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dSPACE MAGAZINE

2/2020

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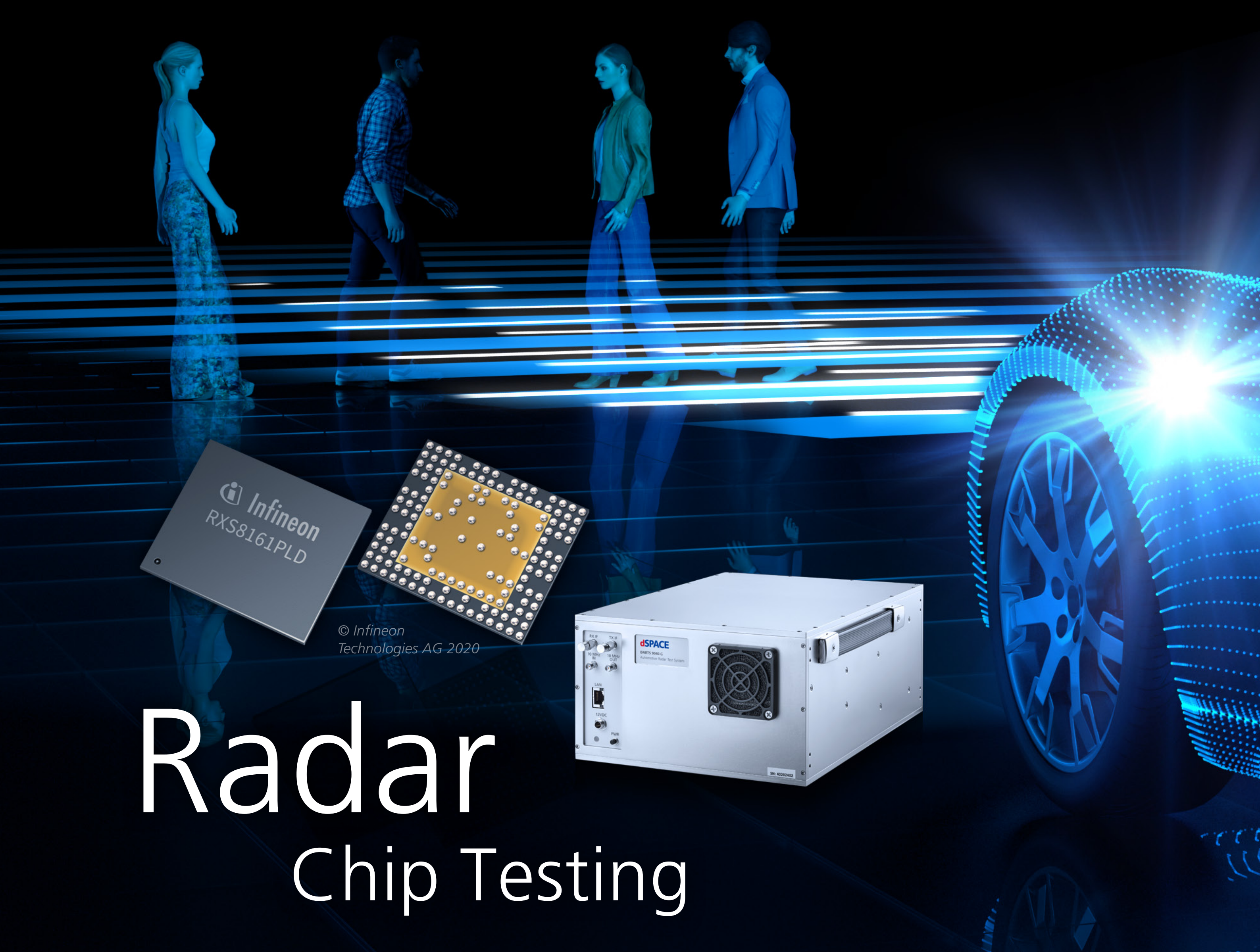
HELLA – Automated Validation for Safe Autonomous Driving | Page 28

> "We rely on the dSPACE Automotive Radar Test System (DARTS) to verify the increasingly feature-rich, high-bandwidth radar chips. The highly accurate simulation of multiple targets allows us to determine the quality and performance of the chips early and easily in the lab."
>
> *Dr. Patrick Alexander Hölzl, Infineon Technologies*



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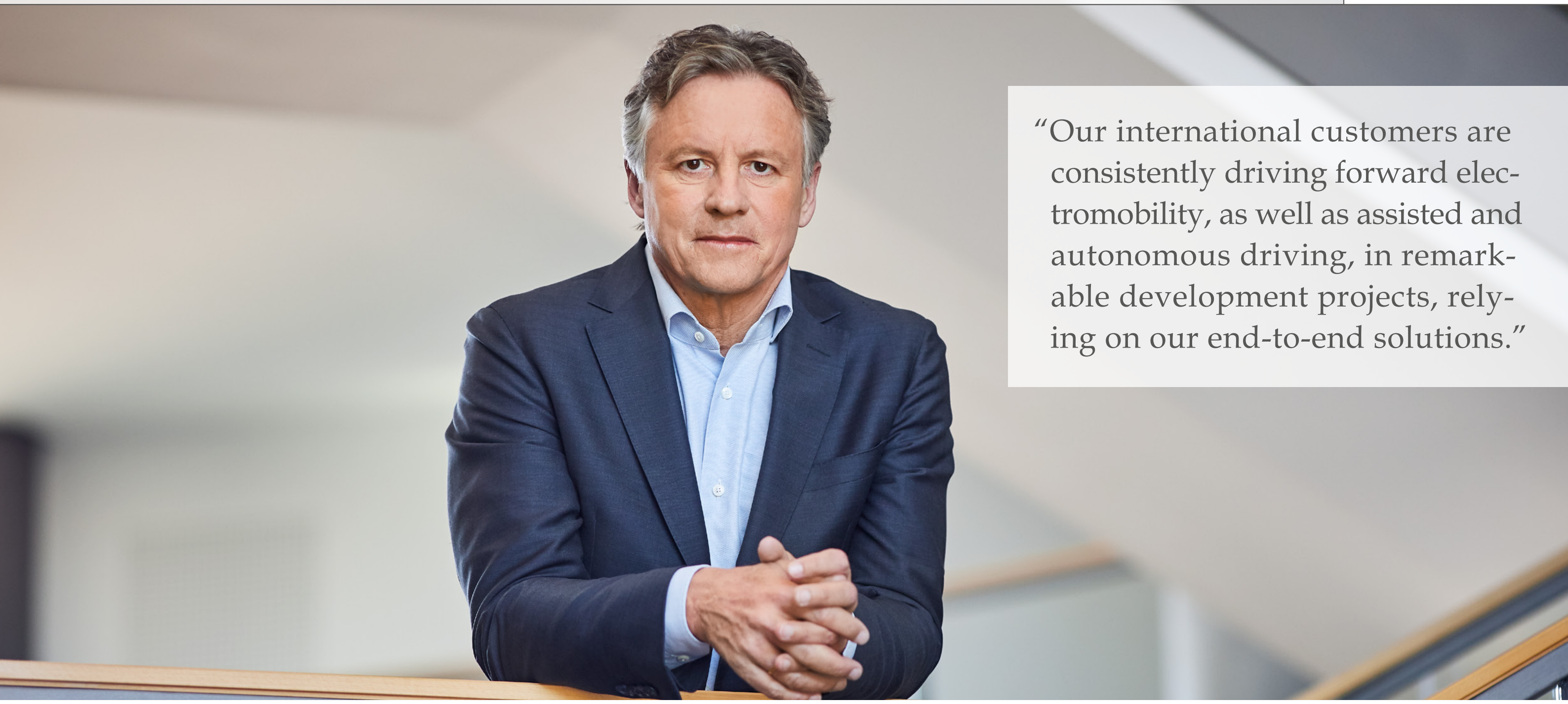
Radar
Chip Testing

To be able to drive more safely than humans, autonomous vehicles must first be able to see more clearly than humans. Radar sensors are the key to building reliable visual capabilities because they can see clearly at night and during the day, in sunlight and rain, and potentially around obstacles. To design radar chips efficiently, performance testing at a very early stage in the laboratory is a must. Therefore, the simulation of radar targets plays a crucial role in the development and verification process of radar chips. In this context, radar target simulators (RTS) have proven to be flexible and reliable. They work according to the over-the-air principle: The real chip is stimulated with radar waves in real time during operation. This means that the RTS receives the wave from a radar chip or sensor, imprints a target internally, and sends the modified radar wave back to the chip or sensor. This allows for operating and testing both the chip and the radar sensor exactly as in a real environment.



"Our international customers are consistently driving forward electromobility, as well as assisted and autonomous driving, in remarkable development projects, relying on our end-to-end solutions."

Dear Readers,

Making complexity manageable and creating new ecosystems are the major challenges in current development projects for electromobility, as well as assisted and autonomous driving.
Electromobility is not only about new vehicle technology, such as batteries or power electronics, but also about redefining the infrastructure, information systems, servicing and maintenance. In the field of autonomous driving, the challenge is to use scalable, AI- and cloud-based technologies in various scenarios to simulate and validate individual components and the complex overall system. This minimizes risk during homologation, when a vehicle is approved for the road.
dSPACE offers the required end-to-end solution portfolio for model- and data-based development. We understand the entire range of application for simulation and validation, up to homologation, and support it with our software and hardware portfolio. To reliably provide our services worldwide, we are collaborating with strong partners in fields such as engineering and cloud computing.
An important related topic is sensor technology. dSPACE has unveiled a new radar target simulator, DARTS 9040-G, which is the first such simulator in the industry to operate at a bandwidth of 5 GHz. DARTS 9040-G sets the first important milestone for further development and validation of radar sensors, as Infineon confirms on page 2.
With electromobility on the rise, an exciting market of the future is emerging very dynamically. While still on a low level, sales of electric vehicles in 2019 climbed by 40% compared to 2018 to 2.1 million passenger cars, opposing the general trend, according to the International Energy Agency (IEA). Electric cars thus accounted for 2.6% of global car sales, half of which were in China. Today, according to the IEA, China accounts for 3.35 million of the 7.2 million electric vehicles worldwide.
The efforts of the automotive industry are also reflected in many development projects in which we partner with our international customers. In this dSPACE Magazine, the supplier JEE, the OEM Great Wall Motors from China, and researchers at the University of Alabama report on how they are pushing electromobility forward by developing charging technology, drive systems and control software. The companies and researchers meet requirements, such as short project turnaround times and high security standards, by using dSPACE end-to-end solutions. This includes our simulation solutions for electrical systems and our production code generator, TargetLink, which is certified for safety-critical applications.
In times of travel and contact restrictions, we have expanded our service for you and set up an easily accessible virtual showroom that is available worldwide. The showroom lets you experience the dSPACE solution portfolio through demos. Simply visit our website and book your individual demo.

www.dspace.com/go/vsr_booking

Wishing you the best of health,

Martin Goetzeler

IMPRINT

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Chassis control tests using a mechatronic test bench

Test Bench in Control

To develop new chassis control strategies, Brilliance has built a laboratory setup that consists of a combination of a dSPACE steering and brake system test bench.

During the development and testing of new chassis control strategies, a large number of components must be taken into account. This includes the brake and steering systems, for example, which play an important role among the vehicle safety systems because they contain a number of electrical and electronic components and make the driving status directly accessible for the driver. Therefore, Brilliance has set up a development environment for functions for chassis control that includes a steering and a brake system test bench from dSPACE. With this setup, Brilliance can perform comprehensive tests to ensure that all functions for chassis control work reliably.

Test Challenges

At Brilliance, the development process is divided into several stages. During each stage, certain hardware and software components are provided by external suppliers. The electronic stability program (ESP) and electric power steering (EPS) systems are also supplied by external sources, and two different ones at that. This is why Brilliance engineers perform both component tests and integration tests to rule out any system inconsistencies. Specific tests were performed, for example, for lane change, slalom, traction control system (TCS), vehicle dynamics control (VDC), antilock braking system (ABS), and hill hold control (HHC).

dSPACE System for Managing Test Variety

The dSPACE system was purchased to save time and reduce the cost of testing while tackling the above-mentioned challenges. In addition, Brilliance also wants to frontload the tests to the early stages of development to detect possible errors as early as possible and thus ultimately increase the technical maturity of the products. In addition, the company wants to easily verify the controllers provided by suppliers via black-box testing, i.e., testing them exactly in the condition in which they are provided to Brilliance. This saves Brilliance the effort of accessing the inner workings of the controllers via interfaces that would first have to be created.

Setup of the Test Bench

The dSPACE SCALEXIO simulator, which provides the required processor power, input and output interfaces, and signal conditioning, is used to control the test bench motors (figure 2). The simulator also records all measurement data. The experiment and instrumentation software dSPACE ControlDesk is used to control the >>

Did you know? dSPACE offers test benches for a wide range of applications, such as steering, brakes, radar, electrics, and test benches with motion platforms.

Figure 1: Launched in June 2018, the Brilliance V7 SUV was the first vehicle that Brilliance developed using the dSPACE test bench. More models are already in development.

Picture credit: © Brilliance

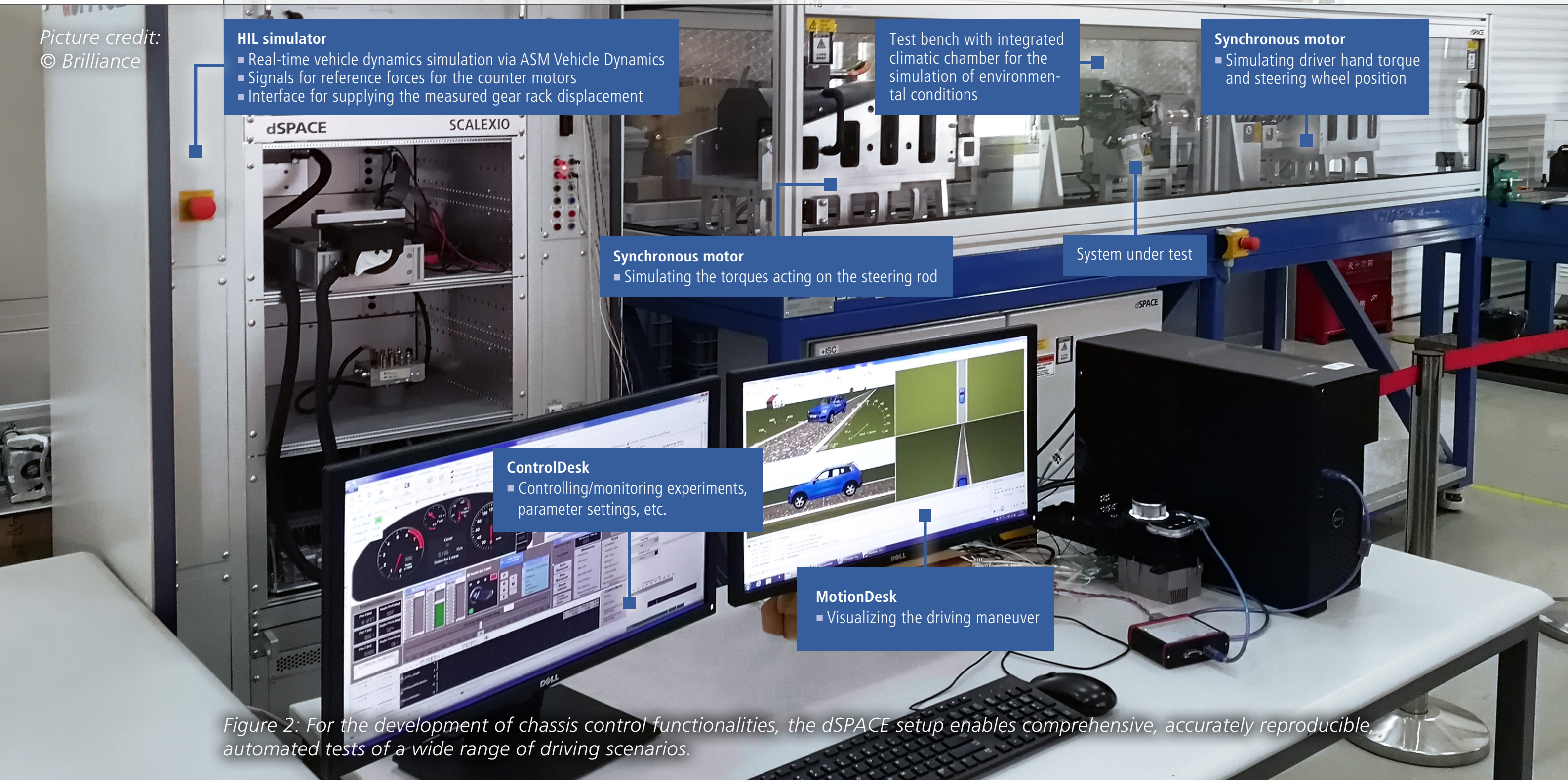


Figure 2: For the development of chassis control functionalities, the dSPACE setup enables comprehensive, accurately reproducible, automated tests of a wide range of driving scenarios.

> "Our engineers were able to use the dSPACE test bench very productively for a wide range of chassis control tests."
>
> *Chenggang Shen, Brilliance*

entire test bench for setting, monitoring, and graphically displaying parameters, for example. The dSPACE test automation software dSPACE AutomationDesk also plays an important role for testing, because it can be used to automate all test sequences, even for overnight tests. Vehicle dynamics are simulated in real time using the dSPACE Automotive Simulation Models (ASM) tool suite. The graphical user interface of dSPACE ModelDesk is used for convenient parameterization of the vehicle models. Using this development environment, the engineers at Brilliance have created dozens of driving maneuvers and road courses

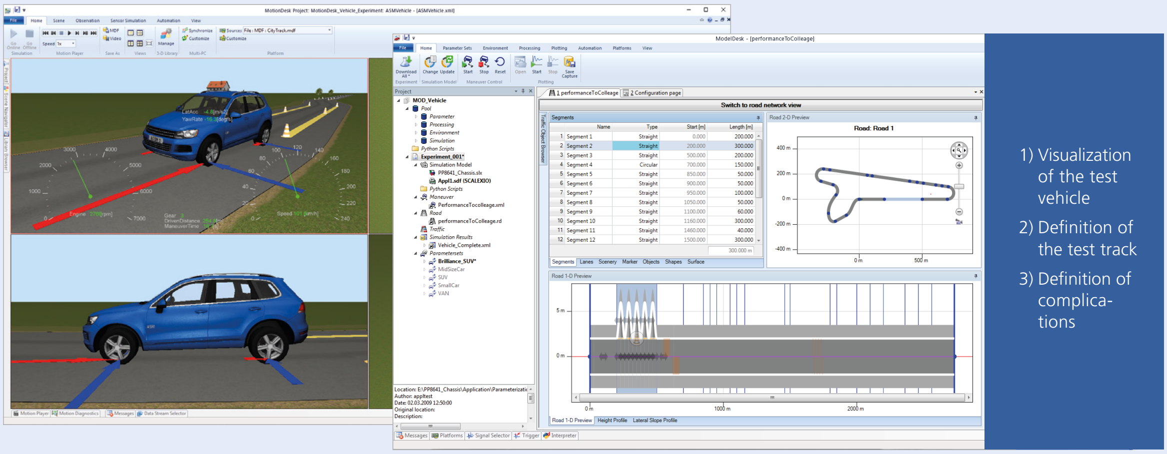
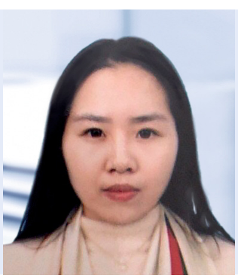


Figure 3: On the left is a typical 3-D animation with MotionDesk, and on the right is the ModelDesk user interface for parameterizing the road tests.

