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dSPACE MAGAZINE

1/2020

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Challenge: Break the Anonymizer!

understand.AI invites you to submit images that challenge our anonymizer. Feel free to send us images that show busy traffic scenes and features like faces or license plates.

Help us to uncover new unusual street scenes where the UAI Anonymizer breaks and win free anonymization of your data!

Send the images to *anonymizer@understand.ai* with the subject *"Break the Anonymizer"*. The competition **ends on March 31, 2020**. Winners will be announced in the next issue and on the website.

Prizes for the top three sent in edge cases

1st place – 10,000 anonymized images
2nd place – 5,000 anonymized images
3rd place – 1,000 anonymized images

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Please adhere to the rules of the GDPR

Identity Protection Anonymizer

With GDPR and other data protection laws worldwide, autonomous vehicles need to be able to collect street scene data with all the critical personal information automatically removed. The AI-powered anonymizer tool from understand.ai, called Identity Protection Anonymizer, ensures your data is compliant by blurring faces and number plates in a fully automated fashion. The system can be used on premise or as a service via the understand.ai cloud platform. In both cases we make sure the anonymizer provides the highest quality data at the scale required. **www.understand.ai**

> "dSPACE – your partner for simulation and validation."

Dear Readers,

Many of you have known us for decades as a reliable partner for prototyping, HIL testing, and code generation, solutions that increase your development efficiency. But dSPACE continues its fundamental transformation. Without neglecting our core business, we have been strengthening our software simulation as well as AI- and cloud-based solutions for several years. dSPACE is repositioning itself as your partner for simulation and validation. Now, we can support you with an end-to-end solution in all domains. Our offerings for data driven development, which is a prerequisite for autonomous driving, range from data logging, labeling, and scenario generation to scenario-based testing and product approval. We established this range of integrated solutions through a combination of our own efforts as well as partnerships and acquisitions. The acquisition of understand.ai is an important building block in this process, and I would very much like to welcome their employees to the dSPACE Group.

We recently presented our complete range of solutions at the dSPACE World Conference in Munich. We are very pleased with the positive feedback we received from you, our customers. We are also particularly delighted that the repositioning of dSPACE including a much wider range of software and simulation offerings was so well-received. The true strength of our new software solutions is illustrated by a project in which understand.ai generated high-precision reference data for Robert Bosch AG to successfully train neural networks.

The SERES project clearly demonstrates our competence in simulation, validation, and radar technology. In this issue, you will learn how our solutions helped developers validate functions for automated driving using complex scenarios and how they were even able to fully integrate real sensors into the simulation.

With regard to electromobility, we are continuously adding to our portfolio. By doing this, we can cover requirements for development and testing using comprehensive solutions from power generation to propulsion technologies. One example is the new dSPACE DS5366 Smart Charging Interface with which automobile manufacturers and providers of charging stations have a complete solution for developing and testing technologies for smart charging at their hands.

As your partner for simulation and validation, we continually invest in solutions that accelerate your development while making it more productive and secure. In this spirit, let us continue on this common road to success.

Martin Goetzeler

IMPRINT

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Aired Scenarios

Testing controllers and sensors for autonomous driving with over-the-air stimulation

The development of autonomous vehicles leads to immense test and validation efforts. To handle complexity and costs, SERES has opted for a testing system from dSPACE that can be used early and flexibly in the development process – with real sensors in the loop.

Picture credit: © SERES

SERES is a global transportation technology company that develops and manufactures intelligent electric vehicles to create safer, cleaner, and more sustainable communities. We at SERES technologies are focused on delivering improved safety, convenience, and performance to a global market. Our company owns and operates manufacturing, assembly, and research and development facilities across the U.S., China, and Japan.

SilkRides and Our AD Strategy

SilkRides is a business unit of SERES that develops autonomous driving (AD) technology. Our team has an OEM heritage with Silicon Valley roots to provide a cost-competitive and open autonomy solution for carmakers. Established in 2017, SilkRides has demonstrated Level 3 and Level 4 autonomous driving in urban and highway scenarios.

The SilkRides AD Stack

The team is set to cover the complete technology required to develop and manufacture autonomous vehicles.

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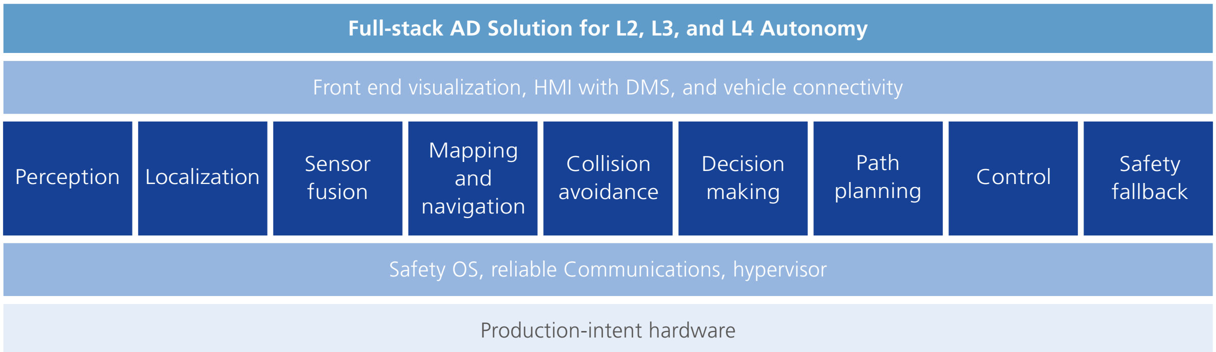


The complex AD solution that is currently under development has to be reliably validated before it hits the road.

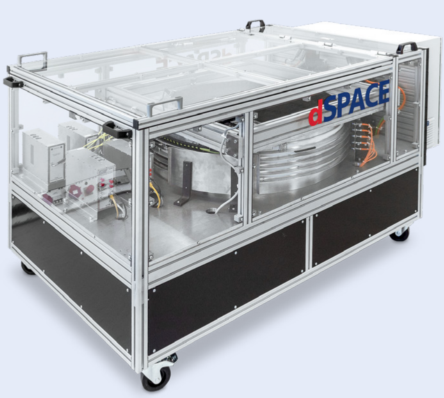
This includes expertise in perception, planning, and control – not only for development but also for the validation of these safety-related areas as well as over-the-air (OTA) software updates, hardware design, etc. A key component is the domain control unit, which is partly based on artificial intelligence. It evaluates the sensor data and determines the driving strategy. In a first step, it is implemented as a prototype controller, which is gradually developed further for mass production.

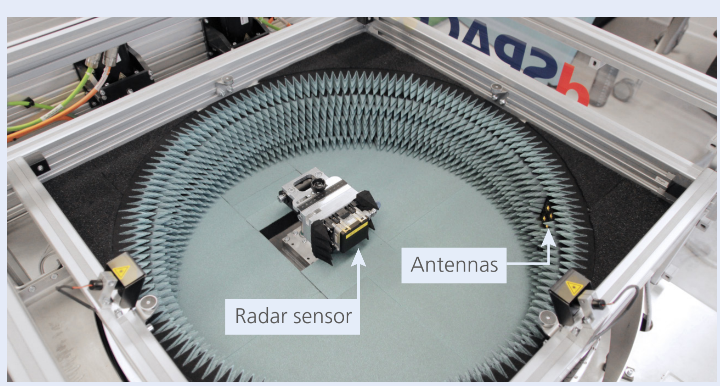
The Challenge of AD Validation

To prove that an autonomous driving system is as safe as an average human

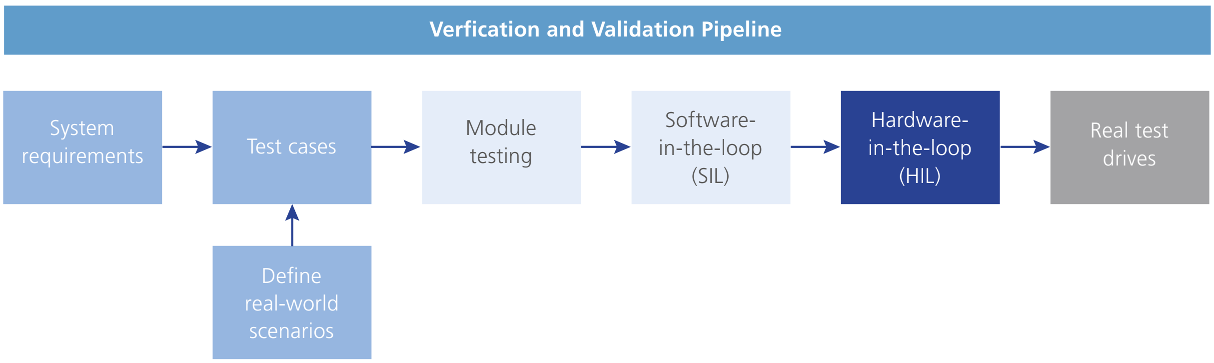
dSPACE Radar Test Bench

To test the entire chain of effects, the dSPACE radar test bench provides over-the-air stimulation of the radar sensor. If desired, the simulation can include the front bumper and parts of the chassis of the vehicle. This way, all the software and hardware layers can be taken into account, from detecting the signal at the front of the radar to evaluating it in the radar ECU. This very compact test bench fundamentally consists of an anechoic chamber with integrated antennas for send/receive functionality, a calibrated dSPACE Automotive Radar Test System (DARTS), and a SCALEXIO HIL simulator. For the test, the radar sensor is locked into the chamber, where it is stimulated with realistic radar echoes. The coherent echoes allow for the radar ECU to reliably determine the distance, velocity, radar cross section (RCS), and angle of the radar objects. The front radar is tested by using two DARTS 9030-M units. For the corner radars, SERES installed a DARTS 9030-MS unit, which is particularly strong at short-range stimulation. This configuration is sufficient to test all relevant driving scenarios.





Testing real radar sensors with the radar test bench. The anechoic chamber with integrated antennas and the sensor under test in the center.



Verification and validation are carried out in consecutive steps, which are repeated according to test requirements.

driver, billions of real-world driving miles for validation might be required. Moreover, each update of the software also has to undergo rigorous testing. Here at SERES, we have limited resources and a tight deadline to accomplish this task, and road testing on a large scale is unrealistic. To speed up our development and validation cycle, we look to establish our verification and validation pipeline with various levels of simulation, where key scenarios and corner cases can be tested for each software release before road tests.

The SilkRides Testing Pipeline

At SilkRides, each software release goes through multiple levels of testing before it reaches the test vehicle. First, unit tests and module tests are performed to ensure that the new software components behave as intended. Then the new components are integrated with the rest of the decision and planning modules for software-in-the-loop (SIL) testing, where the software pilots a simulated vehicle through relevant test cases to evaluate performance. If the SIL testing results are positive, the new software release will be compiled on the domain controller hardware for hardware-in-the-loop (HIL) testing. The process has a certain data consistency for test artifacts, such as virtual roads. During the SIL and HIL testing process, many issues invol-ving the software and the interaction between software and hardware are observed and fixed, reducing the number of test vehicles and road test mileage required to validate the software releases.

Requirements for HIL Testing

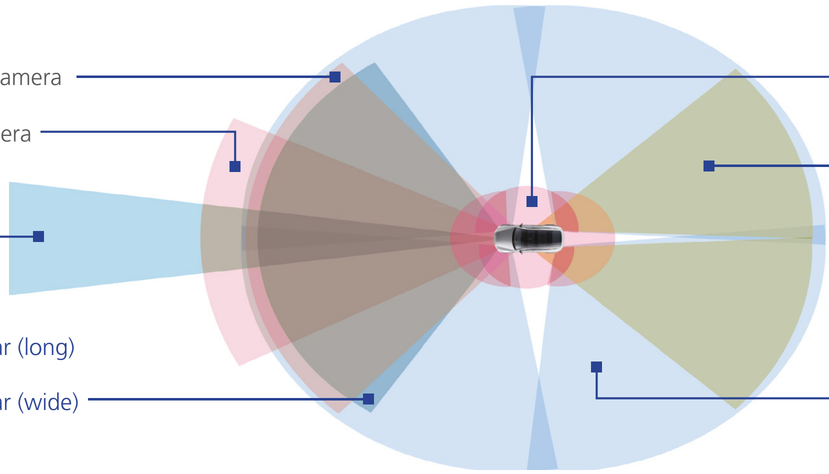
There are a few key requirement that have to be solved by HIL testing for the development of autonomous driving at SilkRides:

- **In-house integration of software and hardware:**
  HIL tests are intended to provide a method to test the software on our domain controller as early as possible. Any issues caused by embedded software integration or the real-time operation on the hardware can be identified and remedied before testing in the vehicle.
- **Integration testing of third-party sensors:**
  With over-the-air (OTA) radar and camera test benches, the integration of the real sensors in the HIL test setup is possible. Issues caused by the sensor drivers, harness, and the sensor itself can be addressed on the HIL test.
- **Safe in-lab testing platform for corner cases:**
  Testing critical corner cases and hardware failures can be dangerous on the road, and impossible to simulate in SIL simulation. The HIL setup lets us to validate these potentially dangerous cases in the safety of the lab. Read more on this in the 'Simulation of Fail Operation Functions' section.

Test System Setup

To perform detailed and comprehensive lab testing, we went for a flexible and complete setup that covers the SilkRides AD stack. Together with dSPACE, >>

> "To prove that an autonomous driving system is as safe as an average human driver, billions of real-world driving miles of validation might be required. The dSPACE test system in our lab provides an efficient way of testing real stuff on virtual roads."
>
> *Ziqi Zhu, SERES*



Overview of the sensor setup in the vehicle.

"The radar test bench gives us the opportunity to evaluate and test radar sensors early on. This greatly improves development of the software for radar processing and autonomous driving."

Samuel Rayseldi, SERES

we defined a system that can handle integration testing of sensors, controllers, and actuators. It consists of a HIL simulator that realistically represents our vehicles. It is further extended by four synchronized sensor test benches, which bring the real radars and cameras into the loop. The ability to use real components also allows us to evaluate the performance of different components at the early stages of development.

Test Definition

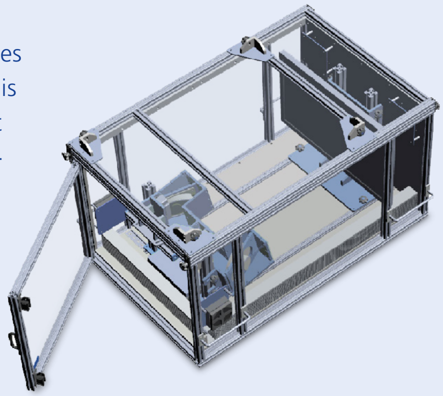
We started testing by performing test drives with ASM Traffic, the traffic simulation model of the Automotive Simulation Models (ASM) tool suite. It lets us define traffic vehicles, pedestrians, traffic signs, etc. on roads imported from HD maps. Moreover, ASM Traffic supports the creation of test scenarios for the assistant functions of our vehicles, such as adaptive cruise control, lane keeping, overtaking assistants, etc. The overall test automation is handled by AutomationDesk, providing additional test options, such as signal manipulation and test reporting.

Closed-Loop Testing

The simulated world is then fed into the sensor test benches to stimulate the radar and camera sensors. The

dSPACE Camera Box

To test the sensing properties of a camera, the dSPACE camera box provides over-the-air stimulation of the camera's imager chip. For this purpose, it is equipped with a monitor that displays the simulated sensor environment (e.g., a traffic scenario with multiple vehicles, pedestrians, roadside structures, etc.). The camera then further processes the data. To minimize any additional light sources or glare, everything is installed in a closed chamber.



