GNSS RECEIVER STIMULATION ON AUTOMOTIVE TEST BEDS FOR SELF-DRIVING CARS

Integrating the R&S®SMBV100B GNSS simulator into the AVL DRIVINGCUBE™ toolchain creates new possibilities for validating advanced driver assistance systems and autonomous driving functions at the vehicle level. Combining a complete vehicle on a vehicle test bed with physical sensor stimulation results in fast, reproducible and cost-efficient testing. All possible driving scenarios can be executed under realistic and safe conditions.

R&S®SMBV100B GNSS simulator

Your task

Self-driving cars are becoming more and more relevant in the automotive industry. From the already available level 2 advanced driver assistant systems (ADAS) to partly autonomous driving to fully autonomous driving (AD) in the future, the complexity of functions is growing drastically.

Validating these functions in all possible conditions and variations poses a significant challenge in the field of automotive development.

As an example, functions such as autonomous emergency braking (AEB) and adaptive cruise control (ACC) or even fully automated functions like a highway chauffeur require a huge amount of functional and nonfunctional validation and optimization within the integrated vehicle – in a multitude of environmental situations and vehicle configurations.

The complexity of the testing scenarios and the huge amount of testing kilometers that have to be driven to assure functional safety of those functions challenges the state-of-the-art validation approaches.

There are three main approaches for ADAS and AD validation today. It is typically done by performing drive tests on public roads or the proving ground, by hardware-in-the-loop (HiL) testing or by pure virtual, software based simulation testing, i.e. without any hardware components.

Tests on the proving ground or public roads are realistic, but not completely reproducible and can be dangerous for the test driver and other test participants. Additionally, resetting scenarios between each test run on the proving ground costs a lot of time. HiL based tests use real electronic control units (ECU) and functions, but are difficult to set up since complex rest bus simulation is needed. Pure simulation is very productive, efficient and flexible. However, since no physical components are used, virtual testing lacks the real interaction between the vehicle systems, which is very important to validate.

AVL and Rohde & Schwarz are technology partners in the sector of validating advanced driver assistance systems and autonomous driving functions at the vehicle level.

AVL

Application Card | Version 01.00

ADAS and AD validation methods

	Validation method	Advantages	Disadvantages
Field	Drive tests on proving ground or public roads	All components tested in real-world environment	Not reproducible, dangerous and expensive
Laboratory	ViL testing with complete vehicle	Presented in this document	
Laboratory	Component level HiL testing	Uses real hardware, is flexible and reproducible	Complex setup
Laboratory	Software simulation without any hardware parts	Flexible, efficient and cheap	Does not test real interaction between systems

Many of the disadvantages associated with each approach can be overcome by using the vehicle-in-the-loop (ViL) method, which is described in the following paragraphs in more detail.

Rohde & Schwarz and AVL solution

The AVL DRIVINGCUBE™ offers a different validation approach, bridging the gap between real road testing and simulation. In contrast to a pure HiL approach that is based on individual components, it tests the complete, integrated and ready-to-drive vehicle operating in a virtual environment on a test bed. Either physical or behavioral sensor models (i.e. feeding sensor outputs from a software simulation to the ECU) or physical sensor stimulators connect the control units under test with the simulated environment. This test environment is designed to evaluate all kinds of ADAS and AD functions, e.g. automatically accelerating or decelerating the vehicle when operating in predictive ACC mode.

