehicle with road resistance simulation (v-t test cycles)
- Manual driving in the vehicle with constant load points
- Semi-automated driving in the vehicle at constant, menu-driven load points
- Fully automated driving at constant load points with driving robot
- Fully automated driving of dynamic load cycles (be-v, Md-v) with driving robot
- Fully automated driving test cycles (v-t) with driving robot
- Manual driving of real-world road profiles in the vehicle
- Manual driving of real-world road profiles with driving robots from the control room
- Fully automated driving of real-world road profiles with driving robot

Technical Specification

Test chamber

- High-altitude simulation up to 5,300 m (500 mbar absolute)
- Temperature simulation from -30°C to +40°C (accuracy: +/-1 kelvin)
- At 20°C, power outputs of 230 kW can be run
- Climate operating mode (humidity control) up to an altitude of 1,800 m
- Controlled ascent and descent: 200 m/min (equivalent to an uphill gradient of approx. 17% at 70 km/h)
- Max. vehicle height: 2.95 m
- Max. vehicle length: 6 m

Roller chassis dynamometer

- 4-wheel roller dynamometer, VULCAN 4WD, with 2 x 230 kW
- Inertia mass simulation from 450 kg to 4,770 kg
- Center distance from 1,800 mm to 4,500 mm
- Integrated automation concept comprising VETS ONE, STARS for Vehicle and CARMAKER
- Driving robot
- 3 analysis lines, undiluted measurement (NOx, NO, CO, CO_2, O_2, THC & CH4)
- Exhaust gas volumetric flow meter
- Pegasor (PM/PN)
- MSSplus – Micro Soot Sensor (PM)

Ancillary rooms

- Dry zone for vehicle transfer
- 2 climate chambers from -30°C to +40°C
- Parking system for nine vehicles (23°C)
- Car lifting platform / prototype room
- Control room
- Measurement equipment room

Equal Partners

DEKRA and IAV cooperate on automotive EMC testing

When a prominent certification service provider and an established automotive engineering partner join forces, customers can look forward to first-class service. This also goes for the cooperation partnership between Dekra and IAV. Combining the strengths of both partners now creates capacities urgently needed for testing electromagnetic compatibility (EMC) at the new EMC facility in Stuttgart.

For Dr. Uwe Reinhardt, the working partnership between Dekra and IAV combines the best of both worlds. "As a well-known certification service provider and already accredited EMC laboratory operator, Dekra can draw on a wealth of experience with accrediting and operating test facilities," says the Vice President of Overall Vehicle Testing and EMC at IAV. "IAV, in turn, brings its automotive expertise to the partnership, letting Dekra carry out complex component and vehicle measurements without having to get involved in the engineering business".

No measurements without engineering

Without engineering support, EMC measurements are becoming increasingly difficult to carry out. Relevant vehicle operating states for activating test-relevant vehicle electronics can not be implemented without major efforts in an EMC facility. Conducting measurements on specific control units sometimes involves deactivating parts of the vehicle. This makes it necessary to simulate the data of deactivated parts in order to feign the semblance of a "complete" vehicle to the electronics under test. Coping with this increasing complexity demands growing support from engineering services alongside the actual EMC testing technology.

The new laboratory in Stuttgart has three chambers, one of which is reserved for automotive tests. Besides classic vehicle components, high-voltage components and battery systems weighing up to three tonnes can be tested there. "For battery systems we have developed a breakdown concept enabling us to test the components even early on in the development process," Reinhardt says. In the event of a fault, the battery can be moved outside very quickly without the need for any further intervention. This is by no means to be taken for granted with a shielded test chamber fitted with absorbers. It is also possible to measure rotating test specimens, such as e-axles, without causing intereferences. In addition to components, the facility also provides space for vehicles up to van size which can be tested in line with the latest requirements. As such, IAV can cover the entire V-diagram for an EMC development activity using in-house resources only.

Increasing complexity demands a greater number of EMC measurements

The subject of EMC has gained great significance over recent years. Advancing connectivity and the ever-growing number of safety-relevant functions, to the point of autonomous driving, is making it increasingly important to ensure electromagnetic compatibility. Hence, verifying the interference-free operation of all electronic systems is becoming ever more complex. This applies to immunity to external and internal sources of interference as well as to suppressing interference necessary to protect receiving and communication systems in the vehicle.

