3/2004

dSPACE NEWS

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dSPACE NEWS
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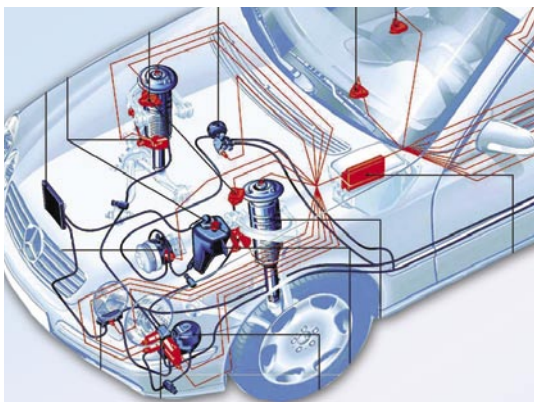


4 *DaimlerChrysler evaluates a prototype of the RapidPro signal conditioning and power stage system for Active Body Control in the Mercedes S-Class Coupé, with positive results.*

6 *The new modular RapidPro hardware from dSPACE, currently undergoing field trials, will provide flexible signal conditioning and power stages for function prototyping.*

When the AUTOSAR development partnership made its first public appearance in September 2003, no one could have predicted how important it would become, and in how short a time. There is now hardly a presentation on the subject of software in vehicle electronics that does not mention AUTOSAR. From six German founding partners (BMW, Volkswagen, DaimlerChrysler, Bosch, Siemens VDO and Continental), the initiative has grown to nine Core Partners and 30 Premium and Associate Members, and gone international.

Many companies were skeptical at first, and joined merely to avoid missing out. Some of AUTOSAR's objectives are indeed visionary, but there are also plans for usable results in the very short term.

My impression is that this project has excellent prospects of success. It has a clear structure, its promoters and supporters are very active, and management is behind it. Perhaps not all of its ideas and goals will come to fruition – for the time being at least. But even if only some of them are achieved, and the rest follow on later, the AUTOSAR standard will still be a major influence on the industry in the foreseeable future. When you see how many work packages are already being tackled intensively, how many engineers have a full-time commitment, and how many concrete results have already been produced, it is obvious that the architecture concept is already having a significant impact. dSPACE joined as a Premium Member and has committed a large number of employees to a whole series of work packages, where they proactively contribute to the results.

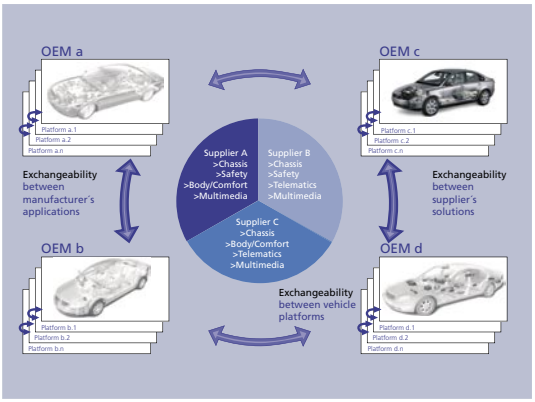
Work on the AUTOSAR standard is only one of dSPACE's commitments. We are also one of the founding members of ASAM, and have helped to shape its activities and decisions. Recently, for example, we played a major role in preparing the new ASAM-MCD 3 standard for linking calibration systems with test bench automation (see the article in the last issue). Moreover, we are also active in the Nexus 5001™ Forum and in the FlexRay Consortium.

On issues like the creation of standard interfaces and enhanced modularization of function software, dSPACE's involvement in the relevant bodies gives our customers the assurance that the latest technologies can find their way into dSPACE products fast, and that requirements that emerge from practical development work will be incorporated in future standards.

Dr. Herbert Hanselmann
President

You can read the interview with the AUTOSAR initiative's spokesman Prof. Dr. Heinecke on pages 18 and 19.

8 *Ecurie Aix, the Formula Student Team at the RWTH Aachen University in Germany, used MicroAutoBox to develop a continuously variable automatic transmission for the formula-type racing-car.*



18 *Prof. Dr. Harald Heinecke, Spokesman for the AUTOSAR development partnership, speaks about the progress made and the impact the new electric/electronic architecture standard will have.*

ABC with RapidPro

- DaimlerChrysler tested the RapidPro in a Mercedes S-Class Coupé
- RapidPro prototype and MicroAutoBox for Active Body Control (ABC)
- Thousands of test kilometers in Germany, Sweden and Spain

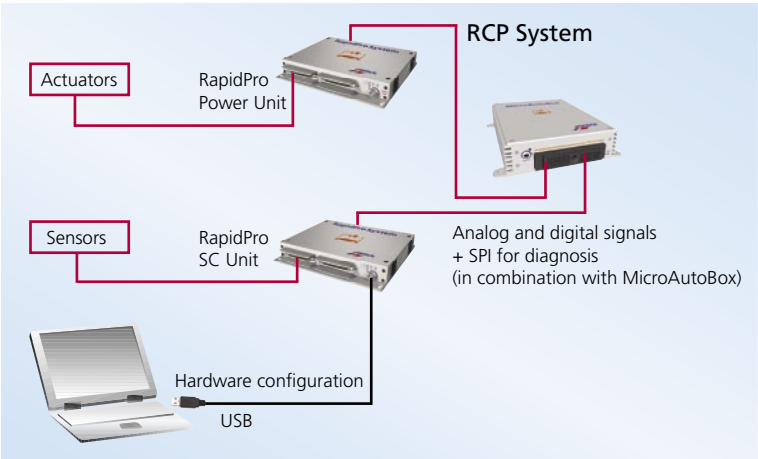
DaimlerChrysler needed a signal conditioning and power stage system for function prototyping that was both compact in size and easy to install in the vehicle, and chose the new RapidPro System from dSPACE as the candidate for evaluation. A prototype system went into action in Mercedes-Benz vehicles, where it successfully performed active body control in conjunction with MicroAutoBox. The RapidPro prototype has since clocked up several thousand test drive kilometers throughout Europe, for example, on the Nürburgring, in Spain, and in winter tests in Sweden.

Active Body Control (ABC)

Vehicle suspensions that provide both optimum vehicle dynamics and a smooth ride were long thought to be hard to achieve, as maximizing the one always meant compromising the other. Then along came electronically controlled, active suspension systems such as Active Body Control (ABC) from DaimlerChrysler, which counteract undesirable vehicle body movement around the vertical, longitudinal and transverse axes to keep the body under optimum control in all driving situations.

Building on Experience

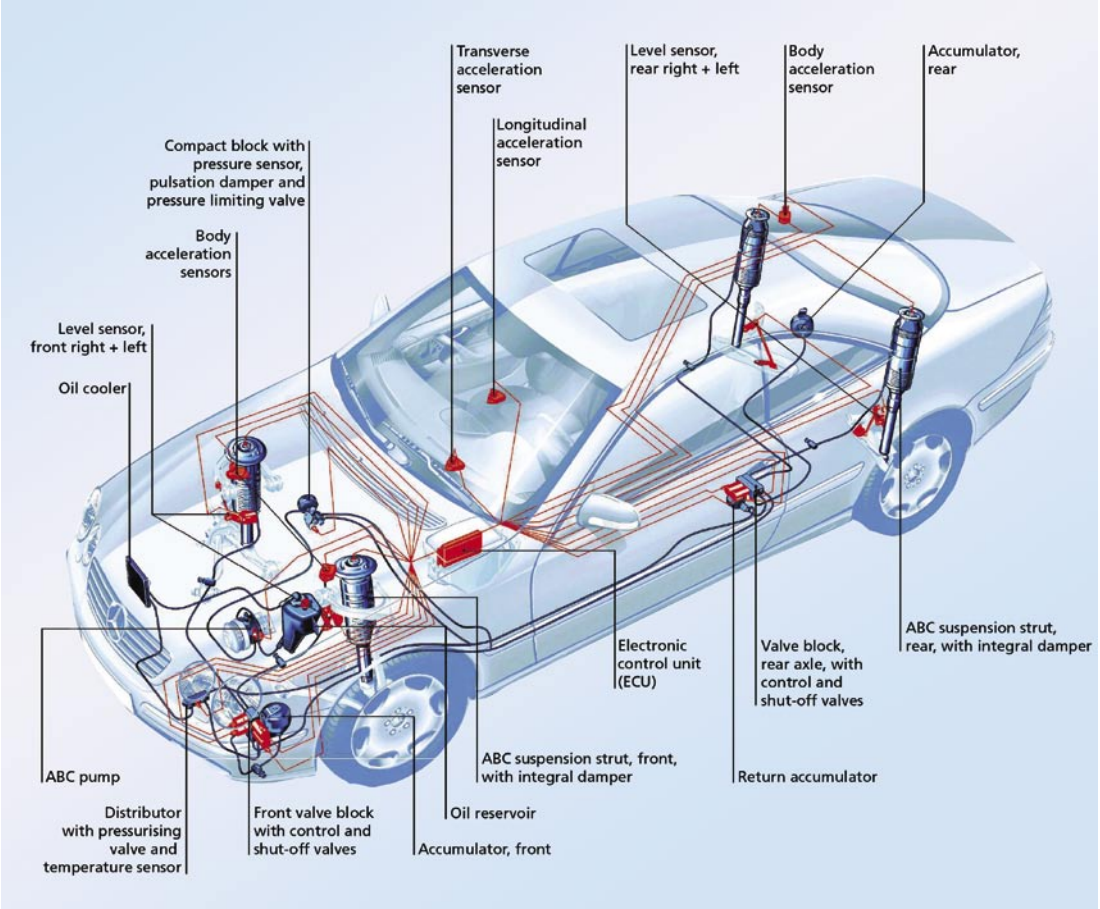
At DaimlerChrysler, we had already used dSPACE Prototyper in 1999 to bring the ABC electronic control unit up to production level for the Mercedes CL Coupé, so we knew from experience that we could rely on dSPACE technology (see dSPACE NEWS, Fall 2000). Since then, we have systematically developed the ABC functions further, again using dSPACE Prototyper and the TargetLink production code generator. One of our main development requirements was that the signal conditioning and the power stages should be quick and flexible to install and also particularly compact, to allow mobile use in different vehicles. In view of our previous experience with the dSPACE tool chain, evaluating the new RapidPro System together with dSPACE Prototyper was an obvious next step.