The camera box for over-the-air stimulation. The camera sensor (left) is aligned to the monitor (right).

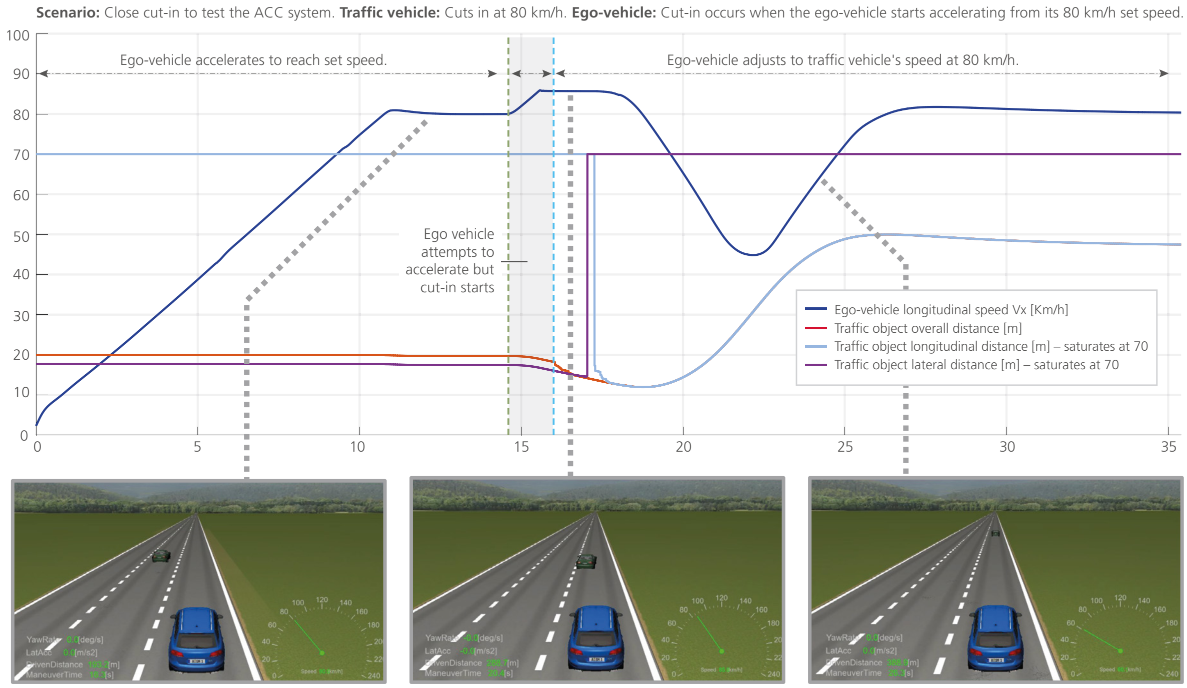


Diagram displaying the ACC performance during a cut-in scenario.

sensor signals are the inputs for the device under test, which is our controller running the developed AD software with perception and sensor fusion algorithms. This way, all AD components are integrated and their real behavior is taken into account. Every virtual test drive can be monitored by 3-D animation in real time.

Test Possibilities and Results

The test system, based on the HIL simulator and the test benches, gives us various test possibilities that lead to excellent coverage. They also help perform quick evaluations under identical conditions. The following evaluations and tests were performed and show what SERES has achieved:

Flexible Sensor Integration

The field of autonomous driving is quickly evolving, so investing in assets that can adapt to changes is crucial. Over-the-air radar and camera test benches from dSPACE were selected for their flexibility in adapting to different sensor types and sensor configurations. The over-the-air approach makes it particularly easy to perform plausibility tests. This way the behavior of the sensors (complete control unit including the signal processing software) is evaluated under defined conditions – and especially in borderline cases. The cases in which objects are detected by a sensor or not detected are fundamental for the development of the software that further processes the sensor signals.

Sensor Benchmarking with Radar Chamber

SilkRides relies on automotive Tier 1 suppliers for radar sensors, so accurate benchmarking of the performance between the sensors is one of the key tasks to be considered when narrowing down the supplier. Radar performance tests on the vehicle generally require a large site, and often require the host vehicle and the target vehicle to be moving simultaneously with ground truth devices installed. With the closed-loop radar test bench, many of the tests can be conducted in the lab, providing clear and consistent results. The dSPACE Automotive Radar Test System (DARTS), which is installed in every radar test bench, contributes to this. It generates radar echoes over-

> "Reality is key when it comes to the development of software for autonomous driving. With the ASM tool suite, we perform virtual test drives in close-to-real environments."
>
> *Hala Al-Khalil, SERES*

Visualization of the imported map data from the Oakland Bay Bridge area.

the-air with moving antennas so that the characteristics of a sensor can be determined exceptionally accurately.

Scalable for Future Applications

Our 1x camera, 1x front radar, 2x corner radar HIL setup is enough to simulate most of the highway driving functions in our system, since the corner radars can be configured to be on the front, side, or rear of the vehicle. As next steps, additional cameras, radars, lidars, ultrasonic sensors, and GNSS simulators can be included on the SCALEXIO platform. Due to the flexible system setup, these can be either hardware or software extensions. For instance, the system supports the integration of a lidar model from the dSPACE Sensor Simulation tool chain that simulates the complete lidar transmission channel, including the 3-D environment.

Simulation of Fail Operation Functions

With the development of autonomous driving systems of SAE Level 3 or above, many parts of the system must be fail-operational in all of the operational design domains. Such failure conditions can be difficult and sometimes dangerous to replicate in the vehicle. The hand-off between primary function and backup function in case of failure and the safe stop maneuvers in various road conditions can all be simulated in the HIL test.

Automation Enabling Regression Testing

dSPACE tools, such as AutomationDesk, allow us to automatically configure the test benches upon startup, which significantly reduces manual entry steps. Moreover, many of our tests can be automatically executed without user intervention, allowing a fixed set of test cases to be systematically evaluated for each new software release or hardware modification.

Scenario Generation with HD Maps: Bay Bridge

The SilkRides highway driving uses third-party maps to assist in lane keeping, lane change, and routing functions. The integration between the dSPACE ASM and HD map import ensures a high-fidelity simulation environment compared to real-world testing. Here in the San Francisco Bay area, the entrances and the exits of the Bay Bridge have presented many

At a Glance

The Task

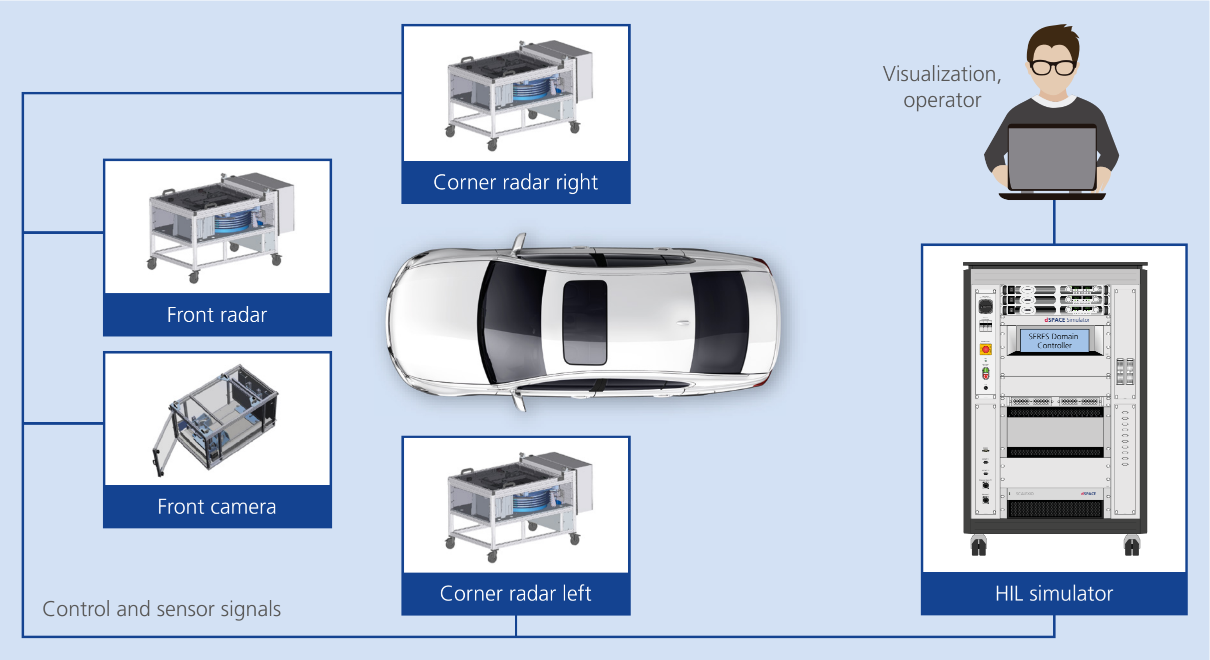
- To prove an autonomous driving system (sensor set and controller) is as safe as an average human driver

The Challenge

- Examination and testing of the entire chain of effects of all integrated components
- Evaluation and identification of the most suitable sensors
- Supporting a flexible replacement of sensors
- Flexible scenario generation based on real map data

The Solution

- Installation of a HIL system for real-time vehicle and traffic simulation
- The HIL system is designed to incorporate real radar and camera sensors into the control loop on dedicated test benches
- The sensor performance can be evaluated in relation to the entire vehicle
- Reliable validation of the controller in an easy-to-use virtual environment



The test system for the domain controller of the vehicles consists of three radar test benches and one camera test bench to stimulate the real sensors. The sensor signals are then processed in the HIL simulator, which performs virtual vehicle simulation in complex traffic scenarios. Those scenarios are fed back as sensor environments to the test benches.

challenging scenarios. We have imported the Bay Bridge map into ASM and recreated many of these tricky test cases in our HIL test setup.

Summary and Outlook

The dSPACE test system provides a unique way of integrating sensors and controllers in a virtual vehicle and testing them together. The use of this extra-ordinarily realistic test environment allows us to gain meaningful insights into the performance of the hardware and software components used, even in the early stages of development. This accelerates the development process because groundbreaking decisions can be made at an early stage. Since test cases can be easily reused, regression testing can be performed to reliably verify troubleshooting. New requirements can be met by expanding both the flexible test system and the test libraries. We look forward to bringing new vehicles onto the road that have been validated by a robust and reliable test system. ■

Ziqi Zhu, Hala Al-Khalil, Samuel Rayseldi, SERES

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Ziqi Zhu is the system lead for the intelligent driving team at SERES in Santa Clara, CA, USA.

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Samuel Rayseldi
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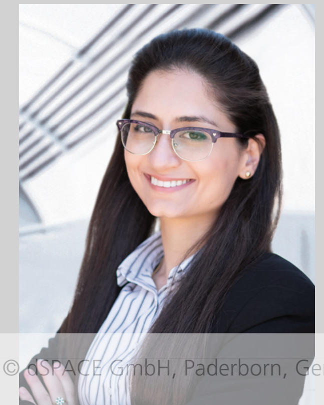

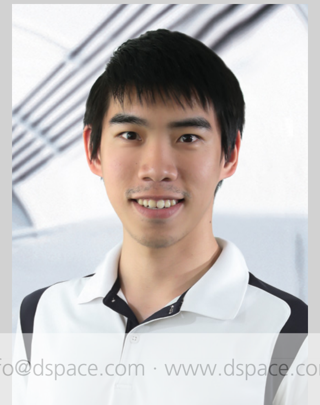

SCALEXIO and PHS systems combined in a test factory for powertrain ECUs

Cumulative Test Power

Renault has set up a new test factory in Romania to achieve a high throughput of test executions when developing and validating powertrain control units. The installed SCALEXIO and PHS systems can be used flexibly for ECU testing – the workflows are the same for both systems. This is achieved with the help of a newly introduced tool chain that is based on a specially developed management system and dSPACE tools.

Picture credits: © Renault

Diversity in the vehicle range increases the number of powertrain variants: The range covers different motor and gear models in various combinations with or without the support of electric motors. In addition to hybrid drives, increasingly more battery electric systems are being developed. Automobile manufacturers, such as Renault, are therefore facing ever more challenges in the area of powertrain ECU development and validation, for example, with regard to efficiently managing development and test data. The aim is to simulate ECU variants by simply making changes in the software. Depending on the vehicle type, engine size, transmission type, and engine concept, the ECU software must be adapted to the respective application. Developers are therefore confronted with enormous workloads, because all possible combinations must be tested and validated. At the same time, the validation process becomes more and more demanding, since an increasing interconnectivity of control units in vehicles and new vehicle functions such as advanced driver assistance systems (ADAS) result in ever more complex tests.

Developing Efficiently...

Renault decided some time ago to optimize its powertrain development and testing processes to meet the future demands and to sustain the delivery of high-quality products with a short time to market. This meant Renault had to install a sufficient number of suitable test systems for control unit validation if they wanted to keep the highly complex tests simple and efficient.

...Using Automated HIL Tests

The large number of variants requires test systems that allow for a high throughput of test executions. It quickly became clear that Renault could only achieve this in the long term by redesigning its hardware-in-the-loop (HIL) tests and reaching a high degree of automation. Merely a few test systems would by no means suffice to do this, so the company decided to set up a new test factory in Romania. The idea: The test systems can be flexibly combined from a pool

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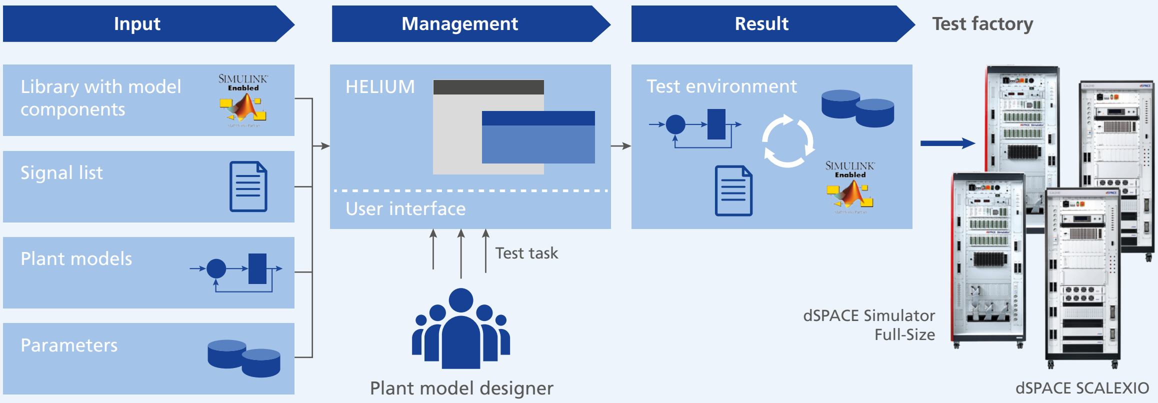

The HELIUM central management system collects a wide range of information for ECU testing, including signal lists, parameters, and plant models, which can be flexibly expanded with various model components. The software uses the information to create a test environment and transfers it to the simulators for the test execution.

of HIL simulators to execute a wide variety of test tasks. Depending on the test task, the developer simply books the required test resources in the factory. This also resulted in new requirements for the simulators.

Variety Requires Processes and Structures

Each ECU variant requires a specific test environment, which essentially consists of the HIL simulator, the parameterized plant model, software tools, and other supporting tools. The environments required at Renault to validate the powertrain are now largely set up at the test factory in Romania where they are also used for ECU testing. One of the most difficult tasks for the developers is to prepare the various HIL simulators on time for the respective test task because each variant requires a new configuration. In addition, each validation team member can book the test systems for their own testing purposes. Smooth procedures therefore require clear processes and structures that accurately define the way the teams work with the systems and the chronological sequence in which they perform the tests. Moreover, the large number of test environments can hardly be managed manually. So, to support their teams during test environment creation, Renault required a higher-level system that manages all necessary work steps and resources and enables build process automation.

