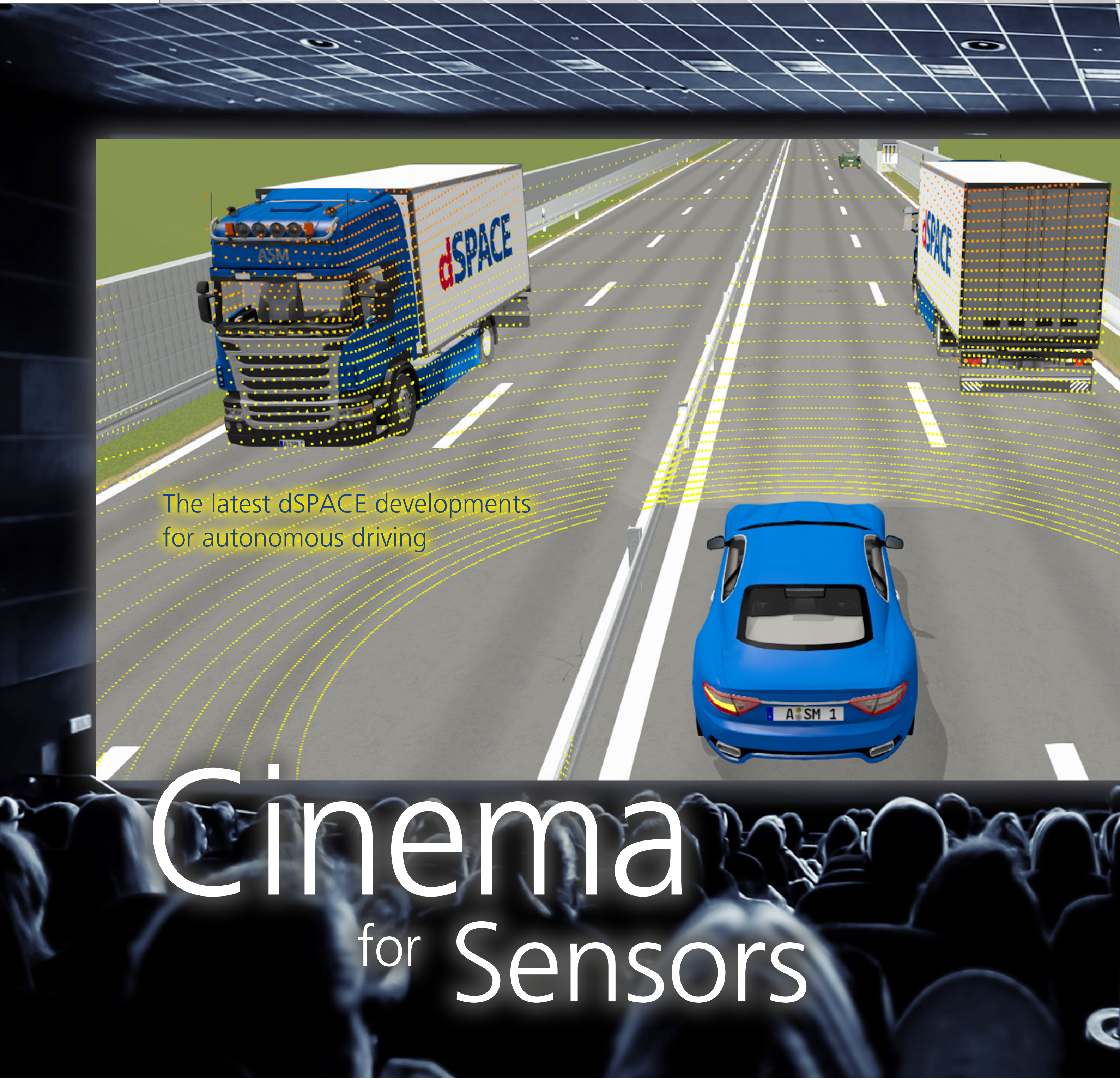
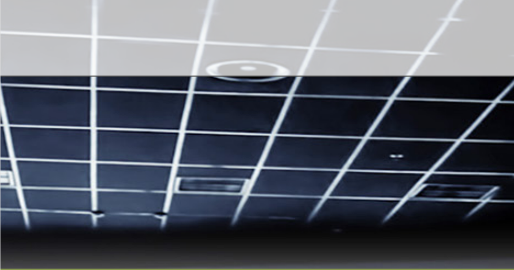
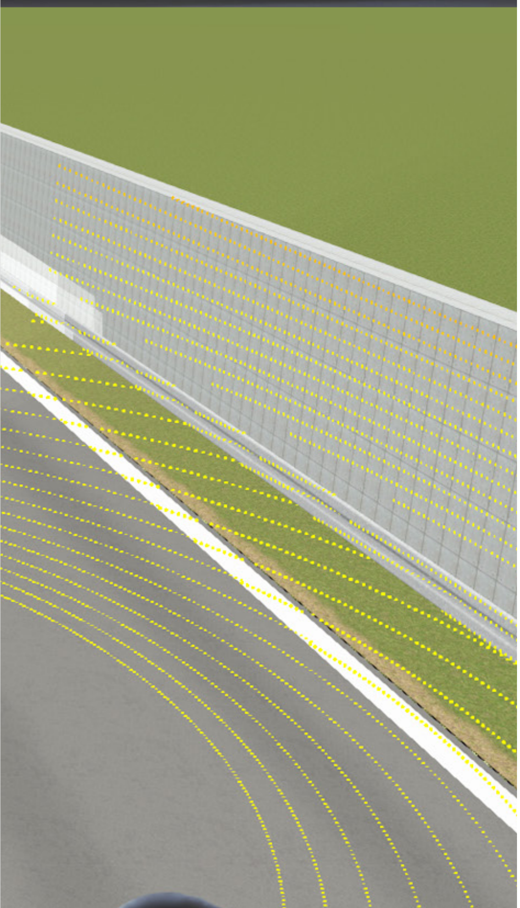


