Verifying Air Spring Systems

- **Realistic software verification of a chassis control on the HIL simulator**
- **ASM Vehicle Dynamics Model extended by Conti air spring model**
- **High performance in load and verifications tests**

Chassis engineers are starting to resolve the conflict between comfort and driving stability in medium-class and luxury cars, even in extreme situations. The main challenges facing them as they strive to meet present-day standards are to engineer the suspension strut, and to design software-supported systems for air spring and damper control. To optimize the development times for production-level software, Continental AG is using hardware-in-the-loop (HIL) simulators and the ASM Vehicle Dynamics Simulation Package from dSPACE.

Comfort and Safety

The Competence Center Chassis Control in Continental's Chassis & Powertrain business unit designs and implements algorithms for controlling the vertical dynamics in vehicles. Working closely with customers, the company uses its years of experience in the development of software components for controlling air spring systems and electronically controlled dampers to produce modules covering tasks such as these:

- Level control system for customer-specific level requirements
- Automatic load leveling
- Speed-related level control
- Reducing car body movement by a skyhook control strategy
- Increasing drive stability by targeted damping in cornering, starting up, and braking
- Increasing damping forces by means of ESP and ABS

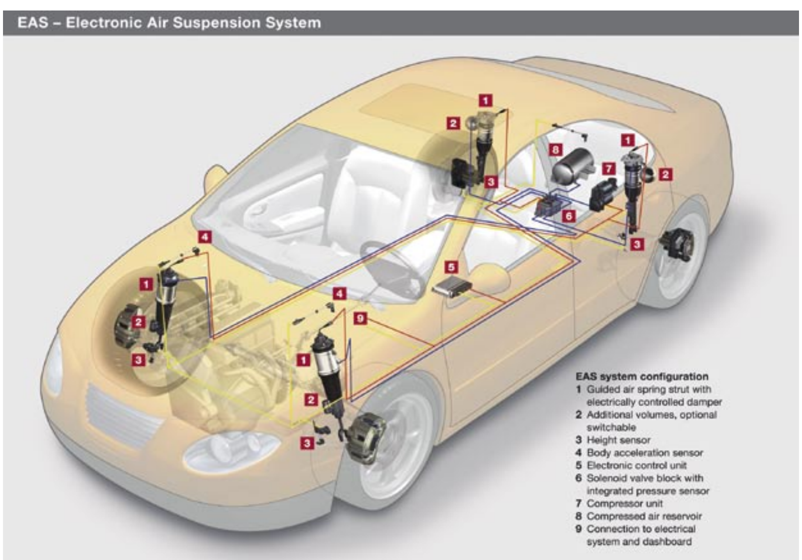


Photo: Continental AG

▲ The air suspension system with a closed-loop air supply combines comfort and safety.

Hardware-in-the-Loop Simulation of an Air Spring System

When a software module has been implemented or modified, the developer usually performs initial verification in a laboratory vehicle, to collect test results on local function behavior. Because of the complexity of the closed chassis control loop, system integration can only be tested completely by means of a modern simulator.

Flexible HIL System

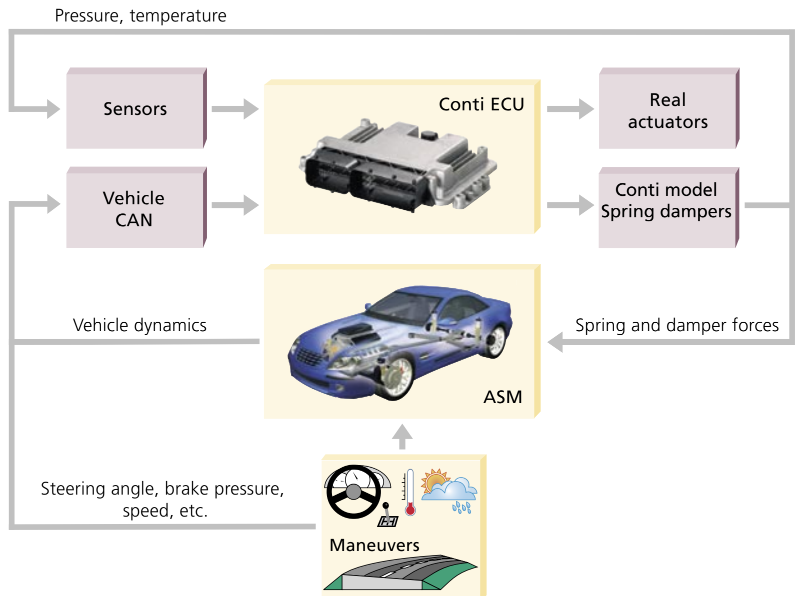
A hardware-in-the-loop simulator from dSPACE was installed in the year 2000, with the ability to simulate a complete vehicle including four wheel suspension systems (4-corner HIL). As part of further development of the chassis algorithms, and particularly because of increasing integration of a closed air supply (CAS), the HIL system was updated in close cooperation with dSPACE. The modular concept of a dSPACE HIL system allows existing hardware to continue in use for CAS after a few modifications.