The HELIUM Management System

HELIUM is the name of the new tool that Renault designed specifically for powertrain development. It enables the automated creation of test environments for HIL-based tests. The developer can use the tool to automatically set up the environment and move

For testing new powertrain control units, Renault set up a test factory in Romania that consists of 13 SCALEXIO systems and 21 PHS-based simulators. Each validation team member can book the test systems for their own testing purposes.

> "The versatility of the dSPACE products allowed us to easily integrate them into our tool chain and flexibly adapt them to our project-specific requirements."
>
> *Jean-Marie Quelin, Renault France*

it to a database or a repository. To do so, the software has an intuitive user interface which allows for starting the automatic build process at the click of a button. When the tool is connected to the simulator, the validation engineer can load the environment using a dedicated user interface in ControlDesk. Thanks to the simple and convenient workflows, testing time and potential errors are considerably reduced.

Test Factory Combining SCALEXIO and PHS Systems

The Romanian test factory currently consists of 34 dSPACE HIL simulators: 13 SCALEXIO systems and 21 PHS-based simulators that are used for testing new powertrain control units. As initially planned, the various systems can now be used flexibly for a wide range of ECU tests. This is possible mainly because of the standardized XIL API-compliant interfaces of the dSPACE tools, which enable interaction between different test hardware and software. The user interface is the same for SCALEXIO and PHS systems: The full parameterization is carried out in HELIUM. The workflow and the component models for automatically creating plant models are also the same. This allows for performing the same automated tests on all test systems.

High Throughput with Reliable Test System

With the help of the new tool and a few process optimizations, Renault can successfully manage the diverse variants in the powertrain area and meet the high demands placed on the validation process. Today, the team in Romania creates more than one hundred different test environments per year. The dSPACE systems played an important role in achieving this goal. Their versatility and easy integration into the Renault tool chain allow for flexibly adapting to project-specific requirements. At the same time, the dSPACE tools are highly standardized, which means that not all ECU variants require an individual test system. Overall, dSPACE test systems proved to be safe and reliable throughout the entire optimization process, creating the basis for today's high ECU test throughput. Experienced dSPACE engineers have supported Renault directly on site in optimizing and executing the test processes.

Conclusion and Outlook

By using the new tool chain, the development team is able to maintain the efficiency of the development process and the quality of the HIL test environments even with a change in staff. Renault is already planning to further optimize the automation and the validation process, including the step-by-step introduction of 24/7 operation. New functionalities of dSPACE tools will also continuously be introduced in the tool chain. The aim is to soon also use the new process and tool chain in the company's business alliance with Nissan.

Jean-Marie Quelin,
Renault France

Jean-Marie Quelin
Jean-Marie Quelin is a specialist for the validation of powertrain control units at Renault France.

Tests for autonomous driving based on SOTIF

Automatic Safety

Autonomous driving requires much more than simply installing ‘a lot of ADAS’ in a vehicle. This was one of the reasons for establishing the SOTIF test standard for autonomous vehicles, which is much more comprehensive than ISO 26262. Pan Asia Technical Automotive Center (PATAC) has conducted tests according to the SOTIF standard.

Unlike traditional vehicles, which are mainly at risk of system failure, autonomous vehicles are more likely to be subject to limitations in the design of their system functions, which could cause them to behave differently than originally intended in certain situations. This is why the testing of autonomous vehicles requires an approach different from those used for traditional vehicles. This subsequently led to the development of the SOTIF test standard (also known as ISO PAS 21448). SOTIF is a supplement of the ISO 26262 standard and is specially designed for autonomous vehicles. SOTIF defines appropriate methods that must be applied whenever tests of autonomous functions are conducted. This approach includes real road tests as well as tests performed with simulators.

Classification of Risks

When defining effective tests, gaining insights about possible scenarios in advance is quite helpful. Generally speaking, there are four types of scenarios (figure 1): Known safe states, known risks, unknown safe states, and unknown risks. The known and unknown risks are the main focus of the function tests. Evaluating the known risks is the easier of the two tasks because requirements-based testing can be used. This involves designing customized test cases and then processing them step by step – much like an assembly line process.

Testing Unknown Risks

Examining the unknown risks is the real challenge. How can you evaluate a risk situation that is unknown to you, and for which no test case can be clearly defined? The solution to this problem involves using driving scenarios applying as many driving variants as possible. This is done in a simulated and reproducible test environment supported by automatic tests. This approach requires creating precise virtualization models of the vehicle, sensors (such as radar, lidar, GPS, HD maps), environment factors such as rain, road conditions, signs, traffic, and various road users, pedestrians, cyclists and their respective behavior. The modeling of such a test scenario is advantageous because it supports the variation of model parameter values in countless test cases – including the unknown risks – all within a reasonable amount of time. This would not be possible when using traditional manual tests.

Example: Testing the Line Keeping Assistant

PATAC has conducted specific tests of the line keeping assistant (LKA) in accordance with SOTIF guidelines. The LKA relies on a camera which monitors lane markings and automatically intervenes to correct the trajectory if a vehicle tends to veer from its path. The steering torque that the LKA creates via the electric power steering (EPS) must be efficient enough to have the desired effect, but at the same time must be smooth enough to not negatively affect the driver. A real test drive was conducted for this scenario (figure 2). As the driver follows a typical curve, the LKA initiates the corrective steering torque in the EPS via the CAN bus. The corrective steering torque is incrementally increased during a series of test runs so that the driver is required to exert more steering torque each time. The process continues until the driver can no longer keep the vehicle in the lane. The maximum limit for the steering torque generated by the LKA is then set just below the parameter value at this moment. >>

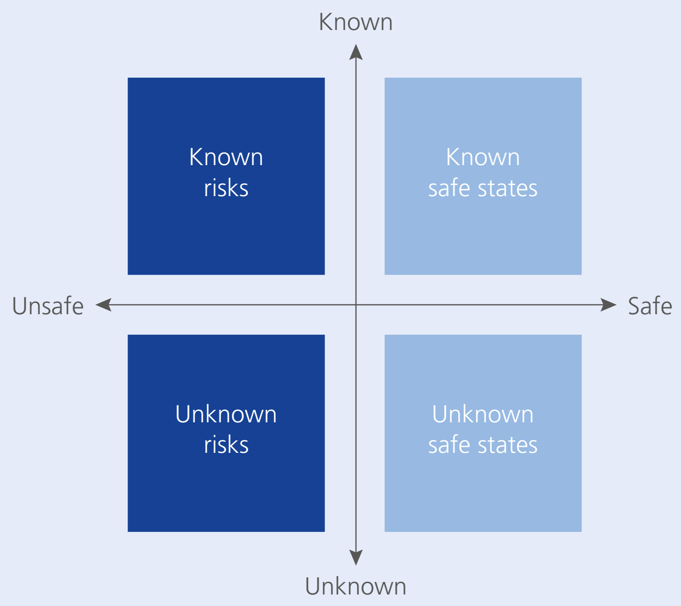

Figure 1: Classification of various scenarios for autonomous vehicles. The focus of testing is on the scenarios shown in the left half of the diagram, namely the known and unknown risks.

"The dSPACE development environment supports very efficient automated testing of autonomous vehicles in accordance with SOTIF."

Shang Shiliang, PATAC

dSPACE Tools Minimize Testing Effort

Several dSPACE hardware and software tools are used in the development environment (figure 3). The first task in a typical work process (steps 1 and 2) is focused on creating the test scripts for the subsequent automatic tests. In classic work processes, these test scripts would be manually created and would have to be rewritten for every test case. This requires quite a lot of time and effort. In the shown work environment, the process is considerably more efficient: Thanks to dSPACE SYNECT and AutomationDesk, new test scripts can be automatically created from existing scripts used for similar test cases. The parameterization of the test cases can be supported by Excel® macro files to additionally simplify the work process. By taking this approach, the variation of test parameters allows for the automatic simulation of countless test cases within a very short time (step 3). This is absolutely necessary for tests that comply with SOTIF to achieve, with the highest levels of probability, a coverage of even the unknown risks. The actual tests of the functions in the autonomous vehicle are then performed using a HIL test platform and/or performing a real test drive (steps 4 and 5) in which the dSPACE MicroAutoBox serves as the controller. Test protocols are automatically created for the HIL tests as well as the real test drive (Step 6).

Conclusion

SOTIF is the first standard specially designed for the development of autonomous vehicles. Tests based on the

Figure 2: Real test drives are used to define the amount of steering torque that the LKA generates in the EPS.

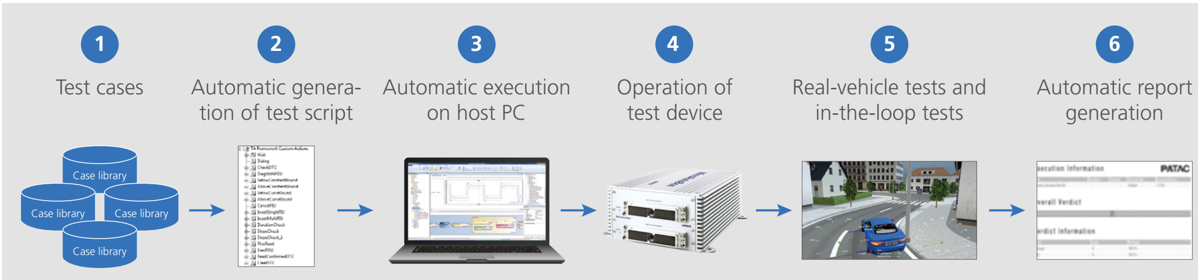

Figure 3: The typical process for automatic tests in accordance with SOTIF. The automatic generation of test scripts and the ability to conduct HIL tests and real test drives with the same tools are key advantages in this approach.

> "The SOTIF approach requires comprehensive test variants. These can be automatically generated with tools from dSPACE."
>
> *Cui Haifeng, PATAC*

SOTIF standard can even detect errors which occurred during the design phase of functions for autonomous vehicles. The test environment at PATAC is equipped with the dSPACE tool chain and supports automated testing in accordance with SOTIF. The ability to perform HIL tests as well as real test drives is a key advantage of this test environment. Another important benefit is the fast, automated creation of multifaceted test cases. ■

PATAC (Pan Asia Technical Automotive Center), founded in 1997, is a joint venture of General Motors China LLC and Shanghai Automotive Industry (Group) Corporation (SAIC Motor). It includes a design and development center in Pudong (Shanghai, China) focused on the development of Shanghai GM products while also serving as the second largest technical development and design center maintained by General Motors worldwide. With the goal of establishing itself as a groundbreaking enterprise of worldwide stature in the automotive development sector, PATAC offers all kinds of automotive development services of relevance to design, technological development, testing, and validation.

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Put a Label on It

Generating highly accurate reference data for training neural networks

How can you solve the particularly challenging tasks of autonomous driving in the processing chain from perception and situation analysis to behavior planning with artificial intelligence? The tech company Bosch shows how to efficiently train neural networks with annotated sensor data from understand.ai.

Picture credits: © BOSCH

New innovative concepts for mobility, such as highly automated or autonomous driving, place enormous demands on the safety and reliability of technical systems. The efficient development of particularly reliable control systems for autonomous driving up to SAE Level 5 also requires the use of suitable technologies. Conventional control-based approaches therefore compete with the capabilities of trained neural networks. When executed on fast graphics processing units (GPUs), neural networks are particularly suitable for processing the vast amounts of data from high-resolution sensors.

Identifying AI Application Areas

In this context, the first step is to identify potential application areas for artificial intelligence (AI) along the entire processing chain from perception to situation analysis and behavior planning. In addition, particularly promising methods from the field of machine learning must be evaluated. This is the starting point of a project in which Bosch investigates both AI application areas and learning methods with a focus on multimodal perception, i.e., the environment perception of a vehicle with the merged data of video, radar, and lidar sensors.

Setting up a High-Diversity Data Set

The raw data of the sensors installed in the vehicle, which is recorded during real drives, is used as training data. The traffic environments used for the recordings must be very diverse (highways, country roads, urban areas, traffic objects, traffic scenarios, etc.). This is achieved in particular by defining the ideal types and characteristics of routes as well as route categories. For the real drives, tracks that match the definitions and cover all defined categories are then selected.

Training Neural Networks Using Supervised Learning

Like the human brain, neural networks learn by means of positive and negative examples: The paths to correct results are maintained, the ones to incorrect results are discarded. Both tasks and solutions are required to identify correct results. In the context of systems for autonomous driving, these tasks and solutions are typically the raw sensor data and the detected objects, respectively. This approach is called supervised learning. The solutions are made available in a previous step by markings (labels/annotations) in the form of reference data (raw data plus label/annotation).

Learning Material for Neural Networks

Successful (machine) learning requires the use of high-quality learning material. Therefore, relevant objects that AI has to recognize by itself later (pixel patterns etc.) must be precisely >>

Picture credits: © Martin Stollberg, BOSCH

The vehicle for the measurement campaign with the installed sensor set (radar, lidar, camera).

> "Highly accurate annotation is an indispensable prerequisite for supervised machine learning. We rely on the labeling service and tools from understand.ai."
>
> *Dr. Claudius Gläser, BOSCH*

marked and classified in the data. Since this step entails very high, partly manual efforts, the anonymized data was transferred to the service provider understand.ai, a dSPACE group company that specializes in labeling automation. Bosch and understand.ai agreed on precise quality goals to ensure successful training.

3-D Annotation of Lidar Data

Annotation was performed with data from lidar sensors. The objects were marked with high-precision bounding boxes placed in the 3-D point clouds of the lidar. The camera sensor data was used for plausibility checks. An iterative approach has proven successful for achieving the defined quality goals. In this approach, interim results were reviewed and discussed in feedback loops with understand.ai. The feedback loops and continuous requirement refinement helped ensure the required level of quality early and continuously.

With the web-based UAI tool, an object in a lidar point cloud is accurately marked and then classified.

Special Challenges During Annotation

Annotation poses special challenges, such as differentiating between cars and vans or detecting vehicles with roof boxes or bicycle racks. Expert knowledge and powerful tools make the difference in these complex tasks. With its web- and AI-based tools for object detection and prediction, understand.ai was able to identify boundary cases and show sophisticated solutions.

Supervised Learning with Annotated Sensor Data

The annotated data is used to identify potential application areas for AI. Networks are trained for specific applications and their behavior and performance are evaluated. Depending on the depth of the network and the amount of data, training can take several days or weeks. A prerequisite for successful training processes is a coordinated IT infrastructure equipped with powerful GPU-based computer clusters.

Results and Accuracy

Highly accurate annotation is an indispensable prerequisite for supervised learning, because the

Exemplary representation of annotated sensor data: Objects marked and classified with bounding boxes.

