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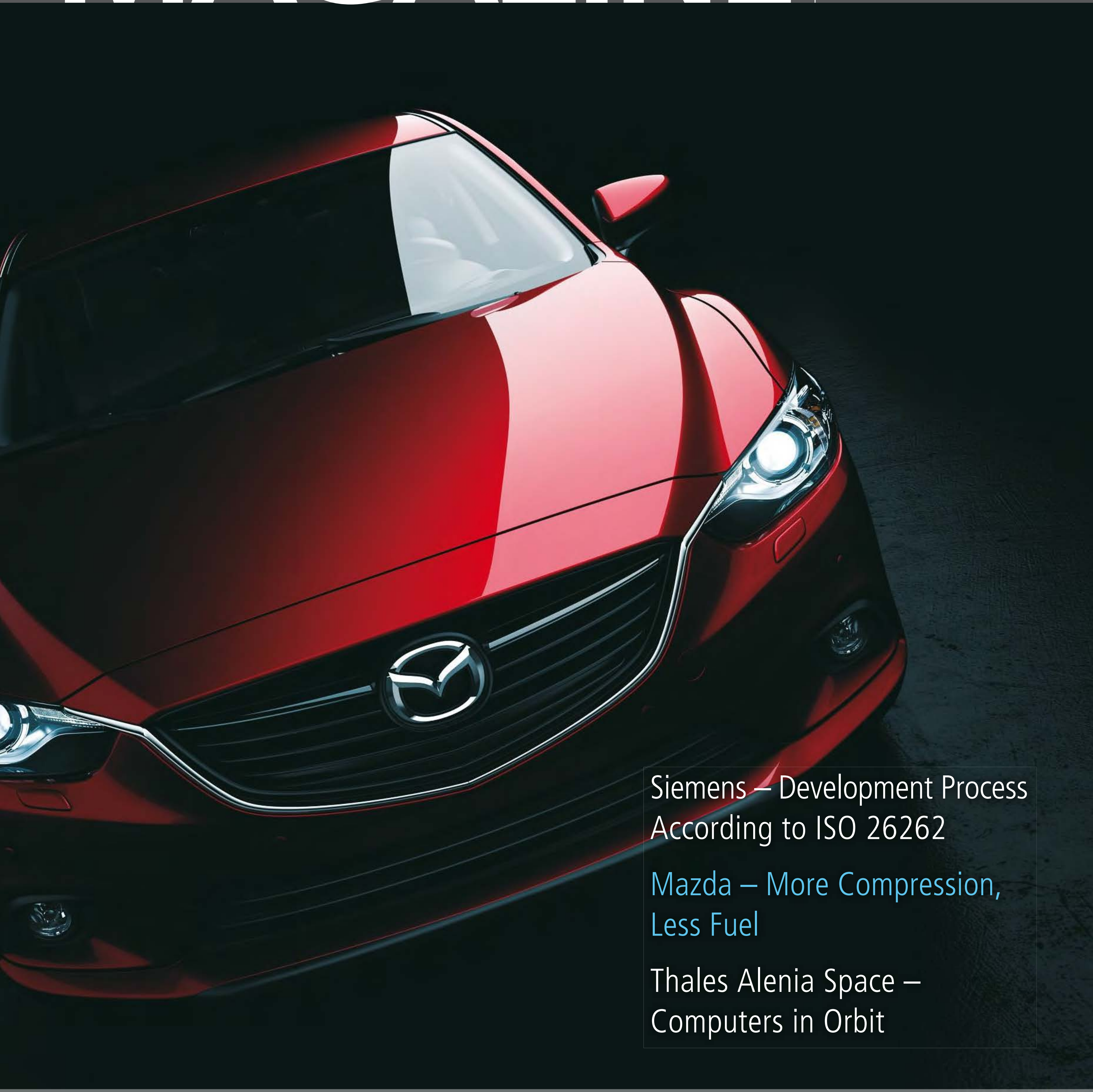

Siemens – Development Process According to ISO 26262

Mazda – More Compression, Less Fuel

Thales Alenia Space – Computers in Orbit

At the end of 2011, we announced our goal of doing something to more effectively handle the flood of data objects that arises in every part of the model-based design process. For developers to keep track of everything, all this data has to be managed and linked from the requirements to the first design, then to the simulation and parameterization, and finally to the tests. Access has to be controlled by user privileges, which requires check-ins and check-outs. There has to be a secure and reliable way for a large number of people to work together, even if they are not in the same room or even the same geographical location. To top it all, variants also need to be accurately represented and managed, not just the versions.

Some of these issues have been solved for software development, but up until now there was no comprehensive solution dedicated to model-based design as we understand it, including the left-hand side of the V-cycle.

dSPACE has been aware of this problem for a long time. Other priorities unfortunately kept us from tackling it earlier. But since 2011, we have been giving full attention to this with SYNECT, our collaboration and data management software. Because SYNECT builds on a proven platform, we are able to quickly produce one solution after another to cover different topics and problem areas. All with full knowledge of what model-based design means and of the data and semantics that have to be handled.

The first modules, for test management and variant management, were released last year. A solution for signal and parameter management followed a short while ago. Support for model management will be the next to join them. And the first public customer feedback is already coming in. Attendees at our User Conference in Stuttgart last January were shown how our customer ABB uses SYNECT Test Management to test their controls for locomotive drives. ABB manages the test plans in SYNECT, controls the test execution with AutomationDesk, collects and manages the test results in SYNECT, and generates test reports from the results. Also at the conference, Audi Electronic Ventures, a subsidiary of AUDI AG, described how they perform signal and parameter management in SYNECT, even for variants.

There is strong interest in SYNECT. So our SYNECT team is busy analyzing our customers' situations, collecting customer requirements and putting them straight into the product, and also supporting pilot projects and production projects. If data management in model-based development projects is causing you sleepless nights, you just need to ask us for help!

Dr. Herbert Hanselmann
President

Embedded Success dSPACE

IMPRINT

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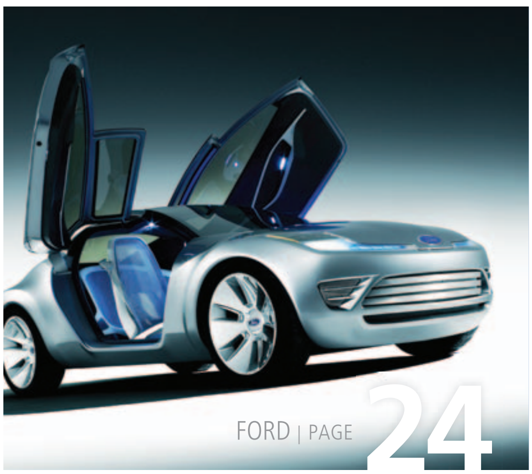

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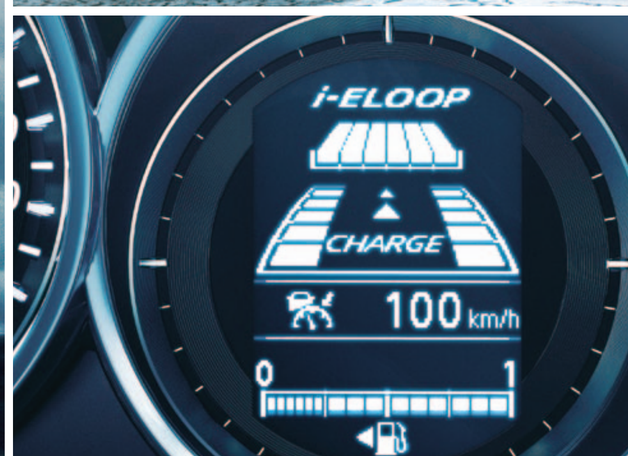
Aiming High

Mazda is pursuing two main goals for its automobiles: an enjoyable driving experience on the one hand, and outstandingly low fuel consumption and emission levels on the other. By 2015, the company plans to reduce consumption by 30 % compared with 2008. So Mazda launched the SKYACTIV program, designed to optimize all the components necessary for reaching these goals. dSPACE Simulators and the Automotive Simulation Models are playing a major role in this.

Function optimization and validation for management of gasoline engines with a compression ratio of 14:1



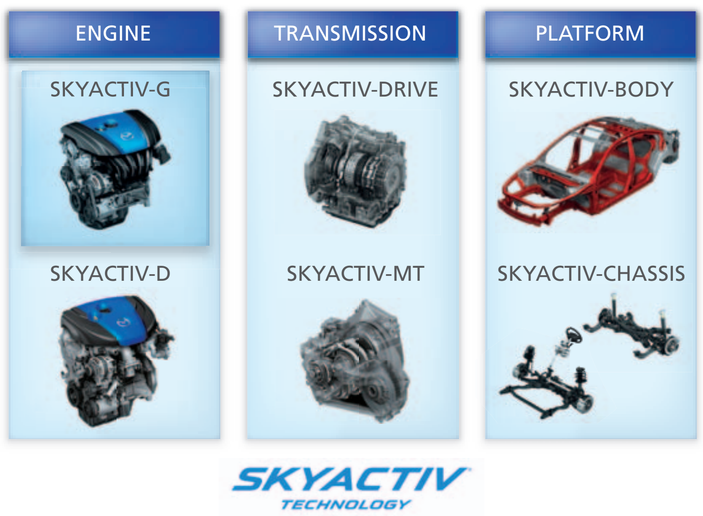
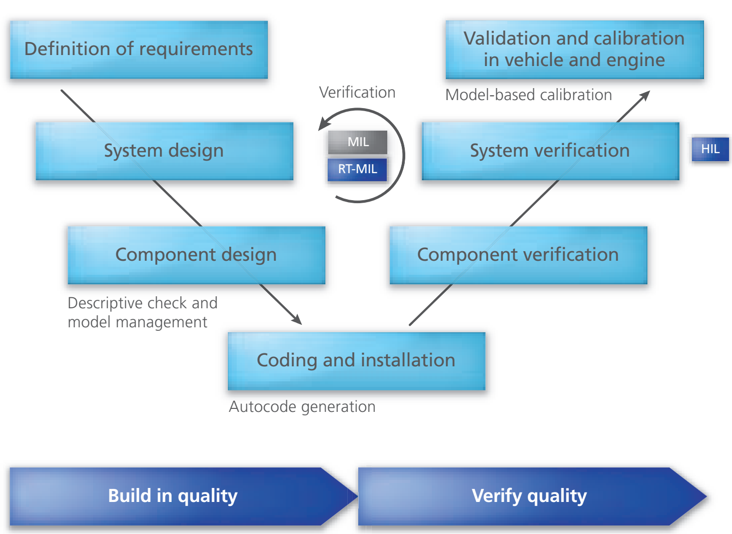


Figure 1: The MAZDA's SKYACTIV program aims at optimizing elementary vehicle components.

Visions for Combustion Engines

In conventional internal combustion engines, 70 % to 80 % of the fuel's energy is "lost" even before it reaches the wheels. Mazda is taking on this unpleasant fact and aims to make the combustion process more efficient by reaching ideal combustion at the highest possible compression ratio. By 2015, the efficiency of the Mazda fleet should be increased by 30 % compared to the levels in 2008. These goals are defined in SKYACTIV-G, a research and development program dedicated to optimizing gasoline engines (figure 1). Not only active engine improvement but also further consumption-reducing measures such i-stop (idling stop system) and i-ELOOP (capacitor-based energy regeneration system) will all contribute to increasing efficiency.

Figure 2: HIL simulation is a key component of quality assurance. MIL simulation opens new possibilities for early function verification.



Optimized Engine Management

A high compression ratio considerably improves thermal efficiency. The compression ratio of current gasoline engines is around 10:1 to 12:1. If the ratio is raised from 10:1 to 15:1, the thermal efficiency theoretically increases by about 10 %. Increased torque loss due to higher knocking is one of the reasons why this is difficult to achieve in reality. Knocking is abnormal combustion during which the air-fuel mixture ignites prematurely. It is caused by the effects of high temperatures and pressures. Improvements in combustion engines therefore require comprehensive engine management measures. To achieve the best management possible, the engine ECU software had to be completely revised and expanded to include many new functions. Improved control strategies were developed to deal with knock, ping and possible misfires. This required that the variable valve timing (VVT) system has an optimal control for the intake air and exhaust gases.

