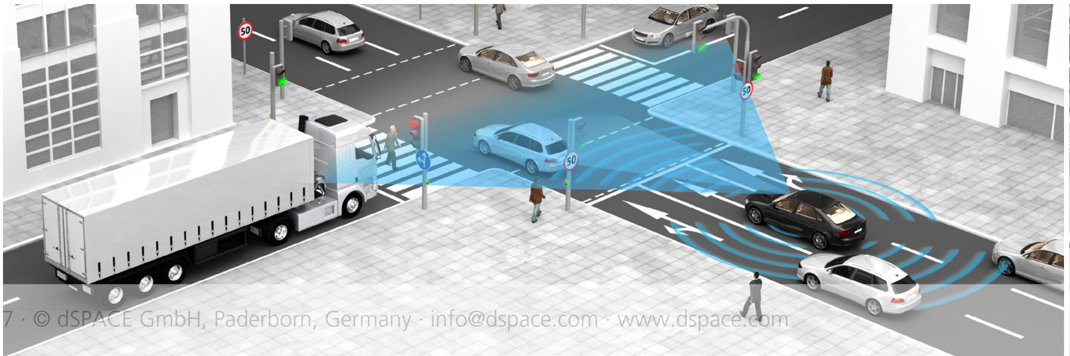
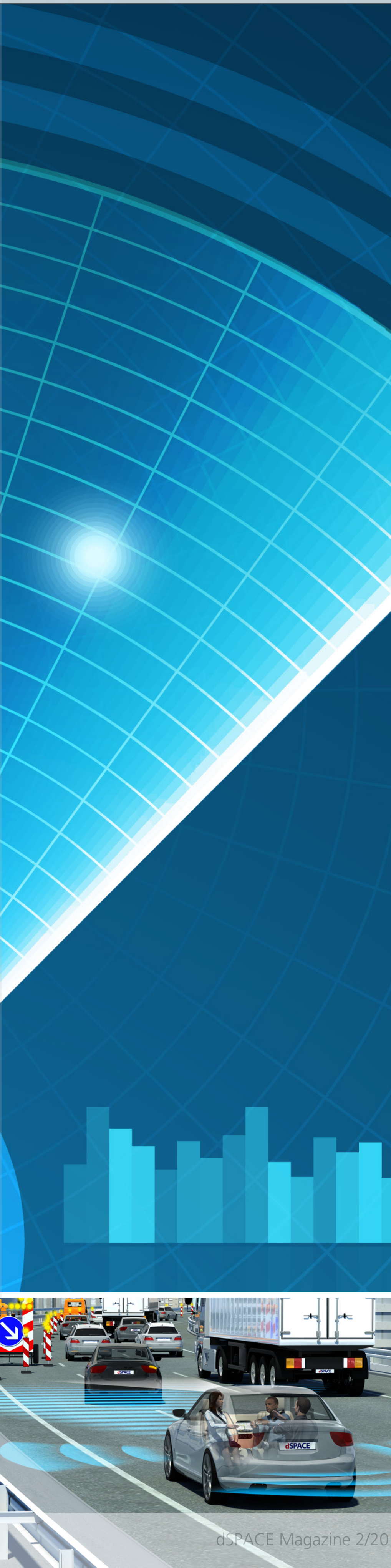
Testing radar sensors with real radar echoes

Real Echoes in the Lab





Testing radar sensors in a closed loop is one of the elementary challenges when developing advanced driver assistance systems. By adding enhancements to their HIL simulators, dSPACE now makes this possible in the limited space of a lab – using real radar echoes instead of virtual ones.

Radar sensors supply the advanced driver assistance systems of modern vehicles with the required environment information to avoid accidents or execute functions for autonomous driving. When the assistance systems are validated, the propagation behavior of the radar waves must be considered as realistic as possible. This means that costly and time-consuming road tests are usually inevitable. However, these road tests can be avoided by using radar sensors with real radar waves (over the air) in the lab.

Testing in the Lab and Not on the Road

To test radar sensors in the lab, a range of requirements must be met:

- Radar echoes of traffic participants, which would normally be present on the road at different distances (ranging from a few meters to some hundred meters) and different speeds, must be generated in the limited space of the lab.
- Changes in the direction of origin of the radar echoes (for example, when the vehicles drive around a bend) must also be simulated as well as radar cross sections (a measure for an object's ability to reflect radar waves).
- Undesired radar echoes that occur on the test bench must be filtered out or the test bench must be shielded from these echoes as they would compromise the test results. Therefore, the tests must be performed in a special absorber chamber.

Because it is difficult to meet all these requirements, most tests of radar-based driver assistance algorithms are done via restbus simulation. During these tests, detected radar objects are fed to the bus, for example, a CAN bus. However, this approach lacks test depth, because the tests are performed without real radar sensors. These disadvantages can be avoided by using real radar sensors and echoes. Thanks to the generic work process of the miro•sys Automotive Radar Scenery Generator, no ECU-specific internal information is required, which lets you treat the radar sensor as a black box and test it as such.