▲ *The sensors and actuators required for active suspension in the Mercedes S-Class Coupé were connected to the MicroAutoBox by means of prototypes of the RapidPro SC Unit (signal conditioning) and the RapidPro Power Unit (power stage).*

Lab Tests

First dSPACE engineers prepared the prototype RapidPro System, including the cabling that would be needed, according to our specifications. Several module types were installed in the RapidPro SC Unit (for signal conditioning): 10-channel analog input, 4-channel analog input, 8-channel digital input, and a 4-channel sensor supply module. Five 2-channel full-bridge power stage modules were installed in the RapidPro Power Unit. The entire system was successfully put into operation at dSPACE in Paderborn. In preparation for vehicle tests, we thoroughly tested the prototype in our laboratory in Sindelfingen, using a stimulator with all the real loads of the ABC suspension system. An existing ABC model for MicroAutoBox was used as the controller model, needing only minor modifications. The modules were easily to configure via software.



▲ *Active Body Control (ABC) from DaimlerChrysler is an electrohydraulic suspension system that counteracts undesirable vehicle movement around the vertical, longitudinal, and transverse axes.*

Mobility

Following the laboratory runs, we performed initial test drives in a Mercedes S-Class Coupé on the test track at Sindelfingen. Frequent changes of test vehicle made tough demands on the mobility of the RapidPro prototype. It fulfilled our expectations. One of the RapidPro System's main uses is in the further development and testing of the ABC chassis controller and the safety concept. The RapidPro System has been used in normal driving conditions, and also on the test tracks at Sindelfingen, Untertürkheim, the North Loop of the Nürburgring, Spain (IDIADA), and Sweden (Arjeplog). We found the RapidPro System's compactness, quick installation, and flexibility with regard to the modules it can take to be particularly useful. We are very satisfied with the prototype and looking forward to the even more optimized end product. In the meantime, the RapidPro prototype is also being used in other DaimlerChrysler development projects.

Team ABC E/E
Component and Function Design
DaimlerChrysler AG
Germany

You can find details on RapidPro on the pages 6 and 7.

◀ *The DaimlerChrysler team testing the RapidPro prototype in Spain.*

Flexible Signal Conditioning

- Signal conditioning and power drivers undergoing field trials
- Capturing and generating complex I/O signals
- RapidPro: Scalable system with large selection of modules

When performing function prototyping, you will have one major objective: to test and verify the new electronic control unit functions on the real controlled system as quickly and as efficiently as possible. Frequently, though, new sensors and actuators are used during the prototyping phase, and these require signal conditioning. Developing and implementing the necessary application- and project-specific circuits is a time-consuming and costly, and often underestimated, task. dSPACE has designed new modular hardware for this very situation: the RapidPro System, currently undergoing field trials.

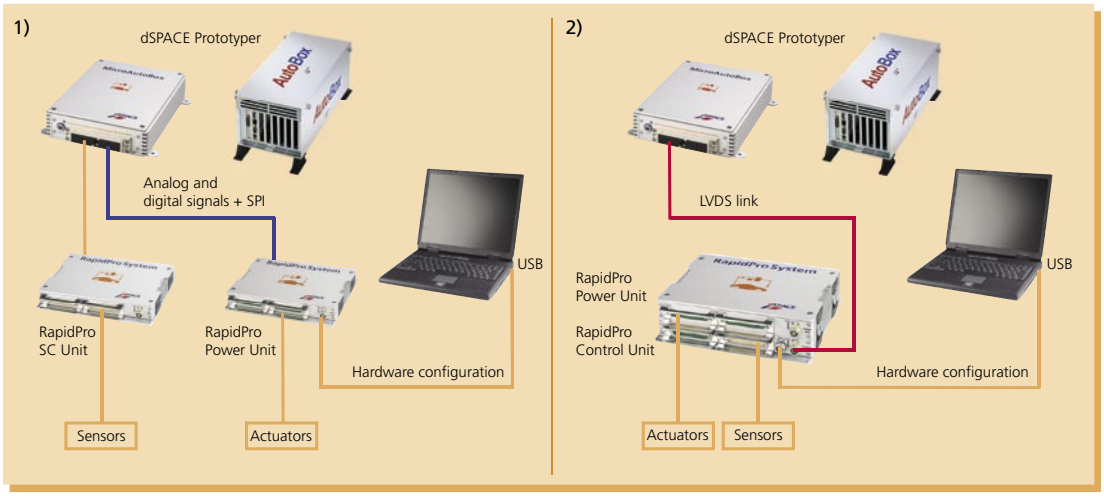
▲ *The RapidPro units – SC Unit, Power Unit and Control Unit – can be used individually and also combined to form a stack. Additional modules allow flexible adaptation to specific applications.*

RapidPro: Useful in Many Applications

Whether you are developing engine, transmission, vehicle dynamics, climate, or other applications, you have to condition the signals of most sensors and transducers before they can be acquired and processed by a rapid control prototyping (RCP) system. The necessary signal conditioning comprises functionalities such as protection circuits, amplification, attenuation, filtering, and galvanic isolation. The RapidPro SC Unit is a flexibly configurable signal conditioning unit that provides these functionalities. The unit will allow fast and efficient adjustment of widely varying sensors to the RCP system. Actuators such as drives, valves, relays and ohmic loads, on the other hand, need power drivers with sophisticated protection and failure detection mechanisms. This is where the RapidPro Power Unit comes in. With their modular design and extensive hardware and software configuration options, the units can be cost-effectively set up for a variety of applications. They can also be reused in later projects, reconfigured, and adapted to individual requirements. Their compactness and robustness makes them ideally suited for use in vehicles, in the laboratory, and on the test bench. Their advanced mechanical concept allows them to be used individually and also combined to form a stack.

Choose from Standard Modules

There will be a range of hardware- and software-configurable standard signal conditioning modules for analog and digital sensor signals. In addition, special modules (for example, for lambda probes and knock sensors) based on application-specific integrated circuits (ASICs) are in preparation for engine applications. On the power driver side, there will be a large selection of modules such as full-bridge, high-side and low-side power drivers. Customer-specific modules will also be available on request.