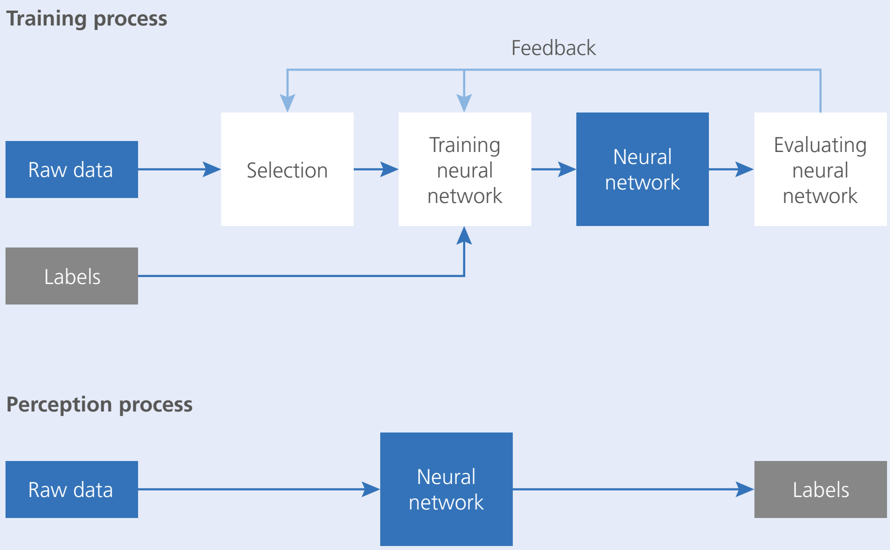
Picture credits: © BOSCH

quality of the reference data determines the subsequent ability of the AI to clearly identify objects. understand.ai achieved the expected and specified quality of the annotation. However, it must be said that while annotation can be good for tasks of this complexity, it will not be perfect. As in other areas of development, annotation is subject to a continuous learning process in which processes and tools are continuously adapted and optimized in order to achieve the highest possible quality. Established processes, powerful tools, and efficient feedback cycles lead to the desired results. The experience and expertise of recognized annotation specialists is invaluable for an economical and efficient approach.

Outlook: Annotating Surround-View Data

A new measurement campaign is planned for 360° environment detection, in which the vehicle environment is recorded in high resolution with camera, lidar, and radar sensors. This creates new challenges in terms of data volume, synchronous processing, and annotation of the merged data. The subsequent steps for this project is currently being discussed by the experts from understand.ai and Bosch. ■

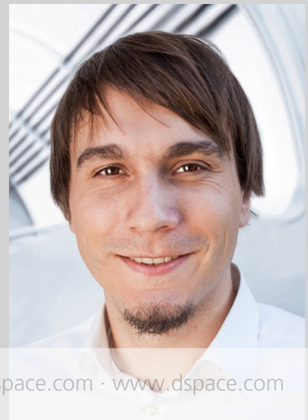
Dr. Claudius Gläser, Dr. Florian Faion, BOSCH Corporate Research



Workflow for supervised learning with annotated sensor data and subsequent data acquisition, including perception.

Dr. Claudius Gläser
is an expert on multimodal perception for automated driving at Robert Bosch GmbH in Renningen, Germany.

Dr. Florian Faion
is a research engineer for lidar perception in automated driving at Robert Bosch GmbH in Renningen, Germany.



We have a clear vision of the future: We want vehicles to reach their destination autonomously, without a driver. But even the first steps towards autonomy are challenging: While vehicles are already partially autonomous, their autonomy is restricted to certain situations.

The sophisticated functions of a (partially) autonomous system, such as a highway pilot, are not only difficult to develop, but the system must also guarantee safe behavior beyond its intended function at all times, regardless of the circumstances. In real traffic, vehicles must handle countless situations that have to be validated by tests. Not all the tests can be carried out on the road. Even simulation solutions that work directly with the ECU in real time are currently overloaded by the sheer volume of data.

The Solution

Our strategy for overcoming this issue rests on three pillars: the test objects, the simulation structure, and the test objectives.

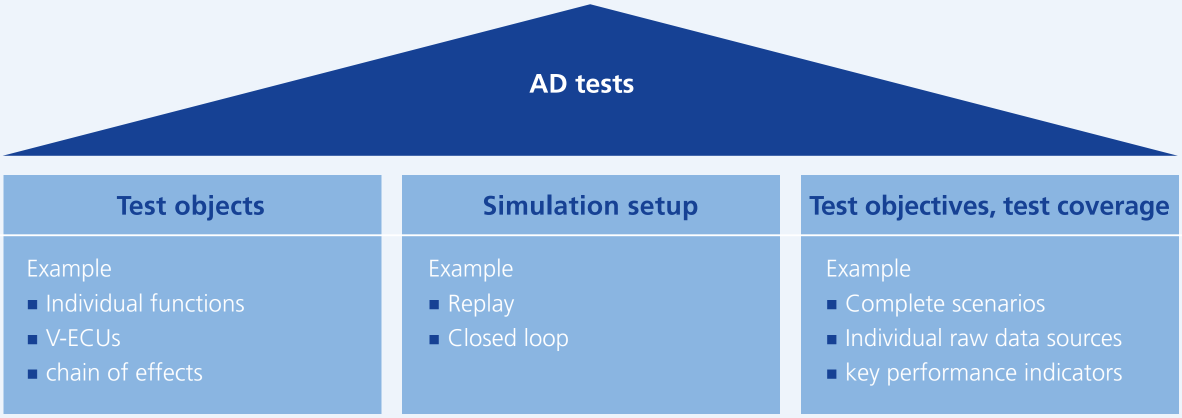
Test Objects and Test Distribution

There must be central, critical tests that are carried out directly with the control unit under test and the control unit networks, or on the road. In order to perform the required number of tests, a substantial part of the tests has to be performed on software-in-the-loop (SIL) systems, requiring a virtualized test object. The solution focuses on the subject under test (SUT), which is the actual code of the functions to be tested. There are several technical approaches to providing the virtual test object: For example, you can integrate the code into the simulation system as a complete and executable unit via appropriate interfaces. dSPACE is working on implementing this type

Did you know? In 2020, dSPACE tools will also operate on Linux systems

Taking Autonomous Driving in Stride

A story about scenario-based testing and SIL-in-the-cloud



The three pillars of the solution strategy for AD testing.

of integration with the help of container technology.
You can also integrate production code in particular as virtual ECUs (V-ECUs). dSPACE SystemDesk offers all the advantages of production code integration, from bus connection to operating system configuration. To determine how to virtualize the test object, the test scope must be precisely defined. Do you want to test individual functions, the complete ECU software, or a specific complete chain of effects? These factors ultimately determine the design of the SUT.

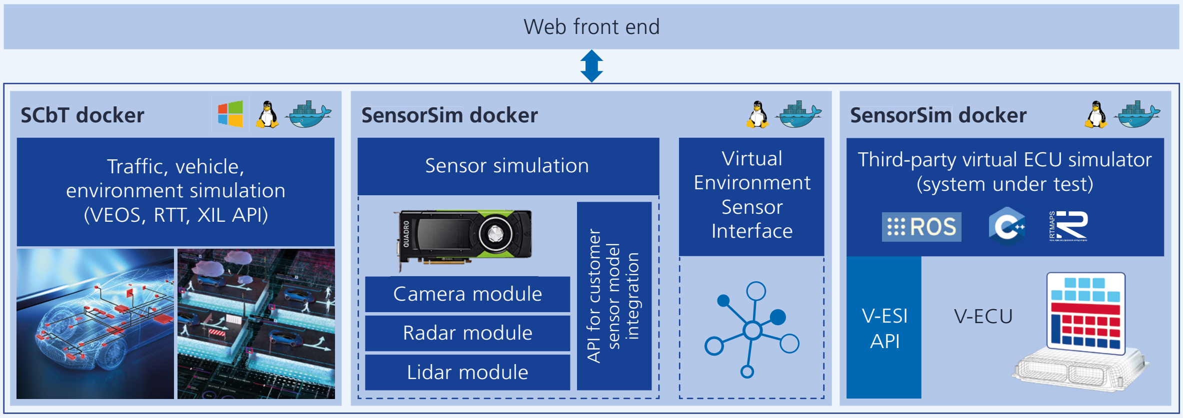
The Simulation Setup

The second pillar is the simulation setup and involves both the simulation system and its infrastructure. The use of SIL technology makes the simulation independent of real time and dedicated hardware. With VEOS, dSPACE offers a PC-based simulation and integration platform that can serve as the basis for SIL tests. This versatility is particularly important for two reasons: First, the enviroment can be simulated with any degree of detail. In addition to motor or battery models, this particularly includes sensor models, which simulate all relevant levels of detail, from object lists to sensor-realistic data. Second, the goal is to easily multiply the test setup to achieve a high test throughput. Cloud systems, both public and customer data centers, use container and orchestration technologies to provide a platform for multiple parallel instantiation. dSPACE is working on seamlessly integrating its tools with cloud systems by providing preconfigured containers that contain, for example, a VEOS installation.

The Test Goals

This leaves the drastically increasing demand for testing. Ultimately, the validation will be based on completing a range of specific traffic scenarios during simulation. This includes the simulation and variation of synthetic scenarios.
But the replay of measurement data recorded during a test drive will also be a central part of the validation. First, the actual source of the tests or, based on the Pegasus method, the scenarios that a vehicle has to successfully complete must be identified. In principle, these are variations of a relatively small number of templates, called logical scenarios. For example, a certain avoidance situation in inner city traffic has to be tested in a wide variety of variants under different conditions, while the basic situation remains the same, for example, another vehicle unexpectedly changes lanes. Once a basic set of scenarios is available, it serves as a source for generating numerous specific test cases. Starting from the configuration of a log-

> "The development of scenario databases, the origin of the scenarios, and their relevance to achieving the test objectives are questions that virtually all of our customers are currently asking."
>
> *Karsten Krügel, Senior Product Manager Virtual Validation, dSPACE*



SIL technology for sensor simulation.

ical scenario, an algorithm generates the final specific scenarios, which are then executed during simulation. Simple algorithms implement permutations, the simultaneous setting of individual parameters, or stochastic procedures. More advanced algorithms try to identify critical scenarios through optimization methods or artificial intelligence. Another aspect is often underestimated in the test setup: The entire process must be automated while enabling central configuration. The validation of the future will not focus on defining sophisticated test processes, but will hone in on the essentials, namely on measurable test case properties. These properties can be calculated from the measured values recorded for the simulation. The benefit: Their formulation is intuitive, for example, the relative speed of two vehicles driving behind one another can be derived directly from the respective speeds. These properties are calculated during or after the simulation, but have no effect on the actual test process. This makes it possible to always use a fixed test process in closed loop operation. It also eliminates the need for manual test step definition. ■

Did you know? dSPACE is also your partner for generating scenarios based on raw sensor data measured in real life.

Conclusion

The development of autonomous driving changes the basic models for cooperation between OEMs, classic suppliers, and platform providers. The focus is no longer on delivering a finished ECU, but on integrating distributed vehicle functions and validating them early on, possibly across companies. The basic principle is: The earlier you find an error, the cheaper it is to correct it. Access to shared simulation and test infrastructures enables new forms of collaboration, but ultimately represents only one of the many challenges of this collaboration. Validating the countless scenarios is one of the central challenges for autonomous driving. Therefore, scenario-based testing at dSPACE is based on these three pillars. They consider many of the aforementioned aspects, but these can be very complex. Because dSPACE positions itself as a one-stop provider for validation, we offer solutions in each of these areas.

Our tool chain lets you complete the validation of functions or simulate ECU networks with just a few clicks, while ensuring high test coverage and scenario variation. It also lets you provide the developers with rapid feedback on their code quality at any time. This reduces the number of required test drivers and test drives to a manageable level.

AUTERA

New high-performance product family for data-driven developments for autonomous driving

Environment perception sensors are critically important to the operation of autonomous vehicles. These sensors generate ever growing volumes of data. With the AUTERA product family, dSPACE now offers a system that can read, process, and record raw sensor data from lidar, radar, and camera sensors as well as from automotive buses and networks, with best-in-class bandwidth.

Autonomous vehicles feature a large number of high-resolution sensors used to perceive their surroundings. These sensors create multiple data streams, which have to be merged into an overall environment image. This overall picture of the operating environment then has to be made available for other algorithms such as trajectory planning. Object recognition and sensor fusion are frequently aided by artificial intelligence (AI). To develop, train, and test the complex AI-based systems, a sizeable quantity (petabytes) and quality of data collected during real test drives is required. Therefore, recording all relevant data plays an essential role in this data-driven development process. The special challenge is to meet the ever-increasing demand for bandwidth. Therefore, a recording system must not only be scalable, it must also be flexibly configurable so that it can be adapted to a variety of vehicle configurations, such as sensor interfaces, buses, and networks.

New System for Data Logging, Processing, and Replay

To meet these demands, dSPACE introduces a new, extremely powerful product family for data recording and prototyping in the vehicle, and subsequent playback of data in the lab: AUTERA. The name AUTERA stands for AUTonomous ERA. It describes products that are specially designed for developments in autonomous driving (AD) and advanced driver assistance systems (ADAS). The first system of the new AUTERA product family is the AUTERA AutoBox, a robust in-vehicle system. The AUTERA AutoBox is the ideal system for recording and processing large volumes of data from various sensors, automotive buses, and networks during test drives. In addition to CAN FD, the AUTERA AutoBox supports Ethernet (1000BASE-T, 10GBASE-T), and automotive Ethernet (100/1000BASE-T1), as well as various raw data interfaces such as GMSL II, FPD Link III or CSI II for camera sensors. All these interfaces are synchronized and record accurate time stamps directly at the data input location so that the data can then be played back with correct timing. In addition to the computing power of the system, the bandwidth is also a decisive factor as it determines the number of high-resolution sensors that can be recorded simultaneously. The AUTERA AutoBox is capable of continuously streaming up to 50 Gbit/s to the easily exchangeable and hot-swappable AUTERA solid-state disks (SSDs) within a compact system. If this extremely high bandwidth is not suf-

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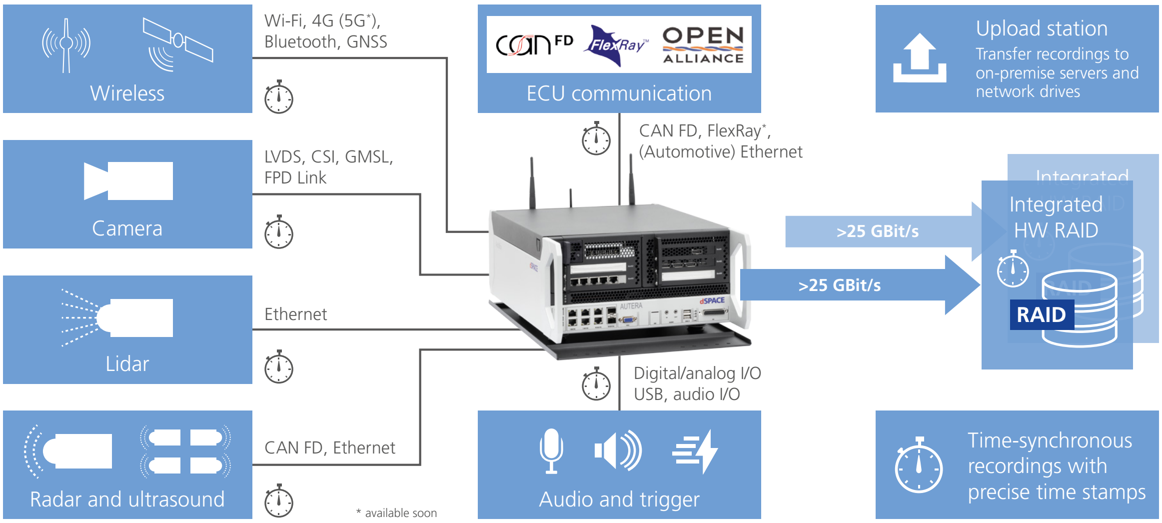
AUTERA: The power of a Linux server - in the vehicle.



Example setup: AUTERA impresses with versatile connection options, enormous computing power, and almost inexhaustible memory.

ficient, you can simply scale it by adding another AUTERA AutoBox. The stored data can be replayed for neural network training, scenario generation, homologation, etc.

