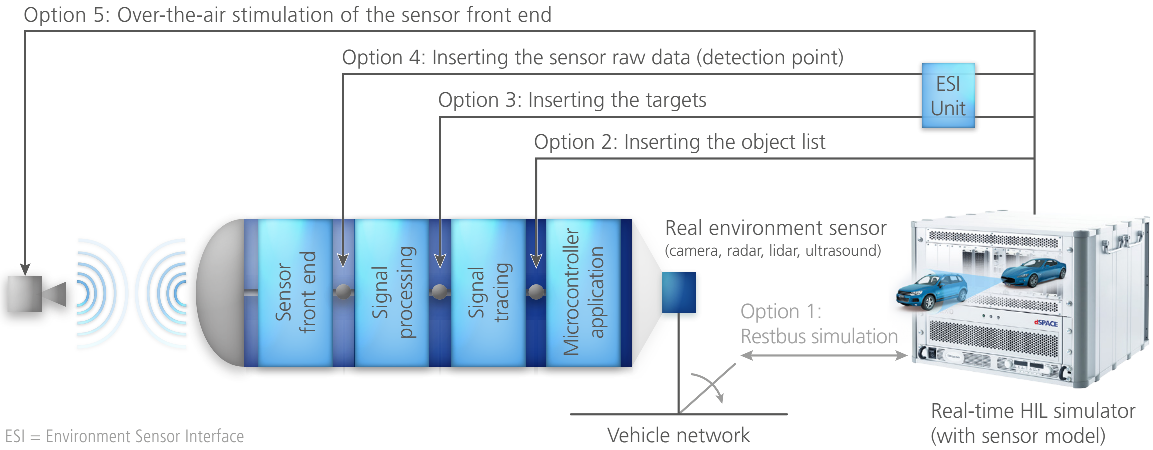
Mastering Variety

dSPACE solutions for highly automated driving

The topic of highly automated driving is the main focus of the development activities of many automobile manufacturers. Karsten Krügel and Hagen Haupt, who are responsible for virtual validation and simulation models at dSPACE, explain what challenges the development of functions for automated driving entails.

Mr. Krügel, everybody is talking about highly automated driving or autonomous driving. Is this also true at dSPACE?
Yes, indeed. Autonomous driving is a central theme at dSPACE, because many of our customers are currently working on solutions for this topic. In the last years, we invested much time and effort into our tools to support the OEMs and suppliers in developing and validating functions for autonomous driving. dSPACE sees itself as a single-source supplier of software and hardware solutions in this area, as can be seen in our webinar series.

Mr. Haupt, what are the core elements for developing and validating these functions?
There are several important aspects: First, you need completely new methods and standards to develop functions for autonomous driving, sensor fusion, and perception algorithms. Adaptive AUTOSAR and Automotive Ethernet are examples for this. Furthermore, the complexity of the real world must be simulated as comprehensively and detailed as possible, because realistic simulations are key to the validation. New description formats, such as OpenDRIVE, OpenSCENARIO, and Open Simulation Interface (OSI) help the manufacturers develop suitable tools. These tools support the configuration for the simulation models to be able to realistically emulate defined scenarios in the simulation.
Naturally, new prototyping solutions are also required for developing the functions. For this, dSPACE has extended its product range with MicroAutoBox Embedded SPU. It offers a unique combination of high computing power, interfaces to automotive vehicle networks and environment sensors, GNSS positioning, wireless communication, and an extremely compact and robust design for in-vehicle use. We introduced this new tool in detail in our article "Multisensor All-Rounder" in dSPACE Magazine 1/2017. >>



Basic principle of a closed-loop test environment with different options for inserting sensor data: Depending on the required level of detail, the sensor signals can be integrated into the HIL simulation in different ways.

What has to be paid attention to during simulation?
Haupt: An especially difficult challenge is the emulation of relevant effects that are specific to a particular use case in the vehicle and environment simulation. Sensor models form an important part of this. They have to bridge the gap between physical reality and highest possible efficiency. To solve these problems, dSPACE offers sensor models with different degrees of detail. The portfolio covers everything from a technology-independent sensor that immediately creates object lists based on the available information to a physical camera model for direct image data input.

What exactly does this mean for supplier and OEM processes?
Krügel: To validate functions for highly automated driving, a large number of tests must be performed with the various degrees of detail, both during the development phase and for the final release. The scope of these tests is enormous and, apart from the established methods, it can be managed only with the help of software-based simulation platforms, such as dSPACE VEOS.
VEOS allows for using PC clusters that let you run a large number of simulations in parallel on hundreds of computation nodes within only a few days. In addition, no ECU prototypes are available during the early development phases, which means that virtual ECUs (V-ECUs) must be used. Since complete chain of effects testing requires many V-ECUs, it is not feasible to integrate software manually. For this reason, continuous integration is becoming increasingly important. Here, V-ECUs are generated fully automatically from the latest integration versions. Because all these changes require the suppliers and OEMs to adjust their processes or create completely new work steps, dSPACE offers comprehensive consultancy and support.