Optimizations in the Development Process

Because the complexity of the functions to be developed is increasing, the software development process also needs to meet the new development requirements. Mazda therefore decided to switch to a fully model-based development method. This involves specialized tools, appropriate processes and enormous engineering know-how. The benefits of this are evident in several areas.

Model-Based Function Development and Validation

There are established methods for

validating the quality of functions developed by model-based development. In the V-cycle, each development stage has a corresponding test phase. Proven test methods include procedures such as hardware-in-the-loop (HIL) and model-in-the-loop (MIL) simulation (figure 2). Both of these methods were used for the SKYACTIV program. dSPACE simulators equipped with Automotive Simulation Models (ASM) were also incorporated. The testing potential of simulators goes much further, though. They can also be utilized for function optimization. To implement the objectives of SKYACTIV-G, clear concepts and approaches were outlined. For the targeted compression ratio of 14:1, it was necessary to improve the cylinder charge level. The throttle valve and the position of the VVT valve are the influencing factors here. However, there are also interference factors whose effects need to be known and accounted for, such as deposits, component tolerances, and the ambient temperature and pressure (figure 3).

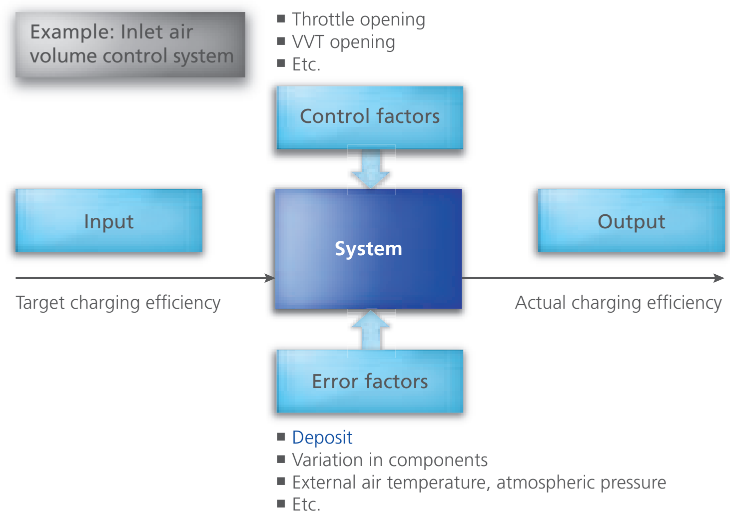


Figure 3: Values influencing the charge of a combustion engine.

Function Analysis and Optimization with HIL

As an interference factor, deposits are a prime example of how HIL simulation can be used to investigate and optimize functions. Deposits are caused by combustion residue that settles on valves and valve seats and obstructs the flow of the gases. They have the greatest impact at a low valve opening. In previous function developments without a HIL simulator, investigations were performed with real components, and just preparing the parts and vehicles was expensive enough. Ever since HIL simulators have been available for this, these investigations can be performed through simulation (figure 4). The plant model used for this simulates the mass flow

> "By using dSPACE systems right from the design phase for controller algorithms, we were able to use the same test scenarios throughout the whole development process."
>
> *Satoshi Komori, Mazda*

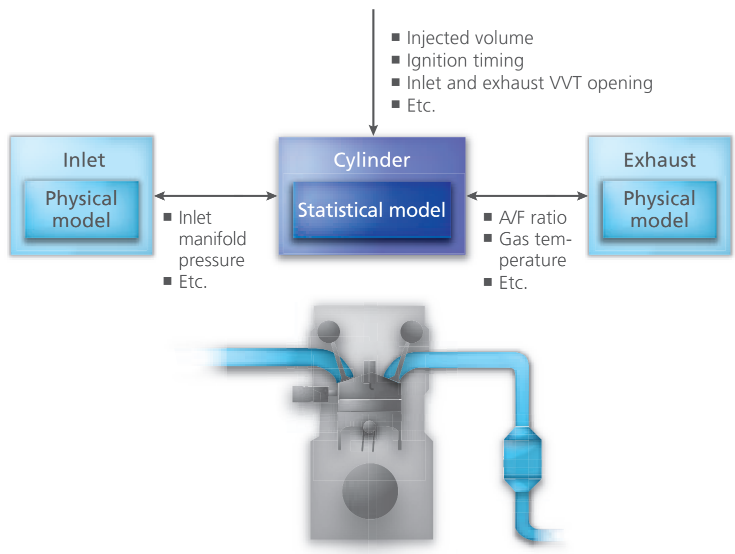


Figure 4: Combining physical and statistical models creates precise simulation models that are easy to handle.

Conclusion and Outlook

For the SKYACTIV program, Mazda relies on MIL and HIL simulation with the dSPACE Simulator and used dSPACE Automotive Simulation Models (ASM) for fast, efficient setups. The test equipment is used for function optimization and validation. Overall, Mazda was able to revise the individual components, such as the engine ECU and the complex electrics/electronics (E/E) system network, and validate them completely and comprehensively. The particular benefits of HIL testing are the automated and reproducible test runs. Initial experience has shown that early testing and test reusability have enormous potential for increasing efficiency. This method has proven its worth in vehicles like CX-5 and Mazda 6, which all benefit from superb SKYACTIVE-G gasoline engines with a compression ratio of 14:1. The testing processes and systems will be optimized and expanded for future developments. It is already clear that they are essential for the further development of E/E systems and will be given additional roles in the development process.

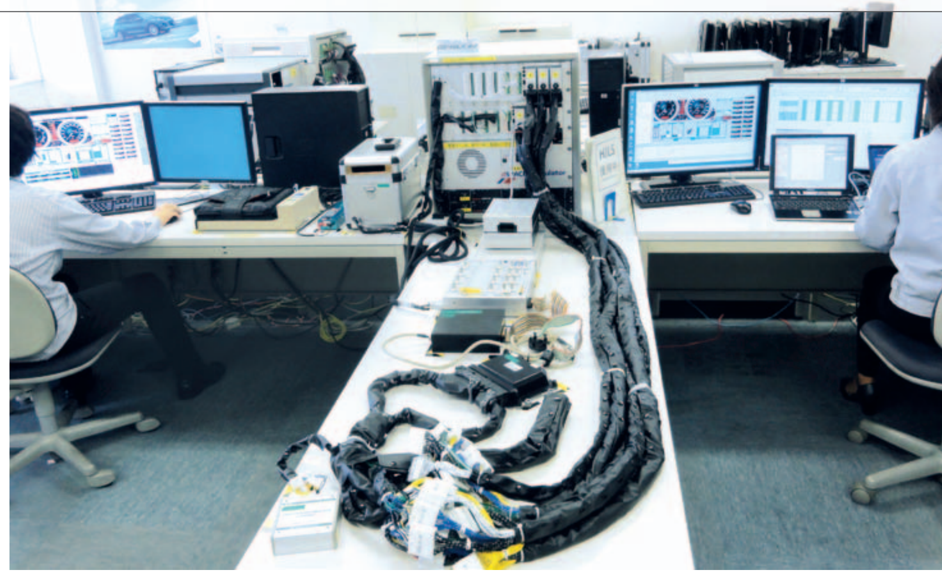


Figure 5: Test bench for the SKYACTIV-G ECUs.

through the valves and the combustion process in the cylinder with a high level of accuracy. To account for the effects of deposits, a new additional model component was implemented and integrated into the plant model. The model's open structure made this very easy. Now the various investigations can be performed and appropriate function optimizations made. If necessary, the tests can even be automated.
A comparison with the conventional approach showed that using a HIL simulator is eight times more efficient. In addition, the HIL simulator helped to recognize controller artifacts, which let the engineers eliminate potential problems. By using HIL simulation early and consistently, it was possible to reliably determine the cylinder charge for the various operating modes and optimize the overall controller strategy. Even though long-term tests were run for interference factors such as tolerances and wear, the proactive use of HIL simulation for function validation in engine control would bring savings of 2,500 hours.

Process Optimization with Real-Time MIL

A further test method demonstrates the flexibility and testing capabilities that simulation brings. The method is based on MIL simulation and was extended to include real-time MIL simulation. The plant model and the controller model both run on the

Figure 6: Stations where real-time MIL simulation is performed.

"SKYACTIV-G posed enormous challenges regarding development time. Products and services from dSPACE supported the model-based development, which enabled us to overcome the hurdles."

Keisuke Yayoi, Mazda

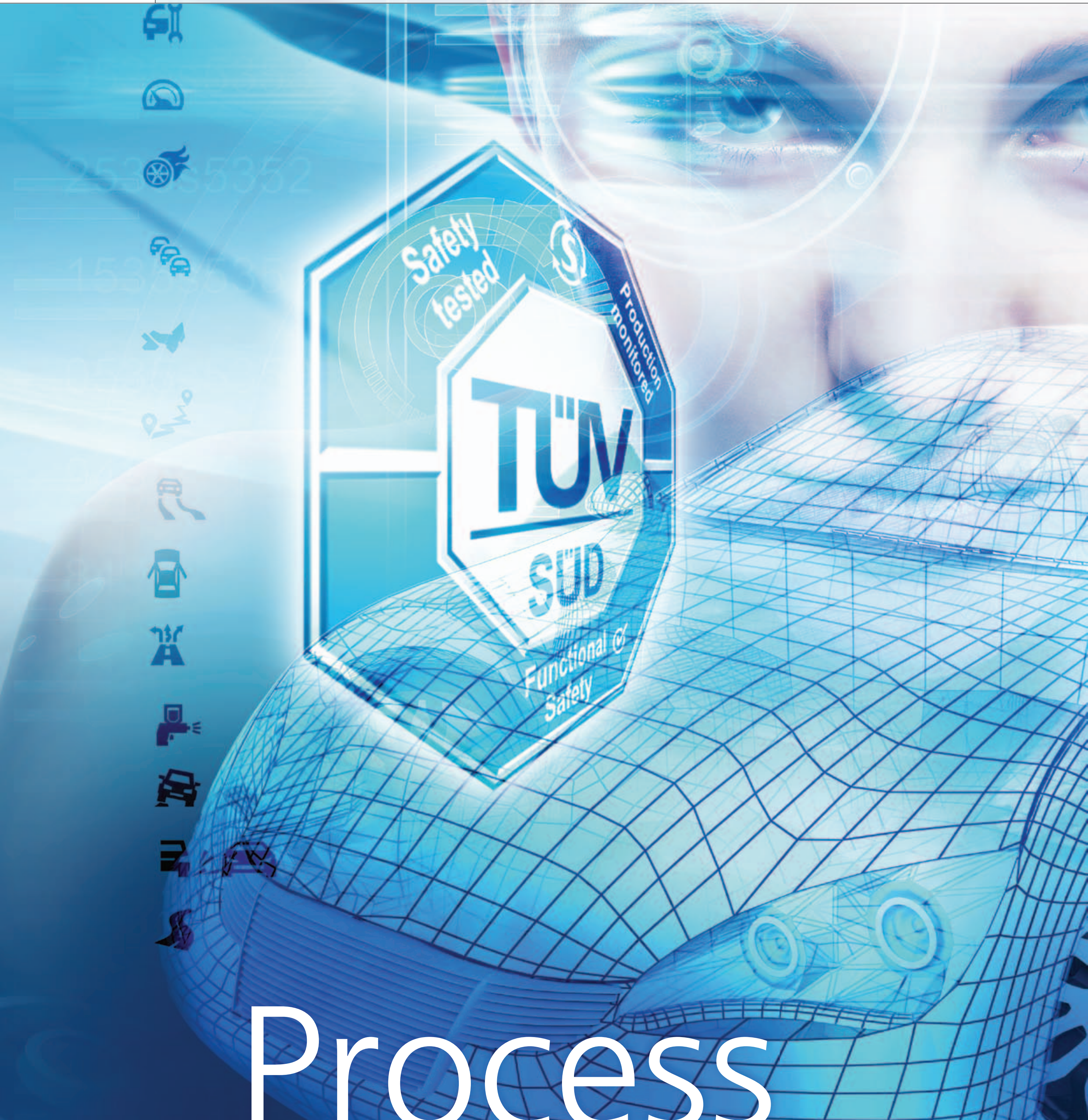
simulator, where they form a closed loop (figure 6). The real-time capability naturally depends on the processing power. In this case, the processor was a DS1006 Quad-Core Processor Board. The advantage of using common dSPACE products is that test cases can be reused between HIL and MIL. The method was used to promptly solve problems that occurred in the actual vehicle. The HIL environment, which is closer to the actual vehicle, is used to analyze the mechanism of problems and find countermeasures. Then the countermeasures are introduced to the control models, where the positive/negative effects are verified in the MIL environment. The engineers were able to carry out a series of verification processes efficiently by reusing the HIL test cases. In order to reduce problems in actual vehicles, we are currently investigating ways to utilize MIL more effectively in early stages on the left side of the development V-cycle. ■

Satoshi Komori,
Keisuke Yayoi,
Mazda

Satoshi Komori
Satoshi Komori is Assistant Manager of the Powertrain Control System Engineering Group at Mazda in Hiroshima, Japan.