The new electric drive systems are exacerbating the problem. They require high, switched currents that generate strong magnetic fields and can interfere with the sensitive electronics in the car. Battery charging in electric and hybrid vehicles is also driving up the need for EMC tests. Here, a vehicle becomes an electrical load connected to the public power grid which must neither interfere with it in any inadmissible way nor must it be disturbed by interference in the grid itself. The increasing integration of cellular telephony and communication services in the public power grid will in future necessitate even more extensive measurements, as is already the case in a smartphone. DEKRA is ready for this too, and, with assistance from IAV, could apply the expertise it has in testing smartphones to motor vehicles.

The new EMC facility in Stuttgart was built by Dekra, with IAV providing planning support from day one. IAV has been given guaranteed access to one shift in the automotive laboratory which has separate sections to safeguard confidentiality. "Our cooperation partnership produces a win-win situation in which both partners can tap into additional resources and customers without interfering with each other's portfolio. And our customers benefit from the expertise we share," Reinhardt reports.

Contact:
uwe.reinhardt@iav.de

Technical Specifications

Dekra and IAV EMC Facility

- CISPR: 25 vehicle and component measurements, interference immunity tests at system and component level, application of the FFT method
- Tests of high-voltage systems up to 1000 V/150 kW/300 A
- Testing of automotive, industrial and medical products
- Floor loading capacity up to 2 or 10 tonnes
- High-voltage power supply unit, electronic loads for high current and high voltage, optical transceivers (CAN-FD, LAN, Flexray), extensive test specimen monitoring methods (CANoe, camera, optical converter, DMM)
- Network analyzer, soldering workstation, interference suppression components, meeting rooms
- Separate laboratory areas to safeguard confidentiality

Testing bandwidth (excerpt)

- Antenna interference immunity 20 MHz to 6 GHz at 30 V/m, 200 V/m or 600 V/m
- BCI 0.1 MHz to 1 GHz, 300 mA
- Emitted interference 1 Hz to 6 GHz and higher (40 GHz) with antenna, LISN, current clamp, stripline, magnetic field coil, field probe
- Magnetic field interference immunity 0 Hz to 200 kHz, up to 10,000 A/m (DC) to 1,200 A/m (3 kHz)
- Equipment for high-voltage tests in compliance with ISO 7637-4 (2019), LV123 (chapter 10.4 with 33 A/66 A/250 A), ISO 21498 (being evaluated)
- Impulses according to ISO 7637-2, -3 burst up to 5.5 kV, surge up to 5 kV, EFT, electric switch
- ESD up to 30 kV

New Test Benches for Electric Mobility

Electric drive systems are playing an increasingly important part in automotive engineering. The demand for testing equipment is growing in the same way. IAV is building eight new test benches for e-axles at the Stollberg Development Center. Each has a system output of up to 500 kW. Three of the new test benches will be available by the end of 2019, with five more planned for October 2020. Controlled by a modular automation system, all test benches will be equipped with cutting-edge measurement technology, battery simulation capability and equipment for conditioning air and water.
Contact: andreas.geistert@iav.de

Expert Student Know-how at the Hockenheimring

Teams from around the globe demonstrated their design skills at Formula Student 2019

Around 3,500 participants in 119 teams flocked to what is probably the biggest student design and development competition, Formula Student Germany, from August 5 to 11. Young developers from a total of 25 nations demonstrated their skills in designing and building single-seater race cars in the FS Combustion, FS Electric, and FS Driverless categories. As usual, however, focus was also placed on extensive design engineering and business knowledge at the Hockenheimring, not just on the cars themselves or on fast lap times. To prove how deeply they understand their subject, the students had to face the questions fired at them by an expert jury. This year, the judges were once again provided by the event's main sponsors. The team fielded by IAV included Dominik Kufer (TI-M), René Hahn (TI-M), and Martin Weber (TP-C).

Dr. Dominik Kufer (middle), judge in the Driverless category

The world's most talented engineering students

The central topic at Formula Student 2019 was 'Future Mobility' and the related networking of technologies. The participants were encouraged to try out new mobility concepts. Besides handling characteristics, both the cost and business plan and the design and engineering features count in Formula Student. The latter were put to the test during the very first few days.