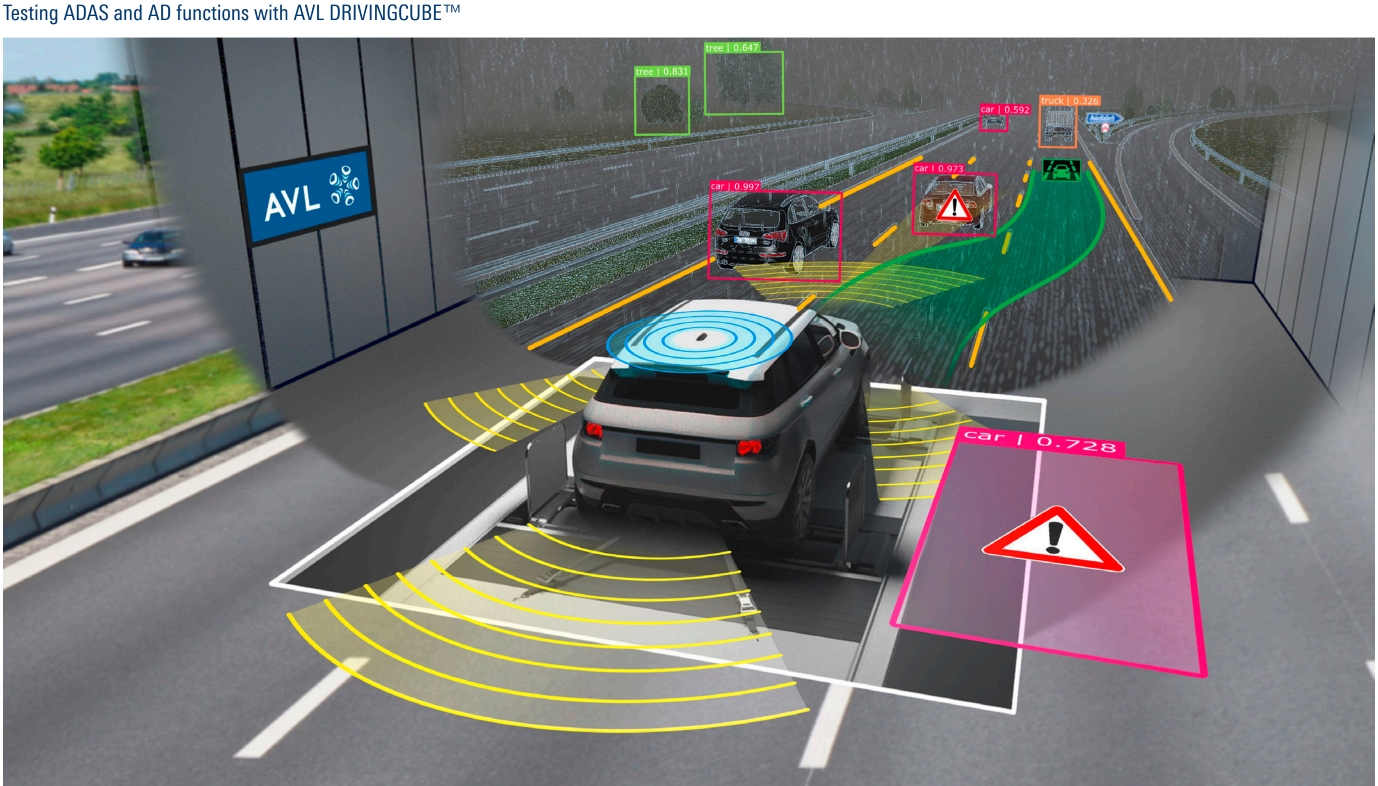
The AVL DRIVINGCUBE™ offers increased efficiency during validation and optimization of the ADAS and AD functions since the scenarios on the test bed are much more reproducible then those on the real road. It also simplifies access to the vehicle during operation. Critical situations can be validated in a safe way, which is not possible on the real road. Especially sensor simulation and stimulation play an important role for reliable validation results when driving complex scenarios.

Stimulating GNSS receivers with the R&S®SMBV100B

Using the flexible R&S®SMBV100B GNSS simulator, the validation environment can be extended by the ability to stimulate the vehicle's built-in GNSS system with real GNSS RF signals. This enables testing of navigation and map based ADAS and AD functions like predictive adaptive cruise control (ACC) or hub-to-hub (H2H) operation.

The R&S®SMBV100B can generate signals for all global navigation satellite systems such as GPS, Galileo, GLONASS and BeiDou as well as for many satellite based augmentation systems (SBAS). With its 60 available channels, it is easy to set up realistic constellations where satellites from multiple, different GNSS can be present.

Testing ADAS and AD functions with AVL DRIVINGCUBE™



Additionally, it is possible to simultaneously generate signals on all frequency bands (for instance L1, L2 and L5), allowing integration and validation of modern multifrequency GNSS receivers.

Satellite visibility and power levels can be adjusted on the fly, offering additional possibilities for modeling obscured and blocked GNSS signals.

The R&S®SMBV100B GNSS simulator accepts remote commands from the test bed over LAN, USB or GPIB interfaces. The position and attitude data necessary for GNSS simulation can be streamed to the simulator using SCPI or UDP commands, making integration into the AVL DRIVINGCUBE™ simple.

High streaming rates of up to 100 Hz combined with a low command processing latency of down to 20 ms ensure high processing and signal accuracy.

Testing of predictive ACC function for trucks in a ViL environment

The AVL DRIVINGCUBE™ can simplify the development of an ADAS system, for example the validation of a fuel efficient, predictive ACC function.

A predictive ACC function considers the road topology ahead based on a geographic height map and the actual truck position calculated by the GNSS receiver. It then adjusts the vehicle speed and engine operating strategy to achieve optimal energy consumption for the entire route.

In order to test the function of the predictive ACC, Rohde & Schwarz and AVL set up the toolchain mentioned above on a chassis dynamometer for trucks in Stockholm.