Keisuke Yayoi
Keisuke Yayoi is Senior Staff of the Powertrain Control System Engineering Group at Mazda in Hiroshima, Japan.

Team at Mazda
Mazda HIL MIL team members who worked on the SKYACTIV control systems. From left to right: Yoichi Teraoka, Yasuhiro Doi, Keisuke Yayoi, Satoshi Komori, Takuro Miyoshi.



Process for Functional Safety

Model-based software development for electric drivetrains according to ISO 26262

The Siemens Drive Technologies Division has added model-based development to their classic software development process for implementing safety-critical vehicle functions. With the support of dSPACE TargetLink Strategic Partner, Model Engineering Solutions GmbH, Siemens Drive Technologies defined a process on the basis of dSPACE TargetLink that satisfies the requirements of ISO 26262 (Road Vehicles – Functional Safety).

Safety-Critical Software in a Vehicle

Many suppliers in the automotive industry are either already using model-based development for their safety-critical software, or facing the challenge of having to add model-based methods to their software development processes in the future. Model-based development brings numerous proven advantages, such as higher software quality and easier software maintenance. With the introduction of the new ISO 26262, there is now an international standard for the functional safety of in-vehicle electric/electronic systems. ISO 26262 is derived from the IEC 61508 safety standard, adapted to meet the specific conditions in a vehicle. Unlike the IEC standard, ISO 26262 explicitly applies to model-based development. This new standard clearly states *what* the development process for safety-critical, in-vehicle software must achieve to guarantee the software's functional safety with regard to the various Automotive Safety Integrity Levels (ASIL, classified in levels from A to D). However, the standard leaves the question of *how* this can be implemented largely unanswered. Practical experience shows that there is no universally accepted approach for applying the standard. Only project-specific solutions can prove successful, because they also take the company's or the department's existing processes and tool chains into consideration.

Electrical Vehicle Components from Siemens

Siemens Drive Technologies develops, produces and markets key components for e-drive vehicles. This is done from a project-based point of view, keeping in mind the specific requirements of the automotive industry customers in each project. Its portfolio covers a wide range from electric motors and power electronics to intelligent onboard charging technology (figure 1). Siemens has already established a classic development process for software functions, primarily oriented around the widespread V-cycle. This development process complies with the Automotive SPICE guidelines (aSPICE: a version of the international standard ISO/IEC 15504 'SPICE', specially adapted to automotive needs) and CMMI-Dev (Capability Maturity Model Integration for Development). Virtually all vehicle manufacturers demand compliance with these two maturity models, so compliance is absolutely essential.

Requirements for Model-Based Development of Safety-Critical Software

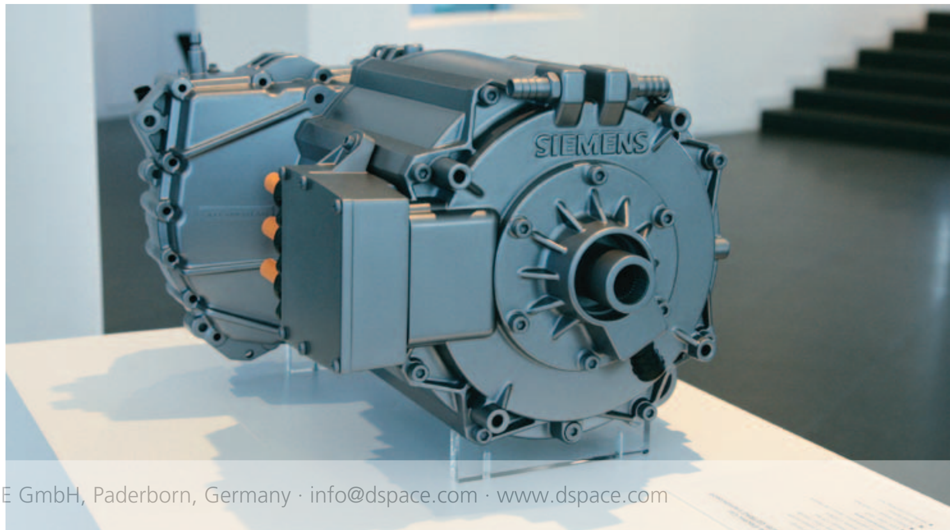
Siemens Drive Technologies wished to integrate model-based development into its existing classic development process because of the plan to develop a larger portion of safety-critical vehicle functions with the model-based methods of MATLAB®/Simulink®/Stateflow® and dSPACE TargetLink® in the future. To reach this goal, several criteria had to be met:

- Define an ISO 26262-compliant process for model-based development that integrates optimally into the existing process environment, considers the available tools and does not violate any of the required process characteristics (such as aSPICE conformity).
- Comply with all requirements from ASIL A – D, focusing on part 6 of the ISO standard (product development: software level).
- Define the procedures and design patterns for designing model architectures with Simulink and TargetLink within the context of ISO 26262.
- Ensure that all functional requirements can be traced back into the generated code (requirements traceability).
- Guarantee that it is possible to test against requirements already on model level, meaning even before the generated code is available.

Planning Project-Specific, ISO 26262-Compliant Implementation

To implement these requirements, Siemens Drive Technologies commissioned Model Engineering Solutions GmbH (MES) as a specialized partner. As a TargetLink Strategic Partner, MES offers industrial customers consulting on quality assurance for in-vehicle embedded software. MES provides dSPACE TargetLink Partner services that cover everything concerning ISO 26262-compliant development with dSPACE tools, including gap analysis (identifying strategic and

Figure 1: A permanently excited synchronous motor for automotive applications.



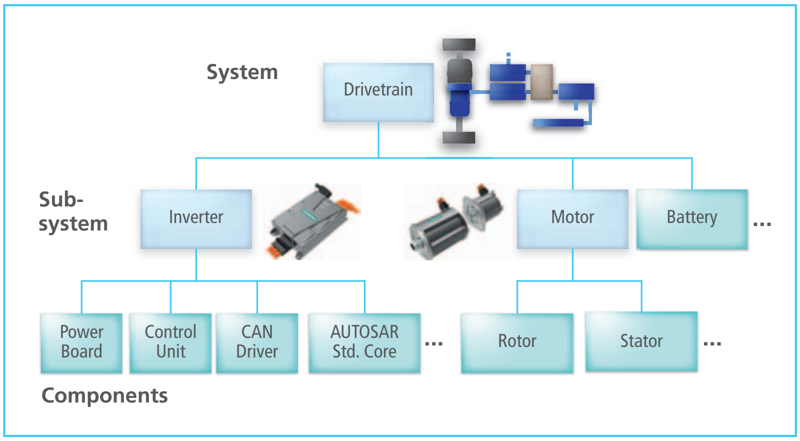


Figure 2: System partition and definition of the levels of an electrical drivetrain.

operative gaps), process modeling, process manuals and support for process implementation. Through numerous production projects, MES has acquired a comprehensive understanding of how safety-critical vehicle software is developed in Germany and how to best implement the requirements of ISO 26262, particularly in model-based software projects.

Model-Based Development Process at Siemens Drive Technologies

At Siemens Drive Technologies ISO 26262-compliant software development is performed in the field of electrified automotive drivetrains. A drivetrain is a complex system that can be subdivided into various subsystems and associated system levels (figure 2). On the subsystem level there is the inverter, which implements the electrical energy flow between the battery (direct current) and motor (alternating current), and the motor, which then converts the electric energy into mechanical energy. These subsystems consist of components themselves, such as the motor stator and the inverter's control electronics. The run-time software running on these control electronics is located on the level below the component level, called the module level. The software itself (not shown here) is divided into several software modules, each of which can be further subdivided into several software functions. In the future some of these functions will be developed with the model-based method, as described in the process presented here.

The Software Development Process

Code- and model-based software development follows the V-cycle (figure 3). At the starting point for module development there are the software module requirements such as the torque control in the electric drive. In the system development process, these requirements are created through step-by-step refinement of customer requirements up to the relevant system level (in this case, the module level). Each design phase has a corresponding test phase to validate the maturity of the functional models and software.

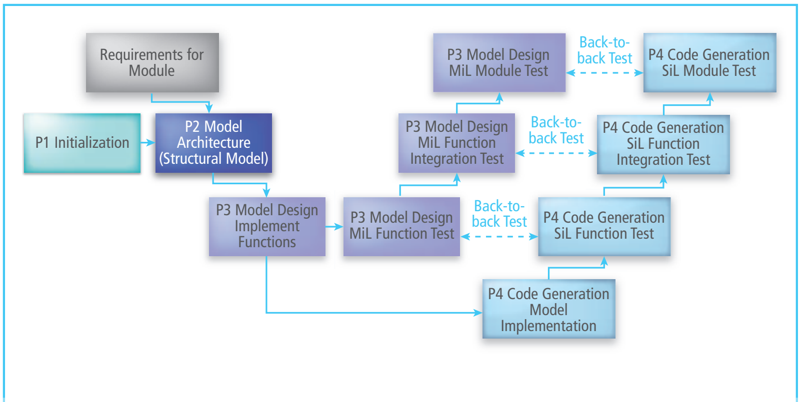
Phases of the Model-Based Development Process

The model-based, ISO 26262-compliant development process has four key phases:

Phase 1 – Initialization:
This phase covers all the preparatory activities performed before project inception, such as the kick-off meeting, setting up the development environment, specifying the requirements for the environment model, and defining and assigning roles and responsibilities. To the classic software development roles of software engineer, software architect and so on, new, additional roles for model-based software development are added, such as the model engineer who performs function modeling in Simulink. One of the requirements of the ISO standard is that this phase selects the project-relevant modeling guidelines (see ISO 26262-6, §5.4.7) that can be tested automatically with Model Examiner (MXAM).