About Brilliance

Brilliance China Automotive Holdings Ltd. is an investment holding company that consists of two business areas: Manufacture and sales of minibuses and automotive components as well as manufacture and sales of BMW vehicles. The company's most important operating subsidiary in China is Shenyang Brilliance Jinbei Automobile Co, Ltd, which accounts for around 90% of sales. The company is also involved in constructing and converting minibuses and limousines as well as providing financing services through its subsidiaries.



"We are very satisfied with the dSPACE test bench. We were able to achieve our quality goals with this powerful test system."

Yiqi Zhao, Brilliance

for their experiments. The 3-D animation software dSPACE MotionDesk displays all test drives, allowing for a rapid evaluation and modification of the driving maneuvers.

Testing Critical Driving Situations

A great strength of the dSPACE system is its ability to perform tests under clearly defined and reproducible conditions in the laboratory as if they were executed with a vehicle on the road. This work method allows for an exact analysis of very special and critical driving situations, the reproducible execution of which is either dangerous or even impossible in road tests in most cases. In addition, the engineers can insert specific errors on the test bench, for example, to simulate a technical defect in components to analyze and optimize the system response. In summary, the company is able to achieve a very high level of test coverage before a prototype vehicle has undergone its first test drive. The various possibilities of the test bench make tests much easier and at the same time very efficient.

Quick Familiarization

In addition to the ease of use and time saved by the dSPACE system in completing the many tasks involved in tests, another outstanding feature is the short familiarization period. The Brilliance engineers required the support of dSPACE staff only during the initial phase. After only a few weeks, the engineers at Brilliance were able to use the system to work independently and extremely productively on various projects.

More Projects Planned

The dSPACE landscape for chassis control development based on the dSPACE steering test bench and various dSPACE software tools has been in use at Brilliance for some time, and has been very helpful in testing the Brilliance V7 SUV (figure 1) as well as launching it on the market in June 2018. Based on the positive experience, the dSPACE development environment is already being used for other projects, and various enhancements are also planned.

Chenggang Shen, Yiqi Zhao, Yancheng Zhang, Brilliance

Yancheng Zhang, Brilliance

High Voltage, Low Risk

Flexible HIL simulation based on a combination of FPGA and CPU makes motors more efficient and their development safer

Modern electric drives combine high power with perfect control, down to the microsecond. In the development of today's drives, manufacturers depend on efficient platforms that release these high powers while ensuring operational reliability. To achieve this, JEE uses hardware-in-the-loop (HIL) testing with powerful software modeling and SCALEXIO hardware from dSPACE.

Picture credit: © JEE

> "The open dSPACE model libraries were of great importance for the project. The use of the ASM and XSG libraries allowed us to carry out measurements under laboratory conditions, which would have posed an enormous challenge on a real test bench."
>
> *Ying Jiang, JEE*

As China's leading supplier of electric drive systems, JEE advances developments in different fields. These range from individual components to highly integrated solutions that consist of electric motor, converter, and reduction gear. In addition to purely battery-electric systems for industrial vehicles and passenger cars, the focus is also on e-drive systems for plug-in hybrid vehicles (PHEV). According to the ISO 26262 standard, the functional safety of the motor control system must be guaranteed as well. To ensure the required safety and achieve the highest possible efficiency at the development level, JEE adopted dSPACE HIL systems in early development phases for software safety tests and validation on the target hardware.

Multistage Control

The typical setup of a motor control system consists of a controller and a power module (figure 1). This powerful system calculates algorithms and converts control signals into three-phase high voltage to drive the electric motor. The torque generated by the motor is transmitted to the drivetrain.

Validation System and Design

To validate the motor ECU, dSPACE provided JEE with a customized HIL simulation system designed for simulation at the signal level. This means that the actual controller of the ECU is connected to the HIL simulator bypassing the power stages, and only the relevant signals are fed in. The advantage of this process is that the controller can be fully validated without the need to generate the real currents and voltages under laboratory conditions. This not only reduces cost and resource consumption, but is also particularly advantageous for occupational safety, as possible risks from potentially dangerous voltages and currents can be avoided in the test phase.

Models of the HIL Simulator

In this HIL system, the model topology is as follows: The simulation model includes an inverter model, motor model, battery model, and the mechanical model (figure 2). The high dynamics as well as the control properties of the inverter and motor model require high simulation and computation speeds. To meet this requirement, simulation algorithms must be >>

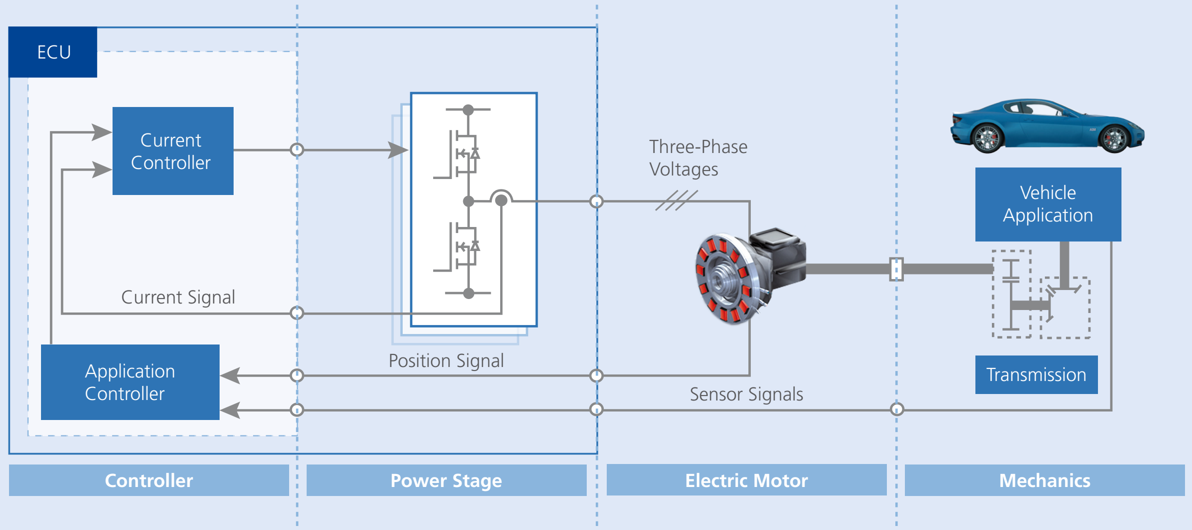


Figure 1: Setup of the motor control.

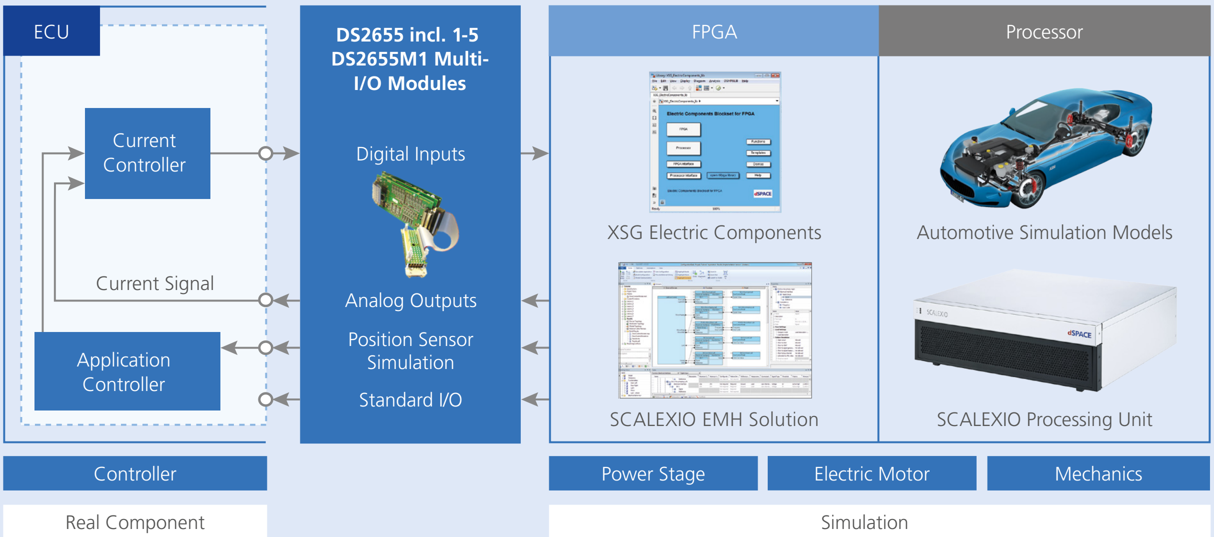


Figure 2: Structure of the HIL model.

implemented via field programmable gate array (FPGA) chips. The structure of the JEE simulation is therefore divided accordingly (figure 3): The FPGA part contains models that require fast computation – inverters, motors, and resolvers – while the main processor part contains the less time-critical models, such as the load model.

Open Models Facilitate Adaptation

The software models from the dSPACE XSG Electric Components Library and ASM Electric Components also play a central role. JEE uses the open dSPACE ASM libraries, which simulate entire vehicles or parts, such as asynchronous motors and controllers. JEE also uses the XSG Electric Components Library, which customers can use in conjunction with dSPACE Engineering Services to develop new models. JEE revised the existing asynchronous motor model to develop the controller for an asynchronous motor from it. The modification also made it possible to carry out measurements that were of decisive importance for the success of the overall project, because performing the corresponding tests on a

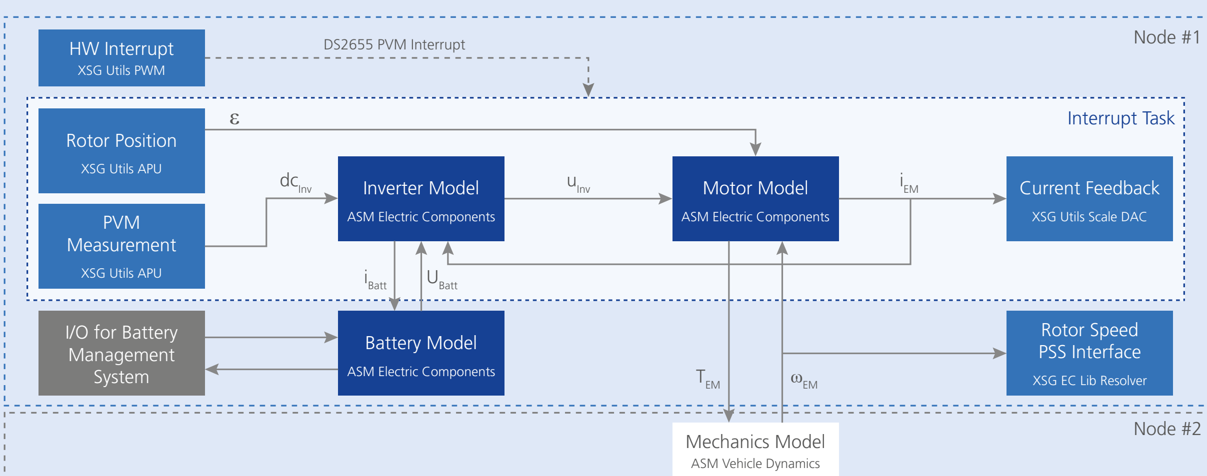


Figure 3: Model topology.

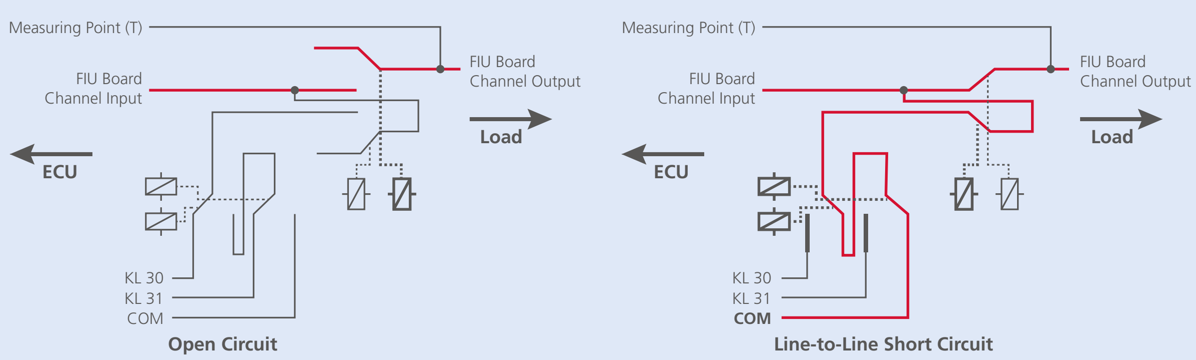


Figure 4: Diagram of the Failure Insertion Unit (FIU).

"By using dSPACE HIL systems early on, both the efficiency of the entire development process and work safety were significantly increased."

Ci Zhang, JEE

real test bench, which would be the alternative approach, would entail considerable challenges.

Functional Safety

During the development and testing of the motor control system's functional safety, JEE simulates various faults on the HIL system to test the control strategies for fault diagnosis and fault handling in the control system. The fault diagnosis unit of the Failure Insertion Unit (FIU) in the dSPACE HIL system is mainly used for the ECU wiring harness to test possible faults in the wiring harness, such as short circuits to ground or potential, or between pins, as well as voltage drops. This task is performed by the host PC, which controls the corresponding hardware modules via an RS232 interface. The Failure Insertion Units of dSPACE HIL systems enable JEE to conveniently implement safety-relevant function tests and fault injection (figure 4). Due to the flexible real-time restbus simulation, this can be done even with incomplete systems. Furthermore, test cases are reproducible and the development cycle can be accelerated.

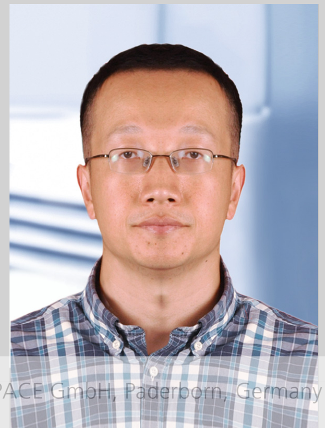
Test Automation

An important part of HIL tests is test automation. Test automation focuses on the execution of automated, repeatable tests and commissioning based on predefined automation sequences. Under the guidance of dSPACE engineers and with the help of the Python API library in dSPACE ControlDesk, test cases can be programmed to perform more complex test routines. JEE built the HIL test automation platform and created a HIL test case database for various projects, which significantly improved the development efficiency and reusability of test cases.

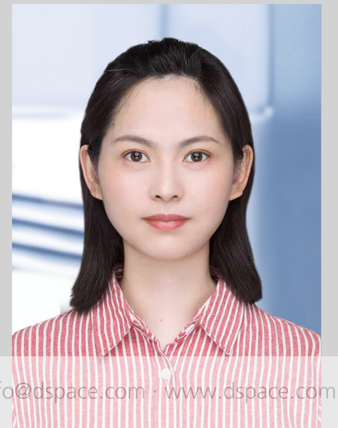
Results

The extensive use of dSPACE HIL systems from the early development stages to the test phase has significantly accelerated the JEE motor control project. In addition to an efficient increase in the technical maturity level, the operating times on the real test bench were reduced. The HIL system thus improved occupational safety while reducing the necessary resources. ▪

Ci Zhang
Ci Zhang is R&D supervisor at JEE in Hefei, China.



Ying Jiang
Ying Jiang is Senior System Engineer at JEE in Hefei, China.



Purely Electric

ZFL and Sikorsky are developing new electrical rotor control technology

ZF Luftfahrttechnik (ZFL) and Sikorsky have teamed up to develop a new electrical rotor control system (LIBRAS™) that provides primary flight control and individual blade control for vibration and noise reduction, power savings, and additional performance enhancements for helicopters in a single system. A dSPACE system is being used to read and process sensor data from the rotor head and control the system to help identify and optimize control functions.

The 80 x 40 ft. test section of the National Full-Scale Aerodynamic Complex (NFAC), where the wind tunnel test will take place.

Picture credit: © NASA

In 1939, the world got a glimpse of the first successful helicopter flight. The VS-300 was conceived by aviation pioneer Igor Sikorsky. It featured a single engine and a three-blade rotor designed with a variable pitch to capture the air flow and enable the helicopter to rise vertically into the air and fly. Since then, the basic configuration of the classical helicopter has not changed by much. Helicopters still rely upon bladed rotors to help them take off, land, hover, and fly forward and backward, and still have combustion engines for power. As helicopters became larger and heavier, hydraulic control systems were integrated to help pilots manage flight movements. But in this era of electrification, the helicopter is primed for significant transformation.

Shifting from Hydraulic to Electrical Solutions

While today's helicopter control systems still use hydraulic servos to move the aerodynamic surfaces, the interest is shifting to electrical solutions. But before a fully electric helicopter can be achieved, proof is needed to show that hydraulic components can effectively be replaced by electrical systems. International helicopter components supplier ZF Luftfahrttechnik (ZFL) and aircraft manufacturer Sikorsky (a Lockheed Martin company) see the possibilities and are collaborating, along with support from the German and US governments, to develop a new rotor control technology based upon a purely electric blade control system for a high-speed rotor system. The eLectrIcal Blade Root Actuation System (LIBRAS™) would replace the hydraulic components that currently regulate flight control, and could bring forth numerous added benefits. "The new Individual Blade Control (IBC) system we are designing and testing in this program is an innovative way to control the helicopter and may offer many benefits by being able to individually control each rotor blade >>

Figure 1: Sikorsky S-92 rotor head with a traditional control system. Hydraulic servos (not visible) are located below the swashplate.

via its own electric actuator," said Chris Sutton, Flight Sciences Technology Lead at Sikorsky. "Those benefits are things like reduced noise, better fuel efficiency, and vibration reduction in the cabin that would otherwise cause pilot fatigue, annoy passengers, and wear out components in the aircraft."

