Fig. 1: Daimler Safety Truck

MiL Test Stand for the Evaluation of ADAS and HMI using SIMPACK Realtime

DAIMLER

The advanced driver assistance systems (ADAS), that are currently being introduced into high-level passenger cars and under development for commercial vehicles, are working in increasingly complex traffic situations. While most of the existing systems focus on a limited range of driving situations and use input from a single sensor (e.g., radar-based emergency braking systems or camera-based lane keeping assistance), future systems will be based on the input of several sensors and will enable driver assistance in highly complex traffic scenarios, thus, leading the way to increasingly automated driving. This development puts a big challenge on the Human Machine Interface (HMI) side. On the one hand, ADAS frees the driver from the driving task; on the other hand, the driver still takes the responsibility for potential mistakes. To keep the driver in the loop, and to inform him which mode the vehicle is driving, an intuitive HMI has to be developed and evaluated at an early stage. The Daimler commercial vehicle development recently established an interactive realtime test stand, where SIMPACK vehicle models are combined with a Prescan traffic simulation and an integration of the assistance system as HiL or SiL. This allows interactive testing of various ADAS and the corresponding HMI in a variety of traffic scenarios and with realistic vehicle behavior.

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HISTORY OF SIMPACK REALTIME APPLICATIONS IN THE DAIMLER COMMERCIAL VEHICLE DEVELOPMENT

SIMPACK has been used by the Daimler commercial vehicles CAE division for a long time as a standard MBS modeling tool for different purposes, e.g. vehicle dynamics simulation and ride comfort investigations. The realtime capabilities of SIMPACK have been used by Daimler since 2006 by transferring SIMPACK vehicle models to hardware-in-the-loop ECU test stands and by using SIMPACK vehicle models on the Daimler driving simulator (see Fig. 1 and 2 and SIMPACK News, September 2010, "Electronic Stability Program (ESP) for Trucks on the Daimler Driving Simulator").

TARGETS FOR THE NEW TEST STAND

Using SIMPACK vehicle models on the Daimler driving simulator created the idea of having a "small simulator" without movement simulation to interactively test SIMPACK models before transferring them to the driving simulator and to combine realistic vehicle dynamics simulation with a powerful traffic scenario simulation.

Furthermore, the test stand should allow interactive investigations of future driver assistance systems in an early stage of development by the advanced engineering division of Daimler Trucks. For the Daimler Trucks E/E series development, the new test stand should provide an enhancement of their already existing test stand for HMI investigations, improving the quality and flexibility of both vehicle models and traffic scenarios. Thus, it was decided to use the existing HMI test stand hardware as a basis and to modify it by integrating SIMPACK vehicle simulation and Prescan traffic simulation.

COMPONENTS/1: TEST STAND HARDWARE

The hardware of the test stand consists of an original MB Actros dashboard, connected to a representation of the vehicle CAN system. Multiple screens for front view, side view and mirror views are available for complete orientation of the driver in virtual traffic scenarios, see Fig. 3. The driver input into the SIMPACK vehicle model is generated by a steering wheel and pedals supplied by Sensodrive.
Three Windows PCs are used for the visualization and for the Prescan traffic simulation, whereas SIMPACK is running on a fourth Linux PC together with the process coordination, which is done via Concurrent Simulation Workbench.

COMPONENTS/2: TRAFFIC AND SENSOR SIMULATION BY PRESCAN

A central part of the new test stand is the MATLAB® and Simulink® based software Prescan by TASS, which allows the user to define the traffic scenarios, to integrate sensor models, to integrate the driver assistance system as software-in-the-loop (SiL) or hardware-in-the-loop (HiL) module, and to generate the visualization output. The GUI-based Prescan definition of traffic scenarios enables multiple stationary or moving traffic objects to be used and has a variety of sensor models available for the interaction between defined traffic objects. The vehicle and controller models available in Prescan may be replaced by third-party vehicle, driver and sensor models or by an external vehicle model and driver input. Figs. 4 and 5 show examples of traffic situations defined in Prescan.

COMPONENTS/3: SIMPACK REALTIME SIMULATION WITH CONCURRENT SIMULATION WORKBENCH

The basic vehicle model that was used for the first tests on the test stand was defined in SIMPACK 9.5.1 and consists of the tractor-semitrailer combination shown in Fig. 2. The SIMPACK vehicle model is running on linux realtime hardware, with process controlling done by Concurrent Simulation Workbench.