Phase 2 – Model Architecture:
In this phase the requirements for the software module or software function to be developed are encapsulated in functionally cohesive units,

Figure 3: V-cycle for model-based software development at Siemens Drive Technologies (excerpt).



a suitable environment model is selected, and the test concept for the components is fine-tuned for model testing. The key task of this phase, though, is to have the modeler and the software architect define and implement the model architecture. The resulting model architecture, including its interfaces, is represented by the structure model, which consists of empty, interconnected Simulink subsystems. This structure model thus defines the basic framework for the software architecture, which is implemented later by TargetLink subsystems and functions. Some of the requirements the ISO standard places on the model architecture and the software architecture (see ISO 26262-6, §7.4, tab. 3) are:

- Hierarchical structure and low software component complexity
- Small-sized interfaces with low complexity
- High cohesion inside software components
- Restricted software component coupling

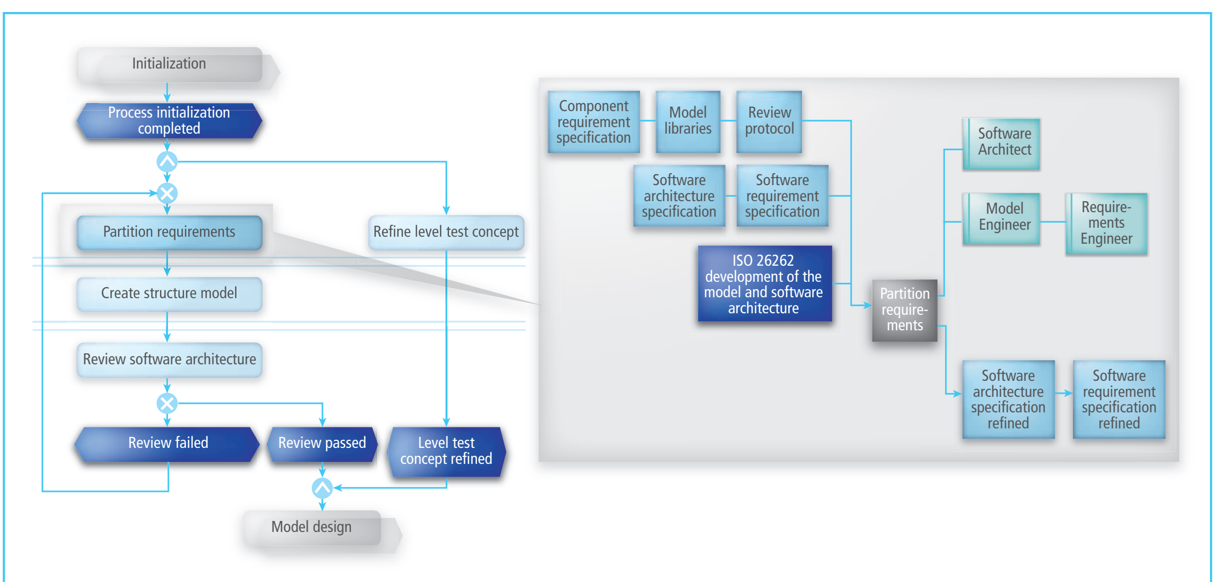
These requirements are fulfilled by various methods such as (1) using design patterns for the model architecture, (2) reviewing the architecture, and (3) using the M-XRAY for measuring and evaluating the model complexity. ISO 26262 also defines requirements for testing the software modules and functions, such as requirements-based testing, interface testing and back-to-back tests between the model and code (see ISO 26262-6, tables 10 and 13).
The test concept for the module or function is expanded in this phase as needed.

lation in double precision against the related requirements.
The advantage is that the model's compliance with the requirements can be verified at an abstract level – even before the code is available (the goal: early testing). The functional model is thus an executable specification of the functional requirements. The ISO standard especially defines the requirements for designing the software modules and functions, such as using a suitable nota-

> "An integrated tool chain made of specialized development tools is absolutely necessary for a development process to be ISO 26262-compliant."
>
> *Dr. Ingo Stürmer, MES*

Phase 3 – Model Design:
In this phase, the functional requirements for the module and the functions are modeled in greater detail in the structure model, resulting in a functional model. In addition, the module is tested in accordance with the test concept in model-in-the-loop (MIL) mode as a Simulink simu-tion. Using Simulink or TargetLink thus already fulfills the requirements for a semi-formal notation for ASIL B – D components (see ISO 26262-6, table 7).
In addition to these high-level notation requirements, the ISO standard also requires very concrete error prevention measures, such as avoid-

Figure 4: Example model of Phase 2, 'Model Architecture', with a detailed representation of the 'Partition Requirements' step.



ing implicit type conversions (see ISO 26262-6, table 8).

Phase 4 – Code Generation:
In the implementation phase, the functional model is given the information required for code generation by TargetLink (function partitioning, number representation, data types, local/global variables, etc.). Depending on the project, this phase might also have subphases. For example, if the functional model is purely a Simulink model, it must be converted into a TargetLink model first. The test results of the generated code are then compared with the results of the MIL test of the functional model as software-in-the-loop (SIL) simulation in back-to-back tests, in accordance with ISO 26262.
As soon as the generated code has been tested, the model-based software development tasks are combined with the code-based software development. This means, for example, that the test activities for the integration tests of several modules or functions once again follow the normal code verification procedure up to the system test. The test methods mentioned above (requirements-based testing, interface tests and back-to-back testing) come into play again and must meet specific integration test coverage criteria such as function coverage and call coverage (see ISO 26262-6, table 15).

Process Modeling for Model-Based Development According to ISO 26262

At Siemens Drive Technologies, development processes are modeled consistently with the tool support from ARIS. This guarantees that all the necessary process steps for the model-based development of program code are completely documented, in accordance with ISO 26262. The documentation is produced in several successive documentation stages that build on one another, as described briefly below. The development process's 'Model Architecture' phase (figure 4) can be represented concisely as an event-driven process chain (figure 4, left). A detailed representation (figure 4, right) shows which role on the basis of which document performs the process step (such as the 'Partitioning requirements' step) with regard to development results and the ISO 26262 requirements.

Process Manual for Model-Based Development

Siemens Drive Technologies provides a process manual that not only includes a graphical representation of the process steps of model-based software development but also explains the development process in detail. The manual contains all the defined process steps with detailed instructions for everyone involved. The manual also includes separate chapters on topics related to model-based development such as model-based testing, designing the model architecture, and the ISO 26262 requirements on the software process. The document structures the information for describing the different process steps in such a way that process users, and any other interested persons, can quickly get a general overview and find the information they need. The manual's chapter and subchapter structure contains five points for each process phase (figure 5). The example presented here is from the 'Model Architecture' phase:

1. Goals:
Defines the objectives to be achieved by the process phase. For the 'Model Architecture' phase this means the functional decomposition of requirements into parts that can be implemented by a hierarchy of software functions. This must also already consider the software architecture that will be defined later by the TargetLink model, to avoid time-consuming restructuring of the functional model into an implementation model.
Another objective is to fine-tune the test concept for the module (figure 4).

2. Prerequisites & Inputs:
Defines which information and work products must be available when the activities are started. To reach the objectives of the 'Model Architecture' phase, the 'component requirement specification' created during the higher-level system development process and the initial version of the 'software requirement specification' must be present, for example.

3. Activities in Detail:
Describes the process steps in detail – who has to do what, which work

Figure 5: Structure of fundamental topics and steps for each phase of the ISO 26262-compliant development process at Siemens Drive Technologies.

products are required and which are created. As already explained with Figure 4, the descriptions of the individual activities must particularly refer to the ISO 26262-relevant requirements. These relate to the software architecture, the test methods, the review process, etc.

4. Work Products:
Contains a summary of all the work products resulting from the individual process phase steps, including the ones relevant for ISO 26262 such as the test level concept and review reports.

5. Success Criteria:
Lists the criteria that must be met for the process step to be declared 'completed successfully' and the next step to begin. For the model architecture, this means that it must have been implemented in the structure model and that the structure model has been successfully integrated with the integration model, to name two examples.
A glossary of all important terms, especially ones relevant for model-based development, makes it easier to understand the manual. Each chapter is a complete section in itself and does not need to be read together with the process description. Another important section of the manual explains how and with what tools the recommended methods must be implemented for model-based development.

ISO 26262-Compliant Process and Tool Chain

External support by MES played a central role in producing a practice-relevant definition of the process and implementing the process. The project partner provided valuable external know-how on what works and what does not. The experience from various Siemens projects was also a factor that contributed to success. The process modeling phase involved experts who design the overall system development process at Siemens. It became clear that the introduced processes can already fulfill the elementary requirements for an ISO 26262-compliant procedure when they are transparent in organization and optimized for safety-critical aspects. Similarly, the software tools being used must be suitable for guaranteeing high product quality and ISO compliance.
For example, the German certification organization TÜV SÜD has already certified the production code generator TargetLink for use in safety-critical development projects up to ASIL D. This qualification is based on a process's compliance with the TargetLink reference workflow, published by dSPACE, which describes the best practices for model and code validation for TargetLink. This workflow was integrated into the Siemens development process. MES used the Model Examiner (functional safety solution) to ensure that the models complied with guidelines, and M-XRAY for model metrics and handling the model complexity. Simply using these tools already fulfilled important ISO requirements for model-based development (complete coverage of Part 6, §5.4.7, table 1). The tool chain used by Siemens proved to be suitable for bringing the process defined in the standard to life in the projects. The tool chain developed at Siemens also ensures bidirectional traceability from the requirements, to the code generator/model, and to the tests.

> "The TargetLink reference workflow, approved by TÜV SÜD, made it easier for us to set up an ISO 26262-compliant, model-based development process based on dSPACE TargetLink."
>
> *Dr. Heiko Zatocil, Siemens*

Earlier Tests, and Greatly Improved Development Process Safety

The new ISO 26262 recognizes model-based development as a high-quality approach for developing safety-critical software for vehicles. Extending the code-based process by adding model-based development brings considerable advantages because the software can be validated earlier and with the support of better methods and tools. To achieve this, the company's internal processes must be adapted to the standard's requirements. Siemens Drive Technologies has already successfully developed the first safety-critical software components in accordance with the new process model. Model-based development will play an increasingly important role next to classic development procedures and is already becoming more widespread because it follows ISO 26262-compliant process steps. ■

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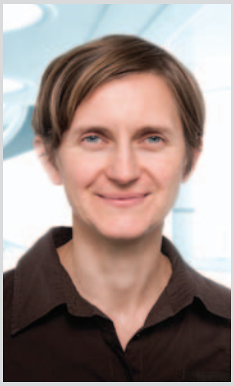
Reinhard Pfundt

Reinhard Pfundt is a software manager responsible for planning and coordinating the software for frequency converters, DC/DC converters and onboard charging devices at Siemens AG in Erlangen, Germany.



Dr. Elke Salecker

Dr. Elke Salecker is Senior Software Consultant at Model Engineering Solutions GmbH in Berlin, Germany. An expert on model-based software development in accordance with ISO 26262, she supports customers in process definition and implementation.

Dr. Ingo Stürmer

Dr. Ingo Stürmer is the founder and CEO of Model Engineering Solutions GmbH in Berlin, Germany. He is an acknowledged specialist in development processes with dSPACE TargetLink, and helps customers optimize their model-based development process and certify their company-specific tool chain in accordance with ISO 26262.