▲ *The RapidPro SC Units and RapidPro Power Units can be used as separate units in conjunction with an RCP system (1). The Control Unit is ideally suited for complex I/O signal processing, where it takes some of the load off the main RCP processor. There is also an internal bus (Unit Connection Bus) for connecting the Control Unit to further SC Units and Power Units to form a stack (2).*

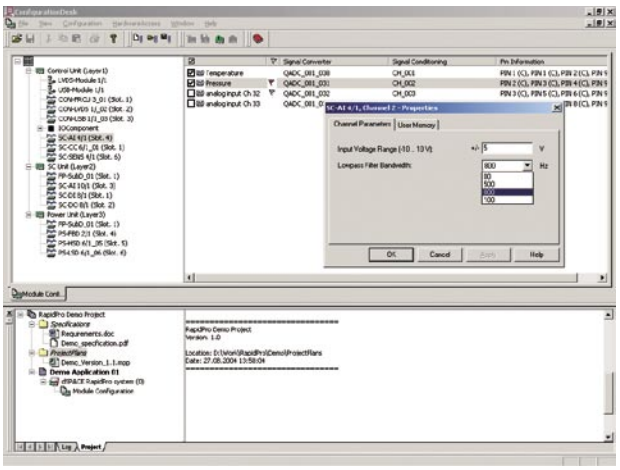
Processing Complex I/O Signals

Applications like engine management need to acquire complex I/O signals, for example, for crankshaft and camshaft positions, and generate complex signals for ignition and injection, independently of the main processor and the simulation step size of the model. Offloading specific, time-critical tasks like these to a dedicated microcontroller decisively reduces the main processor's load. The RapidPro Control Unit is the third of the trio of RapidPro units. Based on an MPC565 microcontroller, it will allow you to add extra I/O functionality to the RCP system, for example, AutoBox (with a DS1005 PPC Board) and MicroAutoBox. The Control Unit can not only have the same signal conditioning modules installed as the SC Unit, it can also be extended by additional SC and Power Units via an internal bus (Unit Connection Bus). This will make it possible to construct a compact, intelligent I/O system, including signal conditioning and power drivers.

Comprehensive Software Support

The ConfigurationDesk PC software was specially developed for hardware configuration. It enables you to set all hardware parameters quickly and intuitively and simplifies commissioning and diagnostics. In conjunction with the RapidPro Control Unit, a generic Real-Time Interface (RTI) Blockset for Simulink will also be available for modular RCP systems (with the DS1005 PPC Board) and MicroAutoBox. The blockset will provide extensive standard I/O functionalities (PWM, bit I/O, A/D) and special functionalities for engine, vehicle dynamics and drives control.

Information on the release date: *www.dspace.de/goto?releases*



▲ *The ConfigurationDesk software allows you to configure the RapidPro hardware to meet individual requirements.*

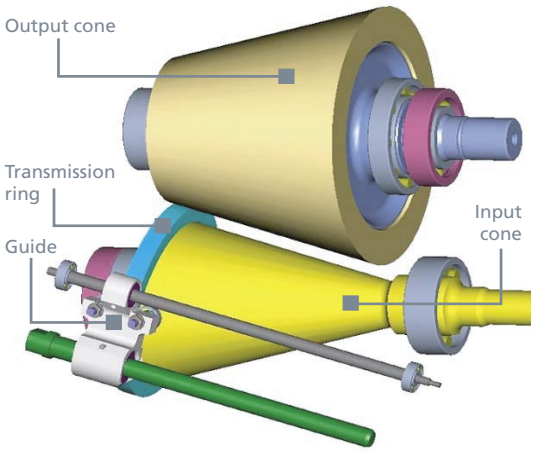
RapidPro Hardware

Continuously Variable Transmission in Formula Racing Cars

- Ecurie Aix – The Formula Student Team at the RWTH Aachen University
- A controller for a continuously variable transmission developed with MicroAutoBox
- Transmission parameters optimized by means of ControlDesk

Formula SAE and Formula Student are international design competitions for engineering students. The students design, build, and drive small formula-type racing cars according to fixed rules. The members of Ecurie Aix, the Formula Student team at the RWTH Aachen University in Germany, have given their car an innovative continuously variable transmission. They used a MicroAutoBox from dSPACE to develop the controller for it.

We, that is the Ecurie Aix team, built the EAC 02 formula racing car for the 2004 season. The vehicle has a unique continuously variable transmission (CVT). It was developed by six of our team members in cooperation with GIF mbH (Gesellschaft für Industrieforschung), a company that does industrial research in Aachen. The transmission allows an infinite number of gear ratios – so there is an infinite number of possible gear shifts. Its particularly advantage is that the optimum engine speed, the nominal speed, can be reached and held. This means that the engine always runs at its maximum performance.



▲ *An infinite number of gear shifts: With a CVT, the engine runs at its maximum performance.*

How the Transmission Works

The CVT consists of two cones with a transmission ring between them. The torque between the rotating cones is transmitted by a traction fluid. The axial position of the ring between the cones determines the transmission's gear ratio. To achieve the correct gear ratio, the ring must be deflected via a guide.

As the cones rotate, the ring in its guide runs with them, until the guide has reached the position computed by the transmission control. A servosystem is used to position the ring and lock the gear in place. We used a DC motor coupled with an incremental encoder to do this.

Unlike other CVTs, this one does not have a high power consumption, as the rotation of the cones and the oblique angle make it possible to change the gear ratio fast, applying very low forces. This means the formula-type racing car can accelerate rapidly. In addition, we also automated the clutch, to make the car easier to drive.

The History of the Formula SAE Series	
1981	Formula SAE is inaugurated as an engineering design competition for students, with the objective of building formula-type racing cars according to strict rules. The competition is run by the Formula SAE Consortium, consisting of representatives from Chrysler, General Motors, Ford, and the SAE.
1998	The first European competition, called Formula Student, is held in the UK.
2000	Formula SAE-A is set up. The first competition is held in Australia.
All three competitions take place annually.	

Rules of the Formula SAE Series (Excerpt)	
Vehicle	■ Open-cockpit, open-wheeled monoposto ■ Wheel base: at least 1525 mm ■ Complete ground clearance ■ Four-stroke piston engine not exceeding 610 cc ■ Engine can be naturally aspirated, turbo, or supercharger ■ Protection against frontal and side impact, and against rollover ■ Any transmission
Track Profile	Bend radius, straights, and chicanes defined
Cost	A maximum of $25,000 according to fixed costing rules
Judging Categories	■ Static events: Safety, engineering design, cost analysis, presentation ■ Dynamic events: Acceleration, skid-pad, autocross, fuel economy, endurance
For more information and the complete rules, see www.sae.org.	

The Team
Ecurie Aix was founded in 2000 and currently has 30 members from six different university courses.
The team competed for the first time in 2002, with the EAC 01.
Their greatest success with the car was 30th place in Formula Student 2002.
54 teams took part in this year's Formula Student (July 8-11, 2004). Ecurie Aix came 27th with the EAC 02.
For more information on Ecurie Aix, visit *www.ecurie-aix.rwth-aachen.de*

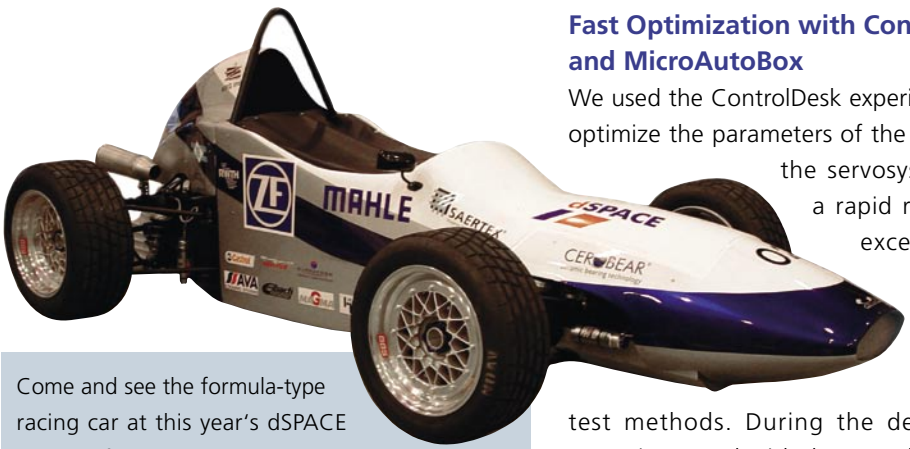
Developing the Prototype

To achieve a high degree of integration, we connected most of the electronic devices to a CAN bus. As the engine, also a prototype, was developed in parallel, the transmission has its own controller. To implement a prototype transmission of this kind, we needed a very flexible and powerful real-time system. MicroAutoBox is the ideal tool for our requirements.