The latest dSPACE developments for autonomous driving

Cinema for Sensors

Autonomous vehicles will be equipped with a wide variety of environment sensors. Testing their functions and complex interaction is an enormous challenge. Holger Krumm and Sebastian Graf, co-responsible for the latest developments for this area at dSPACE, will give an insight into the latest dSPACE activities and the challenges ahead.





Mr. Krumm, the term sensor-realistic simulation is often used in connection with the development of autonomous vehicles. What exactly does this mean?

Krumm: This means virtually reproducing road traffic in the laboratory as it is perceived and recorded by the sensor, i.e., camera, radar, lidar. It is imperative that the sensor functions be validated in the laboratory, because we are looking at many millions of test kilometers due to the wide range of traffic situations. This cannot be done on the road. The dSPACE tools therefore ensure realistic simulation and stimulation of sensors in the laboratory.

Where are sensor-realistic simulations used?

Krumm: This happens wherever the functional chain from the perception algorithm to the object identification must be validated at an early stage. In virtual 3-D worlds used to test ADAS/AD applications, the models return the same signals as real sensors. For this, customers want to perform testing and validation at an early stage of the development cycle for sensors and processing units, such as a central ADAS control unit. This gives greater weight to model- (MIL) and software-in-the-loop (SIL) topics.