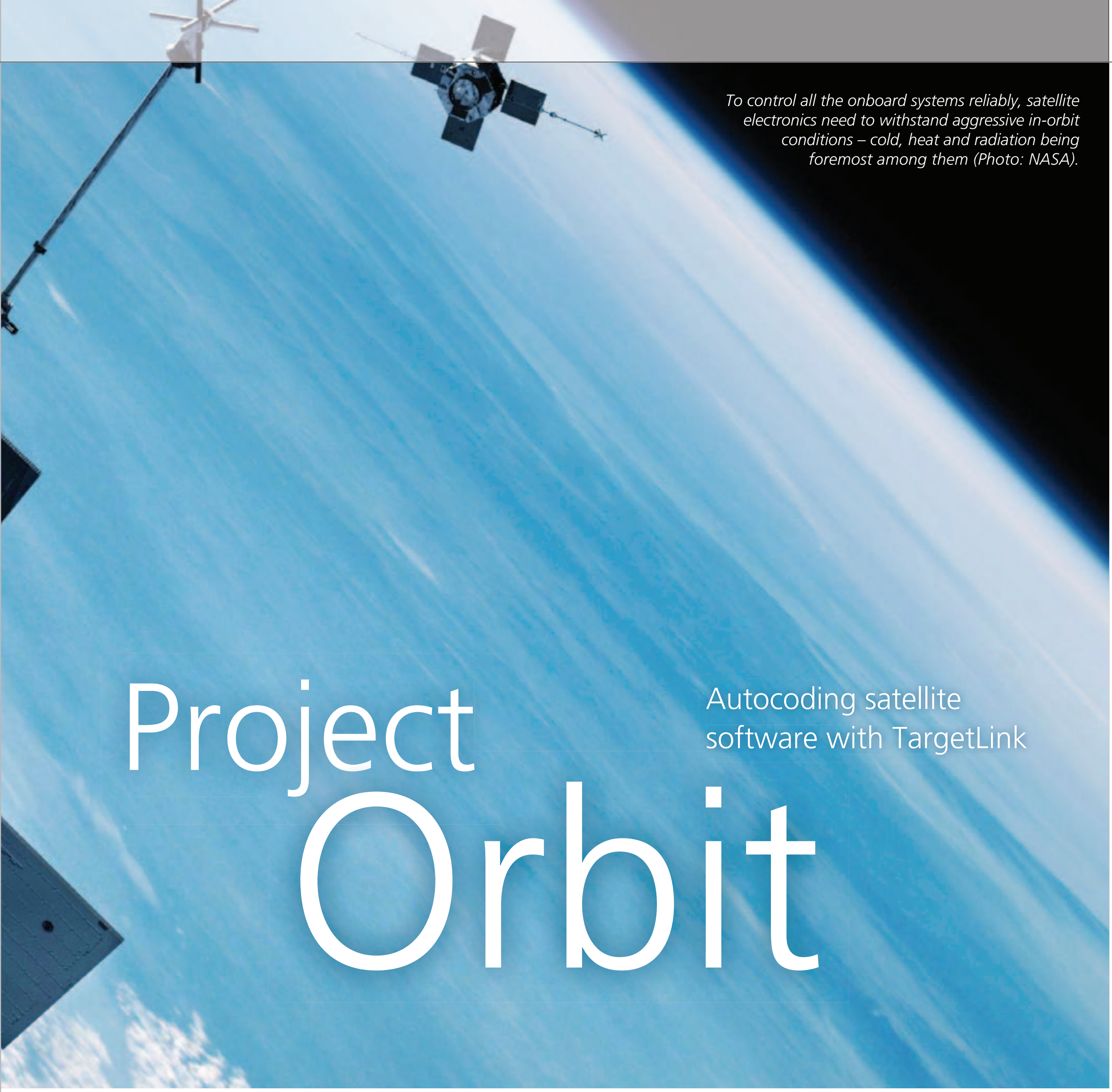
Dr. Heiko Zatocil

Dr. Heiko Zatocil is head of Function Development at Siemens AG in Erlangen, Germany, where he is playing a key role in advancing model-based software development. He initiated and coordinated the creation of the process described here.

Satellite computers have to handle a whole range of monitoring and control tasks. Thales Alenia Space have integrated dSPACE's production code generator TargetLink into the development process for their complex onboard computer software. The approach has already proved beneficial in two projects.

Earth Orbit: A Harsh Environment

Despite its emptiness, space is an extremely hostile environment for electronic components. Satellite electronics must not only endure extreme temperature differences of approx. 300 °C between the sun and the shade, but also face constant bombardment by charged solar wind particles and other cosmic radiation. Being hit by pieces of space junk is yet another danger that has been growing over the years. Satellites in low earth orbit additionally suffer friction from atmospheric particles, even at an altitude of 200 km, and this slows them down. All these influences demand the meticulous monitoring and



To control all the onboard systems reliably, satellite electronics need to withstand aggressive in-orbit conditions – cold, heat and radiation being foremost among them (Photo: NASA).

Project Orbit

Autocoding satellite software with TargetLink

control of all onboard systems. The attitude orbit control system (AOCS) plays a central role, ensuring that the satellite stays on orbit and pointing it in the right direction.

Tough Conditions for Satellite Software

The aggressive outer space environment is a tough challenge to the reliability of satellite software, and developing and maintaining it are hard tasks.

- Onboard computers have low performance compared with other modern computers. This is because the hardware has to be 'radiation-hard', a property found only in less densely packed microchips, whose performance is correspondingly weak. CPUs with a low clock rate (20 MHz) and only little memory (4 MB RAM) are typical.
- Because the satellite is not physically accessible in space, it has to be remote-maintained (patches are transmitted by radio).
- The software has to manage numerous different onboard interfaces, and also maintain the link to the ground station. This complex data flow necessitates a finely coordinated architecture.

Good Reasons for Autocoding

At the start of the millennium, the drawbacks of the traditional hand-

> "The evaluation of several code generators showed that TargetLink from dSPACE is the best match for our requirements."
>
> *Arnaud Dupuy, Thales Alenia Space*

About Thales Alenia Space

Thales Alenia Space is a joint venture between Thales and Finmeccanica that in its current form was created in 2007. The company specializes in developing satellites for telecommunications, navigation and observation. A total of 7,500 employees work for Thales Alenia Space in France, Italy, Spain, Belgium and Germany. The company headquarters are in Cannes, France.

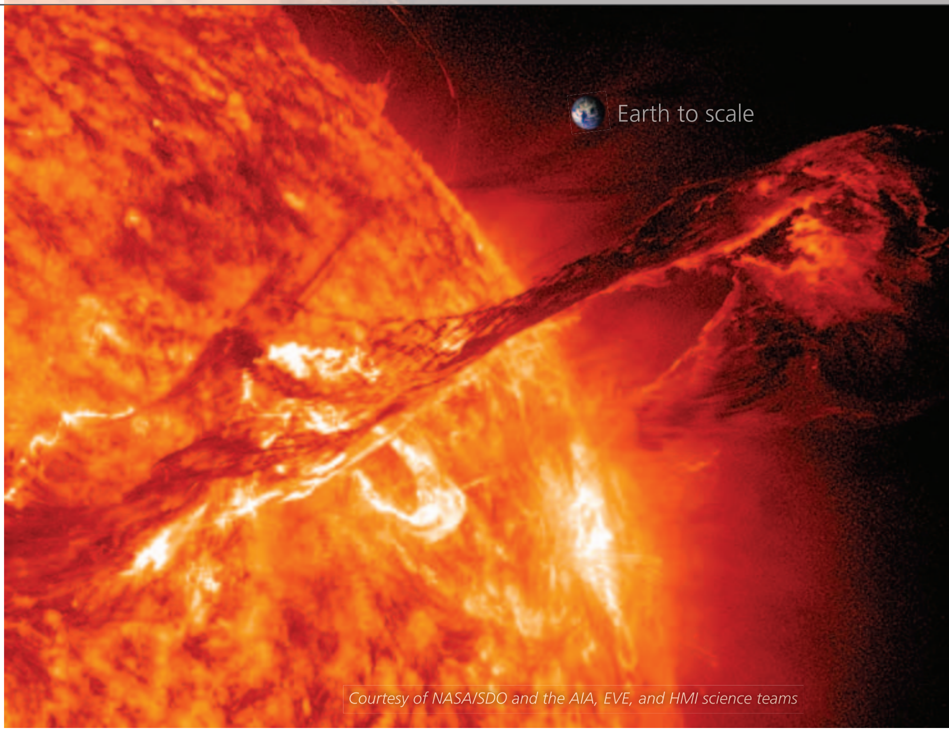


Figure 1: One cause of disruption in satellite electronics is solar flares that hurl charged particles as far as the Earth (the photo shows a large flare that occurred on August 31, 2012).

coding of satellite software were becoming obvious (it was difficult to retrieve information from earlier projects, to perform software maintenance, and so on). Thales Alenia Space therefore started evaluating software tools for automatic code generation in 2004. The goal was a process where different development teams could exchange information in a defined, unambiguous format. At the same time, responsibilities for function development and software development had to be clearly separated. This led to the decision to use model-based development with Simulink® in conjunction with an automatic code generator.

TargetLink Best in Test

Thales Alenia Space investigated the suitability of several code generators. These had to fulfill several criteria: As well as supporting the workflow, the code generator had to be flexible with regard to naming rules, code structure and function interfaces so that it could be integrated into the existing coding scenario. Other criteria were the readability and reliability of the generated code. The evaluation of several code generators revealed that TargetLink was the best match for Thales Alenia Space's evaluation criteria. TargetLink's rich graphical user interfaces provide intuitive and powerful options, including support for structures, pointers and access functions. Moreover, the separation

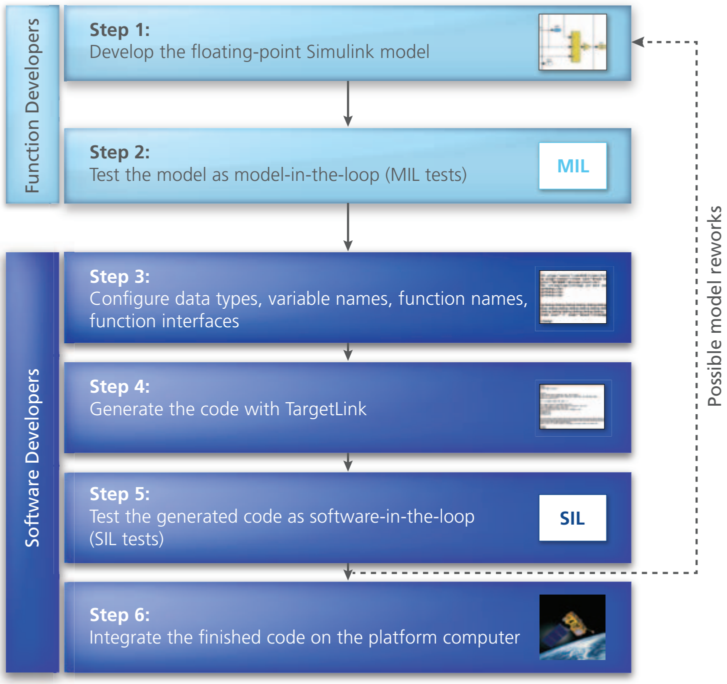


Figure 2: The clearly structured development process ensures clean separation of responsibilities, an unambiguous flow of information and the complete traceability of all the work steps.

between Simulink data types for simulation and TargetLink data types for code generation allows round trips between different development teams, such as function developers on one side and software developers on the other, in which both teams can work on the same model.

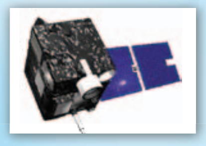
Streamlined Development Process

The process begins with the function developers developing a floating-point Simulink model, which they test with model-in-the-loop (MIL) tests in the second step (figure 2). Then they pass the model to the software developers, who carry out the third step – configuring the data types, variable names, function names and function interfaces. The fourth step is automatic code generation with TargetLink, followed by software-in-the-loop (SIL) testing in the fifth step. If the result of the SIL test indicates that the model needs reworking, the software developers pass it back to the function developers again. This is where the new process reveals its great strength, because although the model has to go "back to the drawing board", the work already done by the software developers is not lost – thanks to the cleanly defined exchange formats and work steps.
As soon as all the model modifications are completed and the SIL tests have run successfully, the sixth and final step is to integrate the finished code on the platform computer.

Real-World Success

The first project with TargetLink was the development of software for two infrared Earth observation satellites ("SPIRALE"), which were launched into orbit in 2009 by an Ariane 5. That same year, Thales Alenia Space also decided to use TargetLink for a new project called "Sentinel 3". Sentinel 3 is part of Global Monitoring for Environment and Security (GMES), a mission of the European Space Agency (ESA). Thales Alenia Space has already generated 12,000 lines of code for this. Sentinel 3 will be launched later this year.

Thales Alenia Space Projects with TargetLink



Project SPIRALE (two identical twin satellites)
- Purpose: Observing the Earth in the infrared range
- 5,000 lines of code generated by TargetLink
- Satellites already launched (2009)

Project SENTINEL 3
- Purpose: Measuring the temperature of ocean and land surfaces, etc., and the topology of ocean and ice surfaces
- 12,000 lines of code generated by TargetLink
- Launch planned for 2013

Figure 3: The code generator TargetLink has convincingly demonstrated its advantages in two projects.

TargetLink Firmly Established

Model-based design and automatic code generation have since become the established practice at Thales Alenia Space. Using models that can be shared by different teams makes work very efficient. And with TargetLink, the code structure and naming rules can be configured flexibly. Thales Alenia Space was therefore able to integrate the code into their existing framework without having to modify it. The new process has already considerably boosted productivity, and is expected to produce further major benefits when earlier models are reused in future projects. ■

Arnaud Dupuy,
Christophe Moreno
Thales Alenia Space

Arnaud Dupuy
Arnaud Dupuy is On Board SW Project Manager of the Sentinel 3 Platform at Thales Alenia Space in Cannes, France.

Christophe Moreno
Christophe Moreno is Chief On Board SW Architect of the SW Solution Competence Center at Thales Alenia Space in Cannes, France.