Ready-to-Use Solution

The AUTERA AutoBox is delivered with a Linux operating system and all required drivers are pre-installed for immediate operation. Moreover, the multisensor development environment RTMaps on AUTERA makes complex relationships manageable with simple graphical methods and visualization of data streams from the connected sensors. It also provides intuitive data fusion and recording capabilities. However, RTMaps is but one of many options. The Linux operating system of the AUTERA AutoBox is also compatible with other software solutions, such as the Robot Operating System (ROS) framework. Additionally, an open API will be provided in the future, enabling customers to use all relevant interfaces and services of the system in their own software environment.

AUTERA Is Flexibly Expandable

One strength of AUTERA is its numerous expansion options. AUTERA architecture allows users to configure systems to cover a wide range of tasks: from data recording with high-performance memory to prototyping of AI algorithms with dedicated hardware accelerators, such as graphics processors (GPUs) and playback of the recorded data.

Expansion options for AUTERA include:

High-performance hardware accelerators

To edit the sensor data during recording, AUTERA can be extended with a

Product Profile: AUTERA

Product class: Data logger, replay, and prototyping system for multisensor applications

Key Functions

- Powerful, expandable system that delivers the performance of a Linux server in a robust chassis for in-vehicle use
- Synchronous processing and data recording of environment sensors and automotive buses
- Flexibly expandable with hardware accelerators for data preprocessing and data fusion
- Hot-swappable AUTERA SSD for easy memory exchange while recording a test drive
- Support of raw data interfaces for environment perception sensors such as GMSL II, FPD-Link III, or CSI II
- Open system with the intuitive graphical software environment RTMaps for the block-based implementation of algorithms or the option to use open APIs in user-specific software environments

fast computing platform based on graphics processing units (GPUs) or field-programmable gate arrays (FPGAs). This allows for data to be preprocessed or labeled during the logging test run. Therefore, you can also use the system for developing, optimizing, and validating perception and fusion algorithms as well as neural networks.

Easy memory expansion
Data is stored on a dedicated, high-performance AUTERA SSD that can be easily hot-swapped during operation. Up to two AUTERA SSDs can be operated in parallel on each AUTERA AutoBox to double bandwidth and storage space. In addition, several AUTERA systems can be operated synchronously so that the memory size and bandwidth can be scaled, as needed.

Fastest upload to the server
dSPACE will offer a dedicated AUTERA upload station to load the recorded data to an existing server infrastructure or the cloud as quickly as possible. It can read up to two AUTERA SSDs simultaneously and streams the data directly to the data center, for example, via 100 Gigabit Ethernet. In addition, the AUTERA AutoBox can be accessed directly via LTE during the recording of the test drive to immediately receive data. In the future, 5G access will also be available.

AUTERA has a memory solution (SSD) that can be easily replaced during operation.

Simple fleet management
Managing and updating the configuration of a larger fleet of vehicles to record data without a centralized access is often complex and time-consuming. Therefore, in the future, dSPACE will offer a web-based solution for managing AUTERA AutoBox systems in vehicles. This solution will help monitor the current status of the system from a central workstation, detect fault status, and determine the current position of the AUTERA AutoBox. At a later stage, the configuration of the system can also be updated centrally and rolled out to the entire fleet. ▪

Technical Data

- Logging bandwidth: up to 50 Gbit/s
- Storage capacity: up to 32 TB
- Processor: Intel® Xeon® CPU with 12 cores
- RAM: 32 GB, up-to 512 GB on request

More information:
www.dspace.com/go/dMag_20193_AUTERA

Use Cases for AUTERA

Data Logging
- Gathering reference data
- Vehicle and ECU tests

Prototyping
- Sensor fusion
- Perception

Data Replay
- Validating AI algorithms

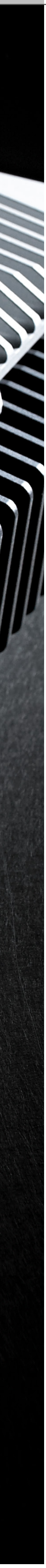
For sensor data preprocessing, AUTERA can be equipped with a powerful graphics card, such as the NVIDIA Quadro RTX 6000.

Smart New Copilot

New MicroAutoBox III – the next generation of compact in-vehicle prototyping

Product Profile: MicroAutoBox III

- Compact and robust in-vehicle prototyping system
- High computing power with quad-core ARM® processor
- Comprehensive bus and network support, including CAN, CAN FD, LIN, FlexRay, and (automotive) Ethernet
- Functional safety monitoring features



From autonomous driving to zero emissions – For the in-vehicle prototyping of the future, dSPACE is now launching the new MicroAutoBox III, the next, much more powerful, generation of the industry-proven MicroAutoBox product family. The MicroAutoBox III is a state-of-the-art development system for future applications that can turn ideas into real vehicle functions right away.

For over 20 years, the dSPACE MicroAutoBox has been used by nearly all automotive manufacturers, suppliers, and service providers throughout the world. It has established itself as a robust, compact in-vehicle system for function development (rapid prototyping). By late 2019, the system's much more powerful, improved third generation, MicroAutoBox III, will become available. A quad-core ARM® processor, comprehensive bus and network support, many expansion options, and advanced functional safety monitoring features (planned for 2020) make the latest MicroAutoBox a real powerhouse. As a standalone unit, it can replace a complete electronic control unit (ECU; fullpassing) or add functionalities and I/O to an existing ECU (bypassing).

Going into Turbo Mode

As control algorithms are becoming ever more complex, they require much more computing power. Each core of the MicroAutoBox III is up to 16 times faster than the previous MicroAutoBox generation. All four cores of the ARM processor are available for model calculation. To run even large models, both the internal flash memory and the working memory have been significantly increased compared to the MicroAutoBox II.

Successful Networking

The new MicroAutoBox III is ready to take on challenging communication tasks. In addition to a high number of analog and digital inputs and outputs, it also features several Ethernet interfaces. There are three standard Gigabit Ethernet interfaces for connecting to the host or other devices, such as PC systems. The MicroAutoBox III also offers two automotive Ethernet interfaces with transfer rates of up to 100 Mbit/s or 1,000 Mbit/s for integration into the ECU network. Depending on the MicroAutoBox variant, serial interfaces and interfaces for CAN, CAN FD, LIN, or FlexRay communication are also available. In addition, a completely new, dedicated bus and network variant of the MicroAutoBox III (DS1521) will be available soon. With a wide range of interfaces (8x CAN FD, 2x FlexRay A&B, 6x automotive Ethernet, 3x LIN, 6x DIO, 4x ADC, 1x serial interface) and even stronger bus performance, this variant will be ideally suited for applications requiring a high degree of networking. Should the number of interfaces not be sufficient, this future variant will be also available with two of these bus and network boards. The MicroAutoBox III, therefore, becomes the ideal prototyping system for scenarios that are later executed on a central control unit, such as supervisory controller or gateway applications.

Keeping an Eye on Functional Safety

The MicroAutoBox III also offers further improvements, particularly in the area of functional safety. To increase the degree of validation, test drives with prototype vehicles are more frequently carried out in real road traffic, especially for driver assistance and autonomous driving. >>

The new MicroAutoBox III covers a wide range of applications.

1 Battery voltage connection (12/24/48 V onboard power supply)
2 Status and user-programmable LEDs
3 I/O units can be added, e.g., the DS1514 FPGA Base Board or the DS1521 Bus & Network Board (coming soon)
4 Wireless option (coming soon)
5 IOCNET connection
6 Quad-core ARM processor
7 USB port (USB 2.0) for mass storage and data logging
8 Automotive Ethernet 100/1000BASE-T1
9 Ethernet ports (Gigabit Ethernet) for host and other devices
10 ZIF I/O connector on the rear panel

Figure 1: Compact design with all interfaces relevant for automotive applications – the new MicroAutoBox III (here: MicroAutoBox III 1403/1511).

A mature and comprehensive safety concept is crucial to be able to react immediately and correctly in the event of a fault. To simplify the use of the MicroAutoBox III in these scenarios, the system offers a three-stage functional safety concept based on the EGAS safety concept established in the automotive industry. The MicroAutoBox III provides monitoring functions, such as memory checks or challenge-response monitors that detect faults and bring the system into a defined state, which facilitates integration into the overall safety concept of the vehicle.

All-Around Software Support

In addition to the hardware, the accompanying software also plays an elementary role for the users of MicroAutoBox III. Just as for SCALEXIO, established implementation software is available in the form of ConfigurationDesk and the Bus Manager. This makes it easy for users to transfer Simulink® models between MicroAutoBox III and SCALEXIO hardware, and existing I/O configurations in ConfigurationDesk/the Bus Manager can be used for different Simulink models. In the future, the MicroAutoBox III will also be able to run AUTOSAR software components represented by virtual ECUs (V-ECUs) and FMUs.

Figure 2: The MicroAutoBox III will be available in several variants (examples below, including a rear panel view with ZIF I/O connectors) for different requirements.

Marius Müller, Strategic Product Manager In-Vehicle Systems at dSPACE, explains why dSPACE is launching an all new MicroAutoBox generation.

Mr. Müller, why was it time for a new hardware generation?

The demand for computing power, especially in the early stages of development, has increased drastically in recent years. Driven by new topics such as highly automated and autonomous driving, the control technology components are also becoming increasingly complex and computationally intensive. We are currently also seeing a strong trend towards centralization and networking, which means that the requirements for bus and network communication are also continuing to grow. In addition, test drives with prototype vehicles are increasingly being carried out in real road traffic, particularly for driver assistance and autonomous driving, which makes functional safety even more important. With the new MicroAutoBox III and its expansion options, users get an excellently equipped, compact, and robust system that addresses all the aforementioned aspects by means of a significantly improved hardware and software architecture.

What applications are the strong suit of the MicroAutoBox III?

The MicroAutoBox III can be used for the development of all mechatronic applications in vehicles, from autonomous driving to zero emissons. Of course, the system is ideal for developments in the hype areas of electromobility and electrification (drive control, battery management, electrification of auxiliary units, etc.), connectivity and networking (supervisory control, gateway or body applications, etc.) as well as highly automated and autonomous driving (trajectory planning, motion control, actuator control etc.).

How easy is it for users to switch from the MicroAutoBox II to the MicroAutoBox III?

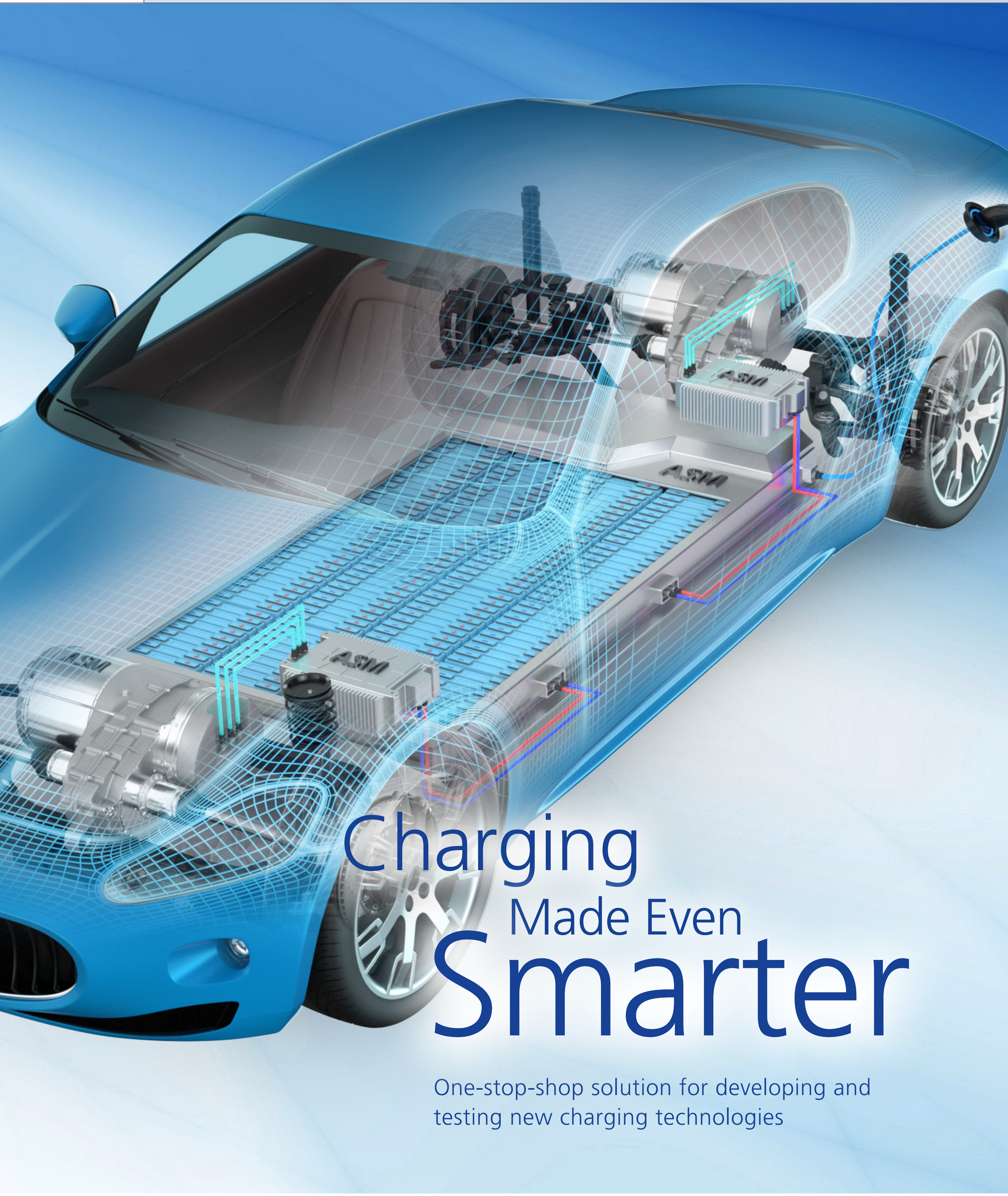
dSPACE supports MicroAutoBox users with detailed migration documentation and a script for automatic conversion from RTI-based models to ConfigurationDesk-based models. In addition, existing wiring harnesses of the MicroAutoBox II variants with a DS1511, DS1513 or DS1514 can be reused for MicroAutoBox III as is, because the I/O configuration has not changed with these variants. They, too, are integrated via ConfigurationDesk or the Bus Manager.

Perfect Match

The MicroAutoBox III is available in different variants, making it adaptable to project-specific I/O requirements. By the end of 2019, four standard variants (1403/1511, 1403/1513, 1403/1511/1514, and 1403/1513/1514) will be available, which users already know from the MicroAutoBox II. New bus and network variants (1403/1521, 1403/1521/1521) will become available in 2020. In addition, the MicroAutoBox III will have its own optional Embedded PC with Intel® Xeon™ processor, 10 Gbit Ethernet interfaces, WLAN, CAN/CAN FD and BroadR-Reach extensions. The Embedded PC will support the Linux and Windows® operating systems, making it an ideal MicroAutoBox III extension for various tasks, including running ControlDesk or RTMaps. The MicroAutoBox III can also be combined with the new AUTERA hardware (p. xx), offering a perfect system combination for data logging and prototyping applications in the field of autonomous driving.