Controlling Blade Pitch – The Conventional Way

In a traditional helicopter design, the blade pitch of a rotor determines how the aircraft will lift and fly. Changes in airspeed and the rate of climb or descent are all regulated by the angle of the rotor blades. The greater the pitch, the greater the air flow. The blade pitch is mechanically controlled by a swashplate device connected to the helicopter's flight control system (figure 1). The flight control system sends inputs to hydraulic servos, which in turn command the swashplate to move and adjust the angle of the rotor blades via pushrods as they travel in a circular path around the rotor shaft.

While the swashplate device allows the pilot to move the helicopter in any direction, its design has kinematic restrictions. Because the swashplate is installed in the non-rotating fixed frame, the blade pitch motion is limited to one cycle per rotor revolution, making it far from optimal. ZFL and Sikorsky are developing Individual Blade Control (IBC) technology as a means of achieving a more efficient and optimized rotor design. This technology uses blade-individual actuators, one dedicated to each blade, that allow for both higher-frequency (usually harmonic) pitch variations and the once-per-revolution primary control combined within a single system. "The IBC system, in combination with being able to provide different inputs to each blade, can also apply what we call 'higher harmonic control,'" Sutton explained. "Traditional control systems can only apply steady and once-per-revolution control inputs to the rotor head. This just means that each blade pitches up and down once each time it makes a revolution. With higher harmonic control, the blades can be pitched two or more times as they travel one revolution. This higher harmonic control and individual blade control are what make things like vibration reduction and better efficiency possible with IBC, if you know how to apply them."

Individual Blade Control (IBC) Technology

For many years, ZFL has pioneered the concept of IBC. In fact, several systems have been developed and successfully demonstrated during various wind tunnel and flight test campaigns. In flight tests using IBC technology, fuselage vibrations have been reduced by up to 90%, the radiated noise has been attenuated by 3 to 9 dB, and the rotor power requirement was consistently reduced by more than 5%. Moreover, such active systems enable in-flight rotor track and balancing to compensate for blade-to-blade dissimilarity and inherently provide reconfiguration capabilities to potentially compensate for dangerous foreign object damage (FOD) effects. ZFL has started to develop novel rotor control systems, which are based on multiple redundant electromechanical high-performance actuators. In the architectural design of this system, not only are all hydraulic elements replaced (no push rods, no swashplate, no hydraulic boosters), but all mechanical control linkages, from the fuselage to the rotor blades, are eliminated as well (figure 2). With the swashplate removed, an IBC system can achieve full functionality, and the aforementioned benefits (vibration and noise reduction, power savings, and performance enhancements) can be achieved. Moreover, when the com-

"The dSPACE system is central to the task of achieving targeted objectives for our electrical rotor control system."

Chris Sutton, Flight Sciences Technology Lead, Sikorsky plete hydraulic system is removed, there is an added safety benefit – the hot, pressurized, and flammable oil required for hydraulics to function no longer has to be onboard the aircraft.

Matching the Power of Hydraulic Actuators

While IBC technology and its electrical counterparts can offer many benefits, more work has to be done to match the very high power densities of hydraulic actuators. To achieve a competitive system weight, a completely new control system topology must be leveraged. Specifically, the primary control and the IBC functionalities have to be combined into a single system. This kind of design could provide the same level of reliability required for the primary control system, enabling use for safety-critical active control applications, such as ground resonance suppression. Moreover, it is conceivable that local failures from a single blade (be it the blade pitch actuator or the blade itself) could be compensated for through suitable reconfiguration of the control inputs applied to the remaining blades. Sutton noted that respective simulations have supported this concept, but it has yet to be tested with hardware in a relevant environment.

Validating the Concept

To validate the feasibility of the IBC design concept, Sikorsky and ZFL have partnered to set up a technology demonstration that tests full-scale hardware under realistic operating conditions. Sikorsky has defined all relevant high-level system requirements for the mechanical and primary control performance, operating loads, electrical interfaces, and IBC performance. Simulations have been conducted to estimate the required IBC authority at the respective higher harmonic frequencies. Expectations are that IBC technology will not only be suitable for established applications like vibration and noise reduction, but also for different and innovative capabilities that relate to the unique characteristics of the co-axial rigid rotor (optimizing lift offset and/or enabling smaller inter-rotor spacing).

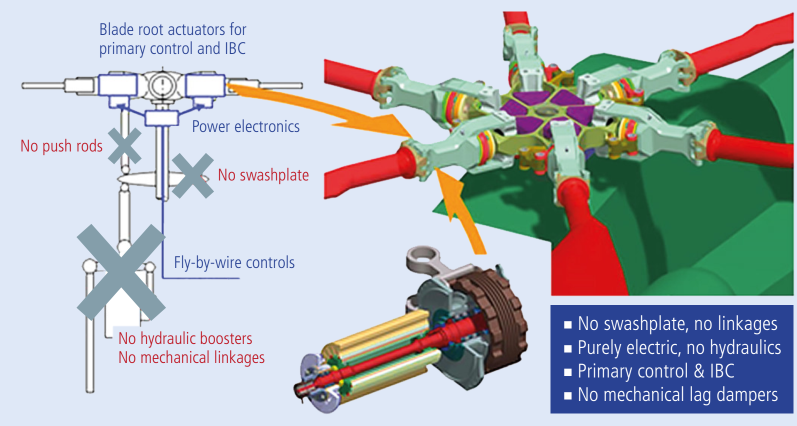


Figure 2: Approach for an electrical rotor control system without a swashplate.

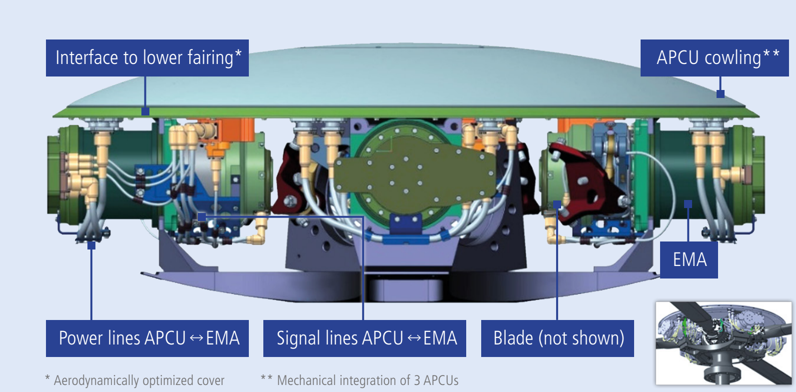
System Architecture

On the basis of the identified system requirements, ZFL has synthesized a system concept and harmonized it with Sikorsky. The high-level system architecture features a LIBRAS™ rotor hub (figure 3), containing the electromechanical actuators (EMAs) along with the power and control electronics, called the Actuator Power Control Unit (APCU). Most of the ZFL components reside in the rotating frame and are shown in red, green, and blue color in the system architecture diagram (figure 4). The hardware and software elements for the control and supply functions are primarily located in the non-rotating frame (blue). The overarching triple-redundant architecture is easily recognized (shown in red, blue, and green, one color for each 'lane' of the triple-redundant system) and carried through from the power supply to the electromechanical actuator and its sensors. The main components of the system architecture are summarized below:

Rotating frame components:

- 4x electromechanical actuator (EMA)
- 3x Actuator Power Control Unit (APCU) (to process the incoming >>

Figure 3: A CAD model of the LIBRAS™ rotor design.



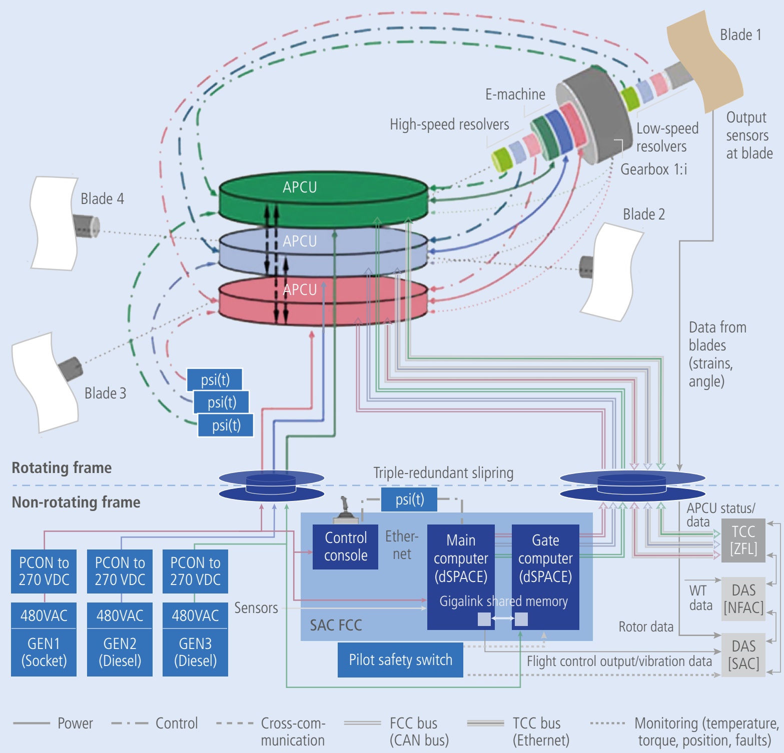


Figure 4: High-level system architecture and control/monitoring periphery setup.

command signals, to control the power electronics, to provide position control for the actuators, and to monitor compliance with the various limits [currents, torques, temperatures, etc.])

- 3x rotor azimuth sensors (required to provide a reliable reference of the actual rotor position)
- Data acquisition systems (DAS) to receive sensor signals and monitor blade loads and other safety-relevant flight parameters

Non-rotating frame components:

- 1x flight control computer (FCC) consisting of:
- Pilot Control Console (provides primary control operator input)
- Higher Harmonic Controller (a dSPACE system synthesizes suitable amplitude and phase values for the higher-harmonic and/or blade-individual components based on entered presets or computed from real-time sensor signals)
- Gate Verification System (a separate dSPACE system that monitors pilot and HHC control inputs against a control range and control rate envelope to inhibit commands which are invalid and/or out of range)

Figure 5: Assembly of the power electronics on the aluminum cowling (left) and the electromechanical actuator (right).

- 1x test control computer (TCC)
- 3x power supply
- Data acquisition systems

Sikorsky and ZFL have built their test platform, which includes an advanced control system. For this test platform, the rotor hub and rotor blade design have been completed and manufactured, along with actuators, power electronics, and power converters. The rotor hub and rotor blades have been integrated with other system components, resulting in a very sophisticated design of both mechanical and electronic parts. Figure 5 shows the custom power and control electronics hardware (APCU) installed into a rotor fairing for cooling and low drag, as well as the custom, highly integrated, highly reliable, and high power density rotor actuator (EMA).

Simulation and Testing

To verify the mechanical design and performance of the electromechanical actuators and software functionalities, Sikorsky and ZFL are conducting simulations and tests at the component level, the subsystem level, and the system level. Various software tests are also being run within a highly automated test environment to verify requirements based on the DO-178 standard. This includes such things as complex sensor data processing, position control, cross-communication, voting, and error handling functionalities of the actuator control unit software. Additionally, thermal simulations were conducted to validate heat distribution under various operational conditions.

dSPACE System Features

ZFL and Sikorsky use dSPACE systems for a variety of applications in this research effort. For example, control and monitoring of all test rigs for component and subsystem testing at ZFL is performed by dSPACE systems. On the Sikorsky side, the dSPACE system features four DS1005 PPC Boards for processing and comput-

Component Level (completed)	Subsystem Level (about to be completed)	System Level (started)
▪ Power supply unit ▪ Power control unit converter ▪ Actuator control unit (initial hardware test) ▪ Actuator control unit (software modul test) ▪ E-motor	▪ Electromechanical actuator ▪ Actuator control unit: hardware-software integration test ▪ Actuator power control unit: functional integration test	▪ LIBRAS system (non-rotating) ▪ LIBRAS system (rotating) ▪ With blade simulator

Picture credit: © Sikorsky

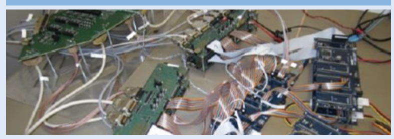
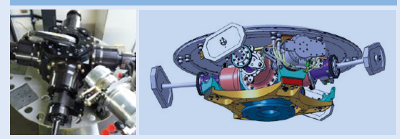




Figure 6: Qualification testing: component, subsystem, and system level.

ing real-time applications, a DS2202 HIL I/O Board for simulating and measuring signals, a DS4002 Timing and Digital /IO Board for generating and capturing digital signals, and a DS2302 Direct Digital Synthesis Board for simulating complex sensor signal waveforms. The dSPACE controller receives sensor data inputs, such as accelerometers and strain gauges on the rotor, processes the data, and then utilizes this information in a control algorithm to identify optimized control inputs. The dSPACE system suggests amplitudes, higher-harmonic phases, and individual blade commands to reduce or change parameters of interest such as vibration, blade loads, or power required. The commands for the pilot controls, along with higher-harmonic and blade-individual controls, are then digitally packaged and sent as a triplex stream by the dSPACE computer to the ZFL IBC system at the rotor head. "The dSPACE system is central to the task of achieving targeted objectives," said Sutton.

Outlook and Future Testing

Upon completing the majority of qualification testing at ZFL in Germany, a full system will be shipped to Sikorsky in the United States in 2020 to begin preparation for the System Integration Lab tests at Sikorsky. The major objectives of the tests are:

1. Verify test article assembly and mechanical integration of the LIBRAS IBC system
2. Verify Sikorsky Flight Control Computer operation (of which the dSPACE system is a main component) in the fully integrated system
3. Validate LIBRAS system operation through a range of rotor speeds and control motions
4. Demonstrate robustness of the triplex system architecture to induced faults
5. Satisfy entrance criteria requirements for the wind tunnel facility (endurance testing, vibration testing, and overspeed testing)

After completion of these tests, wind tunnel testing will take place to demonstrate primary flight control, to quantify the benefits of IBC technology, and to evaluate the IBC design and its implementation challenges. During wind tunnel testing, the dSPACE system will package commands and send them, along with pilot controls, to a human pilot who will use a joystick to fly the model from a control room, adjacent to the wind tunnel. Once the commands are implemented, the controller will read the sensor data to measure what changed and then repeat the process. "In the wind tunnel, we will spend time at a variety of airspeeds and conditions to see how much ability the IBC system has in affecting parameters in a way that could benefit our future helicopter platforms," Sutton said. "If the System Integration Lab and wind tunnel tests go very well, we will consider a follow-on effort involving a flight test in the future – this is the next logical step after a wind tunnel test in our technology development." In the end, Sikorsky and ZFL hope to demonstrate the feasibility of a purely electrical, 'swashplateless' control system that combines both primary and IBC functionalities. ▪

Chris Sutton, Sikorsky

Chris Sutton
Chris Sutton is the Flight Sciences Technology Lead for the Engineering Sciences group at Sikorsky, a Lockheed Martin Company in Stratford, Connecticut, USA.

Great Wall Motors: Electric and hybrid vehicles developed with dSPACE TargetLink

The Versatile Electric

For more than ten years, Great Wall Motors (GWM) has focused on new drive technologies as one of their development paths and operates development and test facilities for electric and hybrid vehicles.
Today, the GWM brand portfolio includes innovative production vehicles such as the Wey P8 plug-in hybrid and the Ora R1 electric car. During development, the company used the production code generator dSPACE TargetLink as well as other tools from the TargetLink Ecosystem.

Picture credit: © Great Wall Motors

Electric and hybrid vehicles and their charging infrastructure have numerous safety-critical functionalities that must be developed in accordance with safety requirements and validated prior to series production. The safety-critical functionalities include battery management to prevent overcharging and overheating, torque control, braking and recuperation, the safety of the electrified steering systems, and charging station management with voltage control. To develop and validate the associated ECU software functions and the generated production code, GWM uses a sophisticated tool environment in which numerous specialized tools are interwoven.

Coordinated Tool Environment

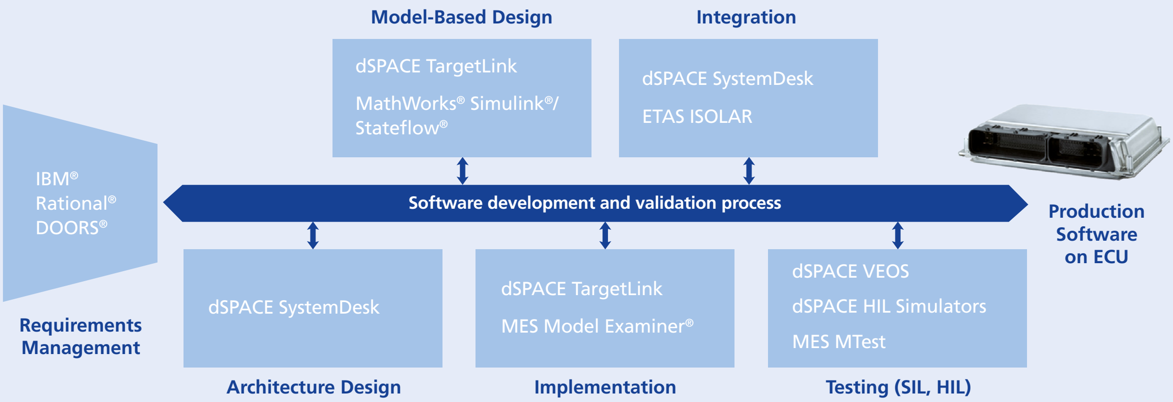
At Great Wall Motors, most of the software for electric and hybrid drives is developed centrally and then integrated into the respective vehicles of the GWM brands. At GWM, work in distributed teams plays a major role. These teams usually consist of up to 20 employees. We use IBM® Rational® DOORS® to manage the complex requirements. We have also used the dSPACE TargetLink production code generator in the New Energy division at GWM since 2015 and have implemented it successfully over ten production projects. The tool has also proved its worth in distributed teams. A special team for functional safety ensures that all safety-relevant requirements are met, including general standards and norms as well as GWM-specific guidelines. Based on Simulink®/Stateflow®, function modeling is now carried out directly in TargetLink. In TargetLink, GWM intensively use the AUTOSAR and simulation functionalities (MIL, SIL) as well as the TargetLink Data Dictionary. We also introduced the dSPACE SystemDesk architecture tool into our work and use it to model and integrate our AUTOSAR architectures. With SystemDesk, we can perform efficient AUTOSAR round trips in TargetLink. Virtual ECUs (V-ECUs) generated in SystemDesk can be tested very early on with the dSPACE VEOS simulation software, long before performing the HIL tests. Compliance with GWM-specific modeling guidelines is checked with the MES Model Examiner®, while MES MTest is used as a test management tool for the requirements-based testing of Simulink® and TargetLink models. After the software is implemented on the ECU, it is validated by means of hardware-in-the-loop (HIL) simulation on dSPACE HIL simulators.