Fuel Cell Revolution

Toolchain for Developing a Fuel Cell Control System

For the past 20 years, Ford has gained a wealth of experience from their research and development of fuel cells for in-vehicle use. Ford's researchers have tested several concepts in the laboratory and on the road. Thanks to this continuous development work, the new technology is approaching commercial viability.

Fuel Cell Systems and Their Control

Fuel cells transform chemical energy into electrical energy. When reactants such as hydrogen and oxygen are supplied to a stack of fuel cells, the resulting electrons can be harnessed to propel automobiles. The electronic control regulates an efficient delivery of the reactants to the fuel cell by monitoring and controlling the flow, concentration and pressure.

Control System Challenges

Early prototype designs like the P2000 used standard ECUs with purpose-built, customized I/O for fuel cell applications. But this architecture left little room for experimentation. When Ford began internal development of control algorithms for fuel cells, typical constraints such as timing, personnel, logistics, and budgets made it necessary to switch from a standard electronic control unit (ECU) to a flexible rapid prototyping system. A well-integrated control system was desired that could drive multiple valves, which control and route the hydrogen, air, and water within the fuel cell system. At the same time, high flexibility and modularity was absolutely essential because I/O demands can quickly change at any time during the research and development of electronic systems. Another challenge was the planned simultaneous introduction of a purely model-based work method.

Ultimate Flexibility with Rapid Control Prototyping

Ford decided on a rapid control prototyping (RCP) system consisting of a dSPACE MicroAutoBox II and dSPACE RapidPro Power Unit, as well as Simulink® from MathWorks (figure 1). The determining factor behind this decision was the positive experience with dSPACE RCP systems in several research and development divisions at Ford. The system provides the desired flexibility because it can be adapted to

The Ford Reflex concept car, introducing an electric propulsion system.

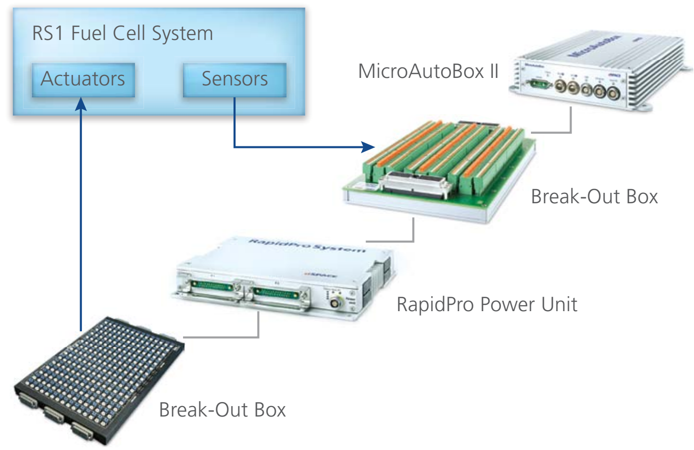


Figure 1: Interface from the RapidPro Power Unit to MicroAutoBox II.

> "dSPACE engineers were by our side from project inception through the detailed implementation, supporting wherever and whenever needed."

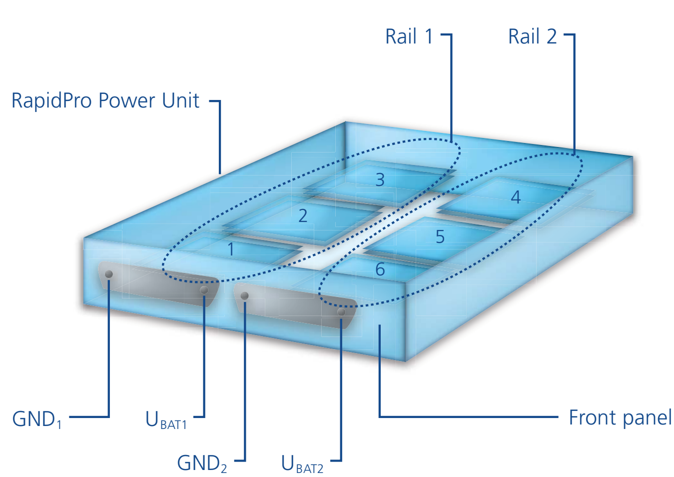
Kurt Osborne, Ford

meet the fuel cell control system requirements by adding any necessary supplementary I/O and interface modules, power units and signal conditioning units.

In-Project Benefits of Using RapidPro

The signals from the sensors and actuators of the fuel cell could be processed directly with the same RapidPro standard modules that are used in regular combustion engine applications. For the majority of the actuators, low-side driver (LSD) modules were used. The electronic throttle body in the air delivery subsystem was controlled by a full-bridge driver (FBD) module. Since the fuel cells are driven by two different supply voltages, the split voltage bus provided by RapidPro was especially beneficial: two separate power rails feed the two respective supply units (figure 2). These are just some of the advantages of rapid prototyping systems.
They are examples of the experience and ingenuity of dSPACE engineers who were on hand from project inception through the detailed implementation, supporting wherever and whenever needed.

Figure 2: Two rails in RapidPro allow for twin independent power supplies.



Convenient Configuration

Operating and configuring the RapidPro Power Unit for the application at hand is done with dSPACE's software ConfigurationDesk and its graphical, intuitive user interface. For example, ConfigurationDesk allows a user to assign channel names corresponding to actuators and sensors and to configure settings for each of the channels. At any time, the user can export a channel list indicating the location of modules in their corresponding slots and the channel names with their assigned pins. ConfigurationDesk makes handling the configuration and documentation tasks very easy.

Diagnostics

With its diagnostic functions, the RapidPro Power Unit uses a serial peripheral interface (SPI) to prepare data that can be monitored immediately in ConfigurationDesk. What is more valuable, though, is that this data can be time-aligned to other system events and thus logged better. For this task, the RTI blocksets

Figure 3: Lab setup of the fuel cell system with MicroAutoBox and RapidPro.

for Simulink are available to poll the I/O channels. The recorded data is processed further in ControlDesk. To use the diagnostic information in other test system controllers, it is retransmitted via CAN messages.

Evaluation and Next Steps

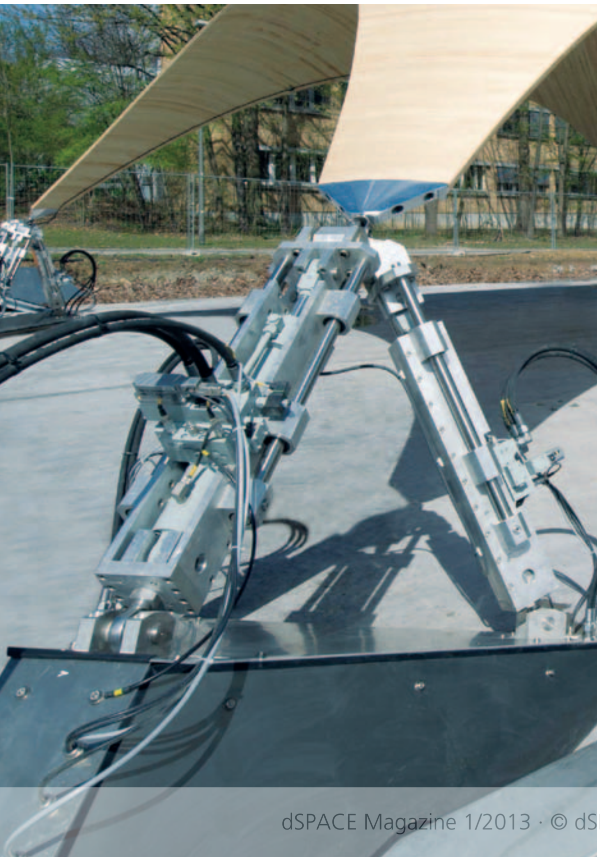
The rapid prototyping systems MicroAutoBox and RapidPro proved themselves to be extremely useful for controlling fuel cell systems during research and development at Ford. All of the specified functions were able to be implemented in the fuel cell system, which is attributable, in part, to the coordinated tool chain. The RapidPro Power Unit fulfilled all of the needs for a flexible and reconfigurable power stage. The RapidPro systems allowed a small team with a limited budget to implement and test new fuel cell concepts without focusing on the optimization details that would have been required for ECUs. The switch to one common tool chain was surprisingly easy.
In the near future, the system will undergo validation testing in freezing ambient conditions. If additional components or novel strategies become necessary, the configurability of the RapidPro Power Unit will allow rapid integration of those components into the control system.
One of the next steps could be integrating the fuel cell system into a demonstration vehicle. In this case, Ford will be able to use the RapidPro Power Unit from the very start. Thanks to its short boot times, the RapidPro Power Unit is very fast, making it compatible with vehicle applications. Furthermore, the RapidPro Power Unit can be selectively disabled by the MicroAutoBox thus saving energy and improving overall energy consumption. ■

Kurt Osborne
Dr. Miloš Milačić
Ford Motor Company

Kurt Osborne
Kurt Osborne is the fuel cell controls technical expert and is the leader of global model-based fuel cell system control design at Ford Motor Company in Dearborn (MI), USA.

Dr. Miloš Milačić
Dr. Miloš Milačić is responsible for fuel cell control algorithm development and implementation at Ford Motor Company in Dearborn (MI), USA.

The Stuttgart SmartShell on the Vaihingen campus of the University of Stuttgart (photo: © Bosch Rexroth) has hydraulic cylinders that compensate for extreme loads on the structure.



Lightweight, safe, sustainable, and economical with materials – modern architectural structures like buildings and bridges have to be all that. But they also have to stand up to constant stresses such as snow and wind. Researchers at the University of Stuttgart are working to develop lightweight load-bearing structures that respond to external loads.

Figure 2: Active support for the Stuttgart SmartShell, with three hydraulic drives (photo © Bosch Rexroth).

Control concept for ultra-lightweight structures

Architecture with Brains

Ultralight, Adaptive Structures

Traffic, snow and wind are typical, everyday loads that buildings are subjected to. In contrast, extreme events such as earthquakes or "the worst winter in living memory" are very rare – yet buildings still have to be designed to cope with them. Today, this means using large quantities of materials to ensure safety margins that are hardly ever needed. So that future buildings can use less material but still cope with extreme events, the University of Stuttgart is investigating ultra-lightweight, adaptive structures with intelligent hydraulics that compensate for a wide range of different loads.

Static Adaptation and Active Vibration Control

The Stuttgart researchers are studying both static and dynamic forces and their effects. Static forces are due to factors such as snow, while dynamic forces (i.e., vibrations) are caused by factors such as wind gusts. To reduce the resulting stresses, the load situation first has to be captured by sensors. The control algorithm then uses the measurement values to compute the optimum control for the actuators that adjust the structure to the external loads. For static forces, the structure is adapted statically. If vibrations need damping, however, the sensors have to continuously capture the stress and control the actuators dynamically. As a result, load-bearing elements can be smaller and lighter: The structural mass saved in the construction is replaced by short-term energy inputs.

The Stuttgart SmartShell Prototype

To test their control concepts, the Stuttgart university institutes worked together with Bosch Rexroth to construct the Stuttgart SmartShell prototype, the first adaptive load-bearing shell structure in the world. Constructed from wood in a four-layer laminate, it is only 40 mm

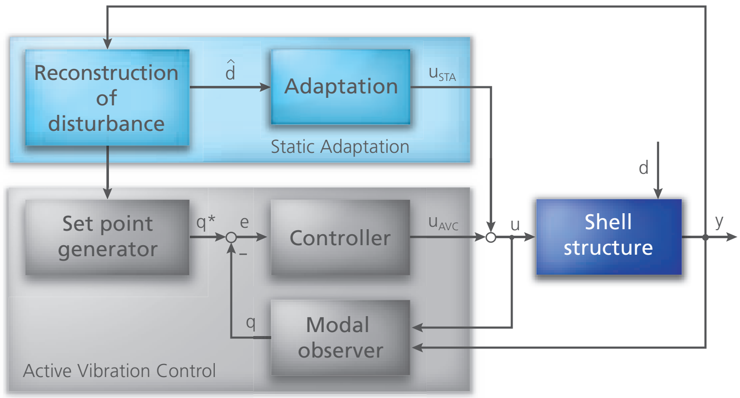


Figure 3: Control concept for static adaptation and active vibration control.

thick. Comparable structures built by traditional, passive methods require several times as much material. The shell weighs 1.4 metric tons and rests on four supports, three of which can be moved by hydraulic cylinders.
Each of the active supports is mounted on a tripod of actuators (figure 2) that allow it to be positioned freely in three-dimensional space. The kinematic relationships between the lengths of the hydraulic cylinders in the tripod arrangement and the positions of the supports are continuously computed online.
A wide range of sensors are available for measuring the system state. For example, the hydraulic cylinders are equipped with high-resolution displacement sensors and force sensors. Strain gauges mounted on the shell structure capture the strain at specific measurement points.