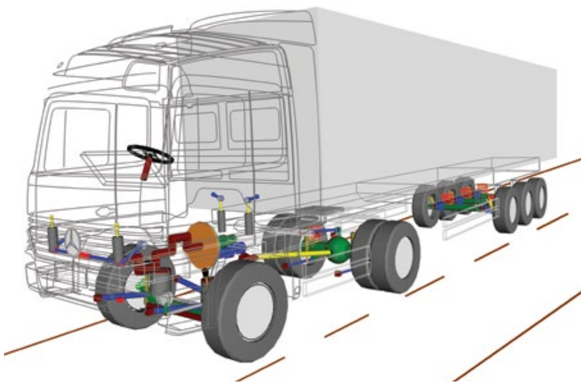

Fig. 2: SIMPACK vehicle model of MB Actros

COMPONENTS/4: ECU OF ADAS SYSTEM RUNNING AS HARDWARE-IN-THE-LOOP

The functionality of the driver assistance system may be integrated as Simulink software-in-the-loop block as well as hardware-in-the-loop integration. For the first implementation, a code of an automated emergency braking system (AEBS) was integrated by using an HiL dSPACE Autobox.

SYSTEM INTEGRATION

Fig. 6 shows a schematic of the data transfer on the test stand.
The driver activities (steering wheel, pedals) are transferred directly via a private CAN into the SIMPACK vehicle model running

Fig. 3: Screens and dashboard

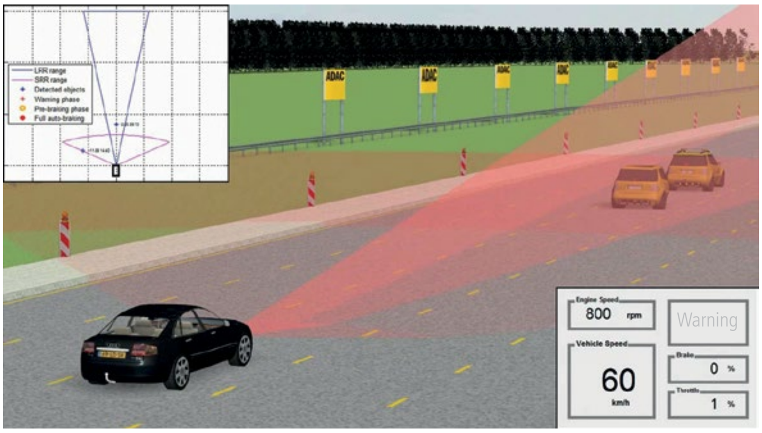

Fig. 4: PreScan sensor simulation

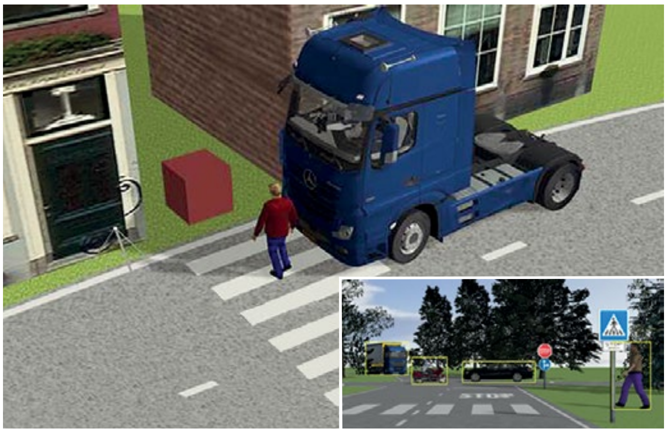

Fig. 5: Prescan traffic scenarios

within the Simulation WorkBench (SimWB) process. The variables of motion created by the vehicle simulation are transferred to the Prescan visualization process via UDP. Prescan generates the visual output and the input for the driver assistance system on the dSPACE AutoBox, which returns the desired actions of the system (e.g., a brake intervention) to the vehicle model. Furthermore, vehicle data such as vehicle speed, distance to a previous car, steering wheel angel, lane-id, etc., is provided by PreScan over a CAN Module, which allows direct recording with a usability tool.

