Virtual Prototyping for Highly Automated Vehicle Function Validation utilizing a Vehicle-in-the-Loop Driving Simulator Facility

Fischer M, Plättner J, Grolms G, Assmann D, Lapoehn S, Köster F
German Aerospace Center (DLR), Institute of Transportation Systems, e-mail: ma.fischer@dlr.de

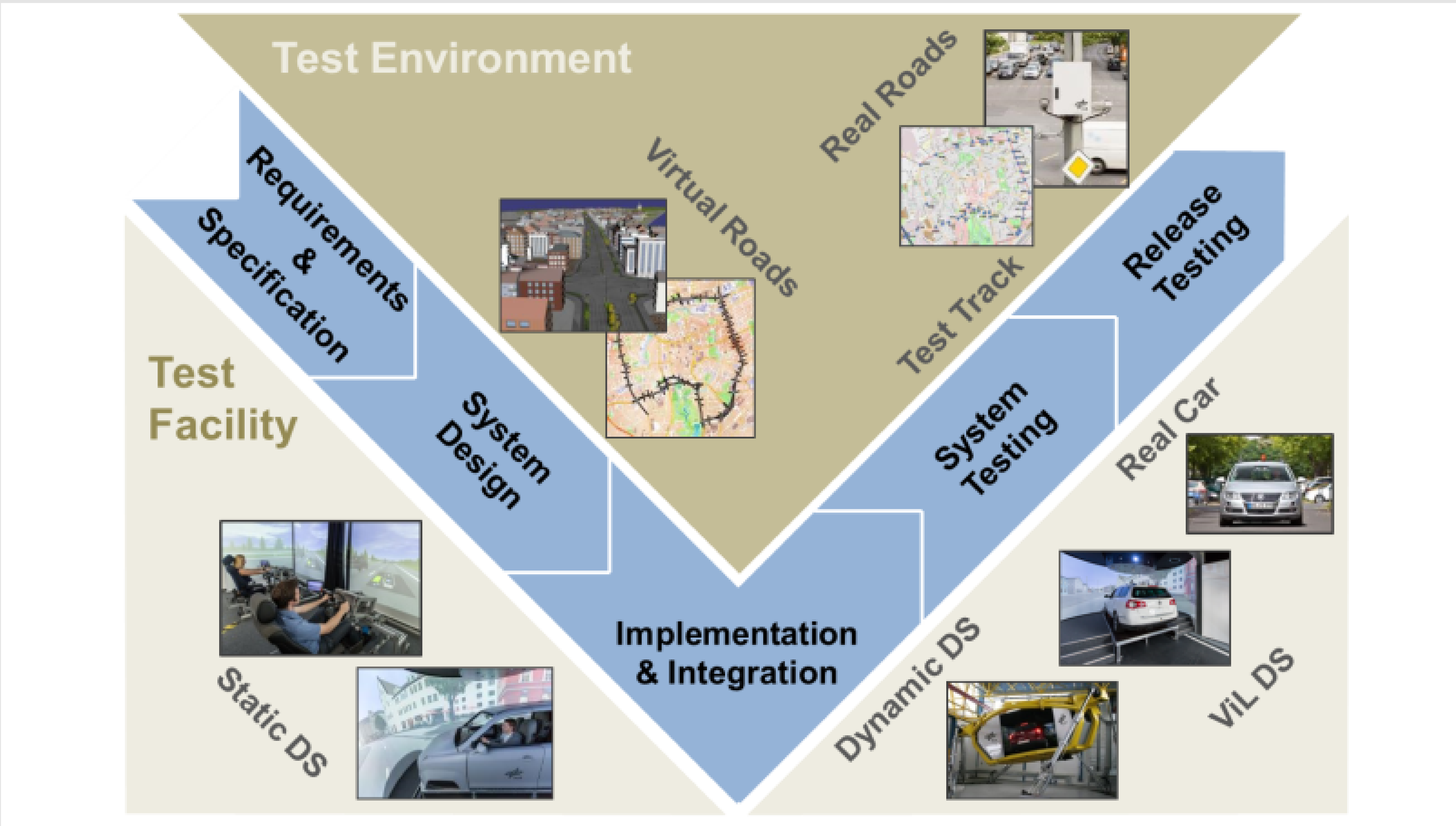

Figure 1: Test facilities and test environments for the continious support of ADAS function development and validation.