The Control Concept

In the first step, simulation models are used to determine the necessary static adaptation. The models represent the behavior of the structure under different loads, and the optimum positions of the supports are calculated from that. To dampen vibrations with maximum efficiency, a description of the dynamic behavior was added to the model. The control concept for vibration damping is based on a dynamic behavior model and on feedback control that is computed from the model and used in the Stuttgart SmartShell. Because the feedback control is derived directly from the analytical model description, it can be adapted to the time-variable parameters of the shell, such as the static load situation or the set points for the support point positioning. The feedback control is designed to optimize the damping properties of the control while at the same time minimizing the energy required for damping. Both these adaptivity requirements can be met simultaneously (figures 4, 6) by combining the set points for the static adaptation and active vibration control (figure 3).

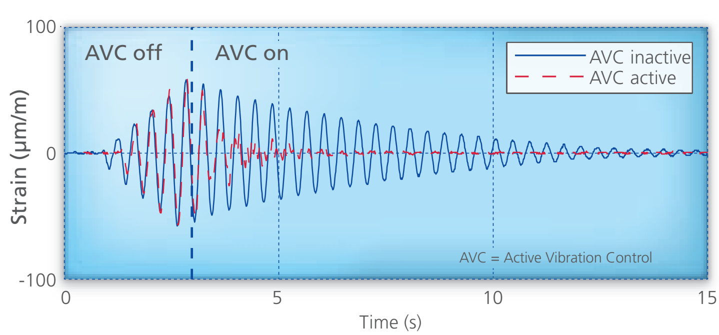
Prototype Implementation

The control system (figure 5) of the Stuttgart SmartShell essentially has to:

- Control the hydraulics
- Cyclically monitor the status and safety
- Read the measurement data from the cylinders and strain gauges
- Estimate the vibration state and reconstruct the static load
- Generate the set points for the static adaptation and vibration control
- Perform high-precision actuator control

The system that performs these complex tasks consists of a dSPACE DS1006 Processor Board and a Motion Logic Control (MLC) unit from Bosch Rexroth. While the MLC performs the control tasks for the hydraulic system and sends the control inputs for positions and forces to the individual hydraulic drives, the DS1006 estimates the state and generates the static and dynamic set points. The DS1006 also computes the direct and inverse kinematics. These are used to convert the set points for the support point

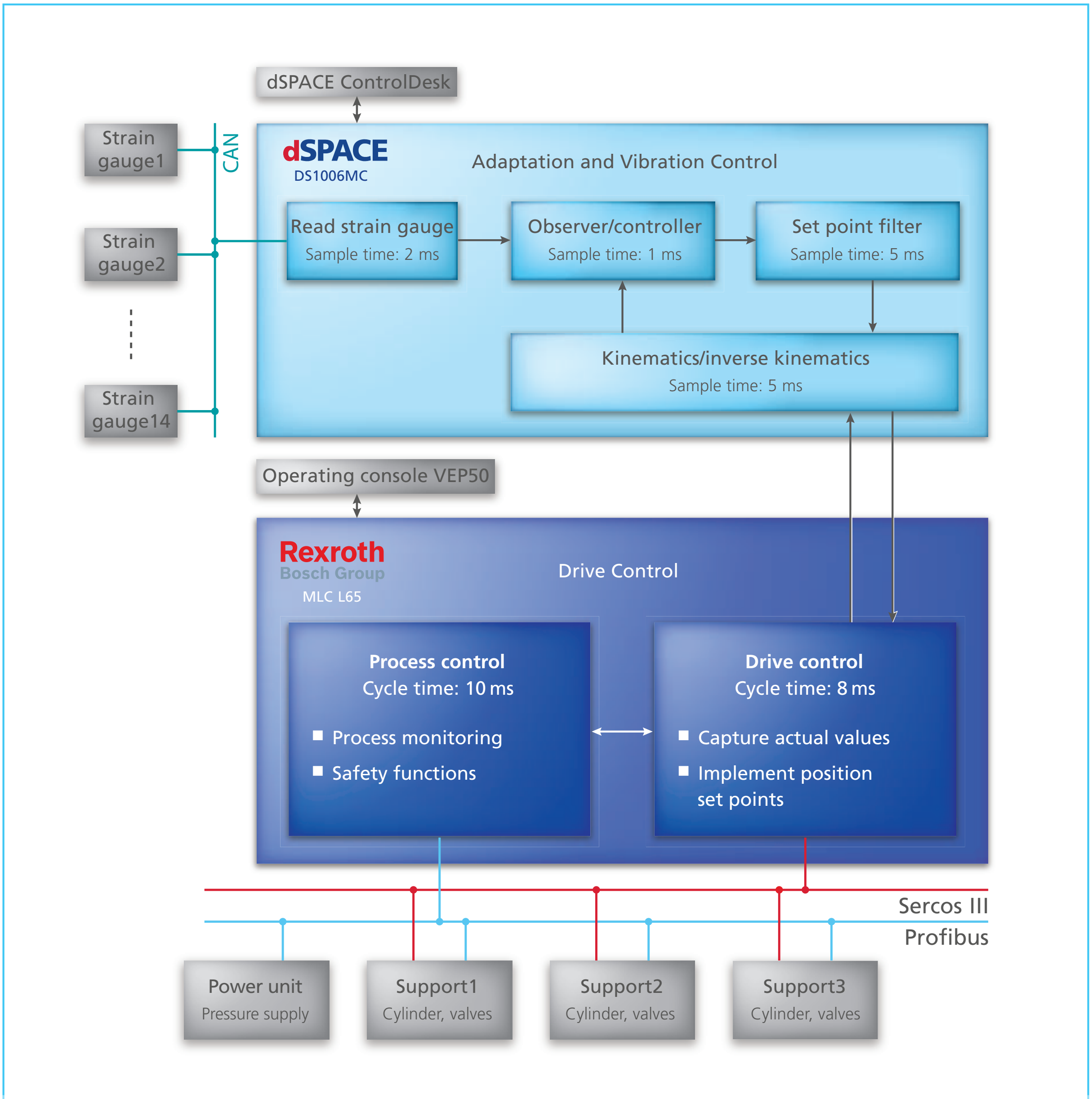
Figure 4: Comparison between undamped vibration (blue curve) and actively controlled vibration (red curve). The damping control is activated at 3 s and reduces the duration of vibration by 80%.



Supporting structure for assembling the Stuttgart SmartShell.

> "With the dSPACE prototyping-system, adaptivity concepts for ultra-light-weight structures can be implemented in a short time."
>
> *Martin Weickgenannt, University of Stuttgart*

Figure 5: Software and hardware structure for implementing the static and dynamic adaptation.



Conclusions

Using a dSPACE controller board together with a Rexroth Motion Logic Control (MLC) combines the advantages of a rapid prototyping system and a process ECU. This means that the tasks of the Stuttgart SmartShell – generating static and dynamic set points, plus process control – can be implemented efficiently.

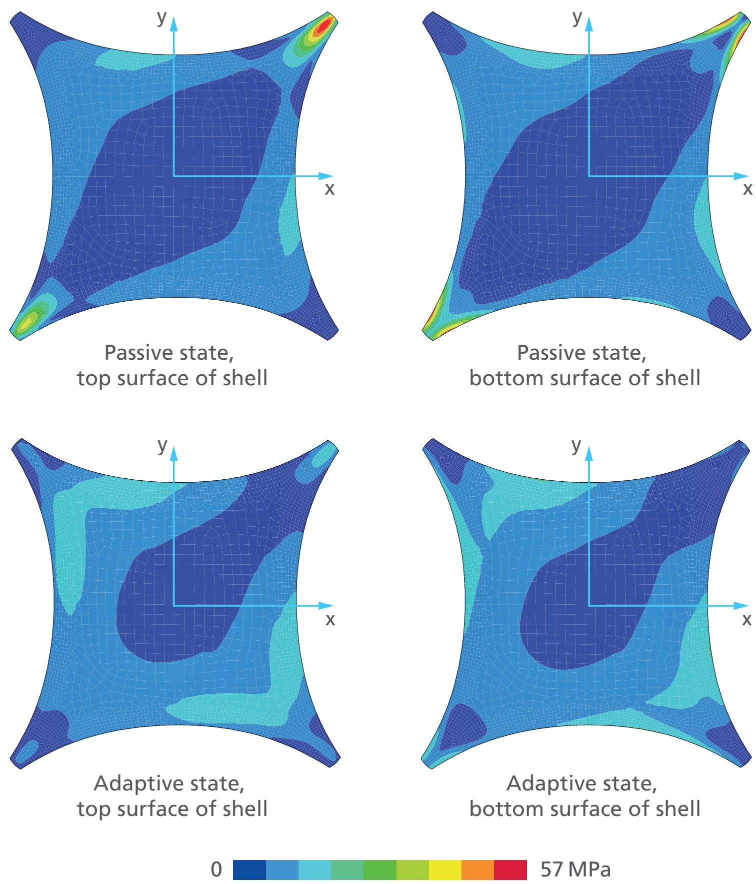


Figure 6: Stress distribution due to an exemplary external load. Adaptation reduces peak stress by 66%.

positions and forces into local set points for the drives. The current values for the positions and forces at the support points are obtained from the local measurements, which are then transformed into the global coordinate system. The high complexity of the kinematic calculations and the short cycle time of 5 ms involve a large computation load. The convenient configuration options of the DS1006 are particularly helpful here, as the computation processes can easily be distributed across its processor cores to ensure optimum use of the processing capacity. The Profibus connection between the DS1006 and the MLC allows the high-frequency exchange of the set points, measurement values and control commands at a rate of 12 MBit/s. The strain sensors are connected to the DS1006 via three separately controlled CAN networks, providing a sampling rate of 200 Hz. The CAN interface can be set up quickly and conveniently by means of the RTI CAN MultiMessage Blockset. Finally, with the experiment software

Snow, wind and traffic are typical forces that structures have to withstand.

The shell structure is only 40 mm thick.

ControlDesk, it is easy to specify items such as set points for the individual drives and to switch between different control strategies. ■

Martin Weickgenannt
Stefan Neuhäuser
Werner Sobek
Oliver Sawodny
University of Stuttgart

Watch this video to see the Stuttgart SmartShell in action: www.youtube.com/watch?v=vDb2h1-7LA0

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Martin Weickgenannt
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Werner Sobek
Werner Sobek is the head of the Institute for Lightweight Structures and Conceptual Design at the University of Stuttgart and founder of the Werner Sobek group.