René Hahn, who has been working at IAV as a development engineer for reversing cameras since 2016, was one of the judges in the Electric category. In a group of eight judges, he asked a total of six teams questions about their designs or, more precisely, about the field of electric propulsion. "I originally studied mechatronics in Chemnitz, which is why I am familiar with electronic powertrains. The challenge involved in judging was to specifically dig deeper to test the students' actual level of knowledge and unearth any gaps." Easier said than done, continued René Hahn, because some of the teams worked on a very professional footing. "It was extremely interesting to see the different concepts. You could see the work that had been put in and the extraordinarily good thought processes involved."

René Hahn's colleague Dominik Kufer, who was responsible for judging the Driverless category, describes the situation similarly. At IAV, he works as a development engineer in the Driver Assistance Systems and Autonomous Driving Division. His expertise is sensors. Dominik Kufer volunteered as an FS judge because he was curious about the participants' skills. "Apart from that, you have the opportunity to meet talented students and network with colleagues from other companies."

Like René Hahn, this was Dominik Kufer's first Formula Student – and he was thrilled: "It was big and very interesting. I was responsible for assessing recognition. We judges were supposed to determine the limits of knowledge so that we could assess how certain the teams were about their concepts."

A former participant as a judge

And then there's Martin Weber. The development engineer, who has been working at IAV since 2014, took part as a judge for the fourth year in succession. But not only that: he also took part in Formula Student while studying for his mechanical engineering degree. Martin Weber is therefore fully familiar with the challenges faced by the teams. "I was a member of the Karlsruhe University of Applied Sciences High Speed Team from 2010 to 2012. At that time, we built combustion engines. This is the category in which I am now an judge."

Martin Weber (rear), judge in the Combustion category

For Martin Weber, the spirit is the best aspect about Formula Student: "Ultimately, your placing is irrelevant. What's important is acquiring experience and knowledge and building up a network. What particularly makes the competition stand out is that the teams help one another – from the design engineering phase to the event itself." In what is now often perceived as a dog-eat-dog society, continues Martin Weber, it is refreshing that all of the teams at Formula Student act on an equal footing.

According to Martin Weber, the most important aspect of Formula Student is knowledge transfer – whether within the teams themselves, in international exchange with other students or also through the judges. "That's why it's important to me to take the time and go to visit the individual teams after the judging. I then give them more detailed feedback and explain how their assessment, even if it is not quite so good, has come about. They are always very grateful for that because it gives them the opportunity to become better."

The Hockenheimring time and again

Be it the Combustion, Electric or Driverless category – all three of the IAV judges agree on one thing: that they most certainly want to partake again. "I wish I had known about Formula Student while I was studying", says Dominik Kufer. "It's fantastic how the students can prepare for their later working lives thanks to the event. They acquire a vast amount of knowledge and experience. That's very impressive and also invaluable." René Hahn, Dominik Kufer, and Martin Weber took away very positive impressions from this year's Formula Student Germany. Thanks to their commitment, they themselves almost certainly had a positive impact on the students as well.

Contact:
rene.hahn@iav.de
dominik.kufer@iav.de
martin.weber@iav.de

René Hahn (left), judge in the Electric category

Back to the Future 4.0

IAV reconstructs historic Horch transmission from 1904

IAV has reconstructed the transmission for the historic Horch 14/17 PS from 1904 at its Development Center in Chemnitz/Stollberg. Old brochures, diagrams, and photos of the individual parts formed the basis for this reproduction. The transmission was handed over to the support club of the Horch Museum in Zwickau. The support club will now use it to complete the Horch 14/17 PS. Once finished, the vehicle will be on show as a new exhibit in running order in the permanent exhibition at the August Horch Museum.

A drivable exhibit of the Horch 14/17 PS will soon be on show in the permanent exhibition at the Horch Museum in Zwickau.

"Our expertise and experience in transmission development proved crucial in reconstructing the Horch transmission," says Dr. Andreas Schild, Powertrain Development Division Team Manager at IAV and head of the voluntary restoration project. "All we had at our disposal to reproduce the Horch transmission was old brochures, diagrams, and photos of the individual parts."