Looking Ahead

The dSPACE MicroAutoBox III is a future-proof, compact, and robust in-vehicle prototyping system that undergoes continuous expansion. Other additions, besides the new DS1521 I/O board, will include a wireless option, web-based access for downloading real-time applications, support for Ethernet time synchronization in line with IEEE802.1AS, and other I/O variants, e.g., for e-drive applications. ■



Charging Made Even Smarter

One-stop-shop solution for developing and testing new charging technologies

The DS5366 Smart Charging Interface from dSPACE provides automobile manufacturers and providers of charging stations with a complete solution for developing and testing technologies for smart charging. The solution takes into account both international and national standards and ensures interoperability.

When developing new charging technologies for electric vehicles, charging speed is a top concern. The charge rate is relatively low when charging vehicles with alternating current due to the AC/DC converters installed in the vehicle. However, if direct current is used for the charging process, the converter is integrated in an external charging station. These external systems are limited neither in size nor weight. Therefore, they can achieve a significantly higher charge rate. Yet, to ensure an ideal and safe charging process for the battery, there must be an extensive exchange of information.

International Standards Pave the Way for New Possibilities

Standards such as the international ISO 15118, the Japanese CHAdeMO, or the Chinese GB/T 27930 open up new possibilities for smart charging control and future billing procedures. They set the prerequisites for interoperability and are the basis for developing smart charging strategies. For example, the charge rate can be controlled depending on the available energy, the line capacity, or the energy requirements by the users.

Avoiding Network Overloads

Conventional AC charging systems perform only very simple checks before they start the charging process. For example, they determine the maximum charging current depending on the current limit of the charging station and the actual current capacity of the vehicle's charging cable. However, with rapid charging, the days of unregulated charging processes are over. During the charging process that uses direct current according to ISO 15118 and DIN SPEC 70121, high-frequency high-level communication is superimposed on the existing low-level PWM communication of the control pilot pin. The vehicle uses power-line communication (PLC) according to the HomePlug Green Phy standard and establishes encrypted communication with the charging station. The Signal Level Attenuation Characterization (SLAC) mechanism ensures the correct connection setup. It prevents the vehicle from establishing a connection with an adjacent charging station due to cross-

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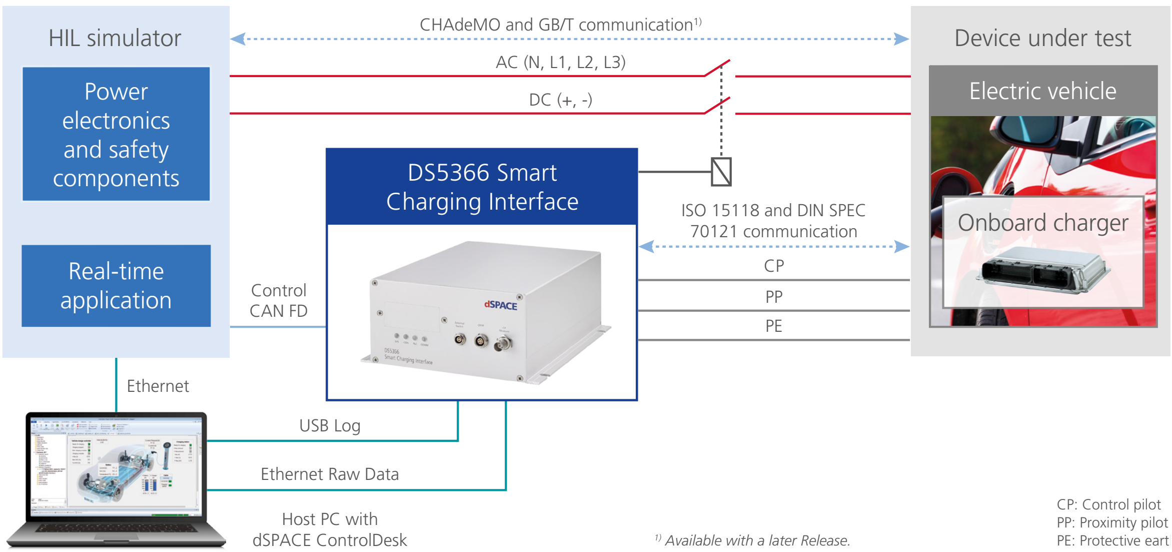


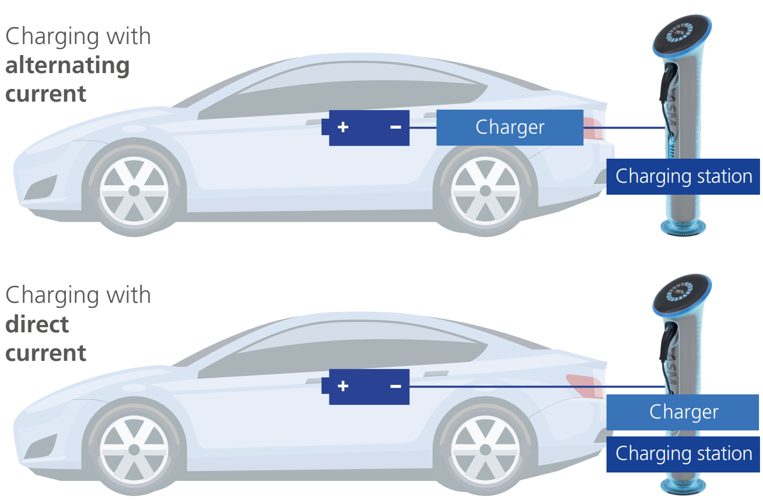
The figure shows typical use cases for the DS5366 Smart Charging Interface: Tests of real vehicles and their behavior at different charging stations as well as tests of control units and power components at composite test benches involved in the charging process. The DS5366 Smart Charging Interface is connected to the simulator via CAN FD and simulates the electric vehicle supply equipment (EVSE) communication controller. By creating a Simulink model, the complete behavior of a charging station can be simulated, including a possible manipulation of timings and messages.

talk of the high-level signals. With inductive charging, communication is exchanged via WLAN. To put it simply, information, such as prices, charging profiles, or status information is exchanged before the charging process starts. During the charging process, information about the state of charge and energy consumption is continuously transmitted. At the end of the charging process, the connector lock is released and the encrypted billing data is sent to the charging station operator. In addition to communication between the vehicle and the charging station, the ISO 15118 standard provides an ideal basis for intelligent network control that can avoid network overloads. Charging technologies that work with the CAN-based standards CHAdeMO and GB/T generally provide similar functions for charging communication as ISO 15118.

Simple Integration: The New DS5366 Smart Charging Interface

The new dSPACE DS5366 Smart Charging Interface supports developers of onboard chargers, charging stations, and, in the future, inductive charging systems with a comprehensive range of test options and dynamic models.

The central requirements while developing the DS5366 Smart Charging Interface were an easy integration of existing test systems and a test depth that can be flexibly adjusted depending on customer re-



There are two different methods for charging vehicle batteries.

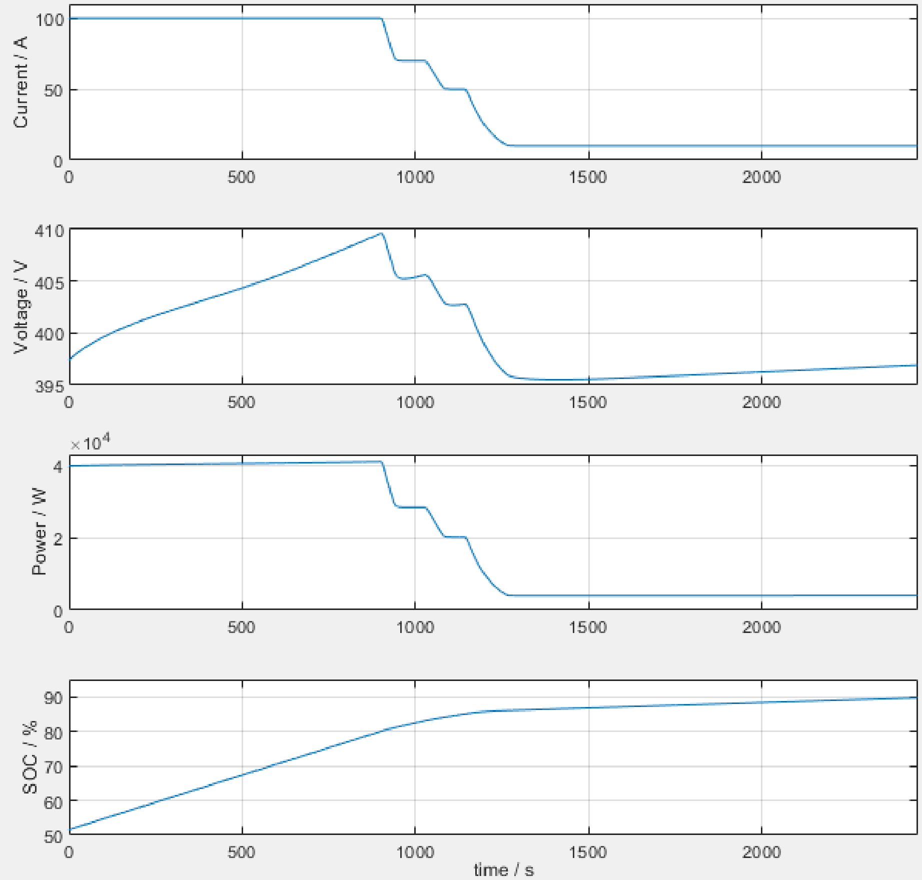
quirements. Manipulations are possible both at the electrical and at the protocol level. Comprehensive logging of all communication events allows for manual or automatic checks of the intended behavior and compliance with the protocol specification as well as performing an error diagnosis.
Typical applications are tests of the onboard chargers and charging stations, particularly the communication modules according to various charging standards. Another important application is error simulation during communication. The dSPACE DS5366 Smart Charging Interface helps simulate a wide variety of charging stations in the lab and ensures that the ECU functions without errors.

Other Application Areas: Developing Onboard Chargers

In the same manner, it will also be possible to test the compatibility between the developed charging stations and numerous simulated vehicles during tests on the charging station. Another focus area is the development of onboard chargers. If no software or hardware is available for charging communication during the development of a vehicle charge controller, the dSPACE solution can replace the vehicle ECUs or their communication controllers for testing in vehicle prototypes.

A Turn-Key Test Environment with the ASM Tool Suite

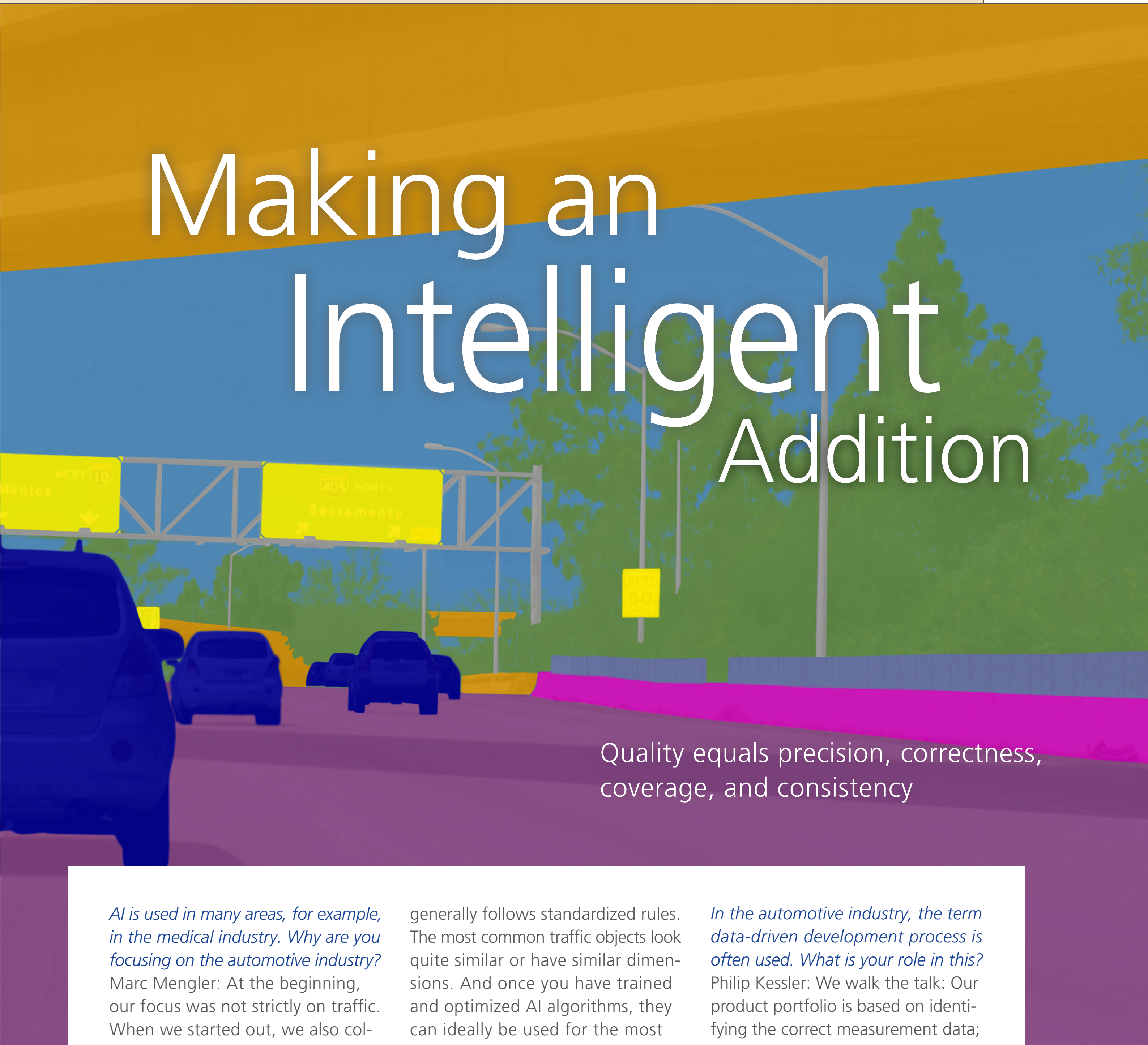
ASM, the dSPACE tool suite for simulating motors, vehicle dynamics, electric components, and the traffic environment, offers a turn-key application for battery-powered electric vehicles, including real-time high-voltage battery simulation. The models also include a charging station emulation in which the charging voltage depends on the vehicle power consumption, which is determined by the charging control unit that is tested in the vehicle. If no charge controller is available, ASM lets users simulate a controller using a constant current constant voltage (CCCV) charging process. The demo models are prepared in such a way that all signals required for communication with the control units are available. This enables testing of the control algorithms and the interfaces between all devices according to standards such as CHAdeMO, ISO 15118, and GB/T 20234.2.



The illustrated curves show the progress of a DC quick charging process for a time period of 40 minutes.

Typical applications for the DS5366 Smart Charging Interface are tests of the onboard chargers and charging stations, particularly the communication modules according to various charging standards. Another important application is error simulation during communication.

In July of this year, dSPACE acquired understand.ai (UAI). The start-up is an artificial intelligence (AI) technology leader with a focus on automated data analysis, data annotation, and extraction of simulation scenarios for autonomous vehicles. These key technologies have strategically added to the dSPACE portfolio and now offer customers a unique, integrated development and test solution for autonomous driving. In an interview, the two UAI founders, Marc Mengler and Philip Kessler, explain the added value of this cooperation and describe how customer projects typically work.



Making an Intelligent Addition

Quality equals precision, correctness, coverage, and consistency

AI is used in many areas, for example, in the medical industry. Why are you focusing on the automotive industry?
Marc Mengler: At the beginning, our focus was not strictly on traffic. When we started out, we also collaborated with the German Cancer Research Center and together published a large set of data for training and testing medical AI. However, the problem with medicine is that our bodies are not very standardized. Cells, diseases, and tumors follow only very few rules.