Does this mean that a HIL simulator is no longer required?
Haupt: For release tests according to ISO 26262, the hardware-in-the-loop (HIL) simulation is still indispensable. During the simulation, sensors, such as camera and radar sensors, are integrated into the HIL system because signal preprocessing in the sensor, sensor fusion, and the creation of environment models in the ECU have an important impact on the chain of effects. Integrating the sensors is possible at various levels of detail – from restbus simulations of the object list and inserting raw data streams to simulating complete systems with over-the-air methods. dSPACE offers custom I/O solutions for all these variants. For example, we developed powerful hardware for connecting image sensors to a HIL simulator at raw data level, called the Environment Sensor Interface Unit.

> Developing and testing functions for autonomous driving influences the tool chain and established work processes of the automotive industry.

Hagen Haupt (left) and Karsten Krügel (right) explain about dSPACE's range of solutions for autonomous driving.

How much more realistic do the latest models have to be in comparison to previous models?
Haupt: Sensor models that are based on phenomenological or physical approaches are becoming increasingly important for supplying the previously mentioned raw data feeds. Typically, they are computed in 3-D graphics environments. dSPACE offers a powerful solution with its new sensor for cameras and point clouds in MotionDesk. Additional models for simulating radar sensors are currently being developed.

Does this mean that the complete simulation environment must become more realistic?
Haupt: A realistic representation of the sensor physics certainly directly affects the modeling of the environment and its components, such as road networks, roadside structures, traffic signs, and the representation of road users, because they always interact with sensor models in the simulation. However, it is not just the traffic objects that must be displayed ever more realistically, their behavior must also be realistic. Some key points are intelligent driving while taking road rules into consideration as well as realistic traffic scenarios whose definition would be very tedious if it was done with traditional methods.

How has environment simulation been improved?
Haupt: New and improved solutions include the integration of intelligent driving and traffic systems as well as the connection of established traffic simulation solutions, such as the Simulation of Urban Mobility (SUMO) and the traffic flow simulation software VISSIM. Additionally, dSPACE Automotive Simulation Models (ASM) allow for multi-agent simulations where multiple complete vehicles with functions for autonomous driving are driving in the same environment. It is certainly also important to have methods that keep the definition of scenarios as simple as possible. Using real map information to describe road networks and importing movement data for the traffic objects is therefore of the essence. We make it possible to generate road networks on the basis of navigation data, such as OpenStreetMap or highly precise HD maps. Our established tool ModelDesk offers interfaces for movement data that let you easily import scenario descriptions from real vehicle tests or recorded measurement and accident data, such as the GIDAS-Pre Crash Matrix (PCM).

What is the big difference between previous tests and tests for highly automated driving?
Krügel: One thing is certain, you need to test much more than before. Yet, it is important to not just perform a large number of tests but the right tests. This means we need entirely new, intelligent test methods that can detect critical scenarios or unwanted false positives, because nobody can define a comprehensive and complete test catalog that is based purely on requirements. Here, dSPACE offers support with its tools, for example, its scenario observers that continuously observe the simulation with randomized tests and prepare the simulation results in such a way that the tester can easily make out and analyze interesting situations from the large volumes of data.

Managing large data volumes is an important task. What does dSPACE have to offer here?
Krügel: Our test and data management software SYNECT provides the required infrastructure to support the fully automated validation

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Webinar Series for Autonomous Driving

dSPACE offers six free lectures about the development and testing of functions for highly automated driving.

For more information, see: *www.dspace.com/go/AD-Webinar*

The combined use of real and virtual PCs in one cluster provides an entirely new level of flexibility for testing complex driving scenarios.

of functions for autonomous driving on the relevant MIL, SIL, and HIL test platforms. SYNECT lets you centrally manage the desired test scenarios and the related data, for example, simulation models and parameters. In addition, you can efficiently plan numerous test runs and execute them automatically, which means you can drive millions of test kilometers on a PC cluster in one night.

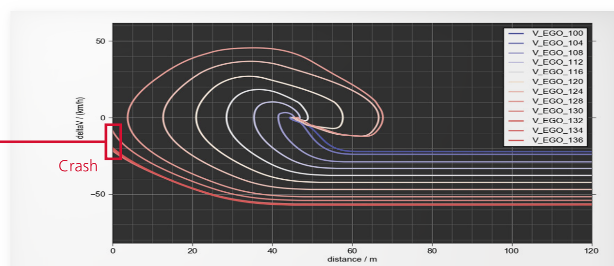
Mr. Krügel, Mr. Haupt, thank you for talking to us.

Dr. Karsten Krügel is a senior product manager for Virtual Validation at dSPACE.

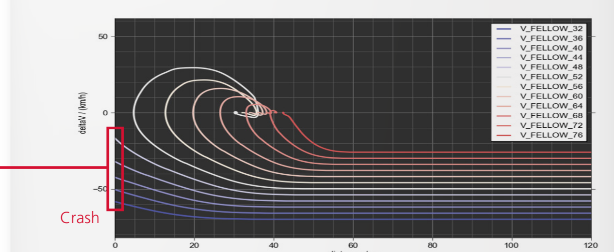
Dr. Hagen Haupt is a section manager for Modeling and HIL Simulation in the Application Engineering division at dSPACE.