Optimized Production Code

We evaluated the major production code generators and, based on these benchmarks, finally decided

>>

> "From the very beginning, we were extremely pleased with TargetLink because of the high quality and efficiency of the generated code, its excellent readability, and the tool stability in continuous operation and interaction with other tools."
>
> *Xuechen Zang, Great Wall Motors*



Using dSPACE TargetLink, tools from the TargetLink Ecosystem, and other tools, GWM is developing and validating software for electric and hybrid vehicles.

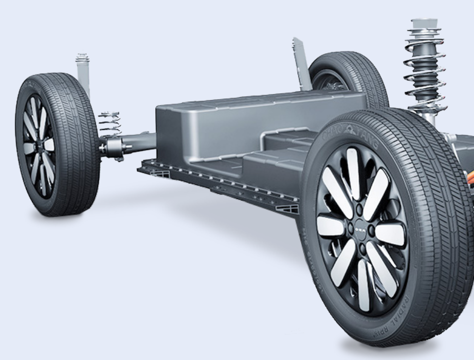
on dSPACE TargetLink in March 2015, because TargetLink proved to be particularly powerful and ideal for our requirements. Since then, TargetLink has been an integral part of our development process. Thanks to the quick start-up assistance from our dSPACE contacts, we were able to set up the relevant process very quickly and start productive work with the new tool after only a short time. Today, we use TargetLink for almost all components of the ECU application software. From the very beginning, we were extremely pleased with the high quality and efficiency of the generated code, its excellent readability, and the stability of TargetLink in continuous operation and interaction with the other tools. The TargetLink Data Dictionary, which we use in all our projects, has proven to be very practical. For example, we use the TargetLink Data Dictionary to manage interface, measurement, and calibration variables, and also use it to generate variable descriptions in A2L format. The TargetLink API allows us to use our own scripts to accompany the process, for example, to handle library functions and add information during A2L generation.

Validated Software in Series Use

Our Wey P8 series vehicle, a plug-in hybrid with four-wheel drive, and the Ora R1 electric car launched at the end of 2018, which is specially designed for city traffic, are examples of software developed and validated with the above-mentioned tool environment in series production. In addition to the fuel efficiency and emission reduction of a hybrid drive, the Wey P8 offers plenty of driving pleasure by combining an all-wheel drive with an alternative combustion/electric drive. The Ora models all use the same intelligent New Energy Platform (hardware/software), from which numerous model variants can be derived. It is the first exclusive platform for electric vehicles from China.

Outlook

We plan to develop even more software in-house in the future, for which we will continue to use TargetLink and the tool environment described above. AUTOSAR and the devel-

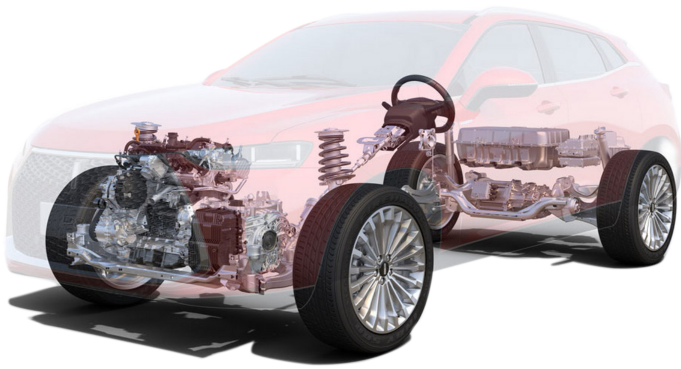


Runs on electricity: Ora R1.

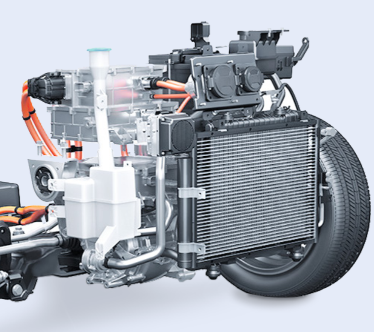
Top and right: The powerful plug-in hybrid Wey P8.

opment of safety-critical functionalities will play an even greater role in the future. Specifically for this, TargetLink offers the right prerequisites, such as direct, native support of the AUTOSAR standard and certification for software development according to ISO 26262, ISO 25119, and IEC 61508. ■

Xuechen Zang, Hangdi Yao, Great Wall Motors

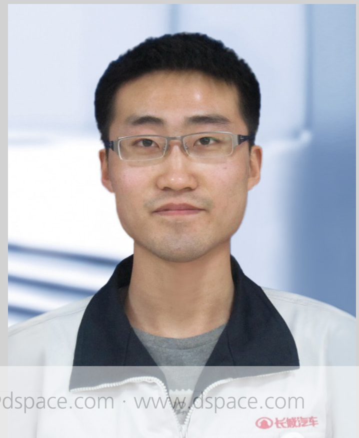


> "TargetLink makes it easy for us to develop safety-critical systems thanks to its certification for software development according to ISO 26262, ISO 25119, and IEC 61508."
>
> *Hangdi Yao, Great Wall Motors*



Xuechen Zang
Xuechen Zang is a software development engineer at Great Wall Motors, China.

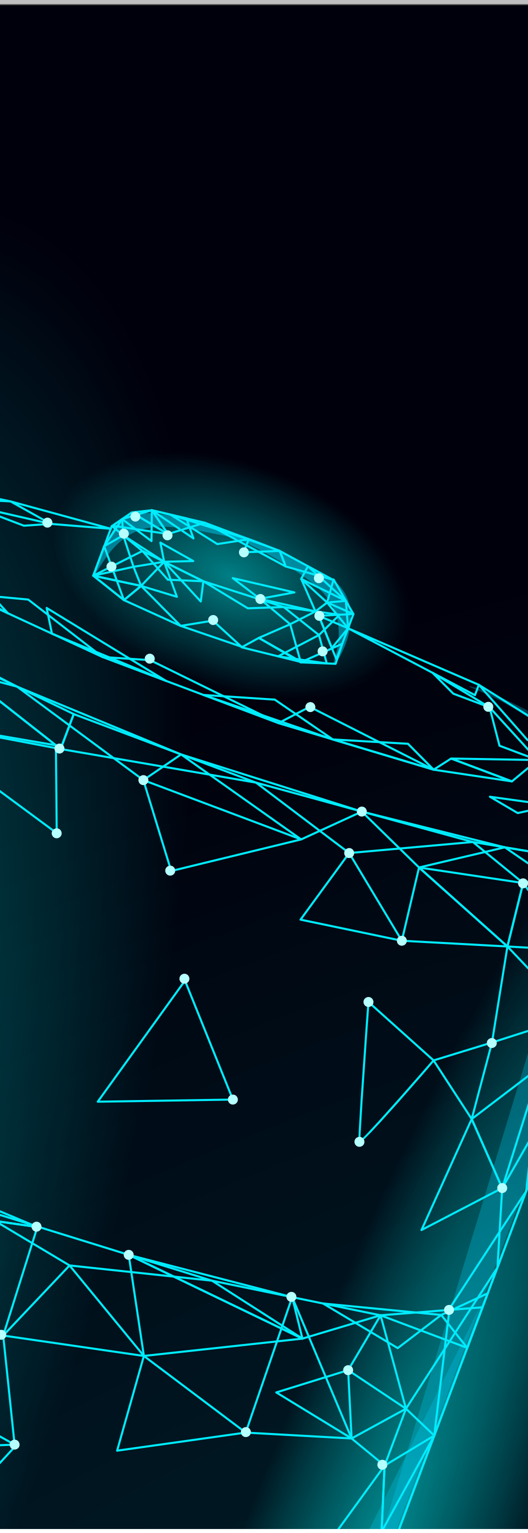
Hangdi Yao
Hangdi Yao is a software development engineer at Great Wall Motors, China.



Analyzing vehicle-to-vehicle charging and its potential for future mobility

Energy Shared

Researchers from the academic and private sectors have teamed up to find a faster and more efficient way to charge an electric vehicle (EV). Their intensive study showed that a vehicle-to-vehicle (V2V) charging solution is a viable alternative that can lead to faster and wider customer adoption of EVs. A dSPACE MicroLabBox was used for testing to verify the feasibility of the V2V charging solution.



When it comes to charging an electric vehicle (EV), everyone can agree on one thing – the faster the better. However, limitations such as the availability of public charging stations, restricted grid capacities, and varying charging speeds can put the brakes on fast charging. A group of researchers from the University of Alabama, the Virginia Commonwealth University, and the University of Akron have teamed up to find a solution for this challenge. The study also involved a partnership with Andromeda Power, LLC, a California-based company that manufactures EV chargers.

The Idea: A V2V Charge Sharing Network

Power-grid-based AC and DC fast charging systems are among the most commonly used tools to charge an EV today. However, the research team is proposing a vehicle-to-vehicle (V2V) charging solution. The idea behind this: The energy is transferred between the EVs using a bidirectional DC/DC converter, which is more efficient than traditional AC/DC power conversion. Dr. Kisacikoglu, Assistant Professor in Electrical and Computer Engineering at The University of Alabama and initiator of the project, explained that most EV owners charge their vehicles overnight from their homes, but on average, they use only enough energy to commute over 25-30 miles (approximately 40-50 km). The surplus energy left in the battery could be made available to sell to other EV owners. In theory, by establishing a V2V charge sharing network, EV owners with unused electric energy on board of their vehicle could connect with users who need a charge at comparable transfer rates to charging stations. "This proposed solution can benefit not only EV owners, but also local communities, municipalities, and the supply network – especially during peak load periods." said Dr. Kisacikoglu. "A charge sharing network could provide a more convenient and flexible way to conduct EV charging at minimal infrastructure cost."

Case Study with Prototype City

To analyze and verify the viability of a V2V charge sharing network and show how such a system could impact the operation of the power grid, the research team developed a virtual environment. They used a Java-based simulation tool to generate a customized simulation environment using different parameters, such as EV types and counts, charging station types and locations, and user mobility patterns. The team created a case study using the Dallas metro area as its prototype city. The number and types of EVs that are present in Dallas were simulated, as well as the number and locations of level 2 (L2) charging stations. Next, the battery charge levels of users and their commuting patterns were factored in to analyze usage patterns of the L2 charging stations.

Adding V2V Chargers to the Equation

During the simulation activity, the impact of growing power demands on the charging stations became more and more transparent with increasing EV counts. To better understand how energy sharing can help meet power demands, the use of V2V chargers was then added into the equation. The team found that a V2V charge sharing network can yield a larger number of EVs operating in the area and meet growing demands without having to install additional L2 charging stations. In their specific use case, they found that V2V charging effectively reduced the peak

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Figure 1: A Nissan Leaf transfers energy to a Tesla Model S through a conductive charging cable. A mobile app communicates with both vehicles and lets the drivers control the charging process.

charging load by 44%, alleviating the load on the power grid system.

Evaluating Various DC/DC Converter Solutions

Once the team determined that a charge-sharing network could, indeed, have a meaningful impact on communities, they turned to the issue of transferring energy from one EV to another. They investigated three bidirectional DC/DC converter solutions: single-phase, two-phase, and three-phase conversion. To evaluate each solution, a test bench was set up that consisted of supplier and receiver EV emulators, a V2V charger solution running on three different power stages, and a dSPACE MicroLabBox to coordinate and control the charge exchange. During the investigation, the team found that multiphase, bidirectional DC/DC converters are most suitable for V2V charging as they showed a better inductor ripple current behavior compared to the single-phase counterpart.

Testing with a Closed-Loop Controller Design

Next, the team set out to validate their analysis. The V2V charger was executed in a closed-loop test bed using a dSPACE MicroLabBox. As part of the hardware implementation, a back-to-back inverter system was interfaced with the dSPACE MicroLabBox to test the different operation modes. The MicroLabBox functioned as the electronics control module, executing all high- and low-level controllers. "The MicroLabBox provided the team with a flexible controller development environment that served well for the closed-loop controller design, which operates at a switching frequency of 20 kHz," said Dr. Kisacikoglu. The tests finally confirmed what the team had established through its investigation – multiphase, bidirectional DC/DC converters should be the first choice for V2V charging.

Developing and Testing Intelligent Charging Technologies with dSPACE Tools

Did you know dSPACE offers dedicated tools for developing and testing technologies involved in the electric vehicle charging process? The new Smart Charging Solution is highly flexible and offers versatile application options, including the simulation of electric vehicle supply equipment as well as the simulation, test, and development of onboard chargers.

Smart Charging Solution – Highlights

- Prototyping and testing charging communication
- Support of region-specific charging standards
- Advanced manipulation and fault simulation options at protocol level
- Emulation of charging stations with real power

More information on the Smart Charging Solution: ***www.dspace.com/go/dMag_20202_DS5366***

Learn more about testing onboard chargers of electric vehicles using dSPACE tools: ***www.dspace.com/go/dMag_20202_OBC***

The Smart Charging Solution from dSPACE combines hardware and software components.

> "The MicroLabBox provided the team with a flexible controller development environment that served well for the closed-loop controller design, which operates at a switching frequency of 20 kHz."

Dr. Mithat Can Kisacikoglu, Assistant Professor in Electrical and Computer Engineering, The University of Alabama (Tuscaloosa, AL)

Summary and Outlook

Through their intensive study, the research team was able to prove that V2V charging could be a valuable addition in the context of future mobility concepts. Moving forward, the team plans to expand the scope of its research. They will investigate a high power density V2V charger design to improve the design footprint. The team will also seek to learn more about how it would impact more EV grid integration and its potential to integrate more renewable energy. ■

With the kind support of The University of Alabama

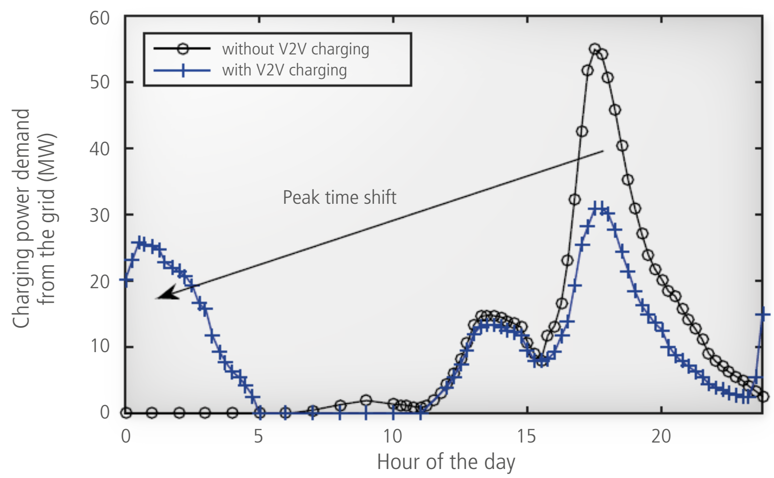
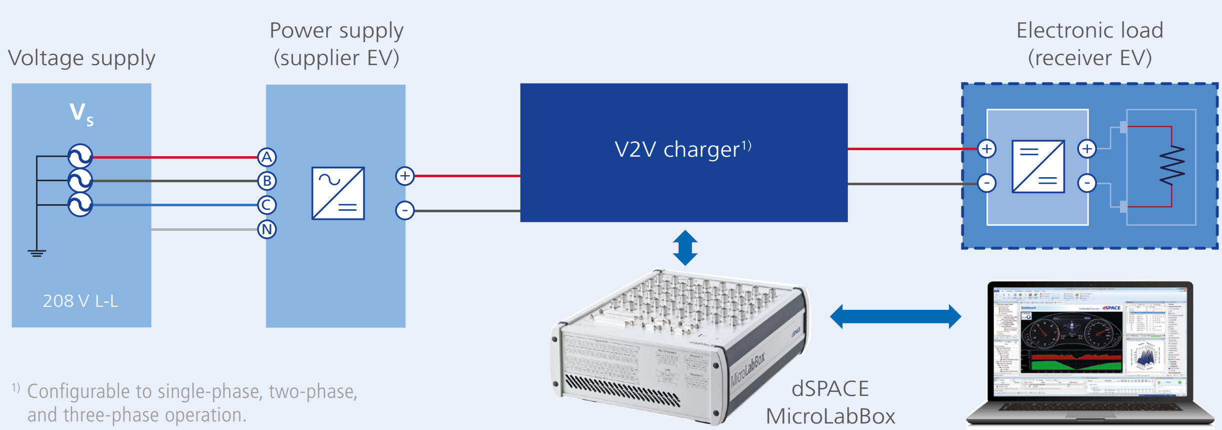


Figure 2: Distribution of charging power demands from the grid with and without V2V charging.

For more information about the study, refer to the following publication:
E. Y. Ucer, R. Buckreus, M. C. Kisacikoglu, E. Bulut, M. Guven, Y. Sozer, and L. Giubbolini, "A flexible V2V charger as a new layer of vehicle-grid integration framework," presented at the IEEE Transport. Electric. Conf. (ITEC), Jun. 2019



[1)] Configurable to single-phase, two-phase, and three-phase operation.

Figure 3: The research team tested three bidirectional DC/DC converter solutions for the V2V charging system: single-phase, two-phase, and three-phase conversion. The test setup included supplier and receiver EV emulators, a V2V charging solution running on three different power stages, and a dSPACE MicroLabBox.

Standard-compliant workflow up to ASIL D paves the way to automated driving

It's the Right Strategy That Counts

For developing the next generation of electric power steering systems, HELLA relies on new test strategies and systems. In parallel to developing the steering system, HELLA and dSPACE Consulting are working on an innovative test strategy that meets the highest safety requirements. The test strategy relies exclusively on automated test sequences, which requires experience and expertise.