Test Bench for Radar-Based Algorithms

The dSPACE over-the-air (OTA) radar test bench for testing radar-based

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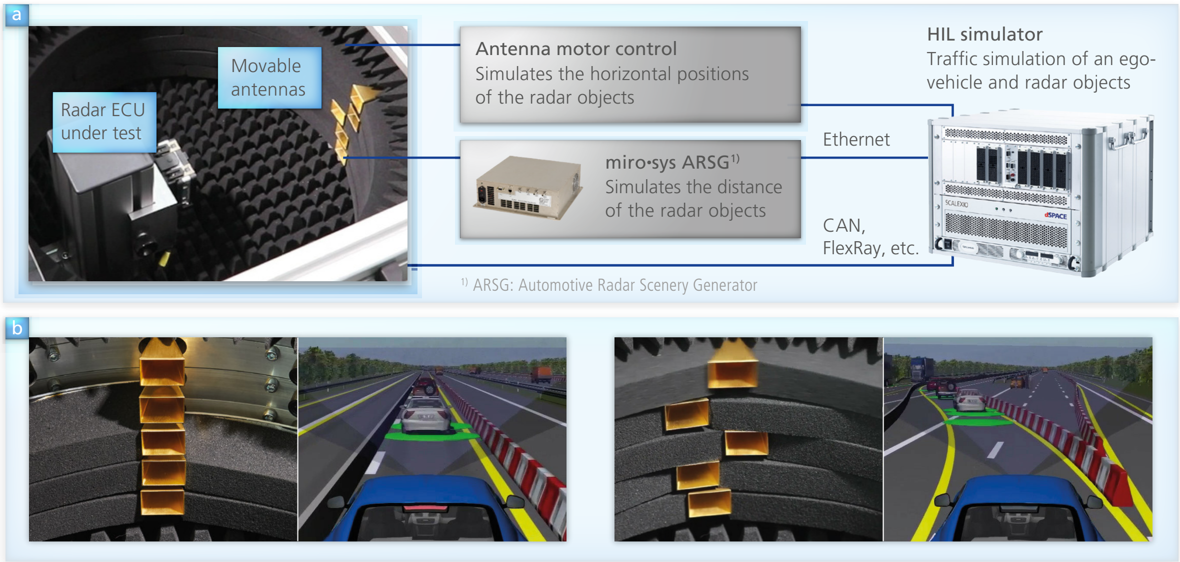
Figure 1: An overview of the radar test bench.

algorithms essentially consists of a mechatronic test bench, a dSPACE SCALEXIO HIL simulator, and the miro•sys Automotive Radar Scenery Generator (figure 2a). The mechatronic test bench includes an absorber chamber (a space with low reflection) in which the radar sensor is located as well as multiple stacked rings that rotate around a common perpendicular axis and are driven by an electric motor. The antennas are attached to these rings.
The rotation of the rings changes the antenna position and in turn the direction of origin of the radar echo (figure 2b). The miro•sys Automotive Radar Scenery Generator receives the radar waves sent by the radar sensor and modifies the original signal on the basis of the driving scenario that is played on the HIL simulator. The elapsed time between the sent and the received signal is varied for this, depending on the distance of the vehicles. As a result, the radar sensor receives radar echoes that match real road traffic. This way, all typical use cases, such as automatic cruise control (ACC), autonomous emer-

Figure 2: (a) The radar measurement device is located in an absorber chamber. The dSPACE simulator calculates the driving scenarios, positions the antennas, and controls the miro•sys Automotive Radar Scenery Generator, which generates the related radar echoes from up to four objects. (b) Two exemplary antenna positions with their respective driving scenarios.



gency braking (AEB), and lane changes can be simulated easily in the lab. The properties (shape, varnish) of the front spoiler into which the radar sensors are usually integrated can be easily taken into account for all tests. The test bench offers enough space to integrate part of the front spoiler and the radar sensor.

The video shows the working radar test bench. www.dspace.com/go/dMag_20172_Radar

Profile: Radar Test Bench

Main Features	Details
Radar objects (number/ properties)	■ Four independent radar objects with the following parameters: ■ Distance ■ Speed ■ Radar cross section ■ Azimuth angle
Refresh rate	■ 1 ms
Distance range/step width	■ 2.0[1)]-1,000 m / 5.6 cm (digital)
Speed range/step width	■ ±700 km/h / 4 mm/s
Azimuth angle range/resolution	■ ±90° / 0.1°
Azimuth angle speed	■ Max. 200°/s
Supported radar frequencies	■ 23-26 GHz, 75-82 GHz

1) Under development. Shorter distances on request.

Michael Rožmann, Managing Director at miro•sys GmbH, explains the challenges of using real radar echoes.

Mr. Rožmann, why is working with radar echoes so demanding?

In contrast to high-resolution images, such as images received from optical cameras, radar signals are harder to interpret. Moreover, the delicate high-frequency technology requires absolute precision with regard to signal quality and coherence. Even the smallest deviations can lead to major mistakes. Short-wave signals are also reflected extremely well, which means that undesired reflections must be managed accordingly.

How did you tackle these challenges?

miro•sys has decades of experience in the area of high-frequency technology and optics, which paid off when we developed the radar signal generator. The device allows for generating precise and coherent radar signals in real time. The tailored absorber chamber fitted with special material removes all undesired reflections so the radar sensor detects only the generated radar echoes.

What are the advantages of real radar echoes? Are there situations that can only be tested this way?

The advantages are obvious: The radar sensor to be tested can be treated as a black box, which means that no manufacturer-specific knowledge about the sensor is necessary. The complete chain of effects, from the radome to the tracking algorithm, can be tested with only this one approach. Moreover, the influence of the surrounding materials, such as the front spoiler, on the electromagnetic signal is taken into account.

What distinguishes your product from those of your competitors?

The properties of the radar echo, i.e., the radar cross section, relative distance, and relative speed can be set each millisecond. Additionally, we have a single compact device that supports up to four completely independent radar objects as well as three conventional radar frequencies, namely 24, 77, and 79 GHz. We can also configure the signal generator according to customer specifications, because it has a modular design.

What type of extensions are you planning for future versions?

We will primarily work on increasing the number of possible radar echoes and reducing the minimum distances of the radar objects.

Mr. Rožmann, thank you for talking to us.