BENEFITS AND CONCLUSION

The interactive test stand described here will serve as a development tool for driver assistance systems and HMI during different steps within the V development process. The vehicle models and traffic scenarios used are exchangeable during the development process between advanced engineering, CAE analysis and series development.

The vehicle model can be easily replaced, which means that the whole vehicle model range available on the Daimler driving simulator can also be made available on the interactive test stand.
New driver assistance systems and HMI concepts can be tested interactively in a variety of traffic scenarios at an early stage of development. The investigation of different driver assistance systems is easily possible via a flexible SiL or HiL integration method.

Final Set-Up:

- PreScan listens to body part state info from SIMPACK and generates sensor output accordingly
- PreScan redirects state info from SIMPACK (including driver input) and adds sensor info, all to be output to CAN for HMI registration purposes
- SIMPACK is linked to dSPACE using vehicle CAN
- dSPACE also receives sensor data on sensor CAN from a separate CAN bus in the PreScan machine

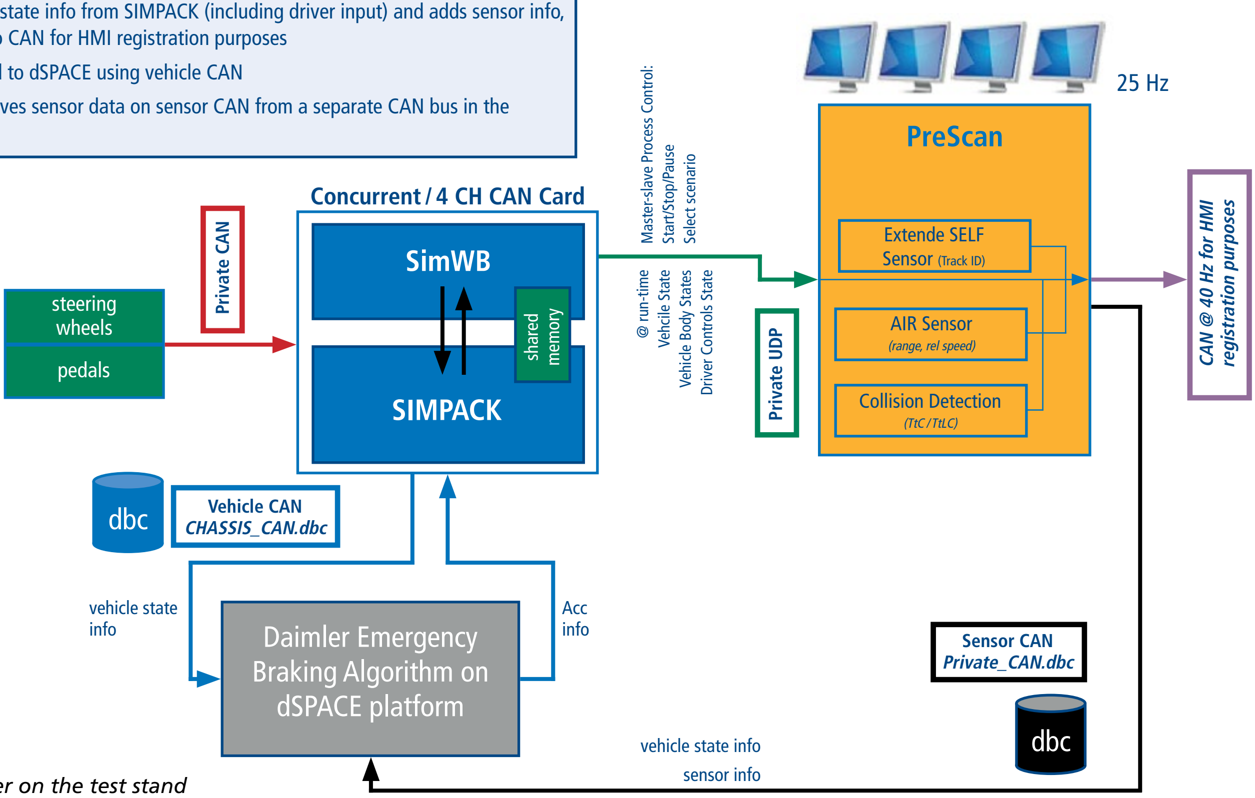

Fig. 6: Data transfer on the test stand