The graphical evaluation shows which parameters (driving speed and distance between the two vehicles) are necessary to allow for the fellow vehicle to safely move back into the lane in front of the ego-vehicle. The settings marked in red lead to a collision.

V_EGO [km/h]	V_Fellow [km/h]	Distance [m]
100	80	75
104	80	75
108	80	75
112	80	75
116	80	75
120	80	75
124	80	75
128	80	75
130	80	75
132	80	75
134	80	75
136	80	75



100	32	75
100	36	75
100	40	75
100	44	75
100	48	75
100	52	75
100	56	75
100	60	75
100	64	75
100	68	75
100	72	75
100	76	75



100	80	25
100	80	30
100	80	35
100	80	40
100	80	45
100	80	50
100	80	55
100	80	60
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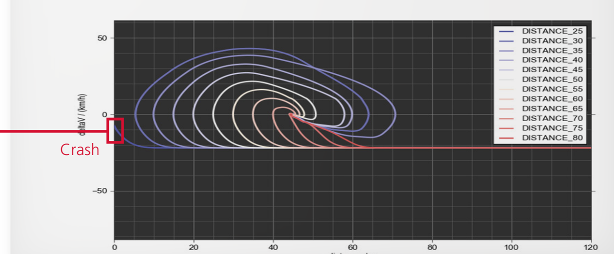
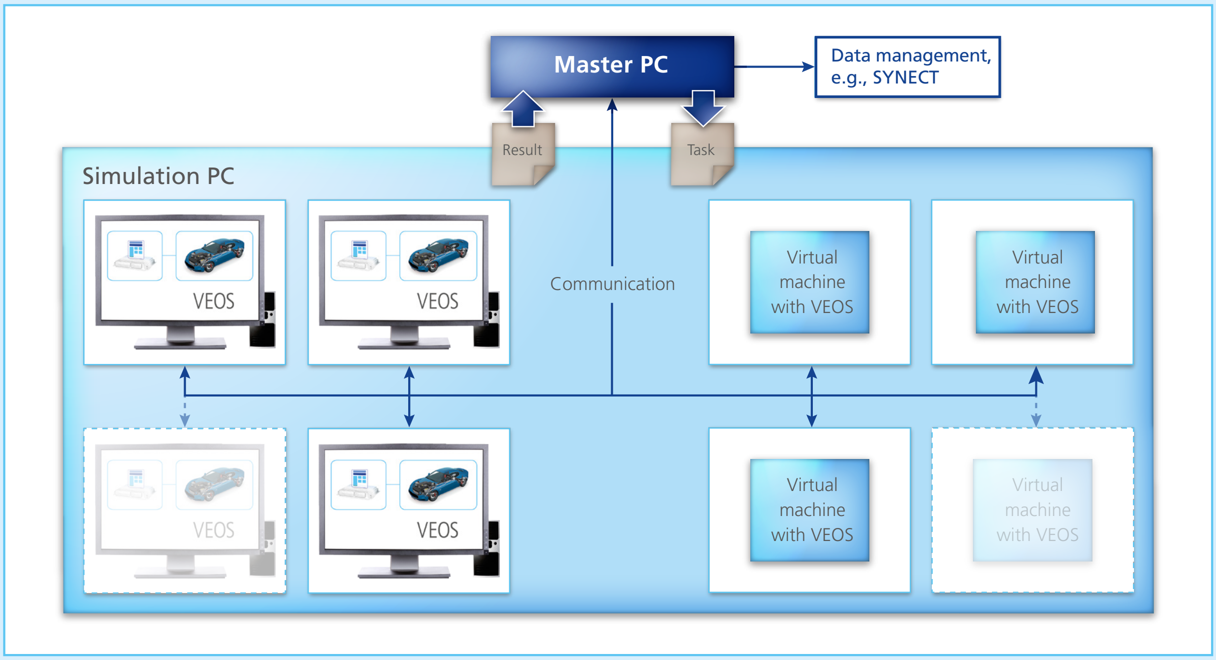
100	80	70
100	80	75
100	80	80



Combined Computing Power for Multi-Agent Systems



An important aspect when validating driver assistance systems and functions for highly automated driving is the interaction of multiple highly automated vehicles with other intelligent road users in multi-agent simulations. This requires that numerous traffic scenarios in which road users behave differently are run, which drastically increases the number of tests required for validation. Using software-in-the-loop (SIL) simulations on Windows-based VEOS clusters makes it possible to significantly increase the test performance and simultaneously ensure scalability. For this, the driving scenarios to be tested are stored on a central master PC. This master PC distributes the individual tests to a network of simulation PCs that are integrated either as PCs or virtual machines. On the installed VEOS simulation platform, the tests are then performed in a batch operation and the measurement results are fed back to the master. Because dSPACE tools are modular and can be automated, every automated SIL test can in principle be performed on a simulation PC.

Test performance increases with the number of nodes as a factor. Integrating the cluster control into the SYNECT test and data management environment enables the ideal integration of existing tests and continuous integration processes.