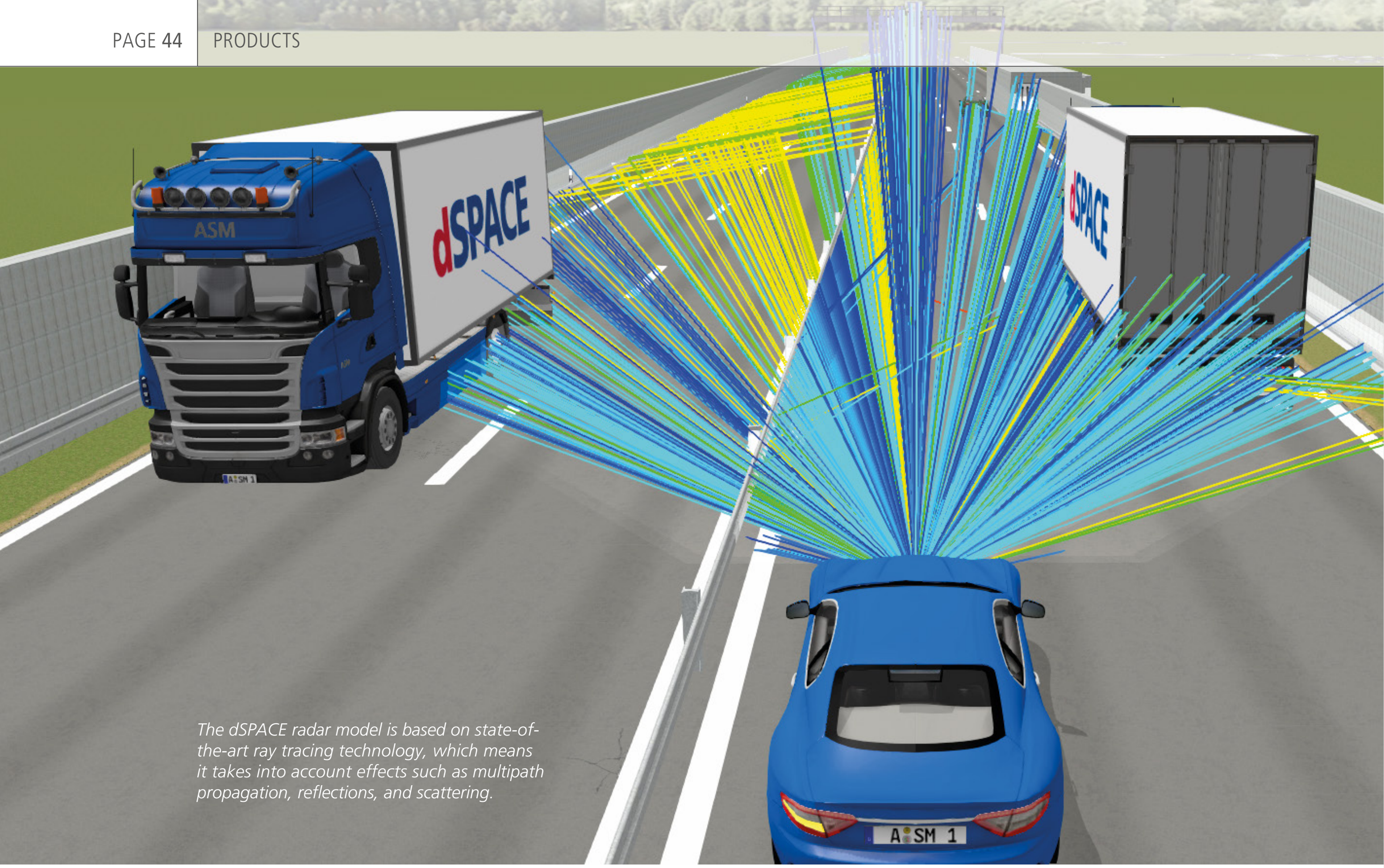
Which sensor-realistic models does dSPACE offer today?

Krumm: Sensor Simulation is the generic term used for the software modules for camera, radar and lidar sensor simulation. As of dSPACE Release 2018-B, we have offered an independent module for camera-based raw data generation that simulates the environment, traffic objects, and effects for weather- and daytime-based lighting conditions. As of dSPACE Release 2019-A, we released two additional modules: the radar module and the lidar module. Both are based on the ray tracing technology. This involves sending beams into a 3-D scene and capturing their reflections, which allows for the integration of physical effects such as multipath propagation into the modeling. The result is a physically correct simulation of the propagation of radar waves or a near infrared laser beam, which is essential for the stimulation and emulation of sensors.

Mr. Graf, what level of detail and scope of services do the models have?

Graf: Generally, the models calculate the transmission path between the environment and the sensor front end as well as parts of the front end itself, for example, the radar antenna. >>

Holger Krumm (left) is Product Manager for Prototyping and Validation Software Tools at dSPACE, Dr. Sebastian Graf (right) is Senior Application Engineer at dSPACE.



The dSPACE radar model is based on state-of-the-art ray tracing technology, which means it takes into account effects such as multipath propagation, reflections, and scattering.

> With the ray tracing engine in Sensor Simulation, the propagation of mm waves and infrared radiation can be simulated with physical accuracy – an essential capability for stimulating and emulating radar and lidar sensors.