Four main tasks are implemented on the transmission controller:

- Processing and preparing signals
- Implementing a servosystem
- Triggering the clutch
- Monitoring and alarm system

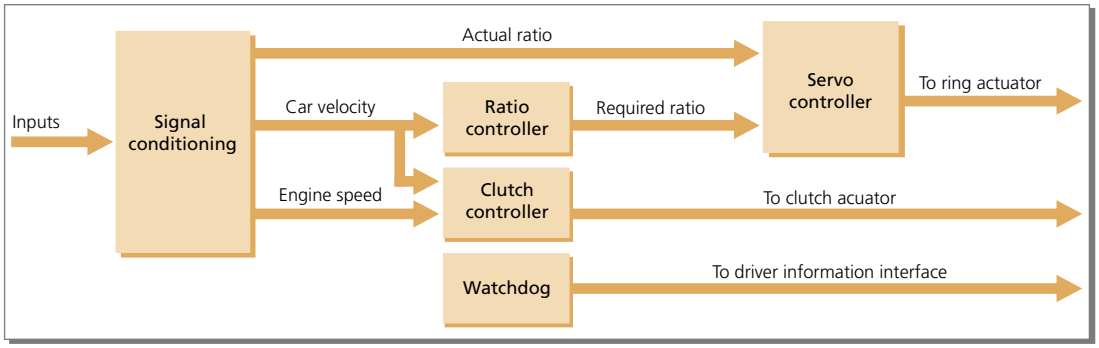
We tested various algorithms and did the fine-tuning with MicroAutoBox. The signals (including CAN, sensor, and digital signals) were processed and prepared by simple Simulink® routines and filters.



Come and see the formula-type racing car at this year's dSPACE User Conference in Stuttgart, October 21-22. Further information: *www.dspace.de/goto?uc_stuttgart*

Fast Optimization with ControlDesk and MicroAutoBox

We used the ControlDesk experiment software to optimize the parameters of the PID controller for the servosystem, to achieve a rapid response without exceeding maximum values. The settings were determined by means of simple test methods. During the development process, it was decided to replace the analog controller for engine control by a simple pulse width modulation (PWM) board to reduce both the



▲ *The transmission controller has four main tasks: processing and preparing signals, implementing a servosystem, and triggering the clutch, and as a monitoring and alarm system.*

cost and the weight. Using MicroAutoBox, we were able to carry out this change fairly effortlessly. The CVT transmission was then tested on a transmission test bench provided by GIF. MicroAutoBox's extensive I/O capabilities meant that diagnostic and monitoring routines could be implemented in conjunction with the test bench hardware. The algorithm for automating the clutch was implemented on a dynamic test bench at the ika (Institut für Kraftfahrwesen) institute of automotives in Aachen. Here too, ControlDesk enabled us to adjust the parameters with no problems. Additional monitoring routines control a variety of temperatures and transmission slip. When the values deviate from their reference values, an alarm is sent to the driver interface via the CAN bus.

Ready for the Competition

The entire powertrain of the EAC 02 is a prototype, so we needed a lot of time for extensive road tests. We used the data logging abilities of MicroAutoBox's Flight Recorder to detect errors in the model of the transmission. The resulting Simulink code was implemented on a commercially available microcontroller by means of TargetLink, the code generator from dSPACE.

Ecurie Aix Formula Student Team
RWTH Aachen
Germany

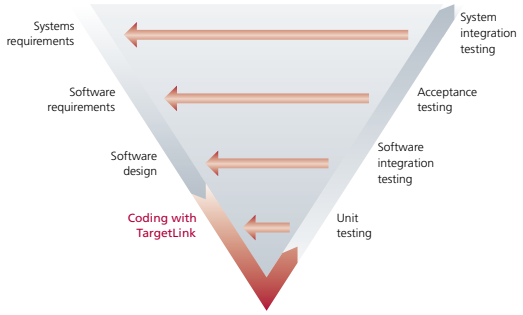
◀ *During road tests, data was captured by MicroAutoBox's Flight Recorder, and later evaluated. This allowed errors in the controller model to be found.*

TargetLink: What Developers Make of It

TargetLink has by now become a quasi-standard for successful and efficient production code generation. It is used in numerous companies from different industries and in a diversity of situations, including safety-critical applications. Below are some of the challenging applications in which TargetLink plays a major role, and the reasons the developers give for using it.

ATENA: Proven Development Process

A software development process with TargetLink support for the implementation phase has been in use at ATENA since November 2002. TargetLink is embedded in a project-specific tool chain. The tool chain ensures compliance with the quality criteria for safety-critical applications and also allows a high degree of automated implementation. It is used to develop safety-critical vehicle systems that are classified according to IEC 61508 SIL3 and whose software comprises up to 25,000 lines of code. Automatic code generation plays a very important part in all this. Using TargetLink, ATENA has succeeded in automatically generating approx. 80% of the entire production code, including hardware interfaces.



Why TargetLink?

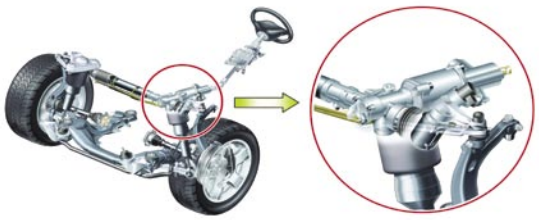
- Reliable – Compliance with quality criteria for safety-critical applications (e.g., IEC 61508 SIL3)
- Flexible – Embeddable in a project-specific tool chain through TargetLink API, allowing a high degree of automated implementation
- Consistent – Simulink®/Stateflow® models consistently converted into C code

Audi: Dynamic and Safe

Audi Dynamic Steering is a new superimposed steering system that will provide both more responsive vehicle behavior and increased safety. All the function prototyping for developing the system was done using MATLAB®/Simulink and dSPACE Prototyper.

Automatic production code generation using TargetLink plays an essential role in meeting deadlines and fulfilling the software consistency required for Audi Dynamic Steering. To optimize the time, quality, and cost factors, great importance was – and is – placed on a seamless tool chain throughout all development steps, from the initial design to production level, with MATLAB/Simulink providing the reference standard. For example, a seamless transition is guaranteed from function prototyping to automatic production code generation.

(more details in dSPACE NEWS 3/2003)

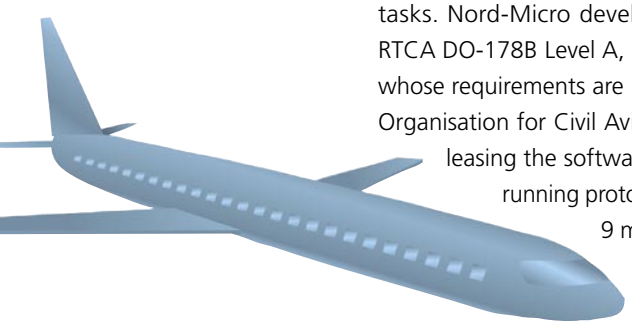


Why TargetLink?

- Consistent – Seamless integration in MATLAB/Simulink
- Efficient – Time, quality and cost factors optimized by using a seamless tool chain
- Flexible – Flawless transition from code generation for function prototyping to automatic production code generation

Nord-Micro: C Code for Cabin Pressure Control Systems

Nord-Micro develops and manufactures cabin pressure control systems (CPCS) for aircraft manufacturers worldwide. The systems include software that has to meet the highest requirements regarding safety and comfort. With TargetLink, Nord-Micro successfully generated C code for all demanding control tasks. Nord-Micro developed software according RTCA DO-178B Level A, the most demanding level, whose requirements are laid down by the European Organisation for Civil Aviation Equipment. From releasing the software requirements to the first running prototype, the team needed only 9 months in comparison to 18 months for former projects that were conducted without TargetLink.



Why TargetLink?

- Reliable – Code fulfills the tough aviation standard RTCA DO-178B Level A
- Flexible – Easy code division into useful function blocks to meet testing requirements
- Time-saving – Early function test results due to processor-in-the-loop simulation on the evaluation board and other intelligent verification features

Conti Temic: Getting There Faster

The electronics of diesel injection systems interact with electromagnetically controlled injection nozzles. This imposes tough demands on the electronics, which have to improve injection and combustion processes and considerably reduce fuel consumption and exhaust emissions. Conti Temic is developing an electronic control unit (ECU) for diesel engines that will meet these demands for use in DaimlerChrysler's commercial vehicles. Conti Temic feels that the improved quality and clarity provided by model-based software development are key factors in the endeavor to cut development times despite the growing complexity of projects. These aspects are relevant to almost all automotive electronics projects, so at Conti Automotive Systems, TargetLink has been defined as a mainstream development tool.

Why TargetLink?

