

# BMW – Highly Dynamic Test Benches

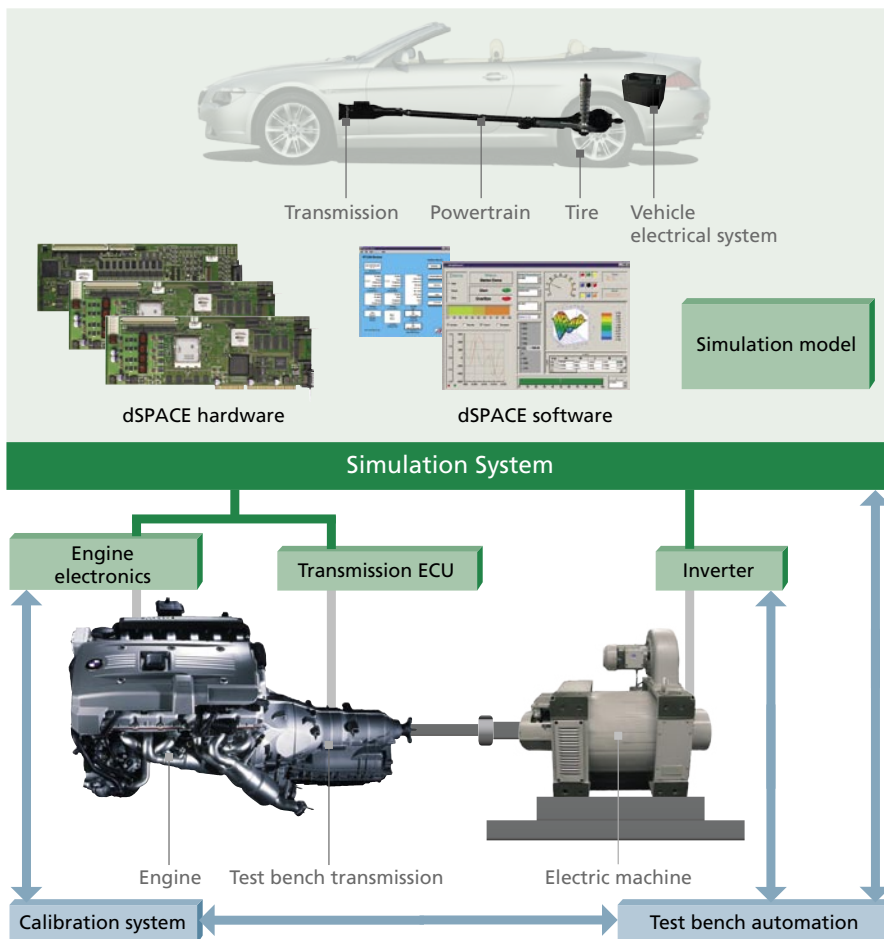
- **DS1006 Processor Boards at 3 GHz for real-time calculation**
- **The next generation of powerful test benches**
- **Flexible calibration options**

Performing calibration tasks on a real test vehicle fleet can be time-intensive and expensive. BMW is able to cut its development times and costs considerably by shifting some of its calibration work to test benches. This requires detailed simulation of real vehicle behavior – for example, in calibrating vehicle dynamics functions on an engine test bench. BMW's solution is highly dynamic engine test benches that can precisely mimic longitudinal vehicle dynamics in the relevant frequency range. The simulation systems of the test benches include powerful dSPACE real-time hardware and software.

## The Test Benches of the Future

These highly dynamic engine test benches are far more powerful than standard test benches, and by using them to simulate longitudinal vehicle dynamics, BMW is able to cut the number of test vehicles needed despite a growing volume of cali-

bration work. The only real component installed on the highly dynamic test bench is the engine, so all the other components have to be represented in detail by the simulation system. This is not possible without powerful hardware and software. BMW is using modular dSPACE systems for real-time calculation, each equipped with two DS1006 Processor Boards running at 3 GHz, DS2211 HIL I/O Boards, and others. Added to these are PROFIBUS interfaces, CAN interfaces, the Real-Time Interface, and the test and experiment software ControlDesk.



## The Test Bench at a Glance

Each of BMW's highly dynamic test benches has one real engine and a test bench transmission installed, the two being connected via a shaft with an electric machine. The simulation system, consisting of dSPACE real-time hardware and software, plus an extensive engine- and vehicle-specific simulation model, accesses the electric machine control directly. The clutch, the transmission ratios, and the efficiencies are mapped in the simulation system via a transmission model. Further model components are tire slip simulation and restbus simulation, using original vehicle data. The entire simulation system is

◀ *dSPACE real-time hardware and software are at the core of the simulation system in BMW's highly dynamic engine test bench.*

modular, so it can adapt to a wide range of calibration tasks. A simulation drive is also integrated into the test bench to represent actions such as starting and stopping the engine, driving off, constant speed; stopping, accelerating, gear shifts and



◀ Highly dynamic test benches were also used for calibration in developing the new BMW 3 Series.

coupling, and load changes. The system can handle any combination of maneuvers, and also dynamic drive cycles. Even though the model is less complex than a real vehicle because of real-time requirements, BMW achieves excellent agreement between test bench measurements and actual vehicle measurements.

**Varied Application Fields**

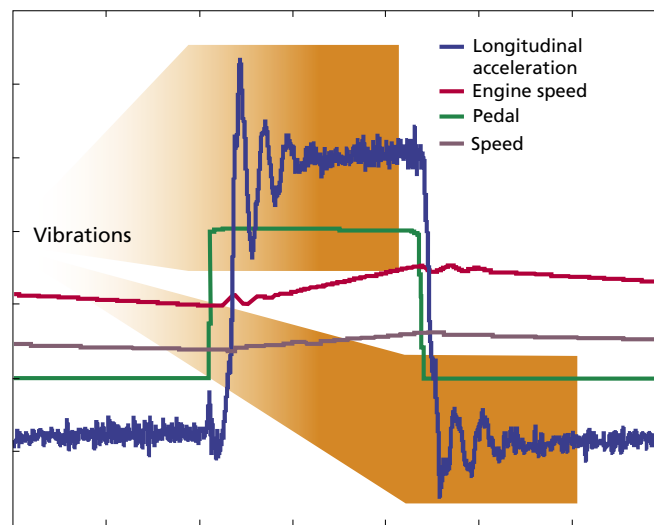
BMW's highly dynamic engine test benches have been in productive use for some time now.

- Load change functions can be calibrated by mapping longitudinal vehicle dynamics. In the vehicle, the effects on driving behavior can be felt immediately; on the test bench, the calibration engineer uses the measured data to evaluate changes in driving behavior.
- Optimized start-up functions in the engine ECU support the driver in driving off, with low or no accelerator pedal angles.
- Switching processes in the intake system on the engine are optimized so well that the driver can scarcely perceive them during constant speed or acceleration.
- BMW compares different ECU data sets to assess the quality of the calibration.

**The Way Forward**

Being able to turn standard test benches into highly dynamic test benches makes for a fast response to increased requirements. BMW now aims to introduce calibration tasks on highly dynamic engine test benches even earlier in the process. Calibration will then be possible before a real test vehicle even exists. The powerful dSPACE hardware and

Vehicle



▲ Jerks in longitudinal vehicle acceleration after load changes: The test bench helps to find the optimum settings.

software, in this case additionally equipped with LIN and FlexRay interfaces, will be at the core of the simulation system.

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Source:  
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