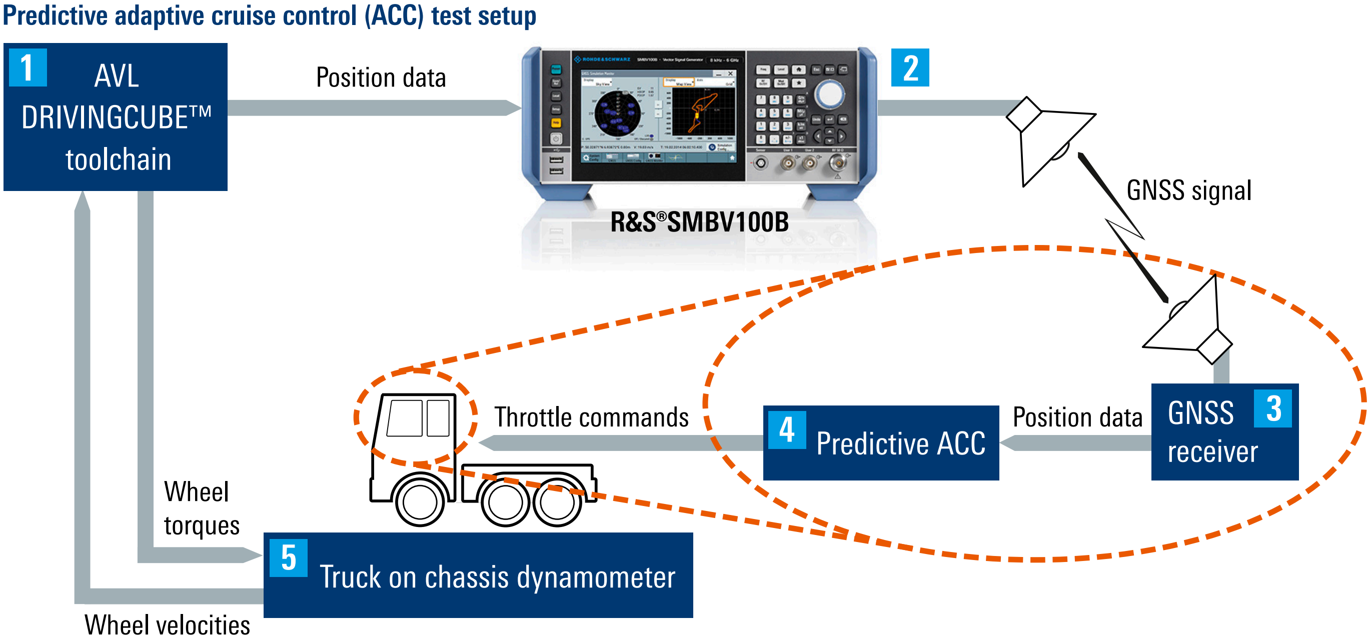
A geographic map is used in the AVL DRIVINGCUBE™ virtual environment to generate a track on which the virtual truck is driving. The movement of the physical truck, governed by the ACC function (4), is recorded by the chassis dynamometer (5) and transmitted to the system controller (1).

The system controller calculates the expected driving resistance based on truck model driving on the virtual track. The driving resistance is then projected back to the physical truck by setting the resistance provided by the dynamometers accordingly.

Based on the transmitted movement of the physical truck, the position of the virtual truck on the track is updated. This position data is then sent to the R&S®SMBV100B (2), which generates the corresponding GNSS signal. The GNSS signal is fed into the physical truck's GNSS receiver (3), which calculates a position fix and allows the ACC function to adjust its operating strategy appropriately.

While using this toolchain and driving the physical truck on the test bed in Sweden, it was possible to drive the virtual truck on a German road. The R&S®SMBV100B GNSS simulator was used to generate the GPS radio signals.

Predictive adaptive cruise control (ACC) test setup



Test vehicle with GNSS simulation for predictive ACC testing on a chassis dynamometer

Key benefits

- All driving tests can be performed at vehicle level under highly reproducible conditions in a lab environment
- The operating conditions, especially for critical manoeuvres, are 100 % safe
- GNSS simulation with high update rate, low latency and excellent signal and processing accuracy
- Simulate any position on earth with different satellite constellations
- Supports GPS, Galileo, GLONASS and BeiDou in all GNSS frequency bands
- Simulate signal obscuration and multipath

This test setup has multiple advantages over traditional methods of ADAS/AD validation and testing. All components are tested at the vehicle level, just like in proving ground testing. However this method retains the flexibility and reproducibility associated with hardware-in-the-loop testing, providing a cost-efficient test setup in a lab environment.

See also

https://www.rohde-schwarz.com/product/smbv100b
https://www.avl.com/adas

AVL and Rohde & Schwarz are technology partners in the sector of validating advanced driver assistance systems and autonomous driving functions at the vehicle level.

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PD 3608.3061.92 | Version 01.00 | January 2020 (jr)
GNSS receiver stimulation on automotive test beds for self-driving cars
Data without tolerance limits is not binding | Subject to change

3608306192

3608.3061.92 01.00 PDP 1 en