- Reliable – Code reliability confirmed by consistency of MIL and SIL tests performed within TargetLink
- Consistent – Model, code, ASAP2 file, and documentation automatically kept consistent
- Efficient – Meets real-time requirements due to processor-optimized code provided by a Target Optimization Module

Honda: Electric Power Steering

A significant step in the development process of ECUs is automatic production code generation. Honda applied TargetLink to set up electric power steering (EPS), and found the generated code completely satisfied the requirements for production code. Honda verified the proper behavior of automatically generated code by performing offline fixed-point simulation (software-in-the-loop). This provided time histories of input/output data to and from the control algorithm. The behavior of the test ECU was identical to the behavior Honda obtained by fixed-point simulation – a result of the highly reliable code generated by TargetLink.

Why TargetLink?

- Reliable – Early code reliability confirmation by comparing MIL, SIL and PIL tests
- Flexible – Convenient integration of hand-written and automatically generated code
- Time-saving – Considerable improvements in development efficiency, for example, due to early offline fixed-point simulation

Nissan: First Ever Partial-Zero Emission Vehicle

Reducing vehicle emission levels has become a big issue in recent years. For example, California, USA, introduced the strict Partial-Zero Emission Vehicles (PZEV) standard. The Nissan 2000MY Sentra CA is the first car ever in series production to meet the PZEV requirements. Having chosen TargetLink for code generation, Nissan shortened the development time

down to 60% for the air/fuel controller. After the Sentra project, Nissan used TargetLink to generate production code for the air/fuel controller of Bluebird Sylphy – an "Ultra-Low Emission Vehicle". So the TargetLink-generated code is successfully running on production ECUs at Nissan, and they will continue to rely on TargetLink for further projects.

Why TargetLink?

- Efficient – Readable, reliable and efficient code
- Time-saving – Up to 60% faster compared to previous development process
- Flexible – Configurable to Nissan's development environment

Delphi: Tool Chain for Control Applications

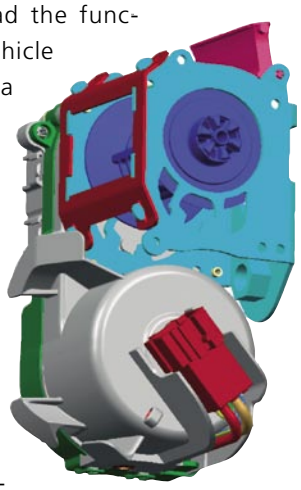
As a part of its effort to increase the quality of products and minimize its development cycle, Delphi is rapidly adopting algorithm modeling and code generation techniques. TargetLink is a major component of the tool chain that Delphi has been using in a new development environment.
Many of Delphi's control algorithms are modeled in the Simulink/Stateflow development environment. Some of these models are more Stateflow-centric. Others are more Simulink-oriented. In all cases TargetLink-generated code has the same quality as handwritten code for a similar application, and satisfies Delphi's criteria.

Why TargetLink?

- Efficient – Optimum memory (ROM, RAM, stack) usage and throughput mean projects stay within budget
- Consistent – The same type of model-to-C-code implementation is repeated
- Time-saving – It takes much less time to code a model and test the generated software

TRW: Active Control Retractor

TRW has developed a reversible belt pretensioner that gives the driver and other vehicle occupants enhanced protection compared with conventional seat belt systems. When vehicle dynamics become critical, the seat belt is pretensioned by an electric motor.
TRWs client already had the functions for evaluating vehicle dynamics in the form of a MATLAB/Simulink model. TargetLink was ideal in this situation, because it could create and integrate the vehicle dynamics software model straight from MATLAB/Simulink. Developers became familiar with TargetLink's easy-to-use development environment quickly, resulting in faster implementation and verification of the specification. Module testing was carried out completely on an evaluation board. This meant that TRW could assure the quality of the production code very early on.



Why TargetLink?

- Flexible – Easy integration of vehicle dynamics software model with existing software project
- Time-saving – Faster implementation and verification of the specification due to complete testing of fixed-point code on a PC and an evaluation board
- Efficient – Easy controlling of requirements regarding microprocessor constraints such as RAM, ROM, stack size, and computing time

Automotive News PACE AWARD Capgemini TRC

TRW received the PACE Award (Europe) for this application on March 8, 2004 (Premier Automotive Suppliers' & OEMs' Contributions to Excellence Award).

20 TargetLink application examples are currently available on the dSPACE Web site *www.dspace.com*

HIL Test Bench for BMW's Active Steering

- **Test bench solution for testing active steering systems for the BMW Group**
- **Optimizing and validating functions for networked chassis control systems**
- **dSPACE technology for test bench and test automation**

For the BMW Group, IABG has developed a complex test bench, used to optimize functions and validate concepts for active steering systems. Failure simulation and test automation were implemented by means of dSPACE technology. The hardware-in-the-loop (HIL) system test bench has proved itself an efficient tool, from the concept phase to production development, and right through to product support during start of production. Essential aspects of function validation and fail-safe testing are no longer covered by test drives, but put on the test bench instead – with additional benefits such as enhanced reproducibility, efficiency and economy.

A Big Step Towards Steer-by-Wire

The BMW Group's active steering systems in the new 5 series are a milestone along the road to x-by-wire vehicles. Active steering combines enhanced comfort with increased agility and greater safety. The active steering systems perform stabilization and steering functions, giving motorists immediate benefits.

System Test Bench and HIL Test Bench in One

Our test bench allows optimization of steering system components and validation of networked system functions in all essential partner ECUs.

▲ *The HIL test bench has proved to be an effective tool for testing active steering.*

For example, as a system test bench, it performs the following tasks:

- Capturing steering properties such as transmission characteristics and elasticity
- Optimizing component properties such as the actuating response of the drive unit
- Calibrating the electrically controlled power-steering pump

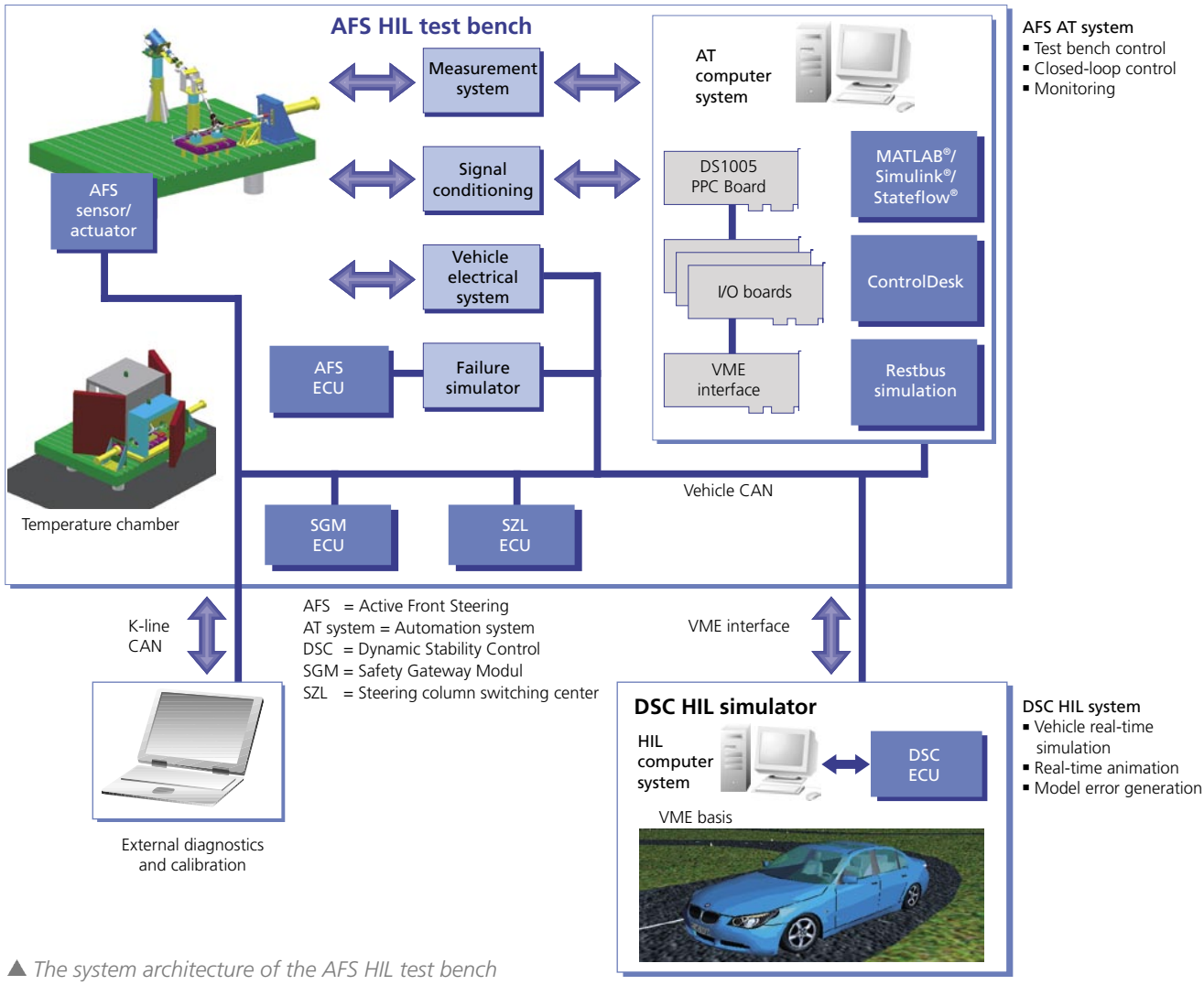
In its capacity as an HIL test bench, it performs extra tasks:

- Simulating the dynamic behavior of a virtual vehicle in real time
- Controlling the dynamic restbus simulation and the test bench actuators

For this type of simulation, an HIL simulator that has an embedded dynamic stability control (DSC) ECU is connected. The HIL simulator simulates the vehicle's dynamic behavior in real time. The computed physical vehicle variables are used for realistic control of dynamic restbus simulation and the test bench actuators.

All this means that developers can use the test bench for the following tasks:

- Analyzing active steering intervention for vehicle stability in critical vehicle dynamics situations
- Systematically testing all driving maneuvers and failure scenarios
- Mapping steering system properties and their effects on vehicle behavior
- Realistic testing, including extreme thermal conditions



▲ *The system architecture of the AFS HIL test bench has a DS1005-based automation system and a DSC HIL simulator as its central components.*

Test Bench Design and System Architecture

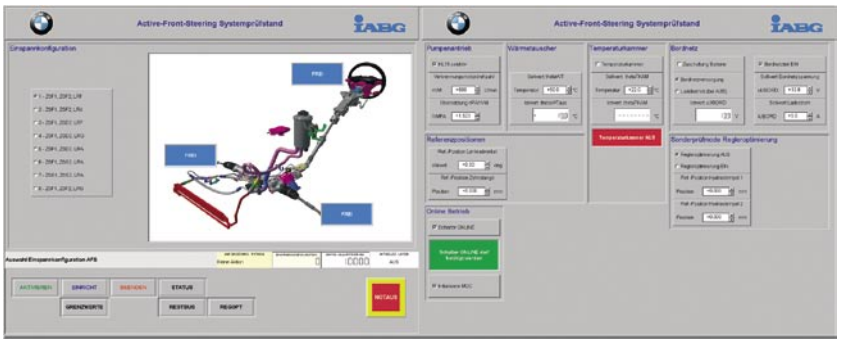
The flexible mechanics of the test bench allow a great variety of steering systems, from a MINI to a Rolls-Royce, to be mounted, in varying configurations. To simulate temperature conditions ranging from -40 °C to 150 °C in the engine compartment, there is a thermally insulated chamber mounted over the steering system. The steering system is linked to three load actuators, and the rack forces can be fed in either on one side or on both sides by a servohydraulically controlled hydropulse cylinder via coupling or drag links. Mechanical, electrical and hydraulic steering system variables are captured by high-precision sensors at more than 40 measurement points and transmitted to the automation system via private CAN connections at a maximum update rate of 1,200 Hz. The core of the automation system is a DS1005 PPC Board from dSPACE, networked with several dSPACE I/O boards. Signal conditioning boards (for example, for level adjustment, galvanic separation and relay control) form the link to the actuators and peripheral components.

The HIL simulator and the automation system communication in real time via a dSPACE VME interface at a rate of 4.6 MB/s. The automation software is based on MATLAB®/Simulink®/Stateflow® and ControlDesk, and on dSPACE's test automation software. The implemented offline functions include:

- Automatic evaluation and generation of test reports
- Accessing and calibrating ECU variables (for example, to the ASAM-MCD standard), and connection to the diagnostic channel (for example, K-Line or Softing)
- Evaluation scripts for representing measurement data graphically

These are some of the functions that have to be executed on the AT real-time system at a 1-ms clock rate:

- Sequence control for the superordinate coordination level
- Control of the hydropulse cylinder, steering machine and pump drive
- Controlling and monitoring the peripheral units
- Data capture
- Safety and monitoring functions
- Dynamic restbus simulation and communication with the HIL simulator via VME interface



▲ *The interactive user interface for controlling the test bench.*

Test Automation and Fault Scenarios

The test automation system on the test bench executes various test runs under batch control, performs the individual operating steps of the test bench in a coordinated manner, and aborts test execution if a fault occurs. The test report and test execution documentation are generated automatically according to the user's specifications.

One of the test automation system's main applications is simulating fault scenarios. For example, various driving maneuvers are studied to determine whether the redundancy monitoring system detects signal deviations or sensor faults, enters them correctly in the fault memory, and triggers the necessary follow-up processes. Faults in the wiring harness are implemented by a "fault insertion box". The DS1005 PPC Board controls the fault insertion box via a serial interface. In addition to wiring harness faults, the test bench can also reproduce signal faults, CAN bus faults, and errors in the model.

Superposition Steering

With superposition steering, the ratio of steering wheel angle to wheel angle is not fixed. A planetary gear in the suspension linkage is driven via a worm gear, allowing an additional steering angle to be superimposed. This makes it possible to implement speed-dependent steering transmission, with direct steering at low speeds and indirect steering at high speeds.

Automation Solution Based on dSPACE Hardware and Software

The dSPACE solution has a number of advantages over conventional automation solutions:

- Model-supported development of automation functions and HIL simulation
- Significant reduction of project time
- Modular, transparent program structure for automation functions via block-oriented representation under MATLAB/Simulink/Stateflow
- Efficient implementation
- Extensive support for the CAN, KWP2000, and ASAM communication interfaces
- Simulation mode for implementing new test bench functions

New HIL Test Benches: Networked Vehicle Mimics

Chassis electronic systems are fast becoming a decisive factor in the competition for automobile customers. ECUs are rapidly growing in number, and so is the diversity of vehicle variants. The volume of networking is expanding, and functions are increasingly being distributed across ECUs. The result is such complexity that only extremely sophisticated test bench functionality can cope with the testing required. To implement this functionality efficiently, and within narrow cost constraints, a powerful development environment was essential. We are currently putting another, very complex HIL test bench into operation, this time for integrated chassis control systems. All the actuators and sensors of the participating chassis control systems, including the vehicle wiring harness, are integrated into this test bench. Issues that were once investigated painstakingly in expensive experimental vehicles can now be solved in the lab.

Dr. Ahmed Abou-El-Ela,
Mechatronic Systems and Vehicle Simulation, IABG
Manfred Wachinger, Martin Krenn,
Development Steering Systems, BMW Group
Germany

A Full House in Japan

Pacifico Yokohama, the world's largest congress center, was the venue for this year's Japanese User Conference on April 21. Leading Japanese automobile manufacturers and suppliers provided comprehensive insights into their current development projects and how they use dSPACE systems.

- OEMs and suppliers from Japan show dSPACE applications
- Great interest in dSPACE solutions
- Insights into current developments

350 developers met in Yokahama to gather fresh ideas from the papers presented, plus information on dSPACE's current product developments. The attendance figures rise every year, reflecting the great interest in dSPACE solutions in this major region of Asia. The successful event was once more organized by the LinX Corporation, which represents dSPACE in Japan.

Customers' Topics

Nissan: As part of setting up the model-based development of engine management, Kenichi Kuroki and Osamu Oomori revealed the design for the future validation process for the complex electronic control units involved. They presented a study to illustrate the necessary changes and particularly stressed the advantages of AutomationDesk for their new approach, which is based on automated testing.

Mazda: Tomohiko Adachi reported on HIL simulation as a key enabler for the virtual testing of vehicle control systems and described how the systems can also be used in production. He also went into detail on the history, and the future goals, of the HIL systems with dSPACE simulators.

Toyota: Toyota has been using dSPACE simulators since 1996 and has developed a very detailed model of the controlled system. Shinichi Soejima stressed the importance of high processing power, like that provided by the DS1006 Processor Board. AutomationDesk also facilitates daily work on test systems at Toyota.