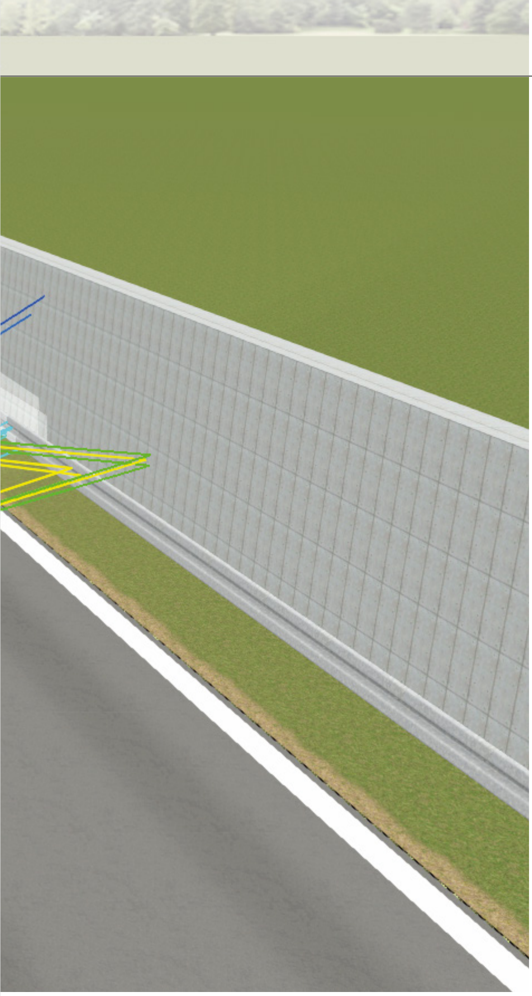
In addition to the wave propagation calculation, the radar and lidar modules have a powerful postprocessing interface that allows for processing the acquired data. This enables creating a detection list or a point cloud for radar and lidar, for example. For the camera, the properties of the front end, meaning the lens system and the image sensor, are simulated. This includes effects such as chromatic aberration, vignetting, complex lens profiles, fish-eye distortion if required, and the output of the image sensor such as the Bayer filter and high dynamic range. Due to open interfaces, the customer can integrate their own postprocessing for special features of their own ECU. This applies to all sensor models.

What are the requirements for using Sensor Simulation?

Graf: The SIL setup requires a standard PC and an NVIDIA graphics card. Using a Sensor Simulation PC from dSPACE is also an option. It offers the benefit of being designed for operation in the dSPACE tool chain. In a HIL setup, on the other hand, the sensor simulation is always performed with a Sensor Simulation PC. The scalability of these PCs makes it possible to simulate any number of sensors. For this purpose, the PCs require a description of the vehicle environment and a simulation of the vehicle dynamics. Both are provided by a SCALEXIO simulator on which the ASM tool suite is executed. Because the sensor simulation products will be platform-independent in the future, they will also run under Linux, for example, so they can also be used on clusters or in any cloud services.

Are there any unique selling points of Sensor Simulation compared to other suppliers?

Krumm: Sensor Simulation is based on a complete vehicle dynamics simulation of the ego-vehicle. This means that all movements of the sensor are taken into account, e.g., when the vehicle leans into a road curve or pitches on cobblestones. Sensor Simulation rises to the special challenge of testing sensors not only by SIL, but also by HIL simulation. This requires real-time capability. The simulation of the radar wave propagation happens



> Sensor simulation is based on a complete vehicle dynamics simulation of the ego-vehicle, i.e., all movements of the sensor are taken into account.

so fast that a stimulation of real sensors – by injecting the raw data – takes place at run time. These computing speeds, which two to three years ago were undreamed-of, are now possible thanks to the parallel use of modern high-end graphics cards. Sensor Simulation is the only tool chain that simulates all three important sensor types, i.e., camera, radar and lidar, at this level. Another remarkable feature of the dSPACE tool chain is the simple transition from SIL to HIL simulation.

Do your customers already use Sensor Simulation? For what purposes do they use it?

Graf: Yes – we have a few key customers in the German automotive industry who are already using the tool in various areas. For this, we picked customers at various levels of the supply chain. Key customers include a large German OEM, ZF as a Tier 0.5, and HELLA as a radar supplier. We also engage in several other medium-sized and smaller cooperations and joint projects. All users give us feedback to make the simulation even more realistic and to adapt the tool chain to the specific challenges of a Tier 2, Tier 1, or OEM.

Can you tell us about the innovations that dSPACE is working on?

Graf: Among other things, we will increase visualization quality to enable camera function testing even in special light and weather conditions. Another topic is neural networks for environment detection. For this type of highly realistic visualization, we use modern, specialized graphics engines to achieve an entirely new level of camera sensor simulation. We are working at full speed to offer our customers full coverage of their applications. For the end of 2019, we are also planning to offer an option to assign material properties to objects. For radar and lidar, prototypes for SIL and HIL implementation at the raw data level of the sensor are already available. This enables testing of the digital sensor back end. For the last few years, this has been the latest standard for cameras. However, this is new territory for radar and lidar. Especially suppliers are extremely accepting of this technology, which proves to us that we are on the right track. The potential lies in testing during development. Moreover, the OEM also benefits from the fact that the supplier can provide sensor-specific models thanks to the straight-forward interface.

Mr. Graf , Mr. Krumm, thank you for this interview.