"If you are committed to automated testing without compromise, simulation and test tools must be absolutely reliable. Thanks to the expert knowledge of dSPACE, we were able to ensure this."

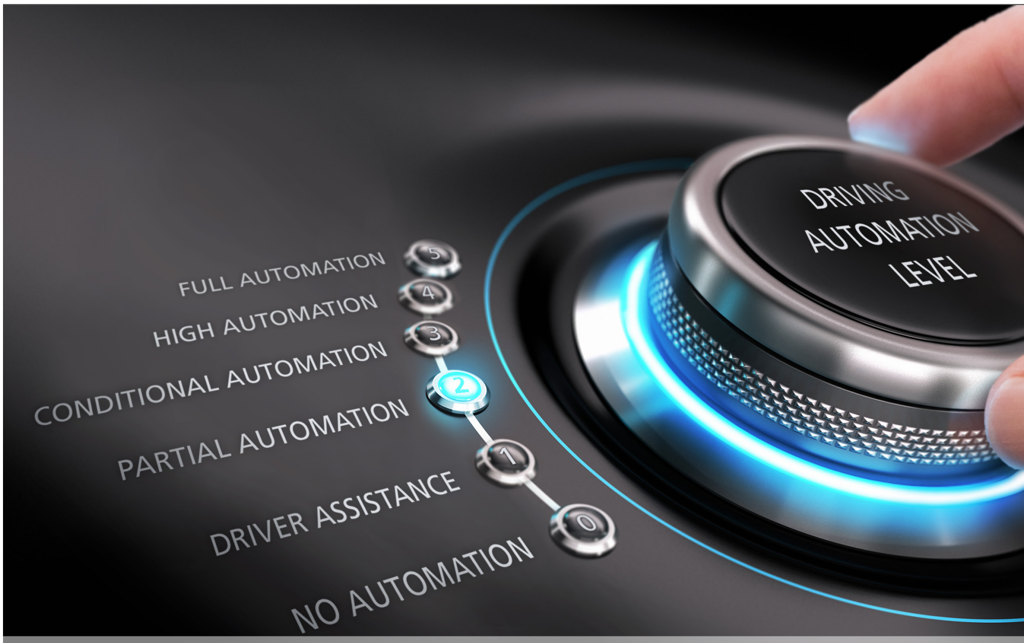
Biju Kollody, test manager at HELLA GmbH & Co. KGaA, Lippstadt, Germany, is responsible for the complete test management of steering ECUs.

Over the last years, HELLA has developed various electrical power steering (EPS) control units that are used in millions of vehicles all around the world. The growing demand for ECUs for partially automated driving (autonomous vehicles from Level 2) was the main reason for setting up an automated validation tool chain in cooperation with dSPACE Consulting. This tool chain had to comply with the standard for functional safety of E/E systems in road vehicles (ISO 26262) and today must provide the opportunity to develop steering systems suitable for highly automated driving up to Level 4 (figure 1). For this purpose, the test process and tool chain had to comply with ISO 26262 up to ASIL D (figure 2). ISO 26262 recommends the use of hardware-in-the-loop (HIL) tests for testing safety-critical functions, components, individual ECUs, and ECU networks, because HIL tests have been state of the art for years. They have been used for testing safety-critical functions for nearly the same amount of time. Test strategy and test environment must be seamlessly integrated and coordinated so that safety-critical systems can be tested and approved and the required test coverage achieved. To prove that this interaction is compliant with the standard, it is necessary to regularly verify that all components and processes involved in the test are suitable. The verification covers a wide range from calibration strategies for the hardware used to the qualification of the software tool chain according to ISO 26262. dSPACE experts quickly identified four areas in which they were able support HELLA:

- Creation of a technical safety concept
- Conceptual design and setup of a test infrastructure that includes several HIL systems
- Development of a tool chain for automated tests
- Compliance with the ISO 26262 standard

With the help of dSPACE, these tasks were carried out in parallel to ECU development and the test systems were put into operation and verified even before the actual tests – including the connection to existing configuration and requirements management tools. "This approach saves a tremendous amount of time, because it avoids detours and dead ends. The result is a comprehensible, standards-compliant process that will also make entirely new customer projects much easier in the future, even if they have completely different requirements," explains Andreas Brentrup from HELLA. >>

Figure 1: Autonomy levels according to SAE J3016, published by SAE International.



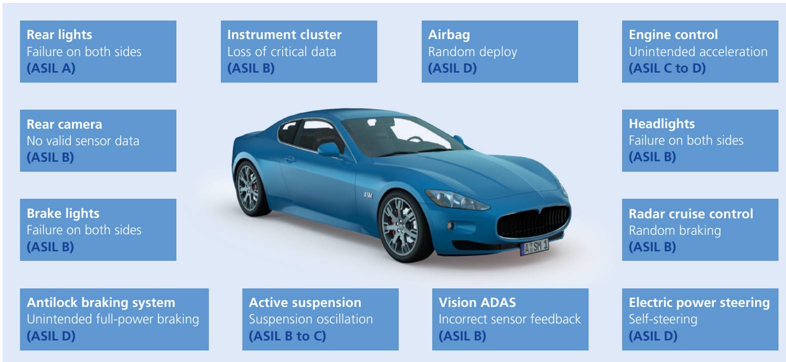


Figure 2: Typical classifications according to Automotive Safety Integrity Level (ASIL). ASIL is a key component of the ISO 26262 standard. The ASIL is determined at the beginning of each development process. The system functions are analyzed and put in relation to possible risks.

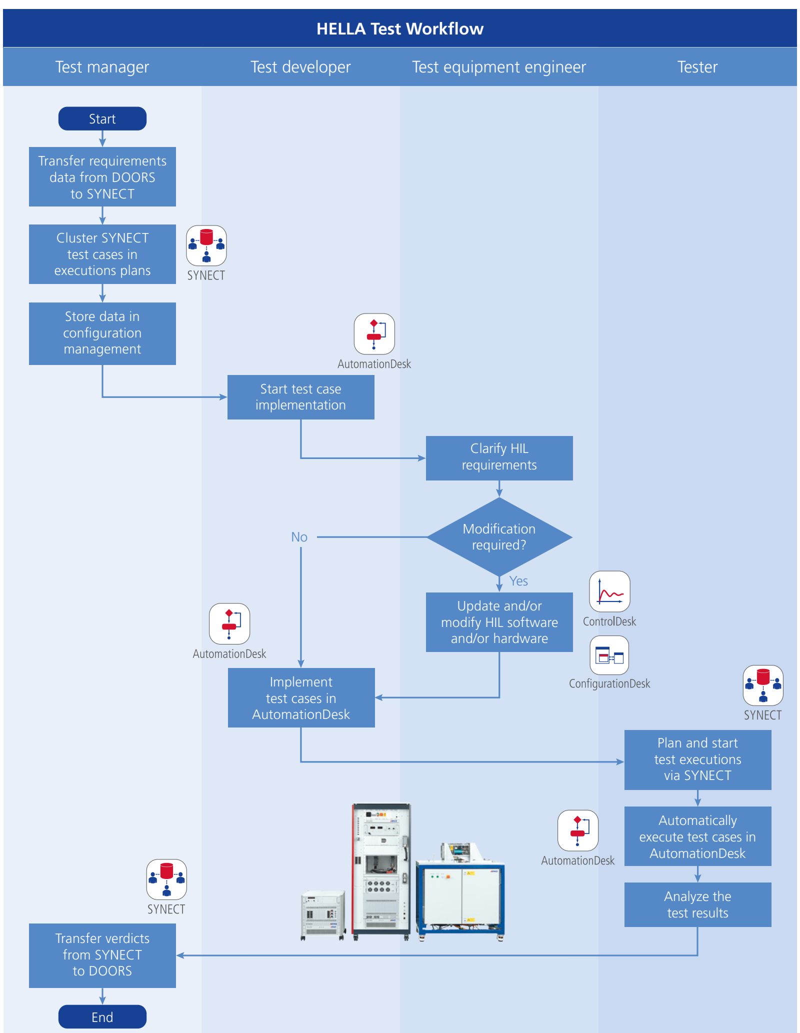


Figure 3: The defined workflow and the documented instructions in the safety manual ensure the trustworthiness of the results and the qualification of the entire tool chain at all times.

Involved from the Start

"Since dSPACE consultants were involved at a very early stage, they were able to work out the test objectives in collaboration with HELLA very early on," adds Biju Kollody from HELLA. The EPS control unit was still in the prototyping phase at the beginning of the project. The test plan was completely rewritten, which in this case required detailed knowledge of both functional safety and testing. To this end, all groups of people involved, such as testers, developers, system architects, and test engineers, were included in the process. The jointly developed validation strategy meets all functional safety requirements for EPS systems and was designed with a focus on easy testability (figure 3).

Simulators and Test Bench – Fit for Purpose

HELLA trusts dSPACE not only for the preliminary work, but also for the actual tests with simulators and test benches. The test hardware consists of two simulators: a SCALEXIO standard rack system that accesses a specially prepared ECU at signal level, and a SCALEXIO full-size simulator that stimulates the ECU at power level. The simulator can also be connected to a dSPACE steering test bench. As a third test procedure, the test bench can stimulate the real engine of the EPS control unit. The FPGA-based dSPACE motor models allow for both realistic motor simulation for tests at signal and power level and closed-loop operation of the ECU. This flexible test infrastructure makes it possible to test different system components individually or in combination, allowing for efficiently implementing the integration and test processes required by ISO 26262. ISO 26262 requires regular calibration of the test systems. For this purpose, dSPACE has written a project-specific calibration manual.

"Developing a validation strategy requires discussions with all parties involved. Whether developer, system architect, safety engineer, or test engineer – all must be equally involved. With the experts from dSPACE, we were able to get everyone on board and ensure reliable, ISO 26262-compliant validation."

Andreas Brentrup, head of the test laboratory at HELLA GmbH & Co. KGaA, Lippstadt, Germany, is responsible for the global test strategy for steering ECUs.

Integration of Existing Tools

"An important requirement at the start of the project was that the software tool chain must work 'from DOORS to DOORS'. This means that a test specification from IBM® Rational DOORS can be verified by the dSPACE tool chain and the result can be imported back into DOORS," Kollody reports. For this purpose, HELLA connected the dSPACE data management software SYNECT to DOORS. The connection allows the test specification to be transferred automatically from DOORS to the dSPACE test automation environment. This enables test developers and test engineers to implement and execute the required tests while continuously maintaining traceability to the requirements. This ensures that requirements, test specifications, and test results are linked at all times. SYNECT then automatically executes the tests on the HIL simulators around the clock and displays the results. Testing an ECU in such a highly automated way is particularly efficient, but requires confidence in the simulation and the tools used (figure 4).

Functional Safety

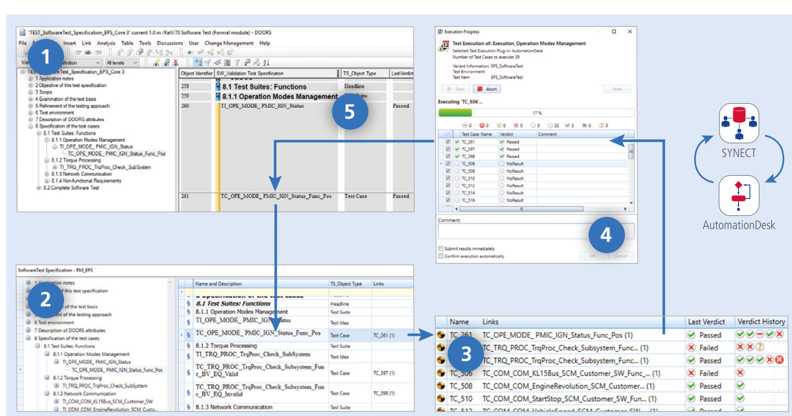
The safety level of the EPS system meets the requirements for ASIL D (Automotive Safety Integrity Level D), the highest possible safety level for an automotive E/E system. To meet the requirements of ISO 26262, the dSPACE Consulting team compiled a safety manual that specifies workflows for the verification process. The software and the defined workflow (figure 3) were determined to be fit-for-purpose.

Conclusion and Outlook

"With the help of the dSPACE consultants, HELLA was able to master the challenges that a safety-related project poses for the process, tool chain, and test equipment at an early stage," confirms Brentrup. The dSPACE tool chain has been successfully used to find errors in the prototyping phase. The fact that an automated test system was already available at that time greatly facilitated the transition to customer-specific development for HELLA. In the future, dSPACE will support HELLA in adapting the tool chain to the requirements of customer projects, ensuring that the working methods continue to be ISO 26262-compliant. ■

With the kind permission of HELLA GmbH & Co. KGaA

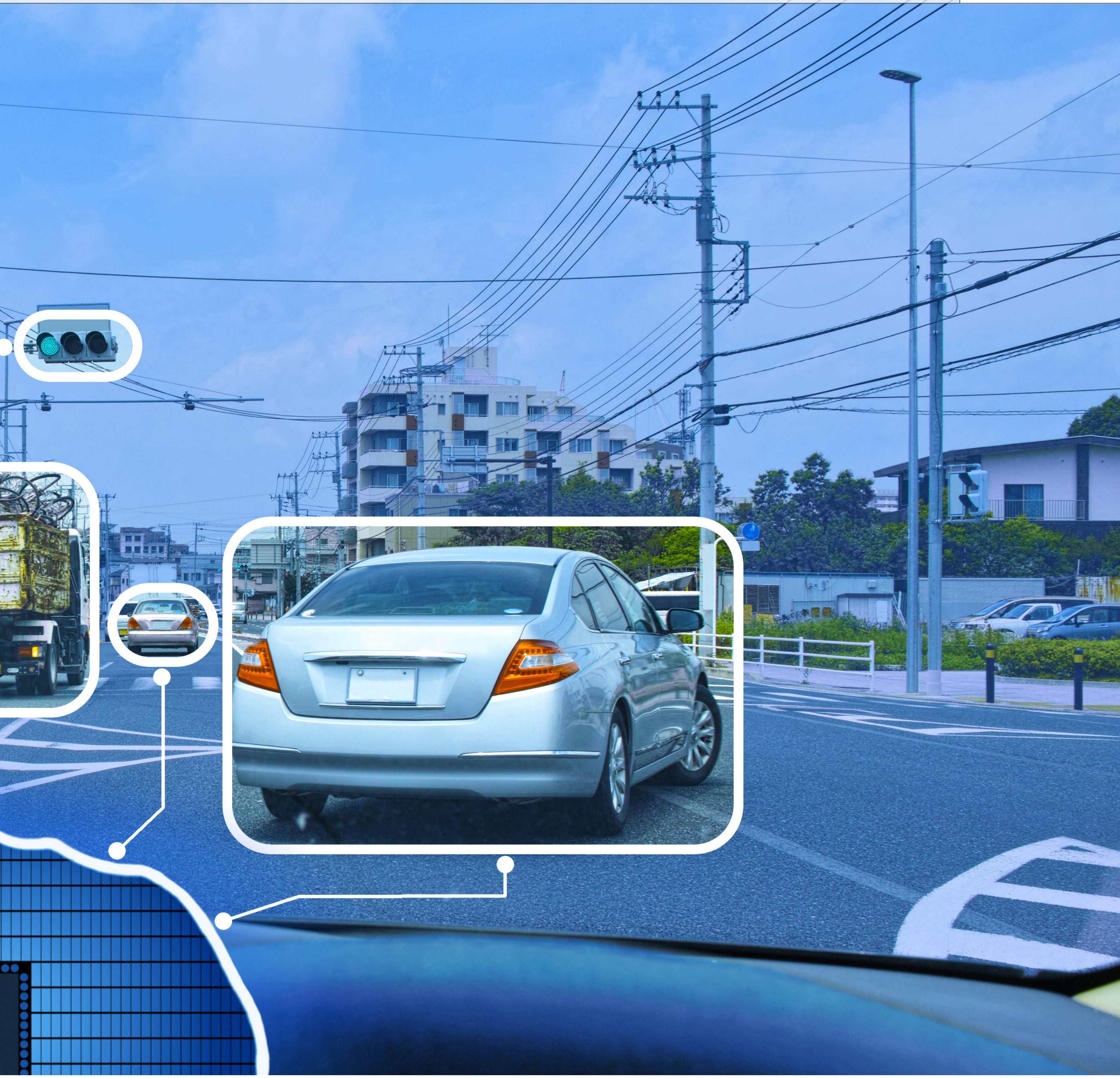
Figure 4: Simplified representation of the HELLA workflow: 'From DOORS to DOORS': The test specification is imported from DOORS (1) to the dSPACE workflow. Therefore, specification changes are immediately visible in SYNECT Requirements Management (2). With SYNECT Test Management (3), the required tests are created, planned, and then automatically executed with AutomationDesk (4). In the last step, the test results are automatically transferred back to DOORS (5).



Intelligently Setting the Scene

AI-based scenario generation from sensor data

To ensure the suitability for everyday use and the safety of systems for autonomous driving despite the ever-increasing complexity of technologies used, the systems must be tested well before they are put into operation. Using the dSPACE and understand.ai solution for generating simulation scenarios, thousands of tests of safety-critical driving scenarios with special hardware and software can be performed by simulation.