Jatco: Toshio Matsumura from this automotive supplier reported on the development of ECUs for automatic transmission in advanced development and presented a complete development process based on solutions from dSPACE. The aim is to continue unifying the individual phases of the process.

Honda: Shintaro Minowa and Hiroki Yokoyama focused on increasing efficiency and quality in the development process. The solutions they presented were coordinated development tools consisting of dSPACE HIL systems combined with TargetLink.

Nissan: The Techno division presented a paper on using hardware-in-the-loop (HIL) systems for chassis controls. Takeshi Katayama discussed the conflicting objectives of increasing the number of chassis variants and at the same time reducing developent time and ensuring quality. They concluded that only an improved development process will ensure that the objectives are met. Nissan's solution is to convert its process to front-loading development, in which system behavior is verified and validated using dSPACE simulators before vehicle testing.

dSPACE thanks its customers and partners for the outstanding commitment during this meeting.

▲ *As the packed auditorium shows, there is enormous interest in dSPACE solutions.*

Joint Initiative: AUTOSAR

Expectations of the AUTOSAR development partnership are high. After all, it has set itself no less a goal than to develop an open, standardized electrical/electronic architecture concept for the automotive industry, with some remarkable solution principles, such as the scalability and transferability of functions. We had the opportunity to talk to Prof. Heinecke, the initiative's spokesman, about the progress made so far and the effect the standard will have, both on the industry and on future functions in vehicles.

- **Cooperation on forward standardization**
- **Future of distributed development**
- **Open standard for electrical/electronic architectures in all parts of the vehicle**

▲ *Prof. Dr. Harald Heinecke works at the BMW Group's Research and Development Center. He has been spokesman for the AUTOSAR development partnership since its inauguration in July 2003.*

The number of members is increasing constantly. How important has the AUTOSAR partnership become?

Prof. Heinecke: AUTOSAR's importance is surely plain for all to see by now. It's obviously a win-win situation for the various partners in the automotive industry, and must also be viewed from the point of view of preparing for future requirements. At Premium Member level especially, the members have all taken on the responsibility for clearly defined tasks from the overall development plan. So all of our members have a decisive contribution to make to standardization. For this very reason, the number of contributing Premium Members is increasing during the initial phase of the AUTOSAR project – as work progresses, it will naturally peak and then settle at a constant level. That will be the time to enter the exploitation phase; we have designed Associate Membership for that.

> *"It's obviously a win-win situation for the various partners in the automotive industry."*

What stage has the development work reached?

Prof. Heinecke: The project plan has been defined, the software architecture decided on, and the specification work on the software infrastructure and the AUTOSAR support processes, including tool definitions, is in progress. We anticipate that essential components of the AUTOSAR standard will be specified as early as in fall this year. That will be an important milestone.

Is there a concrete roadmap?

Prof. Heinecke: Yes, that's AUTOSAR's great strength. All partners and members support the roadmap. According to the roadmap, we will be able to make the first specification available this year, after which the software infrastructure will enter the implementation phase. Our final test phase will begin at the end of 2005, so a solid standard will be available in mid-2006. Naturally, we will be able to start developments based on it from mid-2005 onward, and the industry can start preparing its procedures for AUTOSAR.

Won't joint developments and standards slow down individual innovation too much?

Prof. Heinecke: On the contrary. We will be able to make better use of development time, instead of wasting valuable time on proprietary infrastructure developments. Moreover, fixed interfaces and processes are also a sound basis for cooperative development between several partners – this will be a vital task as functions are increasingly networked. Looking towards the future, we need our forward standardization called AUTOSAR.

How do you see the contributions that dSPACE can make to this initiative?

Prof. Heinecke: dSPACE is to play an active and important part in development tools and testing issues. This will be dSPACE's contribution to quality assurance for the infrastructure and to introducing an AUTOSAR development process.

"We're preparing for the future."

Can the OEMs expect concrete cost savings from AUTOSAR?

Prof. Heinecke: We're preparing for the future. The ability to reuse software, and the standard of the infrastructure, will save costs and support the deployment of new technologies.

How will end customers be able to see that a solution is from AUTOSAR?

Prof. Heinecke: I don't like answering a question with a another question, but who are the end customers – the vehicle users? I don't think they will be able to detect any outward sign – and that indeed is the goal: Cooperate on standards – compete on implementation.

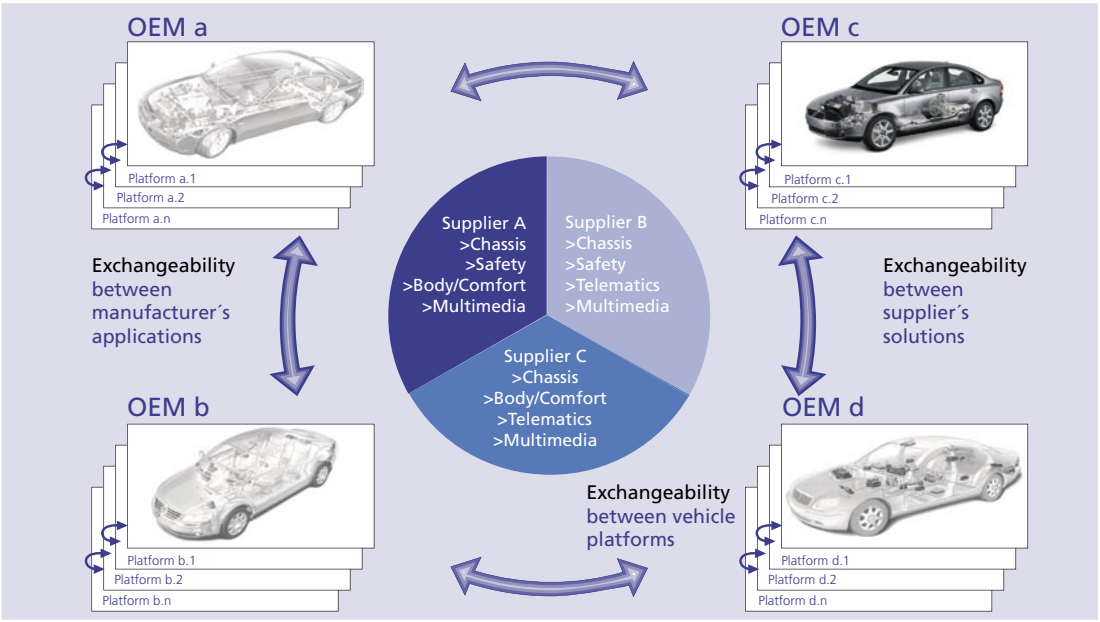
"Cooperate on standards – compete on implementation."

What effect will AUTOSAR have on processes in the automotive industry?

Prof. Heinecke: We need to make a steady transition here. AUTOSAR will lay the foundation for a future electrical/electronic development process involving cooperation between companies and good reusability of functions. The foundation will be capable of sustaining requirements and development processes now and in the future, and intercompany cooperation will continuously build on that foundation.

Prof. Heinecke, thank you for speaking to us.

The complete interview is available under *www.dspace.de/goto?autosar_interview* at our Web site. For further information, please see *www.autosar.org*



◀ *Exchangeability of functions between OEM and suppliers.*

Invest in Development! US User Conference

The 3rd biennial dSPACE User Conference, held in Plymouth, Michigan, from June 21 to 23, 2004 was a dynamic success! In attendance were over one hundred participants from over twenty-five companies, including Caterpillar, DaimlerChrysler, Delphi, Ford Motor Company, General Motors, Hitachi, IAV, John Deere, MSC, Motorola, Nissan, New Venture Gear, Ricardo, Siemens VDO, The MathWorks, TRW, Visteon and Xerox.

The conference was launched by a message from dSPACE CEO Herbert Hanselmann, who outlined the dSPACE strategy: Invest in development. As a key company indicator of our commitment to development, he stated that of 500 full-time employees, 80% work in the development departments, namely in product creation and application engineering. With product offensives within the ranges of production code generation, calibration and rapid control prototyping, dSPACE offers a complete and particularly efficient tool chain.

Users on Stage

dSPACE users gave presentations sharing their experiences and achievements using dSPACE products. The 20 impressive presentations gave insight not only into the tool chains, but also into the varied applications, challenges and processes used in the latest controller development technology.