> *"Close contact with dSPACE in the update phase of the HIL test bench meant the test system could go back online quickly and efficiently."*
> ***Andreas Rieckmann***

Open Simulation Models

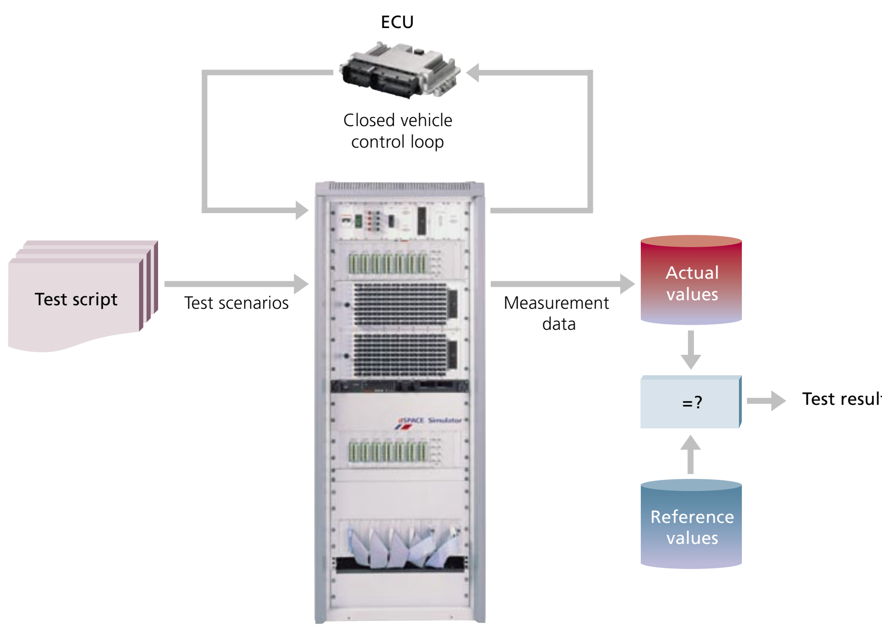
The really decisive advance that came with the HIL update was in the simulation software. In the original HIL system, the actual vehicle model was encapsulated, so the user could only modify it by suitable parameterization. In contrast, the new software contains an open real-time simulation model from the Automotive Simulation Models (ASM). It was therefore easy to integrate the self-developed Conti models for the CAS, the air springs, and the adjustable dampers into the ASM vehicle model. With the intuitive parameterization software, ModelDesk, maneuvers and road models can now be created to fit very diverse test requirements.

> *"By integrating our own models in the Vehicle Dynamics Simulation Package, the simulation environment was adapted to our requirements for a closed control loop."*
> ***Andreas Rieckmann***



▲ *Hardware-in-the-loop simulation of an air spring system.*

▼ *Script-controlled test sequence.*



High Simulator Performance for Specific Test Strategies

The HIL simulator performs two essential tasks in software verification. The first is to subject a software update to nonstop operation, in which the production ECU (Electronic Control Unit) runs through a defined test cycle for several days, before handover to the customer. The test cycle can generate special, recurrent load cases for the air spring and damper control via Python script programming. This methods simulates real-world load cases for the ECU and the software. The other task, also script-controlled, is to verify individual function modules. The expected controller output values are compared with the actual controller output values using a suitable test profile. In implementing this, we focused particularly on test automation, the main aim being to reduce the number of test loops in software verification so that the overall development time for creating a production-level ECU is shorter.

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Glossary

CAS – Closed air supply; highly compressed air is pumped back and forth between a reservoir and the air springs as required.

4-corner HIL – HIL system for fully load-bearing level controls and dampers, effective on all 4 wheels.

Skyhook – Strategy for keeping the car body as steady as possible regardless of road surface conditions, as if the vehicle was hooked up in the sky.