No technical design engineering or production documents were available any longer due to destruction during the war and the inadequate archiving of the remaining documents. In addition, vehicle construction was in its infancy at the beginning of the 20th century and was unfamiliar with standards such as those that are the norm today. Each manufacturer developed and produced vehicle components as it saw fit. Without the originals of the production drawings, reproducing vehicle components from this period is thus tantamount to pure detective work – this is also true of the Horch transmission.


The IAV engineers reconstructed the transmission from the Horch 14/17 PS from 1904 on the basis of old brochures, diagrams, and photos of the individual parts.

Reconstruction of the transmission for the Horch 14/17 PS therefore started with in-depth research. From Horch catalogs dating from 1904, the IAV engineers discovered that the vehicle was fitted as standard with a three-speed transmission – according to the standards at that time, this was ultra-modern, particularly due to the direct drive with a stationary countershaft. The new chromium-nickel steel and the cutting-edge technology of a ball bearing in a sand-cast aluminum housing were additionally used.

The particular challenge was to design the functional transmission reproduction as authentically as possible although the technologies, the knowledge, and the manufacturing processes from that era are in no way comparable with their modern counterparts. "We are proud that we have reconstructed the transmission for the Horch 14/17 PS and that we can now hand it over to the Horch Museum support club. The development of transmissions, engines, and other powertrain components has been one of IAV's core competences for over 35 years. On the road to CO_2-neutral mobility in 2050, we use this knowledge each and every day in our development projects. With the Horch project, IAV know-how is now found not only in the powertrains of the future but also in those of the past," says Dr. Andreas Schild.

Contact:
andreas.schild@iav.de
www.horch-museum.de

IAV Live and in Color!

IAV has a new website that has quite a lot to offer!

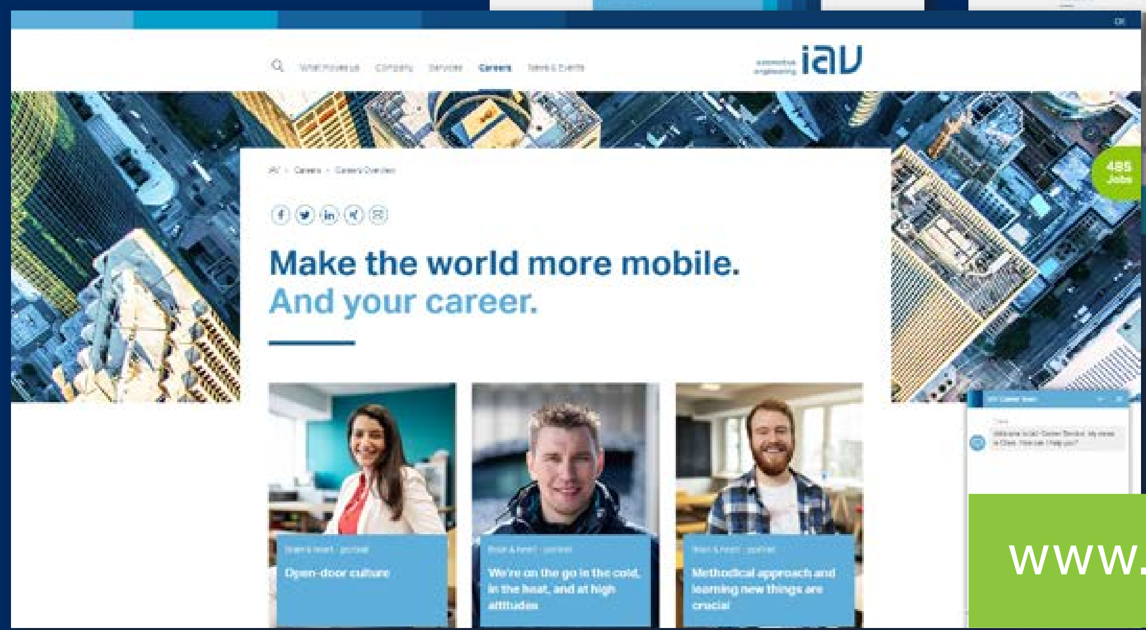
Technical eye-catchers:
IAV innovations and expertise are portrayed in exciting videos and close to the action.