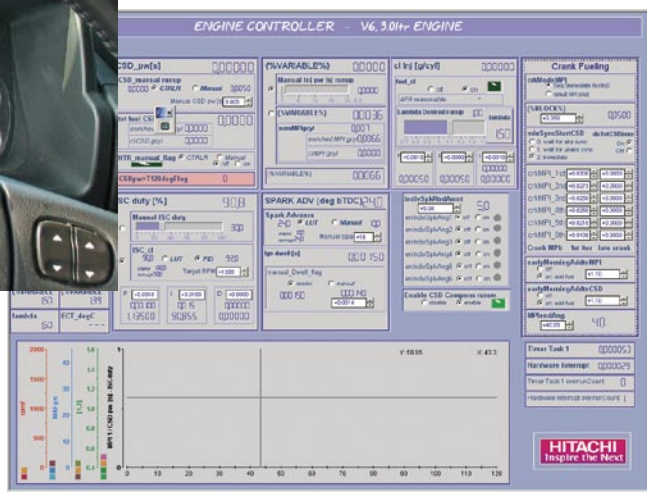
Each session – Target Code Generation, ECU Testing, and Function Prototyping – was started by presentations from dSPACE Product Managers on the latest developments in each product line. Sessions were wrapped up by an expert panel discussion and audience Q&A.

Networking

During the conference and accompanying events, attendees had various opportunities to spend time networking. The interesting mixture of dSPACE users, partners and employees, including top management, was used by many to get useful information and make valuable contacts. The dinner reception and golf course were just right for professional conversation.

◀ *The auditorium in the beautiful conference room at the St. John's Conference Center in Plymouth.*

▲ *Sessions were wrapped up by panel discussions. Here the Target Code Generation Panel Discussion with the panelists Salim Momin, FreeScale; Eric Bansbach, NVG; Lev Vitkin, DELPHI; Bill Milam, Ford Motor Company and Tom Pruett, DaimlerChrysler Jeep/Truck (not in the picture).*



ControlDesk has options for individualized settings and display (below) and can show the results in a realistic, virtual cockpit (left).

Thanks and Outlook

dSPACE thanks all those that participated, our customers and our partners. We carefully listened to the feedback received during these three days. We appreciate the opportunity to learn more about your applications and challenges to ensure that our future products and services continue to meet your controller development needs.

Key Statements from our Customers

Visteon, Syed Nabi:
HIL In Powertrain I/O Testing

Visteon anticipated that using HIL simulation for validation and testing of Powertrain Control Modules (PCM) would improve quality and also reduce development time and cost. Visteon has proven that there are significant benefits of HIL testing during the initial phase of software development by performing unit level software verification. The initial strategy in Visteon Powertrain Systems Engineering was to implement HIL for PCM software testing only. However, over time it became apparent that the same implementation could be easily tailored for the Software/Hardware Interface and Low Level I/O software validation as well.

Hitachi, Jonathan Borg and Frank Hunt: Implementation of an Emissions Reduction Device

Hitachi described the implementation of a cold start emissions reduction system. The system comprises a fuel-vaporizing device, called Combustion Stabilizing Device (CSD). The CSD enables an engine to generate significantly less emissions at engine start up without the need for a heavily loaded catalyst. The stock powertrain controller of the vehicle was kept in the loop, but the engine control functions were bypassed using the RCP controller (AutoBox). Emissions testing results show that the CSD yielded an hydrocarbon emissions reduction of approximately 50% in the first 20 s.

Motorola Automotive, Mike Bauer: Modeling and TargetLink Code Generation for Powertrain Application Software Development

Motorola challenged the production code generator to meet the following requirements:

- Tools must work within a repeatable and efficient production process.
- Tools must support interdepartmental, multi-sited development.
- Software must be efficient, high-quality, and maintainable, and correctly implement system requirements.
- Software must support company coding conventions and integration requirements.

Delphi Electronics & Safety, Peter J. Schubert, Ph.D.: Design and Implementation of a Rollover Algorithm in Production

Delphi had great success in improving the efficiency of its rollover algorithm, which is now in production. Integration was actually done in 1.5 days. RAM was reduced by 75% and maximum throughput was also reduced by 75% due to algorithm insights from using TargetLink on an evaluation board with the target microprocessor.

The presentations held during the conference are available at *www.dspace.de/goto?us-uc-2004*

New Functions Integrated in AutomationDesk

AutomationDesk is an experiment tool for intuitive handling of automated and model-based tests for electronic control units (ECUs) in every phase of the development process. In future, it will provide even more functions, for example, for:

- Connection to DTS V7 (diagnostic tool from Softing)
- Connection to the calibration tool CalDesk 1.1

Because the Diagnostic Tool Set (DTS) is integrated in the dSPACE systems, convenient ECU tests can be set up with simultaneous diagnostic access to the ECU. DTS Version 6 is already supported, Version 7 will soon be added. Users can also remote-control dSPACE's calibration software CalDesk, allowing them to perform tasks such as adjusting or measuring the ECU's internal variables while a test is running. Both these tool integrations comply with the current ASAM-MCD 3 standard.

For more detailed information, please refer to *www.dspace.de/goto?releases*

MATLAB R14 Compatibility Update

With the MATLAB® R14 Compatibility Update, dSPACE Release 4.1 can be used with MATLAB R14, which was released in June. In addition, some of MATLAB R14's new features are now available for developing Simulink® models and configuring the models for Simulink, Real-Time Workshop®, and Real-Time Interface. The new features include the Model Explorer, configuration sets, the Signal & Scope Manager, duplicate input ports and the Environment Controller block.

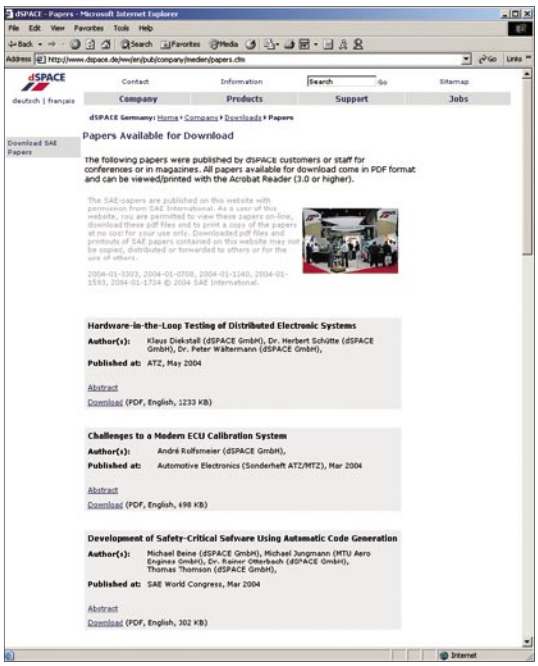
For more detailed information, please refer to *www.dspace.de/goto?releases*

dSPACE User Conference 2004 in Stuttgart

Major system users from Germany and other European countries will be revealing details of their current development work on October 21-22, 2004. The Liederhalle Cultural and Congress Center Stuttgart will once more be a meeting-place for high-caliber speakers and an expert audience to discuss wide-ranging solution approaches. Ancillary product demos and generous intervals will give further opportunity for intensive conversation. To obtain the program and other up-to-date information on the Conference, visit our Web site at *www.dspace.de/goto?uc_stuttgart*

Papers to Download

The latest papers and journal articles are all in the download section of our Web site, where they are now even easier and faster to find. The extensive pool contains papers by dSPACE customers and employees that were either published by technical journals or presented at conferences such as SAE 2004: *www.dspace.de/goto?paper_download*



Papers

J. Stroop, R. Stolpe, Dr. R. Otterbach
"Designing and Testing FlexRay Systems"

Paper download, SAE World Congress 2004:
www.dspace.de/goto?SAE_Papers

Job Opportunities

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Due to our continuous growth, dSPACE is looking for engineers in

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Events

EUROPE

MeasComp
September 28-30, Wiesbaden, Germany
Rhein-Main-Hallen, Hall 1
Booth #33/34
www.meascomp.com/index_de.html

Aachener Kolloquium
October 4-6, Aachen, Germany
Eurogress Aachen
http://www.rwth-aachen.de/ac-kolloquium/

4th dSPACE User Conference
October 21-22, Stuttgart, Germany
Cultural and Congress Center Liederhalle
www.dspace.de/goto?uc_stuttgart

SPS/IPC/Drives
November 22-24, Nuremberg, Germany
Messe Nuremberg

Safetronic
November 30 - December 1, Munich, Germany
Forum Hotel Munich
http://www.safetronic-veranstaltung.de

Training

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- TargetLink
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