Introduction

On the path to fully automated vehicles a lot of challenges have to be faced. I. e. functional safety and reliability of complex advanced driver assistance systems (ADAS) have to be evaluated for a huge number of scenarios in order to guarantee a safe automated driving experience. Prototypic testing on test tracks and real roads alone can't solve this task within a reasonable amount of time and money. Other test facilities using virtual test environments can already strengthen the system design in early development phases utilizing virtual prototypes

Current national (e.g. Pegasus) and european projects (e.g. Enable-S3) aim for evolving validation procedures and criteria for effective test facility choices for partially (Pegasus) and highly (Enable-S3) automated driving functions.
While the gap between virtual and real life environments is permanently reduced, the step from driver-in-the-loop (DiL) driving simulator (DS) tests in the integration phase to hardware-in-the-loop (HiL) and vehicle-in-the-loop (ViL) system testing is still noticeable.

This poster presents an approach for a driving simulator set-up providing an intermediate step between classical driver-in-the-loop and hardware-in-the-loop/vehicle-in-the-loop testing.

ViL driving simulation for system testing

Classic DiL simulator studies typically implement early concepts or function-prototypes in a simulated virtual environment, e.g. a static or dynamic driving simulator. ViL simulation combines a virtual visual simulation with the kinesthetic, vestibular, and auditory feedback of a real car. Usually, a head-mounted display for presenting an augmented reality is used.

The concept of a ViL driving simulator (ViL DS) combines the classical DiL and ViL approaches by integrating a real vehicle inside a static driving simulator. This type of test environment is providing all the advantages of a fully controlled virtual environment and at the same time a high immersion is guaranteed due to the real vehicle chassis and interior design. Furthermore, the human-machine-interface can be adapted to the new functionality and does not need to be changed for later tests on real roads within the same vehicle.

Figure 2: VR-Lab with FASCar II

The ViL driving simulator test facility

At DLR Institute of Transportation system a static simulator, the virtual reality laboratory (VR-Lab) was recently renewed in order to serve all requirements of a modern driving simulator, i.e. high visualisation quality, and to add the possibility to integrate real vehicles.

VR-Lab
The VR-Lab is a static driving simulator providing a 360° field-of-view with high resolution visualisation.

Vehicle Integration
The aim is to be able to use all the institutes equipped vehicles in combination with the VR-Lab simulator platform. The FASCar II is a steer-by-wire vehicle with full access to the steering and pedal inputs. The integrated force-feedback motor can be used in order to present the correct driving torque at the steering wheel. With the new FASCarE, an electric vehicle, this option is not available. Hence, another solution has to provide an appropriate steering force-feedback.
Thus, a steering force induction system was designed.

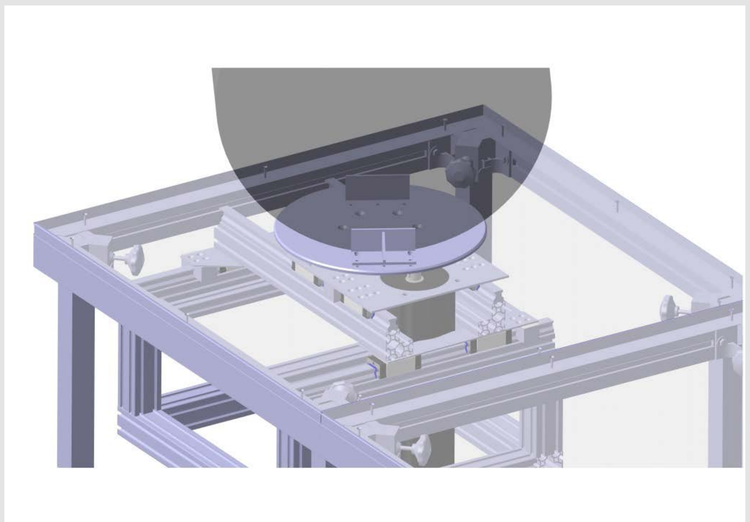

Figure 3: Steering force induction construction

Steering force induction
First of all, the wheels can't stay in a fixed position as with the steer-by-wire vehicle. Placing the front tires on rotating plates solves this issue. A motor is connected to the plate in order to provide the correct force feedback related to surface conditions and driving speeds

The force feedback is calculated based on a tire model (e.g. Dugoff-tire model), simulating the tire-road contact.