With an innovative method based on artificial intelligence (AI), dSPACE and understand.ai offer a new service for generating scenarios from real measured raw data. Compared to classically generated object lists, which are calculated in real time, or online, in the vehicle, the subsequent scenario generation from raw data is not subject to any restrictions in terms of computing capacity. This avoids imperfections caused by incorrectly detected or undetected objects (false positives or false negatives, respectively) in the database. To cover as many different road traffic situations as possible, many factors are tested virtually before a physical prototype is available. This is done with the help of test scenarios, which are used in numerous tests and in different variants to obtain a meaningful result. However, this requires realistic scenarios. Since these scenarios are subject to special requirements, expert scenario generation is essential: The scenarios

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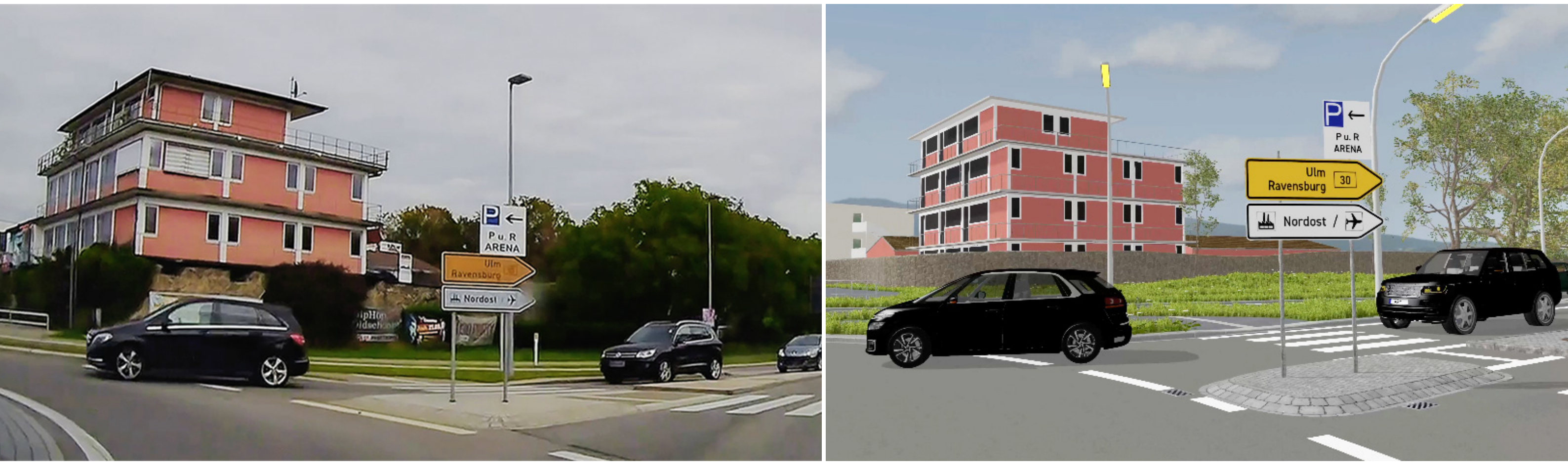


Figure 1: Roundabout scene as a camera recording and as a generated scenario.

From the road to the lab – with test scenarios using real data

must reflect situations in many different real-world environments. In addition to a high variance of variables, such as weather and traffic density, a balanced mix of both critical and non-critical situations is crucial.

Analyzing Real Situations and Validating Autonomous Driving

To meet customer requirements, we differentiate between two scenario types: logical scenarios for the validation of autonomous driving and replay scenarios, which can be used to analyze faulty algorithms in simulations of real situations. Replay scenarios are an exact reconstruction of real situations based on recorded sensor data. Scenarios of this type cannot be adapted by parameterization, but they are excellent for simulating malfunctions and other real events in the laboratory. This way, failures of the driving function can be investigated and corrected in the lab under reproducible conditions. Furthermore, replay scenarios can be used for sensor model validation by comparing sensor data of a real scenario with simulated sensor data of the identical virtual scenario. In addition, there are logical scenarios in which the movements of the vehicles are abstracted and generalized to expose parameters of the scenario, which can then be adjusted to vary the scenario. These scenarios are used for the validation of ADAS/AD algorithms using scenario-based testing. Generated scenarios offer the great advantage that critical situations, such as accidents, can be simulated and run as often as required. This allows users to determine exactly those parameters that represent the challenges for the ADAS/AD algorithm.

Generating Scenarios

Before scenarios can be used in simulation and testing, they must be generated. There are different approaches to scenario generation. The example in this article will first explain the generation based on measurement data. Video recordings, lidar point clouds, and vehicle bus data are used for this. They can be recorded with special data logging hardware, such as dSPACE AUTERA. The realism of a scenario generated this way increases with the quantity and quality of the available data. A combination of different algorithms enables a semantically correct replication of the real scenario, including the motion profiles of all road users as well as the road and a 3-D scene that reflects all essential elements of the static environment. First, relevant information about the road and its surroundings as well as the trajectories of the road users are extracted from the raw data by means of AI-supported methods. The special quality assurance method of understand.ai ensures that the ground truth that is generated guarantees the semantic consistency of the generated scenarios. The extracted data is then converted into simulable (replay and logical) scenarios for the dSPACE simulation environment and into scenario descriptions based on the OpenDRIVE® and OpenSCENARIO® standards. The generated scenarios can therefore be immediately used for a wide range of tests, because in addition to the road description and the

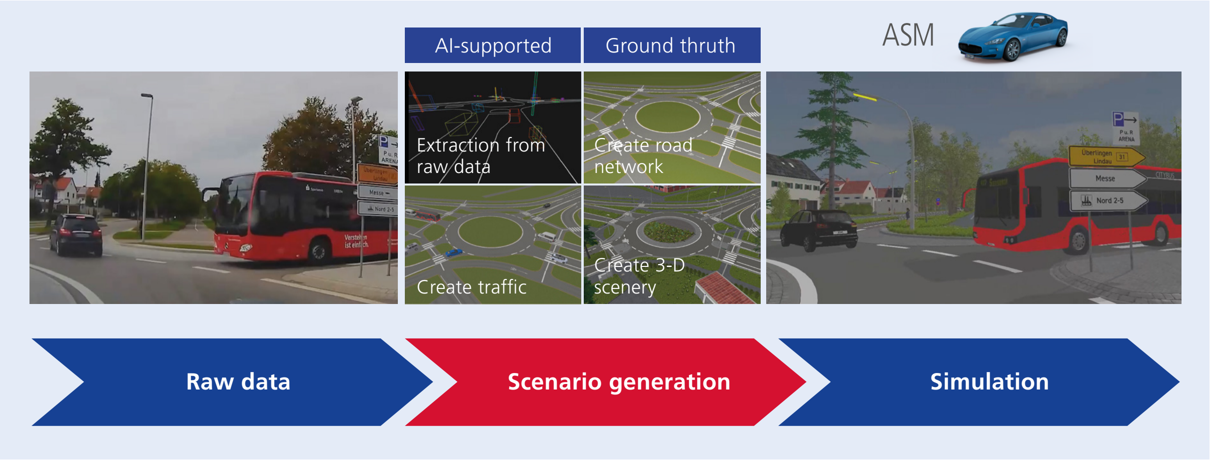


Figure 2: A scenario for the simulation is generated from the acquired measurement data using the solution from dSPACE and understand.ai.

description of the movement profiles of the road users, a detailed 3-D scene is also generated, which enables physical sensor simulation. A scenario can also be created completely artificially and digitally on the computer using scenario editors, such as dSPACE ModelDesk. This means that users can design scenarios according to their own ideas and requirements. Although the design possibilities are in principle unlimited, diversity is ultimately limited by the requirements of the respective order or the creativity of the users. One advantage of this method is the possibility to construct scenarios that would be very difficult to re-record in the real world, for example, because they would be expensive or dangerous. Both for scenarios generated from measurement data and for artificially generated scenarios, it is possible to change parameters such as vehicle speed, weather, or the behavior of other simulated road users as required within the dSPACE solution by adjusting the corresponding parameters. The major advantage of scenario-based testing is its scalability depending on the available computing capacity. In addition, tests can be moved to the cloud, where the practically unlimited cloud capacities offer ample opportunities for the field of virtual validation and thus for the entire production chain.

New Solution Portfolio

The solution for scenario-based testing in combination with scenario generation from dSPACE and understand.ai helps customers overcome the obstacles on their path to a functioning prototype. The solution is underpinned by the many existing scenarios created by experienced developers and by the scenarios that can additionally be generated on the basis of real recorded sensor data or object lists. This allows for millions of test kilometers in a wide range of realistic and relevant scenarios.

Re-Simulation of Critical Edge Cases from a Real Test Drive

Take the realism and complexity of the real world to the simulation:

- Use scenarios that reflect realistic traffic situations.
- Derive new test cases by adapting existing simulation scenarios.
- Use generated scenarios in the dSPACE simulation environment – immediately and without additional conversion effort (compatible with OpenDRIVE and OpenSCENARIO).
- Make the most of your data: Use the petabytes of material you have already recorded for the simulation.

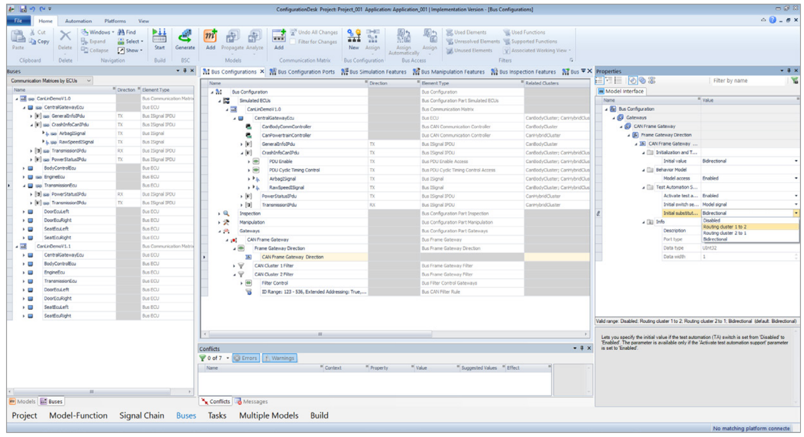
The new DS1521 variants of the MicroAutoBox III offer a wealth of connection options from CAN FD, Automotive Ethernet, and LIN to FlexRay, analog inputs, and digital inputs/outputs.

Perfectly Connected

New MicroAutoBox III variants with DS1521 Bus and Network Board

Additional variants of the new MicroAutoBox III with an even wider range of bus and network interfaces make the product range even broader and stronger. A new DS1521 Bus and Network Board integrated in the MicroAutoBox III provides an exceptional range of channels in the familiar small MicroAutoBox form factor.

With the release of the MicroAutoBox III, which offers the highest all-round power for numerous applications from autonomous driving to zero emissions, compact, in-vehicle dSPACE prototyping systems reach an entirely new level of performance. This is achieved, for example, by the significantly higher computing power and improved monitoring mechanisms for functional safety.
The MicroAutoBox III offers four processor cores and is up to 16 times faster per processor core than its predecessor, the MicroAutoBox II. Moreover, additional MicroAutoBox III variants with the new DS1521 Bus and Network Board will also be available. With their impressive range of channels, the new variants are particularly suitable for applications such as intelligent gateways as well as executing superimposed controllers (supervisory controllers) to control other ECUs in real time via buses and networks. They are also suited for designing central control units with service-based Ethernet communication. To ideally address these applications, the DS1521 Bus and Network Board provides eight CAN FD channels, three automotive Ethernet ports (100/1000BASE-T1), two FlexRay connectors (A/B), three LIN channels, and additional UART, digital, and analog interfaces.


Example: A gateway application in the Bus Manager.

Software for Full Control

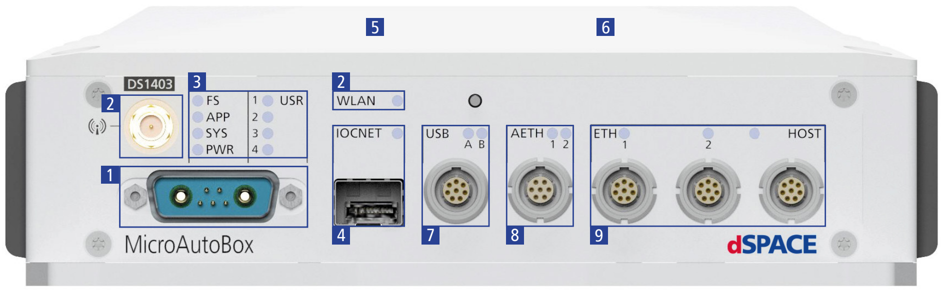
To configure the hardware easily and flexibly for each application, the MicroAutoBox III is supported by the tried and proven ConfigurationDesk implementation software known from SCALEXIO, including the seamlessly integrated Bus Manager. This allows for bus communication to be configured clearly and conveniently for gateway or supervisory controller applications, all based on the latest standards and communication descriptions such as AUTOSAR (ARXML), FIBEX, DBC, and LDF. For integration into an existing vehicle electrical system, current AUTOSAR features such as secure onboard communication (SecOC), end-to-end protection, and global time synchronization (GTS) are also supported on all relevant bus systems, including service-based Ethernet communication (SOME-IP). To be able to respond flexibly and at short notice to project-specific adaptations, a comprehensive extension framework is available, which can be integrated and implemented by dSPACE to the customer's specifications with very short

A vast range of channels in the compact MicroAutoBox form factor combined with a comprehensive software tool chain for bus and network communication.

Focus:
Gateway applications and supervisory controllers

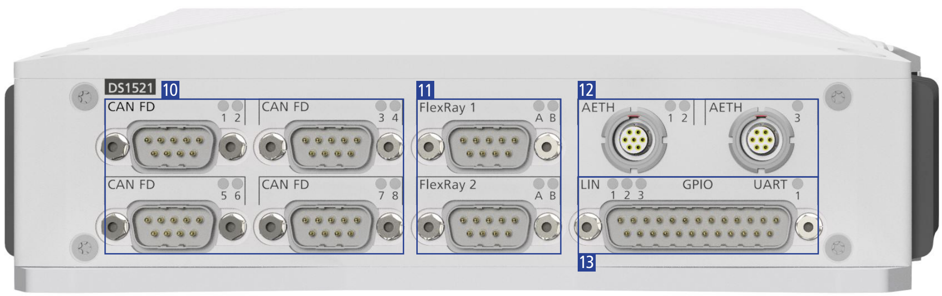
Buses and networks are increasingly used to connect the numerous control units, sensors, and actuators in the vehicle. When new functions are developed, this bus and network data often has to be redirected, filtered, or extended by new control components via gateways or domain controllers as central network nodes to new or existing recipients. One example is the integration of a new drive system into an existing vehicle platform.
To reduce costs, space requirements,

MicroAutoBox III 1403/1521



DS1403 Processor Board (connectors at the front panel of the MicroAutoBox III)

1. Battery voltage connection (12/24/48 V onboard power supply)
2. WLAN option
3. Status and user-programmable LEDs
4. IOCNET connector
5. Can be extended by I/O units, e.g., DS1514, DS1521
6. Quad-core ARM® processor
7. USB port (USB 2.0) for mass storage and data logging
8. 2 x automotive Ethernet (100/1000 Mbit/s)
9. Ethernet ports (Gigabit Ethernet) for host and other devices



NEW: DS1521 Bus and Network Board (connectors on the back panel of the MicroAutoBox III) with additional interfaces

10. 8 x CAN FD
11. 2 x FlexRay (A/B)
12. 3 x automotive Ethernet (100/1000 Mbit/s), additional
13. 3 x LIN, 1 x UART: RS232 or RS422/485
    4 x Analog In, 6 x Digital In/Out

Even the "small" MicroAutoBox 1403/1521 offers a wide range of channels. If this is not sufficient, you can simply double the DS1521 channels – by selecting the MicroAutoBox 1403/1521/1521 – or, depending on your requirements, by choosing one of the many other MicroAutoBox III variants, for example, to increase the number of analog and digital channels.

turnaround times. At run time, variables in the model can be visualized clearly and easily in ControlDesk. For access to the bus and network signals, the Bus Navigator offers the option to create preconfigured layouts for transmit and receive messages. In addition, live bus monitoring and bus analysis can be activated directly while the application is running. The ControlDesk Bus Navigator provides clear and synchronized access to bus and network data with all other used inputs and outputs, eliminating the need to acquire additional dedicated systems (hardware and software) for live monitoring. This significantly saves costs and also simplifies the system design. ■

and system complexity, the required gateway components must ideally already be covered by the function development system used to execute the new control functions in real time. In combination with the dSPACE software tool chain, the MicroAutoBox III development system with the DS1521 Bus and Network Board is ideal for this task. The hardware offers a maximum channel count and maximum computing power with the smallest footprint, while the powerful, proven software guarantees fast development cycles by means of simple configuration.

4-D Radar Simulation

5 GHz – new benchmark for radar target simulators

Ultra-high-resolution imaging radar sensors, often referred to as 4-D radars, provide detailed images of the radar environment with a wide field of view as well as elevation, range, and speed information. Tests of these radar sensors place high demands on the capabilities and bandwidth of the radar simulator used. The dSPACE Automotive Radar Test System (DARTS) 9040-G is the first simulator to successfully meet these challenges with powerful high-frequency technology.

Profile: Radar target simulator for over-the-air testing of automotive radar sensors

- Optimized for imaging or 4-D radar sensors.
- Simulates the reflections of a freely definable radar target (extension for additional targets possible).
- Simulates distance, speed, width, and elevation.

Technical Data

- Frequency range: 76 to 81 GHz
- Bandwidth: 5 GHz
- Range: ≤ 2.5 to 300 m
- Range increment: 2.5 cm
- Speed: ± 500 km/h

For more information, visit:
www.dspace.com/go/DARTS_9040-G

> "With the new DARTS 9040-G, dSPACE is once again positioning itself as a strong development partner for simulation and validation in the field of radar sensor technology."
>
> *Dr. Andreas Himmler, Senior Product Manager, dSPACE*

Assisted and automated driving poses enormous technological challenges for environment detection: For a self-driving vehicle to appropriately respond to any unforeseeable traffic situation, however complex, a reliable 360-degree panoramic view of its surroundings is required. This is where radar (RAdio Detection And Ranging) sensors are key. Until now, radar sensors have been able to detect their surroundings as a three-dimensional space only to a limited extent. They usually detect the speed, distance, and width of an object. The sensors can make only rough estimates of the object elevation at best.

New Technology: 4-D Radars

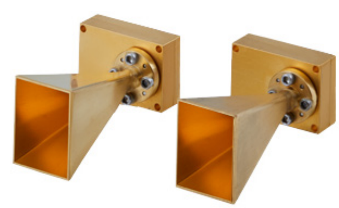
To ensure a more comprehensive image of detected objects, industry is pushing the development of high-resolution radars that also accurately detect the angle of elevation. The radar therefore becomes a de facto 3-D imaging technology – with speed as an additional fourth dimension of measurement. These sensors, also known as 4-D radars, provide the basis for precise real-time object detection that works in all weather and lighting conditions.

High Test System Requirements

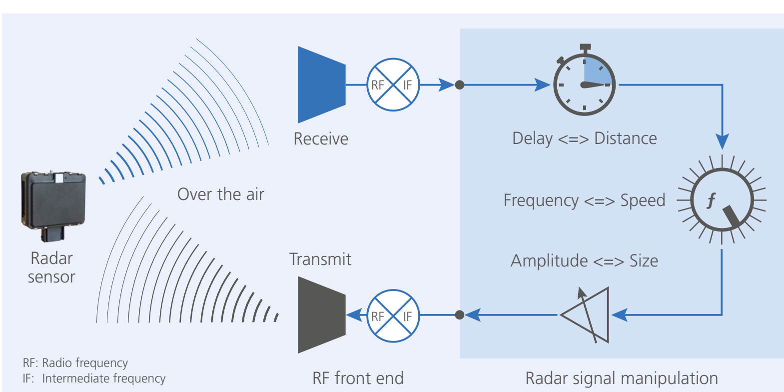
To transmit the additional information with the high-frequency signal, ultra-high-resolution radars operate with a particularly high modulation bandwidth, which is typically 4 GHz. Previous radars usually operated with a bandwidth of only up to 1 GHz. Comprehensive testing and validation of the new sensor class significantly increases the demands on the test systems. Users therefore call for technology that covers more than the 4 GHz bandwidth of radars to be able to accurately analyze behavior in edge cases. This especially applies to radar target simulators, which simulate radar targets at long ranges, high speeds, and of different sizes under laboratory conditions and in real time.