Real people:
Each technical story is linked to a video portrait that presents the people behind our topics and shows the exciting tasks our skilled, creative colleagues deal with on a daily basis.

What moves us:
We focus on the most important current topics and invite you to browse through appropriately networked stories, articles, messages, and events.

Career:
Applicants can take a look behind the scenes at IAV and use the chatbot to quickly and easily ask their most burning questions.

Focus on user experience:
Visitors can obtain information with ease or read through the stories at leisure. All pages have been optimized for mobile devices.



www.iav.com

Our Engineering – What We Develop Moves You

Passenger cars and vans

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

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

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

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

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

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

Hybrid
- Components
- Energy management
- Integration

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

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

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

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

Product Life Cycle
- Aftersales
- Quality assurance

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

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

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

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

Commercial Vehicles and Work Machines

Chassis
- Brakes and retarder
- Chassis

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

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

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

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

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

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

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

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

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

Energy Supply

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

Methods and Test Facilities

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

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

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

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

Quality Management

Product Solutions

- Electronic systems and components
- Development tools
- Vehicle retrofitting

Digitization

- Competency development
- Business models
- Solutions
- Change management

We look forward to hearing from you!
IAV GmbH
Carnotstraße 1, 10587 Berlin
GERMANY
Phone +49 30 3997-80
Fax +49 30 3997-89444

Find out more about our unique breadth of expertise and contact us at: www.iav.com

Our Product Range

Please send us your enquiry to: engineering-tools@iav.com

INCA-FLOW
Guided Calibration and Automation

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

IAV Kasai
Model-Based Calibration

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

IAV Flexmore
List comparison, processing and analysis

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

IAV Barito
Calibration of Battery Models

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

IAV Teslin
Efficient and automated reporting

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

IAV Mara
Automated Measurement Data Analysis

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

IAV Engine
Dimensioning and Optimizing Engine Mechanics

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

IAV Macara
Processing, Validating and Visualizing Calibration Parameters

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

IAV Dragoon
Universal Control Unit

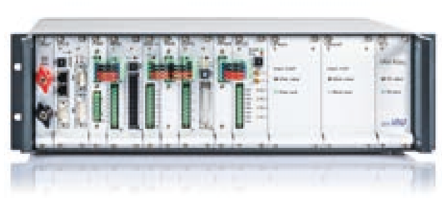
IAV Dragoon connects vehicles with the Internet of Things and modern driver assist systems. It is a scalable control unit for prototypes and small-scale production in the passenger car and commercial vehicle sector.

IAV Cross
Injection Analyzer

IAV Cross is a powerful system for hydraulic measurement of injection valves. It is used when there is a need for differentiated investigations of injection procedures.

IAV Primero
Lambda Sensor Fault Simulator

IAV Primero supports the entire OBD development process: algorithm development, calibration, vehicle homologation (OBD demo).



IAV Kivu
Flexible Engine Control

IAV Kivu is a flexible control unit with versatile configuration options for developing new combustion methods and injection components.

IAV Meru
Indication System

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

IAV Meru
Knock Indication Systems

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

IAV Vaal
Simulation System for Valve Trains

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

Product by IAV

IAV diary: let's meet?

January

January 7–10, 2020
CES (Consumer Electronics Show)
Las Vegas, USA

February

February 11–13, 2020
E-World Energy & Water
Essen, Germany

February 19–20, 2020
Hybrid and Electric Vehicles Symposium
Gifhorn, Germany

February 25–27, 2020
Embedded World 2020 Exhibition & Conference
Nuremberg, Germany

March

March 3–4, 2020
Automotive Software Strategies
Munich, Germany

March 16–19, 2020
TWENTY2X
Hannover, Germany

March 17–18, 2020
20th Stuttgart International Symposium
Stuttgart, Germany

March 23–24, 2020
Future Mobility Summit
Berlin, Germany

March 31–1 April, 2020
6th International ATZ Conference Automated Driving
Wiesbaden, Germany

April

April 22–23, 2020
SAE Transmission Symposium China
Bejing, China

April 22–23, 2020
41st International Vienna Motor Symposium
Vienna, Austria

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