If you look at the traffic situation in a metropolis during rush hour, you might doubt that order and rules exist…
Philip Kessler: Some traffic situations are really complex. However, traffic generally follows standardized rules. The most common traffic objects look quite similar or have similar dimensions. And once you have trained and optimized AI algorithms, they can ideally be used for the most common object classes around the world. This is a decisive factor in creating a scalable and increasingly precise product. Precision is crucial for our first product, which creates training and test data for AI algorithms. This is why we decided to focus on one domain. There was another reason for this decision: We at understand.ai are convinced that our generation will be measured by whether we can make autonomous driving possible or whether we will postpone it further. We are determined to become key enablers.

In the automotive industry, the term data-driven development process is often used. What is your role in this?
Philip Kessler: We walk the talk: Our product portfolio is based on identifying the correct measurement data; enhance it to the appropriate quality level, meaning we annotate it; and extract the result to a simulation environment. In the simulation, the recorded real-world scenarios, for example, passing a parked car, are enhanced with relevant variants. This enables us to simulate critical scenarios in the right quantity. Hence, our products play a major role in the data-driven development and validation of autonomous vehicles.

How does the UAI product range fit into the dSPACE family of products?

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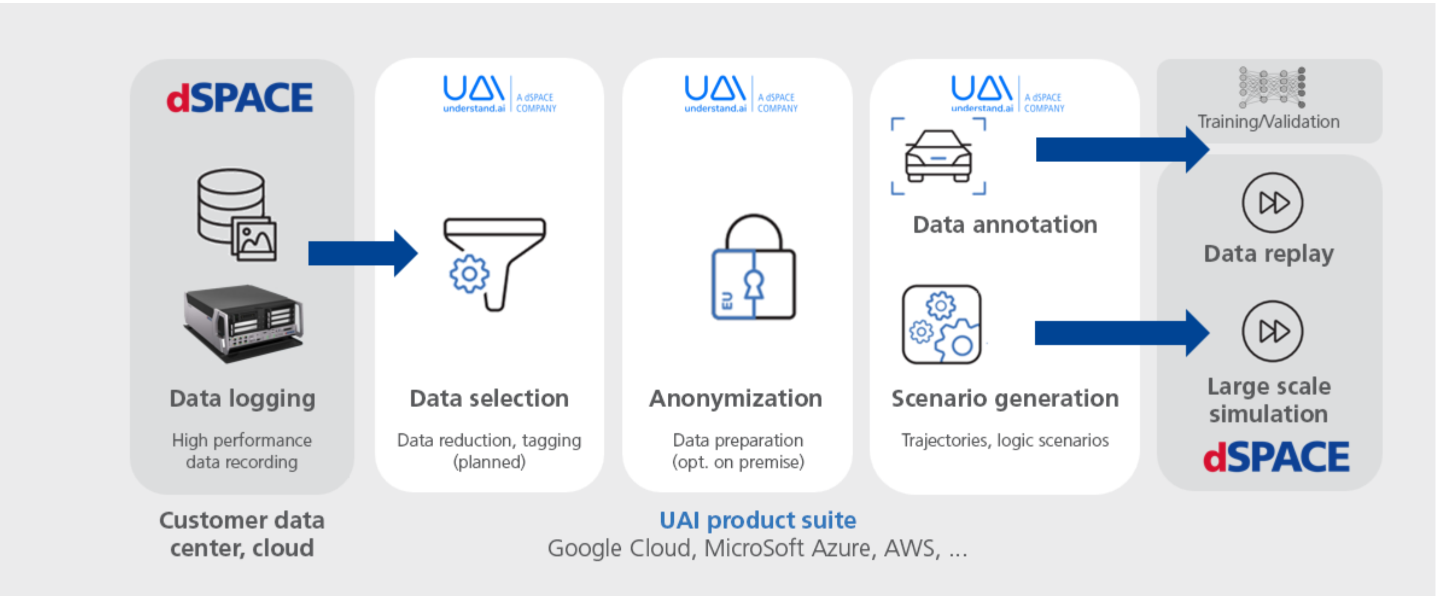
Marc Mengler: We complement each other perfectly. The UAI portfolio covers data selection, anonymization, annotation, and scenario generation, and integrates seamlessly into the dSPACE data logging as well as the data replay and simulation products. The combination of both product portfolios lets us map the data-driven process in a single comprehensive tool chain. A common vision regarding data- and scenario-driven development and validation of autonomous driving was the deciding factor for our team to partner with dSPACE.

How would you describe a typical UAI customer project?
Marc Mengler: All our customer projects are based on raw data, meaning measurement data, which the customer records with several vehicle cameras, lidar, and radar sensors and then provides to us via API. However, raw data can be used only to a very limited extent for training and testing AI algorithms and can become substantially usable only when it is enhanced, for example, by bounding boxes around objects or by assigning each pixel to the relevant object (semantic segmentation). This sounds easier than it is. In the end, we must reach an accuracy of 98% and the devil is in the details. For example, there are dozens of ways to place a two-dimensional rectangular box around a car in a two-dimensional camera image.

And customers do not always define the dimensions of a vehicle in the same way?
Philip Kessler: This is true: Some customers require a box that includes the side mirrors, vehicle antennas, roof rack, etc. and others do not. Some customers want an extrapolated box that includes the non-visible parts of the car, which might be covered or not included in the camera image. To find the right specification for each of the often more than 50 different object classes, which are also used in marginal cases, we work very closely with the customer, especially in the initial phase, and support them in finding the right specifications. We then demonstrate these on a significant subset of the data set. For this purpose, we use highly automated processes and expert algorithms which, in combination with human validation, allow for an almost pixel-perfect enhancement of the sensor data. Once this subset has been tested and approved by the customer, we optimize our algorithms, tooling, and processes according to the respective specifications and can scale very well to higher volumes within these specifications. However, autonomous driving is a very dynamic field with ever changing specifications. Often, the specifications in a customer project change, sensors are switched or installed in a different location in the vehicle. Thanks to our close cooperation with dSPACE, we can now respond faster and more customer-centrically.

What distinguishes your product portfolio from other competitors?
Marc Mengler: The main difference is that understand.ai aims for high automation and high quality and is able to achieve them both. The more we automate, the fewer people will be required for automation and the higher the achievable consistency. Usually it is like this: The more people work on a problem, the more disagreements there are. The cooperation with dSPACE makes a huge difference. dSPACE provides us with global sales teams that can respond to the specific customer requirements and changes in project specifications in the individual countries because they speak the local language. This works throughout the



End-to-end solution chain: The understand.ai (UAI) product suite completes dSPACE's portfolio for autonomous driving.

Marc Mengler (CEO) and Philip Kessler (CTO) are the founders of understand.ai.

About understand.ai

understand.ai has special expertise in the area of training and validation data, with which algorithms for autonomous driving can be efficiently trained and tested. For example, the company uses self-learning algorithms to process sensor data recorded during measurement runs and prepares them for simulation. The underlying key technology is based on artificial intelligence and ensures an efficient and precise evaluation, which contributes to the high accuracy of the driving algorithms used by customers. understand.ai was founded in 2017 and has 55 employees. The head office of the company is in Karlsruhe.

For more Information, see **www.understand.ai**.

entire tool and value chain of dSPACE and understand.ai.

How do you define quality?
Philip Kessler: The quality of annotations and extracted scenarios consists of four criteria: Precision, correctness, coverage, and consistency. For each quality criterion, we define in a contract which measured values must be achieved. It is always our goal to exceed our customers' expectations. After all, providing the highest possible quality of training and test data was one of our founding goals and is still our mission, because every data error leads to an error in the algorithm.

How does the cooperation with dSPACE affect your relationship with international customers?
Marc Mengler: In collaboration with dSPACE, we can provide better customer and consultancy services as well training for customers worldwide. OEMs receive a unique, integrated development and test solution for autonomous driving from a single source.

What innovations are you working on at the moment?
Philip Kessler: Our customers always have the same rule of three: the right data in the right quality and right quantity. We are already covering the aspect of quality with our annotation and scenario generation solutions. We will launch a new solution for quantity at the beginning of 2020 – the continuously growing Scenario Library. This leaves us with the aspect of the 'right' data. In mid-2020, we will launch a product to also cover this aspect, which will help customers pick the right data for the annotation and scenario generation from data volumes in the petabyte range.

Who can customers contact if they want to avail of your services or purchase your products?
Marc Mengler: dSPACE sales staff and key account managers worldwide are trained in our products and available as contact persons for customers. If customers require more expert knowledge, our UAI experts will gladly support them.

e.GO Mobile proves that emission-free driving is possible with today's technology at low cost and with a customer focus

We Must Embrace New Technologies

e.GO Mobile AG develops and manufactures affordable electric vehicles in Aachen, Germany. The company was founded in 2015 with the development of the e.GO Life. Since 2016, the electric-vehicle manufacturer has also been developing the e.GO Mover minibus. e.GO has access to more than 3,000 researchers and developers on the RWTH Aachen Campus, a science and industry

Professor Günther Schuh, founder and CEO of e.GO Mobile AG, started with the development of the compact car e.GO Life in 2015.

research network. Professor Günther Schuh, founder and CEO of e.GO Mobile AG, wants to use the two vehicle platforms to prove that emission-free driving is already possible with today's technology at low cost and with a customer focus thanks to Industry 4.0. Read this interview for more insights into current developments in the e-mobility market, the pleasure of driving, and air taxis.

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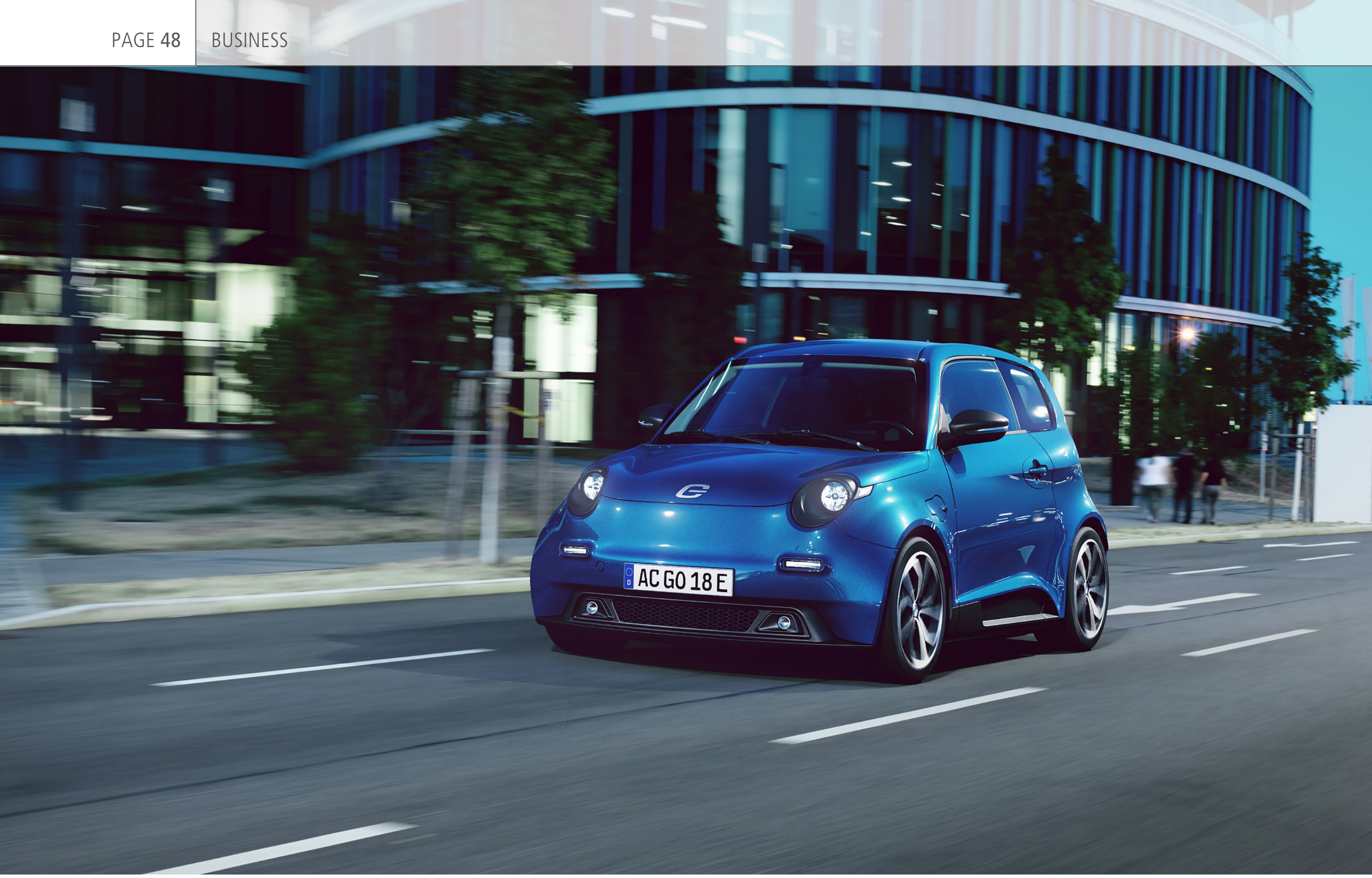


The e.GO Life is a compact vehicle for short distances which is particularly suitable for multiple-resident households or as a fleet vehicle.

The shift to e-mobility is slower in your home market of Germany than elsewhere. When can we expect the next big leap?

At e.GO Mobile AG, we are convinced that enthusiasm for electric mobility is already there. We are simply lacking a sufficient supply of affordable electric cars. We expect demand in Germany for new city vehicles to reach around 400,000 units per year over the next ten years. However, our first plant has a production capacity of only 30,000 vehicles, so we are excited to see vehicles from other OEMs enter the market. With the e.GO Life, we wanted to demonstrate that you can offer an affordable electric car with existing technologies. In addition to automobile manufacturers, cities and local authorities have a particularly strong interest in ensuring that we drive emission-free in inner-city areas as soon as possible. Everyone is working towards this goal and the authorities are also doing their utmost to support it. If the range of vehicles develops further in the coming years, electromobility will also achieve its breakthrough in Germany.

With the e.GO Life, you are focusing on a small car with a rather short range. Will electric cars be predominantly used for traveling short distances?

There is no indication that the development of solid-state batteries will advance sufficiently in the coming years to significantly lower their price. From both an economic and an ecological point of view, an electric vehicle with a comparatively large battery for higher ranges is therefore not sensible. This means that an e-vehicle with a similar range as a combustion vehicle will still be too expensive. We expect electric cars to be used for short distances in the coming years, while hybrid vehicles will be the most sensible solution for longer drives.

From battery electric to hybrid to fuel cells, different drive concepts are being discussed. What is your advice for the automotive industry when it comes to the drive systems of the future?

In order to implement emission-free driving in the long term, we need more solutions than just battery electric vehicles. This is why we must embrace new technologies. Battery electric drives, plug-in hybrid vehicles, fuel cell electric drives as well as conventional combustion engines with e-fuels can all be part of the solution. For longer distances or commercial vehicles, the combination of a comparatively small battery supplemented by a range extender in the form of a

In our opinion, driving has to be fun.

The electrically powered e.GO Mover minibus can transport up to 15 passengers and provides an economical on-demand service in private shuttle traffic and in local public inner-city transport.

We expect electric cars to be used for short distances in the coming years, while hybrid vehicles will be the most sensible solution for longer drives.

fuel cell is a good solution. However, infrastructure advancements are just as important as advanced vehicle development. This includes improving the charging infrastructure and the hydrogen economy in Germany and Europe.