First Radar Simulator with 5 GHz Bandwidth

In collaboration with its development partners ITS and miro•sys, dSPACE has designed the world's first radar simulator that operates at a bandwidth of 5 GHz. The new DARTS 9040-G is designed and optimized for all next-generation automotive radars, such as imaging and 4-D radars. It completely covers the 77 GHz radar band without synthesizer tuning of the center frequency. The simulator has an exceptionally high, spurious-free dynamic range with a particularly low noise figure. This makes the new DARTS 9040-G ideal for all 77 GHz radars. Due to its easy-to-use over-the-air technology, the system can be used in all development phases, from chip design and sensor development to end-of-line tests. The new DARTS 9040-G is available in several variants, which are tailored to the different requirements of the tests in the different development and production phases. ■



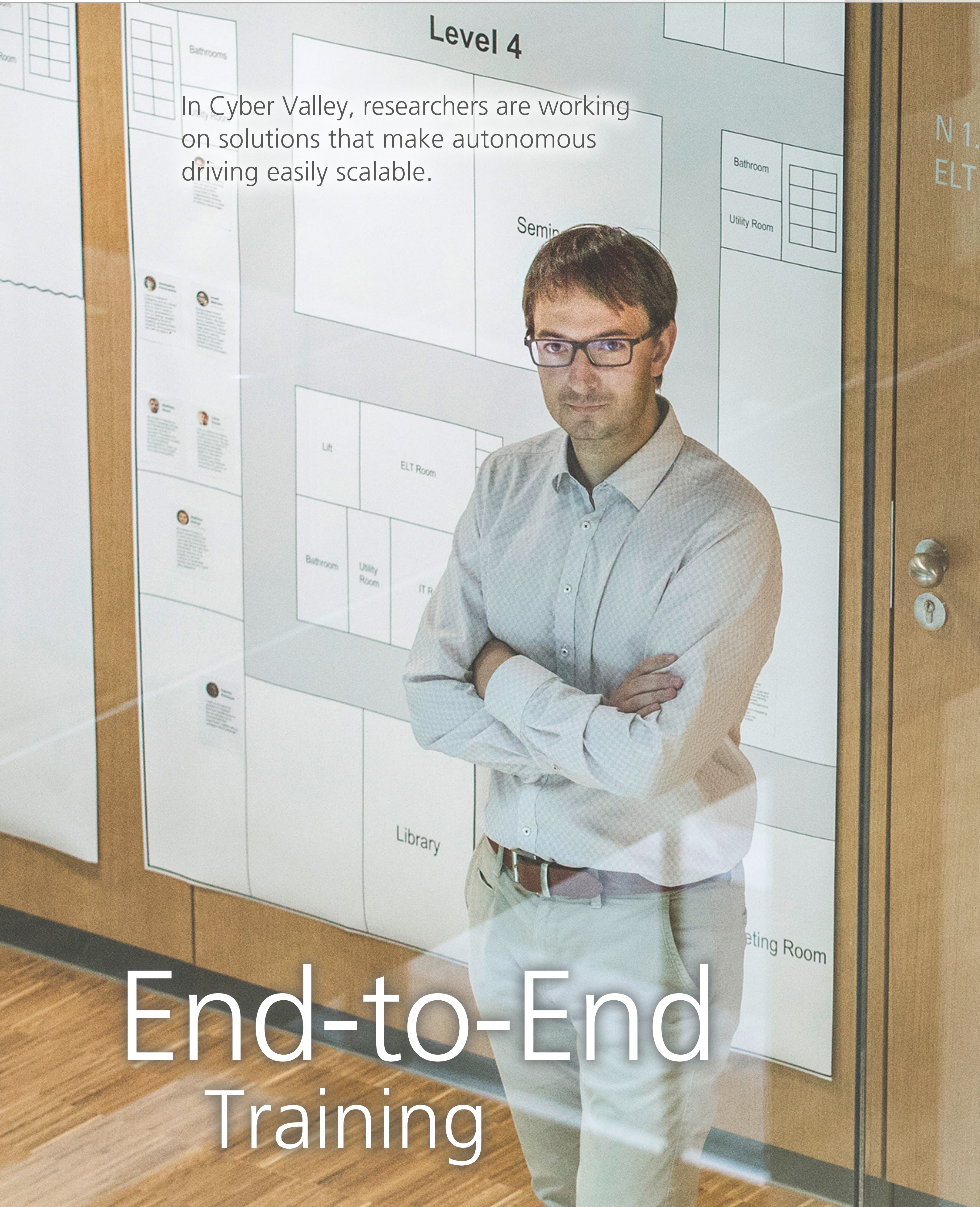
The DARTS have the world's smallest radar front ends and are therefore very flexible to handle.



The over-the-air method: The DARTS receives the radar waves from a radar sensor, generates a freely definable echo, and sends it back to the sensor.

In Cyber Valley, researchers are working on solutions that make autonomous driving easily scalable.

End-to-End Training



Picture credit: © A. Cardinale

Professor Dr. Andreas Geiger is Head of the Autonomous Vision research group at the Max Planck Institute for Intelligent Systems (MPI-IS) and Professor for learning-based computer vision and autonomous vision at the University of Tübingen. In this interview, he talks about the challenges of developing self-driving cars, explains how attractive German universities are by international comparison and elaborates on what has to be done to keep young talents in the country.

In 2018, you received the IEEE PAMI Young Researcher Award for your outstanding contribution to bridging the gap between computer vision, machine learning, and robotics. Can you briefly describe what the award means to you?
The award means a lot to me because it recognizes the international importance of my work and shows that we are on par with the best computer vision research labs in the world. I was the first German researcher to receive it and the third researcher in Europe. The award is the most prestigious distinction in the field of computer vision for a young researcher.

What exactly did the award honor?
I was awarded for my research on self-driving cars. I first developed algorithms and approaches to achieve scene understanding in my dissertation at the Karlsruhe Institute of Technology. Since I wanted to work with real data, I equipped a test vehicle with comprehensive sensor technology – several cameras, lidars, and GPS. At some point, we decided to make the tediously collected data available to the general public. This created a by-product of my dissertation: the KITTI Benchmark, which was created in 2012 and has become one of the most influential data sets in the field of autonomous driving. Today, the KITTI Benchmark is the state of the art in the field of computer vision for evaluating algorithms.

In your words, what is the difference between control engineering and machine learning?
The lines between machine learning and control engineering are blurred and a matter of perspective. For a control engineer, perception is peripheral, for computer scientists, control engineering is peripheral. Personally, I think the more daunting challenges for autonomous driving are perception and AI-supported decision making. Compared to the control technology for a humanoid robot with 50 actuators and tactile sensors, the control system of a vehicle is relatively simple. Basically, a car is controlled only by steering, accelerator, and brakes. In addition, the industry has been working on vehicle control for a long time and has gained an immense amount of know-how accordingly.

Would you ride in an autonomous vehicle today?
Why not? I would not mind being a passenger in a Level-4 vehicle if the opportunity arose – There is usually a service employee in the car who can intervene if necessary.

And when do you think the first autonomous vehicles without service employees will be on the road?
Many industry representatives had promised that this would be the case in 2021. By now, many have retracted their promise and are being more realistic. I do not expect Level-5 autonomous driving in the next ten years because fundamental questions in the field of artificial intelligence have not been answered. Whether driving at Level 4 is successful depends on the defined framework conditions. In specific areas, under specific weather conditions, this may be possible in the next few years – as shown by Waymo. I suppose that we will start out with remote operators and speed limits. Tesla is a pioneer in this field, but I would be surprised to see an autonomous Tesla vehicle with Level 5 functions on the market within the next five years.

What are the greatest obstacles?
At present, we count one traffic fatality per 100 million miles. This shows that we humans have mastered driving quite well. An autonomous vehicle is intended to make fewer mistakes than the human driver and at best be better by a factor of ten or 100. It must therefore be safe in a whole range of different situations: For example, the cars have to perceive their surroundings at night, in the rain, and when it snows. Even though cameras are still far from being as good as the human eye, we have made considerable progress in the field of sensor technology in recent years. Autonomous vehicles must then be able to master busy or blocked roads. They must also be able to deal with arbitrary pedestrian behavior, reflections, and unpredictable and rare events.

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> We are working on making simulation more efficient, because I am convinced that in the future, simulations that are as realistic as possible will become increasingly important for validation and training.

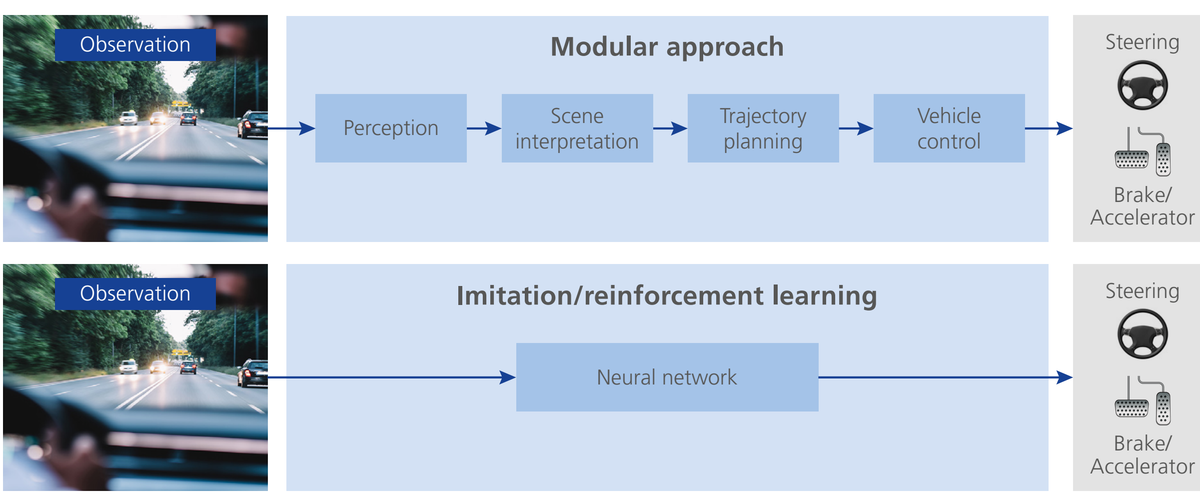
In order to train algorithms for these rare events, we therefore need an incredible amount of data. Another obstacle is that algorithms cannot perform causal inference, meaning they are not able to draw conclusions. Therefore, a high level of manual reprogramming is required in the systems. Add to this ethical and legal issues that must be clarified. As you can see, there is still some work to be done.

On which areas do you focus?
Our research group focuses on classical computer vision topics. For example, we are investigating how to improve depth perception and make it more robust. We also take a look at how algorithms can learn with less data. And we are working on making simulation more efficient, because I am convinced that in the future, simulations that are as realistic as possible will become increasingly important for validation and training. Lastly, we train algorithms for autonomous driving. In contrast to the automotive industry, which today works according to the classic modular approach, we are pursuing the approach of comprehensively trainable systems.

How does end-to-end training work and what are the benefits?
In end-to-end training, you try to view the whole system as one process, from perception to control, and represent it in one neural network. The system collects perception and control data of the vehicle, i.e., steering, acceleration and brake data. This gives us the advantage of training the system directly towards a goal instead of training individual modules towards subtasks, such as object recognition. We believe that these comprehensive models are the solution to better scale autonomous driving. Currently, these models are not as precise and robust as the modular concepts used in industry, for which a large number of engineers are working on individual modules. Once we manage data complexity, machine learning will allow us to move our system much faster into a new city, into new environments.

How closely do you work with the industry?
Even though the industry follows the modular approach, we cooperate in many subprojects with suppliers and car manufacturers in the region. Our focus on the end-to-end approach is of great interest for the industry, even if they cannot apply it immediately. We are currently involved in the KI Delta Learning project, which analyzes self-learning methods for the automated processing of environment sensor data in the context of automated driving. The project has been commissioned by the Federal Ministry for Economic Affairs and Energy and involves leading industrial companies from the automotive industry as well as several universities, including the University of Tübingen.

What keeps you in the Cyber Valley in Tübingen, and how attractive are German universities by international comparison?
Europe is a strong player in academic research, and the automotive industry has a great interest in AI. The University of Tübingen and the Max Planck Institute are part of a large network of researchers who not only work on computer vision topics, but also apply AI in related disciplines, such as the neurosciences.



Professor Dr. Andreas Geiger is head of the Autonomous Vision research group at the Max Planck Institute for Intelligent Systems (MPI-IS) and is Professor for learning-based computer vision and autonomous vision at the University of Tübingen.

KI Delta Learning
The aim of the KI Delta Learning research project is to evaluate the differences between domains and design new methods so that artificial intelligence can transfer existing knowledge from one domain to another and only has to learn the additional requirements, the specific "deltas". This reduces the need for test data and accelerates the learning process when new knowledge has to be added.

In this network, we can learn from each other across disciplines. This makes working here very attractive. We also continue to network in various initiatives at the European level. One of these is ELLIS, the European Lab for Learning and Intelligent Systems, which promotes the exchange of information between institutes and doctoral students on machine learning and AI. You do not have to be in Silicon Valley to work with the big companies there. Amazon is currently expanding its site here, Bosch is building a new location in our neighborhood, NVIDIA is sponsoring us, and I am working closely with Intel. However, we do have some catching up to do when it comes to start-ups.

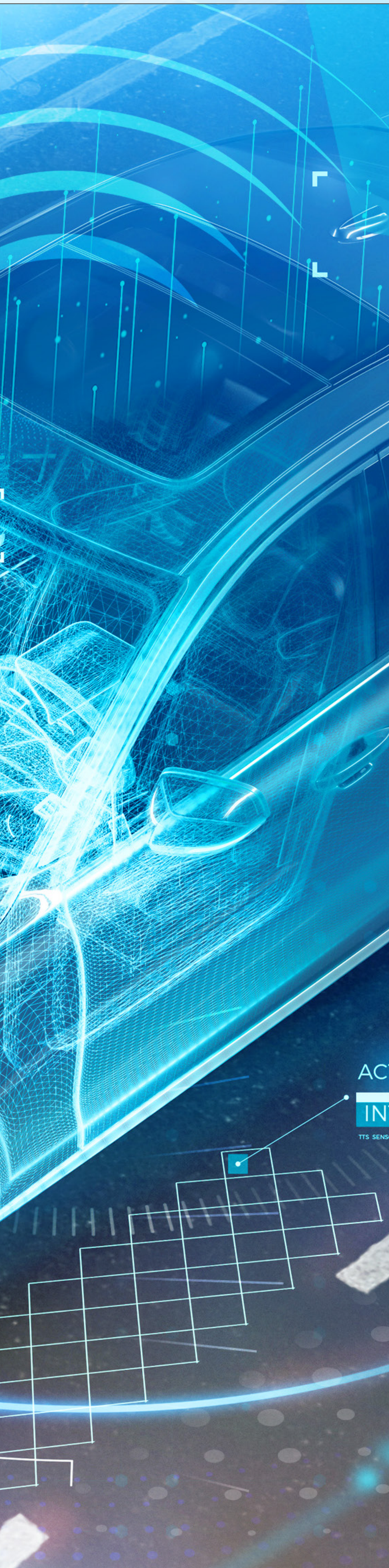
What exactly do you mean?
One, we need to change the public mindset. Two, start-ups need more support. The founder's mindset is currently changing, but we need more incubators and less bureaucracy so that talented young people can turn their ideas into a reality here instead of being poached by the tech giants in the USA. Once they leave, they might never come back. Keeping talent here is vital.

Thank you for the interview.

The founder's mindset is currently changing, but we need more incubators and less bureaucracy so that talented young people can turn their ideas into a reality here instead of being poached by the tech giants in the USA.

Strengthening the AD Portfolio

Software tools from Intempora complement dSPACE solutions for data-driven development



In July, dSPACE acquired Intempora, a pioneer in the area of real-time development software. The two companies already had a long-standing strategic partnership. Through the acquisition, dSPACE now offers a unique and reliable end-to-end solution as well as optimized support for innovative development projects. In this interview, Nicolas du Lac, CEO of Intempora, explains the history of the company and how this closer cooperation will bring a unique value.

Nicolas, 20 years ago Intempora was one of the first companies to develop software for sensor signal processing. I am sure that in the early days, no one talked about autonomous driving. How did your first developments come about? And how did your software evolve to meet the requirements of the automotive market?

The reason for founding Intempora in 2000 was the success of our core technology RTMaps, which was developed at the Center of Robotics of Mines ParisTech in 1998. At the time, a team under former Director Claude Laurgeau was working on robotics and intelligent transport systems (ITS). The team participated in the Eureka Prometheus project, one of the very first EU-funded R&D projects focusing on automated driving. At the outset of the project, autonomous vehicles were considered robots. The project therefore focused on overcoming the challenges associated with mobile robotics: perception, positioning, control, capability to move fast, safety requirements, interaction with humans, etc. Back then, Bruno Steux and Pierre Coulombeau, PhD students in Claude's team, aimed to develop computer vision algorithms and Bayesian-network-based data fusion for vehicle perception and accurate positioning. Their objective was to execute these algorithms in real time in a prototype vehicle equipped with a front camera, a front radar, and the very first models of lidar scanners. The pair soon realized they spent 90% of their time working on their software architecture rather than on the algorithms at the heart of their thesis. They needed a modular (component-based) environment to manage the different parts of their complex software, such as data acquisition from multiple vehicle sensors and data processing as well as visualization, recording, and playback features for offline work. Additionally, they decided to incorporate a time-stamping and data synchronization process to ensure smooth and coherent

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"The majority of our customers use RTMaps to develop algorithms for assisted and automated driving."

sensor data fusion across the different streams and asynchronous data sources. Since no development tools on the market met their requirements, they developed their own software solution: RTMaps (Real-Time Multisensor applications). A few months later, another European project consortium, called CarSense, was actively looking for a data logging solution for numerous camera, radar, and lidar sensors on a vehicle. They tested RTMaps and found it worked great, inspiring Claude and Bruno to create a company based on the idea that such software could be useful for the automotive industry in the future.