Is rational and efficient driving your top priority? Or should driving be fun, too? After all, you are the first industry partner with permission to use the new Modular Electrification Toolkit (MEB) by Volkswagen for a vehicle with an electric drive.

In our opinion, driving has to be fun. We cannot only think along the lines of reason. Our e.GO Life is an electric car that is not only practical and affordable, it is also fun to drive. Electromobility in general is fun, because an electric motor has a higher torque in relation to power, which lets it accelerate much faster than a combustion engine. The e.GO Life not only has very good acceleration, its rear-wheel drive also gives it a very sporty driving style.

Yes, we are allowed to use the VW electrification toolkit, but currently we cannot give you any more information on this.

As a hobby pilot, you are already flying mile-high in a sports aircraft. Now you are working on the air taxi. When will it take off?

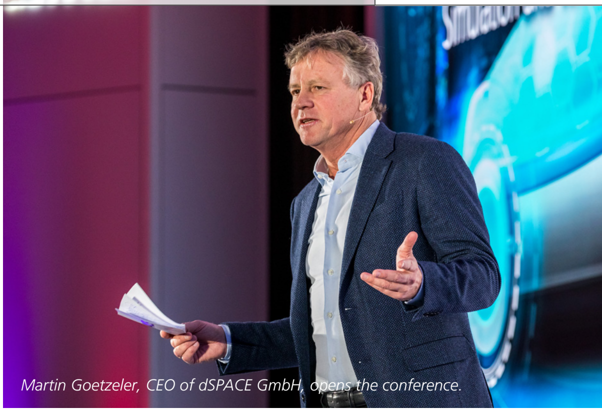
We are planning to put the Silent Air Taxi into operation in 2024. The first flight is scheduled for 2022. The Silent Air Taxi is an hybrid electric aircraft with an efficient combination of electric motors and combustion engines. For the time being, it is not possible to achieve the required power purely by battery electricity. In addition to reducing pollutant emissions, e.SAT GmbH focuses primarily on minimizing aircraft noise. Using airspace can decongest rail and road transport, currently the main modes of transport. Due to increased demands on travel times, punctuality, and flexibility, the Silent Air Taxi can be a sensible part of the individual mobility chain. Using urban airfields means that there will be no waiting time before the flight or at baggage claim.

We thank you for the interview.

Partner Dialogs

dSPACE positions itself as a reliable partner for simulation and validation

"Empowering Future Mobility Solutions" was the motto of the first dSPACE World Conference, where industry leaders from all over the world gave attendees a glimpse of their latest development activities. dSPACE showcased its unique chain of solutions for data- and scenario-driven development as well as a comprehensive solution portfolio for developing and testing e-mobility applications.


Martin Goetzeler, CEO of dSPACE GmbH, opens the conference.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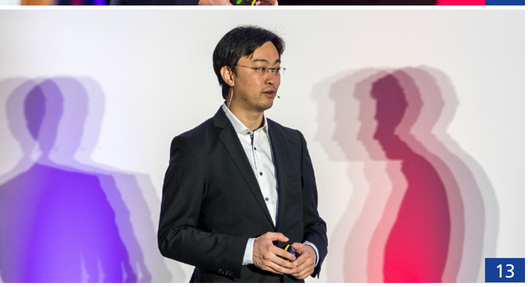
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The first dSPACE World Conference took place in November 2019 in Munich, Germany. More than 500 automotive industry experts from 30 countries came together, taking a break from their day-to-day business, to be inspired by presentations from global players and innovation leaders. The participants also used the conference as a platform to discuss pioneering solutions in the areas of e-mobility and autonomous driving with other industry experts.

Partner for Simulation and Validation

"Amid the dynamic transformation of our industry, the dSPACE World Conference has provided concepts and solutions for the challenges that our customers are currently facing," said Martin Goetzeler, CEO of dSPACE. Developing electric and autonomous vehicles brings about new requirements for simulation, validation, and homologation. "In this environment, dSPACE has clearly positioned itself as a reliable partner for simulation and validation," added Goetzeler.

Exhibition Highlights

In addition to the presentations, the conference focused on new technologies and solutions from dSPACE and its partners. dSPACE employees demonstrated around 30 exhibits, showing how vehicle manufacturers can test batteries or motors for electric cars and how they can bring autonomous driving onto the road faster by using end-to-end solutions. An important part of the exhibition was the solution offering for a data-driven development process, which was fully represented from data recording and scenario generation to cloud testing and validation with the demo stations.

Thank You

dSPACE would like to extend a heartfelt 'Thank you' to all of our speakers, guests, and partners. We appreciate your commitment and enjoyed spending time with you during the two conference days. We are looking forward to seeing you again at the next dSPACE World Conference. ■


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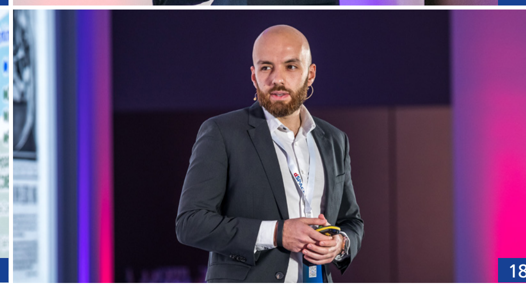
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Our Speakers

1. ***Stefan Teuchert, Senior Vice President, MAN Truck & Bus SE***
   Keynote: Truck 4.0 – The digital challenge of a truck OEM – autonomous driving

2. ***Dr. Peter Oel, Head of E/E Integration, Simulation and Test, Volkswagen AG***
   Keynote: 24/7: integration & test factory as a service

3. ***Alex Heslop, Electrical Engineering Director, and Andy Griffiths, Chief Engineer – Software Integration & Validation, Jaguar Land Rover***
   Keynote: New Defender, new electrical architecture: Enabling the software validation factory – the challenges found and fixed, the challenges that need fixing

4. ***Alejandro Vukotich, Senior Vice President Fully Automated Driving and Driver Assistance, BMW AG***
   Keynote: Automated Driving at BMW Group – our way towards future mobility

5. ***Prof. Philipp Slusallek, Scientific Director, German Research Center for Artificial Intelligence***
   Keynote: Understanding the World with AI: Training and Validating Autonomous Systems Using Synthetic Data

6. ***Dr. Ondrej Burkacky, Partner, McKinsey & Company, Inc.***
   Keynote: Automotive Software Market 2030: the rise of verification and validation

7. ***Dr. Tim Fricke, Modeling & Simulation Specialist, BMW AG***
   Enabling Efficient Testing of Higher-Level Automated Driving Systems

8. ***Gene Afanasyev, Senior Validation Engineer, NIO***
   System Validation through Continuous Integration

9. ***Ola Jakobson, Test Environment Architect, Volvo Car Corporation***
   VCC Complete HIL rigs meeting our next generation core based service oriented architecture

10. ***Heiko Ehrich, Head of Department Automotive Electronics, TÜV NORD Mobilität GmbH & Co. KG***
    Homologation for automated and connected driving – Current status on regulation and existing challenges

11. ***Dr. Philipp Freidl, Lead Engineer Radar MMIC Lab Validation, and Dr. Patrick Hölzl, Engineer Radar MMIC Lab Validation, Infineon Technologies AG***
    Radar Target Simulation in the context of Radar MMICLab Validation

12. ***Jordan Roe, Hardware-in-the-Loop Verification and Validation, Nexteer Automotive***
    End-to-End HiL Testing Using Electromechanical Test Benches

13. ***Dr. Chen Ma, Product Owner, Volkswagen AG***
    Virtualization of ECU compound test – an agile journey

14. ***Jean-Marie Quelin, Powertrain management system validation specialist, Groupe Renault***
    E-mobility impacts on HIL powertrain validations

15. ***Fabian Mürdter, R&D Engineer, ZF Friedrichshafen AG***
    AI-in-the-Loop – Next Gen AD validation at ZF

16. ***Xi Liu, Senior R&D engineer, Expert in Test Automation, Beijing Electric Vehicle Co. LTD***
    Relying on dSPACE: Development of Automated Testing Platform for EV Control Units in BJEV

17. ***Yuji Yasui, Chief Engineer, Honda R&D***
    Honda's automated driving technologies aiming at collision-free society with the joy and freedom of mobility for everyone.

18. ***Ahmed Yousif, Software Design Engineer, Valeo***
    Virtual Validation and Verification

A video about the conference and the presentation slides are available at

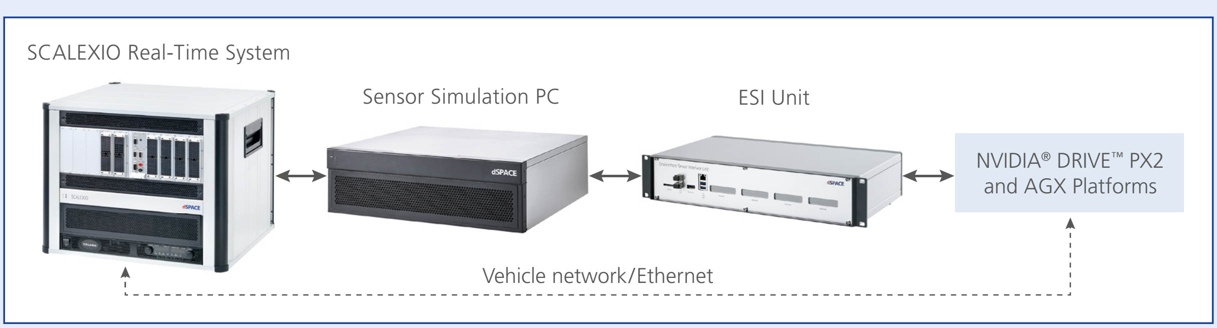
www.dspace.com/go/dWC19

TargetLink: Production Code for the AUTOSAR Adaptive Platform

The production code generator TargetLink, the long-time market leader for the model-based development of software components for the AUTOSAR Classic Platform, is now available in version 5.0. The new version also supports model-based code generation for the AUTOSAR Adaptive Platform. In addition, TargetLink 5.0 makes it even easier to implement distributed development with incremental code generation. For example, you can specify data store memory blocks in the TargetLink Data Dictionary to use them together in modules that were developed separately. dSPACE analyzed user feedback to further improve the user experience of the new version's Data Dictionary Manager and Property Manager, the dSPACE tool for convenient model property handling in TargetLink. The Property Manager now features a dynamic message view for quick error handling: the Validation Summary. One example of the improvements to the Data Dictionary Manager is the revised user interface for AUTOSAR file export. TargetLink 5.0 also offers other new features and improvements, for example, for better analysis of inherited data types. ■

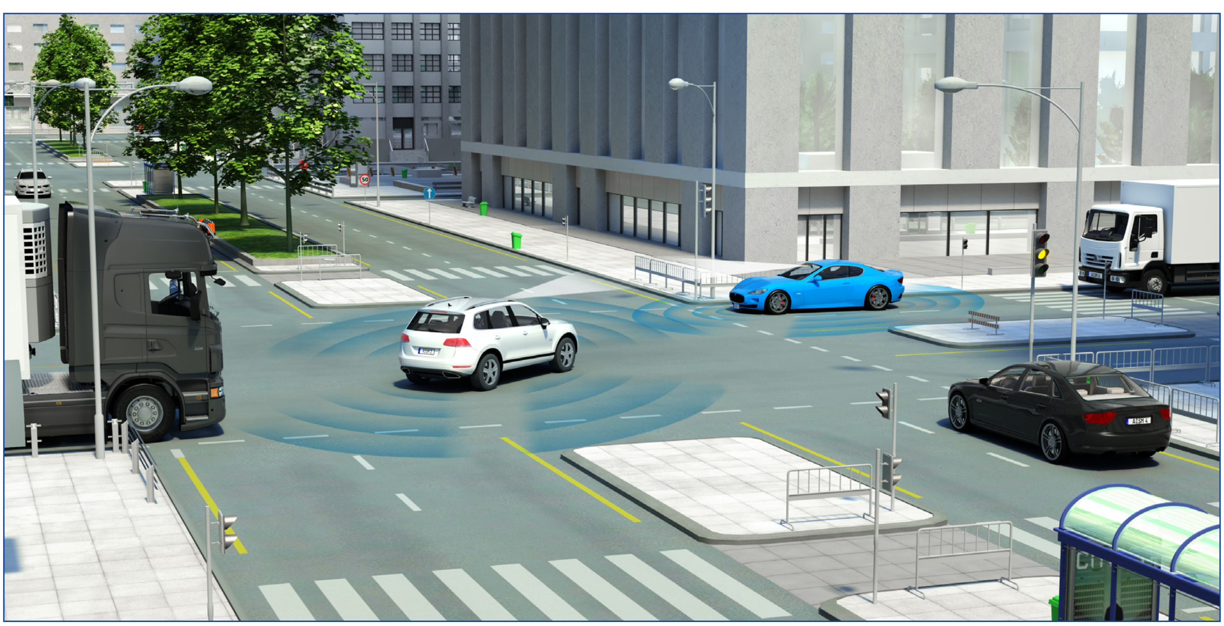
ESI Unit: Preconfigured Solution for NVIDIA® DRIVE™ PX2 and AGX

The dSPACE Environment Sensor Interface (ESI) Unit is the flexible answer to the question of how to feed broadband digital signals into camera, radar, and lidar ECUs while maintaining time correlation and low latencies. One of the greatest challenges in the development of functions for automated driving is the validation of environment sensors. Because many development departments use the NVIDIA® DRIVE™ PX2 and AGX platforms in their predevelopment and research for automated driving, dSPACE now offers the ESI Unit in an out-of-the-box variant that is preconfigured for these NVIDIA® platforms and can be used for inserting camera raw data. The dSPACE solutions for sensor and environment simulation can be used directly with the preconfigured ESI Unit to validate functions for automated driving. ■



V&V-Methoden Research Association Launches Project for Legally Compliant and Efficient Approval of Autonomous Vehicles

Testing and validating vehicle systems plays a key role in the introduction of functions for fully automated and autonomous driving. Supported by the Federal Ministry of Economics and Energy, 23 renowned partners from industry and research are jointly developing legally compliant, time- and cost-efficient verification and validation methods over a period of four years. dSPACE is one of these partners and will contribute its expertise primarily to the 'Simulation Control' and 'Exemplary Test Environment and Application' subprojects. It will build the HIL demonstrator used to demonstrate and evaluate the methodology.
Validation and testing will account for a significant share (more than 25%) of added value in the areas of fully automated and autonomous driving. In the foreseeable future, only the first automobile manufacturers and suppliers to master the corresponding processes within the framework of the legal requirements will ensure a competitive advantage. AI-based vehicle systems are challenged by an infinite number of possible traffic situations. This raises the question how to prove that fully automated and autonomous systems can always handle these situations safely. V&V-Methoden brings about essential innovations in the interaction of virtual and real tests by using the example of a complex application case at an urban crossroads.
"The Simulation Control subproject coordinates the cooperation with SET Level 4to5. The subproject implements the developed concepts and solutions and plays back the requirements for SET Level 4to5. One of the tasks for dSPACE will be to advise the project partners on topics such as the real-time capability of the models," says Fredrik Ikemeyer, Product Engineer at dSPACE.
In the „Exemplary Test Environment and Application" subproject, dSPACE is contributing its know-how to setting up the demonstrator. This task focuses on the analysis and definition of the technologies required for sensor data input, evaluation of concepts for the architecture of the HIL system, and development of methods for ensuring the consistency of the test framework.



V&V-Methoden brings about essential innovations in the interaction of virtual and real tests by using the example of a complex application case at an urban crossroads.