What were some of Intempora's first milestones?
At the IEEE Intelligent Vehicle Symposium in Versailles in 2002, Ecole des Mines de Paris demonstrated an autonomous vehicle prototype, called LaRA, which used RTMaps as the onboard data processing software. The vehicle was driven on a track at more than 100 km/h with no hands on the wheel, using a single camera for lateral control and a Pentium II computer in the trunk. In 2004, one of Intempora's first customers, the LIVIC Laboratory presented a fully autonomous vehicle with similar capabilities, but with both lateral and longitudinal control. A few years later, the Grand DARPA challenge in the US launched a worldwide race towards autonomous driving. RTMaps participated in the challenge alongside the DotMobil Team. RTMaps was also showcased on the SwRI vehicle at the ITS 2008 exhibition in New York. Today, we have customers around the world, some of which have been using our solutions for more than 15 years. Needless to say, our software has evolved and greatly improved since then.

You have observed developments in autonomous driving for quite some time now. What are the major challenges we have to overcome to get a self-driving car on the road?
When talking about self-driving cars, we have to distinguish between robotaxis and personal vehicles. The former are heavily equipped with sensors and computing resources, and evolve at quite a slow speed. Personal vehicles have to be affordable and follow a different maintenance schedule. We still have many challenges to overcome on the path to Level 5 autonomous (personal) vehicles for public roads that can be further developed at high speed. The main challenge is ensuring safety in all driving conditions and situations. Safety is a prerequisite to gain acceptance and for authorities to allow mass deployment. Achieving safety involves several technical challenges, including:
Sensor accuracy and efficiency in all conditions:
Sensors are continuously improving in resolution and range. We have to combine sensor technologies for an autonomous vehicle to properly handle diverse situations, including driving at night, in the fog, rain, snow, dirt, etc.
Mastering software complexity:
Autonomous vehicles are highly complex real-time systems and require complex software to process numerous high-bandwidth data streams. Multiple robust and efficient algo-

A Success Story: Navya Shuttles

To develop complex functions for autonomous driving, NAVYA, one of the leading suppliers of autonomous shuttles, relies on the multisensor development environment RTMaps. "We have accompanied the company since its foundation. The Navya team already consists of 250 employees, is still growing rapidly and already operates more than 150 vehicles worldwide," says Nicolas du Lac. RTMaps is a tool that many developers use on a daily basis. "We are proud that we were able to make our contribution to this success story," explains du Lac.

Nicolas du Lac is the CEO of Intempora.

rithms and software tasks have to be executed in parallel, with safety constraints on execution timing, latency and error management.

Data management and algorithm validation:
Data is the virtual fuel of autonomous vehicles. To train, test, and validate perception and deep learning algorithms, engineers have to collect various large sensor data sets in different driving conditions. Data annotation, labeling, and management tools for data selection and postprocessing, as well as simulation tools, are critical for the development and validation of robust and safe systems.

Since the recent acquisition by dSPACE, our software engineers and consulting experts have been collaborating closely to bring reliable and efficient solutions to the market. We are definitely thinking about the next steps – we aim to deliver a unique software tool chain, from prototyping to production, to address all stages of the development process for autonomous driving, and we are bursting with ideas.

RTMaps is the core solution of Intempora. What makes this software so special and who is working with it? Can you briefly present an example project?
The majority of our customers use RTMaps to develop algorithms for assisted and automated driving, but some also use RTMaps in other applications and domains, including autonomous trains, robotics, offshore wind turbines, smart rearview mirrors, inspection robots, simulated driver and pilot behavior, mobile mapping systems, cognitive applications, and system and video monitoring for race sailing ships. The high versatility and performance of our solution is appreciated by many of our customers, with some of them considering RTMaps the real enabler for drastically speeding up their development processes. Valeo uses RTMaps in R&D in different countries. We recently established a technology partnership with them to publish the Valeo Drive4U Locate algorithm in the RTMaps AI Store. Valeo Drive4U Locate is an affordable, precise, and robust localization and mapping solution developed by Valeo for automated driving. This proprietary SLAM enables centimeter-accuracy positioning in situations with limited or no GPS signal. This algorithm was developed with RTMaps and demonstrated in the streets of Paris with a Level 4 autonomous vehicle.

Complementary solutions to RTMaps include your new data annotation software, RTag, and the Intempora Validation Suite (IVS). What is the functionality of these two solutions?
RTag is an annotation software application for mobile devices. With RTag, it is easy to manually monitor in-vehicle data recorders and manually annotate recording sessions while driving to identify relevant scenarios. The Intempora Validation Suite (IVS) is a cloud-based software tool chain for training, testing, benchmarking, and validating ADAS and AD software functions, including perception and deep learning algorithms (designed with RTMaps, for instance) against large driving sensor data recordings stored in big data architectures (cloud or on-premise).

How does the cooperation with dSPACE influence your relationship with international customers?
The acquisition was very well received by our customers and partners around the world. It is definitely a new chapter in the history of our company.
We will continue to work as we always did – delivering best-in-class software solutions to all of our users. Our Cooperation with dSPACE is going well, as we are already involved in many strategic discussions. The acquisition boosts our ability to provide optimized support in customer projects.

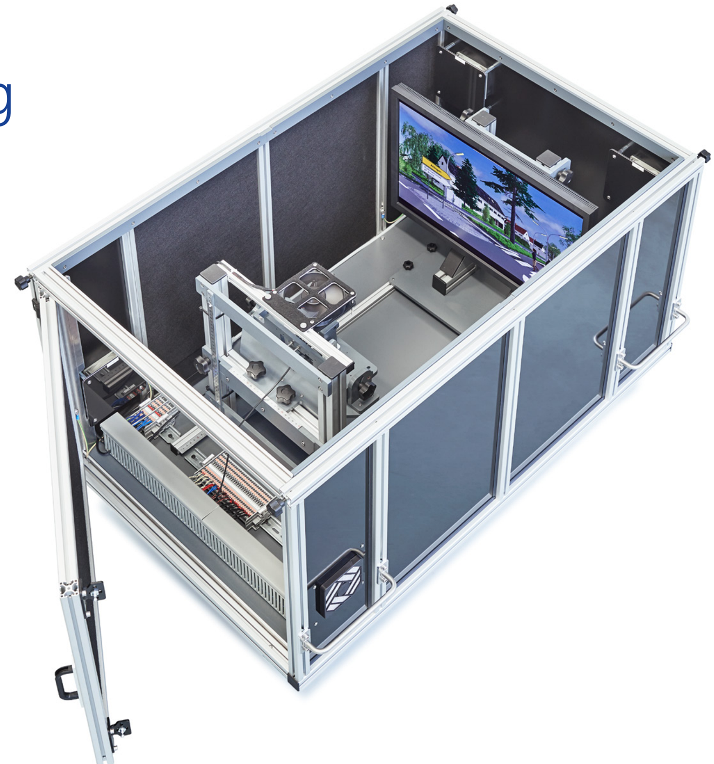
How does the cooperation with dSPACE influence your relationship in terms of technology development?
Technologies are evolving fast, and we are continuously refining and developing our solutions to bring cutting-edge software to the market. We are working with dSPACE to offer a seamless and complete end-to-end tool chain. We are also working on new enhancements for IVS by integrating tools from understand.ai, another company in the dSPACE family. We continue to establish technology partnerships with semi-conductor companies such as NVIDIA, NXP, and Renesas, to better meet customer expectations. We are also working on our product roadmap with dSPACE consulting experts, which will define our strategic approach to future challenges.

Who can customers contact about your products?
The best way is to contact your regional dSPACE company and account manager. dSPACE has offices around the world, offering personal and optimized support in your native language.

Thank you for the interview.

Camera ECU Testing with Simulated Driving Scenarios

In autonomous vehicles, the electronic control unit (ECU) that interprets the camera's environment images plays a key role. dSPACE offers a system for testing these camera ECUs, consisting of a dSPACE camera box, a dSPACE SCALEXIO simulator, and dSPACE software.



Application example: Driving scenarios are played back to the camera on a screen to test the relevant ECU. Not only can the camera be individually positioned. It is also possible to install different lenses to create a sharp image for different camera types. During operation, the box is closed and completely darkened to prevent disturbing light reflections and glare.

Simulation Platforms

The dSPACE hardware-in-the-loop test system SCALEXIO is a proven platform that is quickly ready for use. Users also benefit from the advantages of HIL testing, namely the reliable reproducibility of tests, test automation capability, and the resulting time savings in the test process. The dSPACE Automotive Simulation Models (ASM) can also be integrated to simulate the vehicle, other traffic participants, and the environment. The dSPACE Sensor Simulation for Camera lets users visualize the test drives on a high-definition monitor.

Possible Use Case: NCAP Crash Tests

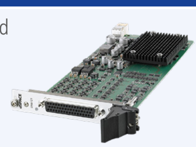
A possible use case for the dSPACE camera box is the implementation of New Car Assessment Program (NCAP) crash tests. Test sequences can be created using the dSPACE test automation software, AutomationDesk. These test sequences can be started automatically to make the test process more efficient. For managing different test variants, dSPACE SYNECT is ideal. Both software products, AutomationDesk and SYNECT, help increase the number of completed test variants and improve the test quality. ■

The ECU evaluates the driving scenarios visualized in dSPACE MotionDesk and responds accordingly. Tests include the verification of the correct detection and classification of environment objects, such as other vehicles, pedestrians, road signs, and trees.

The new boards can be used in the following SCALEXIO systems (from left to right): SCALEXIO LabBox, SCALEXIO AutoBox, SCALEXIO rack system, SCALEXIO customized rack system.

New Functions for SCALEXIO Systems

New hardware continuously expands the range of functions and performance of the SCALEXIO systems. The products listed below are further strengthening the SCALEXIO product portfolio, particularly in the field of electromobility, and offer customized solutions for function development and ECU testing of highly dynamic electric drive concepts as well as the associated power electronics. ■

Product	Description
DS6121 Multi-I/O Board 	■ A multi-I/O board with application-specific functional layout for the dynamic control of electric motors and power electronics ■ Various interfaces for processing encoder signals, synchronized current/voltage measurement, and for generating multichannel PWM signals ■ Integrated sensor supply
DS6651 Multi-I/O Module 	■ An I/O expansion for SCALEXIO FPGA boards ■ Ideal for developing and testing highly dynamic controls in the areas of electrical drives and power electronics ■ Six powerful analog input and output channels and 16 digital channels ■ Up to five modules can be connected to one dSPACE FPGA Board (DS2655, DS6601, DS6602)
DS6342 CAN Board 	■ A bus I/O board with eight independent CAN/CAN FD channels ■ Ideal for applications that require a high number of CAN/CAN FD channels
DS6321 UART Board 	■ A bus I/O board with four independently configurable controllers for the communication protocols RS232, RS422, RS485, and K-Line ■ Ideal for connecting a SCALEXIO system to a control unit or external device via a serial interface

MicroAutoBox III Embedded PC – The ideal PC Extension for Computation-Intensive In-Vehicle Tasks

The new MicroAutoBox III Embedded PC has everything that is required for in-vehicle use, both as a PC extension for the MicroAutoBox III real-time system and as a stand-alone PC system. Despite its compact size and robustness, an Intel® Xeon® server processor provides high processing power for demanding Linux®- and Windows®-based tasks. This includes applications for assisted driving (ADAS), for example, the execution of the multisensor software RTMaps and ROS (Robot Operating System), or infotainment and telematics applications. You can also conveniently execute dSPACE software, including ControlDesk, in the vehicle to reduce the number of additionally required devices, such as laptops, on a test drive. This lets you connect displays or touchscreens for various status displays as well as dashboards directly to a MicroAutoBox III system.

To access internal MicroAutoBox III data during the test drive, an optional LTE module including a GNSS receiver can be integrated. This way, data can be sent directly to the cloud or to another server, for example.
Two 10 Gigabit Ethernet interfaces (10GBASE-T) let you connect sensors with high bandwidth, such as cameras. It is also possible to equip the Embedded PC with extensions for WLAN, CAN FD, and BroadR-Reach. ■

High-End Simulation of Power Electronics – Even Without Expert Knowledge

In the electromobility industry, many manufacturers are currently facing the challenge of developing solutions for the charging infrastructure of the future. Intelligently controlled power electronics are key – whether you use them for quick charging in public places or overnight charging at the wallbox at home with the charging technology installed in the vehicle. But how can you test the control algorithms efficiently and with maximum performance? Manually creating real-time models is usually time-consuming and requires considerable expert knowledge. With the Electrical Power Systems Simulation (EPSS) Package, dSPACE offers a comprehensive toolbox that supports you in completing this task. Whether you are working with complex topologies or compact rectifiers and DC/DC converters: The toolbox lets you generate the real-time-capable model from the circuit diagram with only a few mouse clicks. Combined with the optimized algorithms of the EPSS toolbox, the dSPACE DS6601 and DS6602 FPGA base boards now enable even higher switching frequencies and larger model topologies. For circuits with particularly high performance requirements, the dSPACE toolbox offers semi-automatic model splitting: Algorithms analyze the overall circuit and provide information on resource consumption and stability to determine the optimal separation point for model splitting. By using the new optical high-speed communication interface (multi-gigabit transceiver, MGT), large topologies can then be easily distributed across multiple FPGAs. ■

dSPACE V-ECU Task Force

Early virtual validation of ECU software with PC-based simulation platforms makes it possible to design particularly efficient development processes. By supporting and integrating different modeling approaches and standards, realistic simulation environments can be implemented easily and quickly.

As a PC simulation platform for virtual ECUs, dSPACE VEOS offers added value, for example, when frontloading tests. Our software supports a variety of simulation formats, such as Simulink implementation containers (SIC), Functional Mock-up Units (FMU), restbus simulation (BSC), and virtual ECUs (V-ECU). Various interfaces, such as XCP and XIL API, allow for convenient instrumentation of the simulation.

Our many years of experience in the field of virtual validation have shown us that the challenges do not lie in the simulation itself and the test integration but in the virtualization

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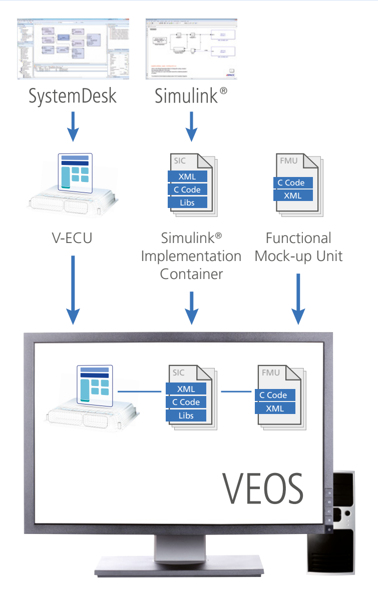
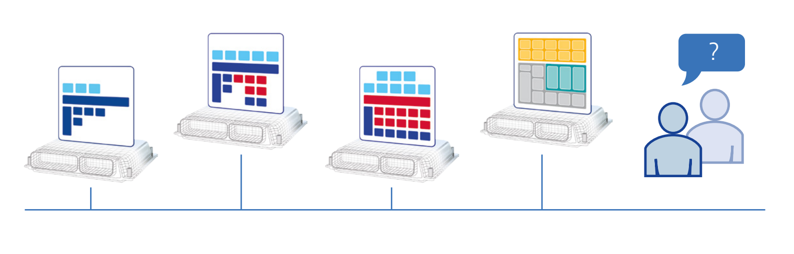
of the artifacts required for the simulation. There is a number of processes and workflows, especially for generating the virtual ECUs, due to their varying complexity. While creating a V-ECU with only the application software (level 1) is still relatively simple, the application and basic software of a V-ECU at MCAL level (level 3) might have considerable dependencies on the underlying hardware. In addition to the technical challenges that have to be overcome when creating V-ECUs, the different software managers of an ECU bring about additional political and process-related dependencies during virtualization. If, for example, the OEM is typically responsible only for a part of the application software, large parts of the application software, and often also the majority of the parts of the basic software, might be provided by different suppliers. While the system under test (SUT) in the hardware-in-the-loop (HIL) test is the real ECU, the SUT in the software-in-the-loop (SIL) test consists of a variety of artifacts that represent only a part of the real ECU and that have to be transferred to a V-ECU. Testers face great challenges especially when tests are frontloaded from HIL to SIL, because the parties involved in the V-ECU are different from those involved in the typical HIL test.

To support our customers in tackling these challenges successfully, dSPACE has set up the V-ECU Task Force. We want to help our customers to a successful start with our SIL tool chain and especially support them during V-ECU generation. For this purpose, we have brought together a team of technical experts from product development and Engineering Services departments that can quickly and flexibly come to the customers' help. The team offers a wealth of experience with the V-ECU workflow and also aids customers in process-related challenges that involve different parties. The V-ECU Task Force supports not only the generation of V-ECUs, but also the integration of a V-ECU or SIL tool chain into the test process.

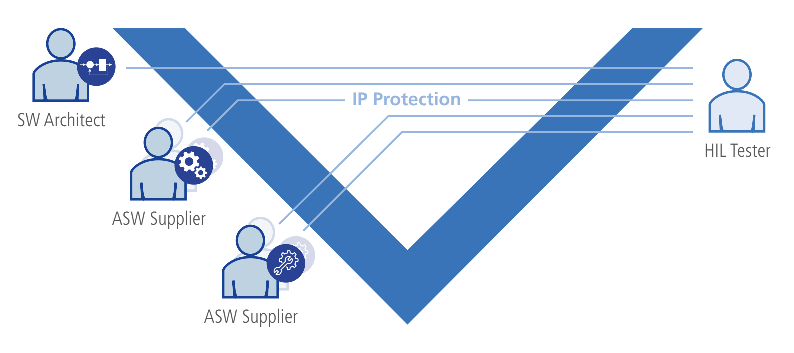
You can immediately contact the V-ECU Task Force via your sales contact or directly at *V-ECU_TaskForce@dspace.de*. ■



VEOS processes data from a variety of sources.



A clear separation between the hardware and software layers as called for by standards such as AUTOSAR is usually not feasible.



In SIL validation, different parties interact with each other than in HIL validation. This also creates new challenges.

Our Solutions – Your Success:

In the last months, we had the opportunity to implement numerous steering and braking test benches for and with our customers.

dSPACE