Oliver Sawodny
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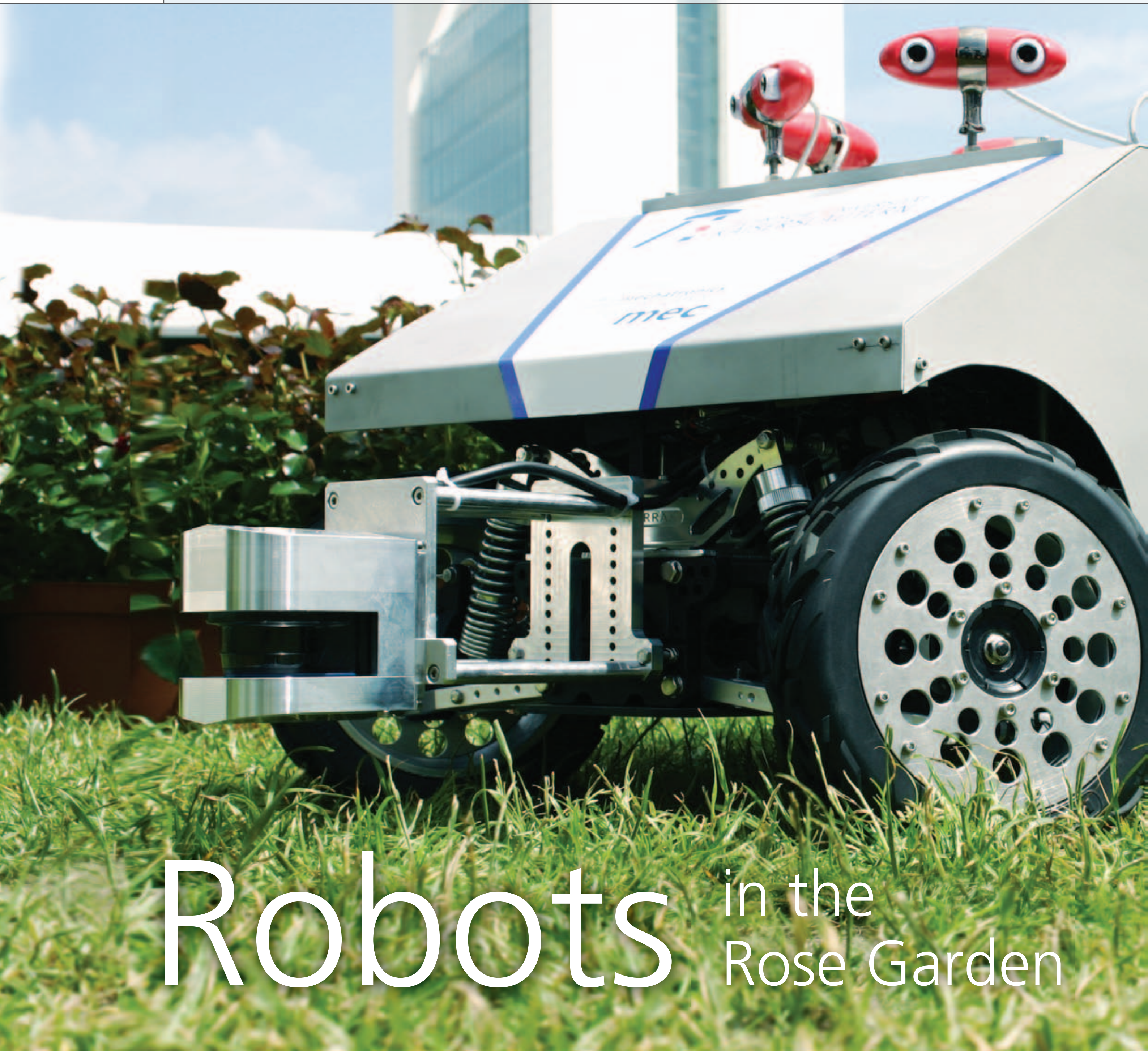


Robots in the Rose Garden

Limited resources, climate change and a rapidly growing world population make efficiency and sustainability the biggest challenges in horticulture and agriculture. Using the latest technologies is the key to meeting these challenges. Year for year, a team of students from the Institute of Mechatronics in Mechanical and Automotive Engineering at the University of Kaiserslautern, and many other teams, participate in the Field Robot Event, an international competition for autonomous field robots, giving a detailed picture of the new generation of agricultural technology.

Autonomous Vehicles for Horticulture and Agriculture

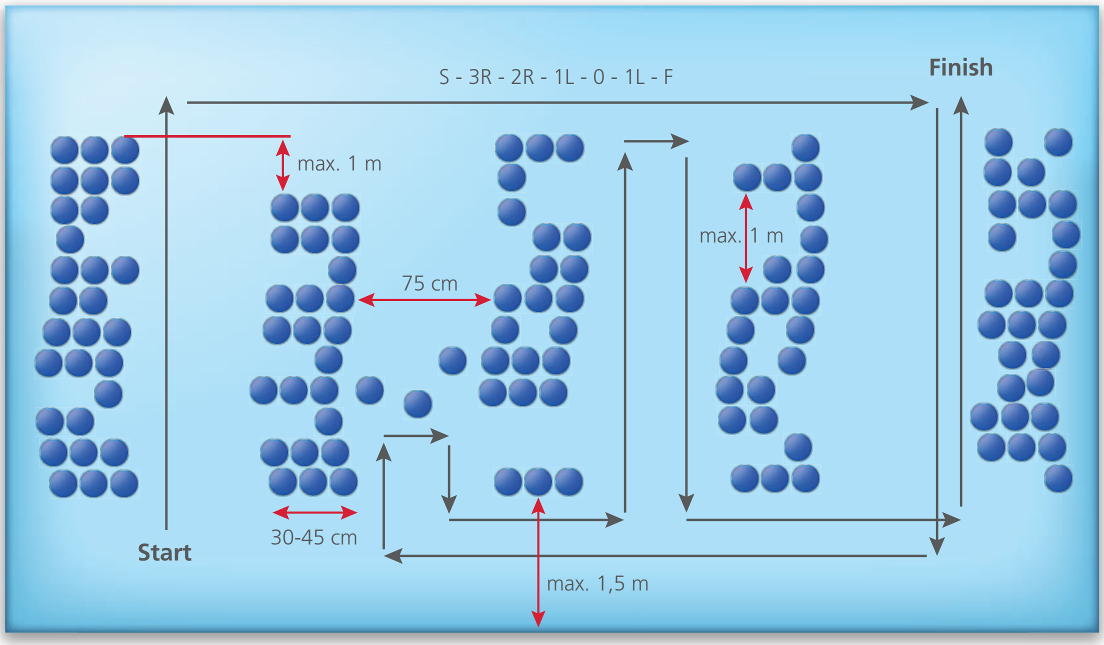


Figure 1: A task of the Field Robot Event 2012 was to drive autonomously through rows of plants in order to complete a given route.

> "Because dSPACE's MicroAutoBox II plus Embedded PC combines the proven tools of hardware-related ECU development with the flexibility of a PC, it was an excellent platform for our autonomous vehicle."

Roland Werner, University of Kaiserslautern

A Small Revolution

Intelligent sensors, GPS-based automatic steering systems with centimeter-level accuracy, robots and autonomous vehicles are the next major step in agricultural engineering. To meet these enormous technological challenges, new creative approaches and interdisciplinary thinking are needed. The Institute of Mechatronics in Mechanical and Automotive Engineering (MEC) at the University of Kaiserslautern set up a team of students to take on this task. Together, the students developed an autonomous vehicle for field use.

The Competition

The highlight of the team's year on the project was participating in the Field Robot Event, an annual international field robotics competition, held in 2012 in Venlo (Netherlands) as part of the Floriade (international garden show). The overall task of the Field Robot Event was to let a vehicle navigate autonomously through rows of plants (figure 1). Missing plants, and curved and blocked rows made it difficult for the vehicles to move along. On their way, the vehicles were required to perform additional tasks related to agriculture. The assessment of the teams was based on the distance traveled in 3 minutes, with bonus points for completed tasks and penalty points for plant damage and manual intervention. A particular challenge of last year's Field Robot Event was finding, picking up and returning a randomly chosen, specially marked plant among rows of rose pots.

The World from the Vehicle's Eye

A large number of sensors give vehicles the ability to recognize their environment (figures 2 and 3). One

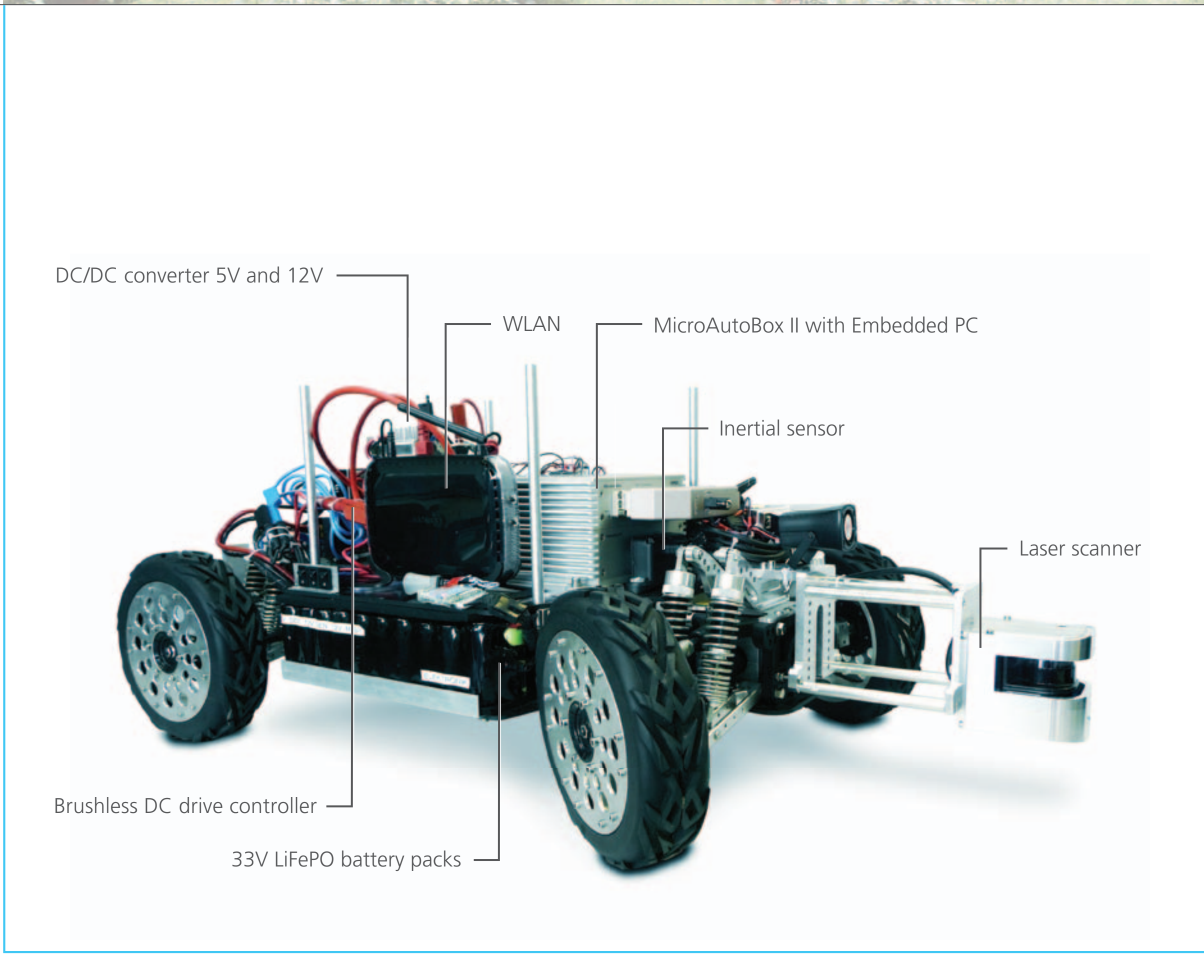


Figure 2: The main components of the autonomous vehicle developed by students from the Institute of Mechatronics in Mechanical and Automotive Engineering (MEC) at the University of Kaiserslautern.

important component for autonomous driving is a set of two laser scanners mounted on the front and back of the vehicle. Delivering a 240° field of view in one scanning plane, the scanners allow to detect obstacles in the vehicle's surrounding environment. For the turning at the row's end, the yaw rate measured by inertial sensors and the resulting calculated vehicle orientation is crucial. Located on the vehicle roof, six stereo webcams with a total 360° field of view allow to find the marked plant and provide information on the vehicle's distance to the plant. In addition to these sensors for autonomous navigation, the vehicle carries a WLAN interface and an R/C receiver for development and testing purposes.

Four-Wheel Steering and Drive

Unpaved surfaces, obstacles and narrow turns between rows are challenges for the vehicle's actuators. Four servo motors allow for steering all wheels individually. A central brushless DC drive with 2 kW power and a permanent four-wheel drive provide the necessary force at the four tires. An intelligent power converter supplies the drive from the vehicle's 33 V LiFePO battery pack.

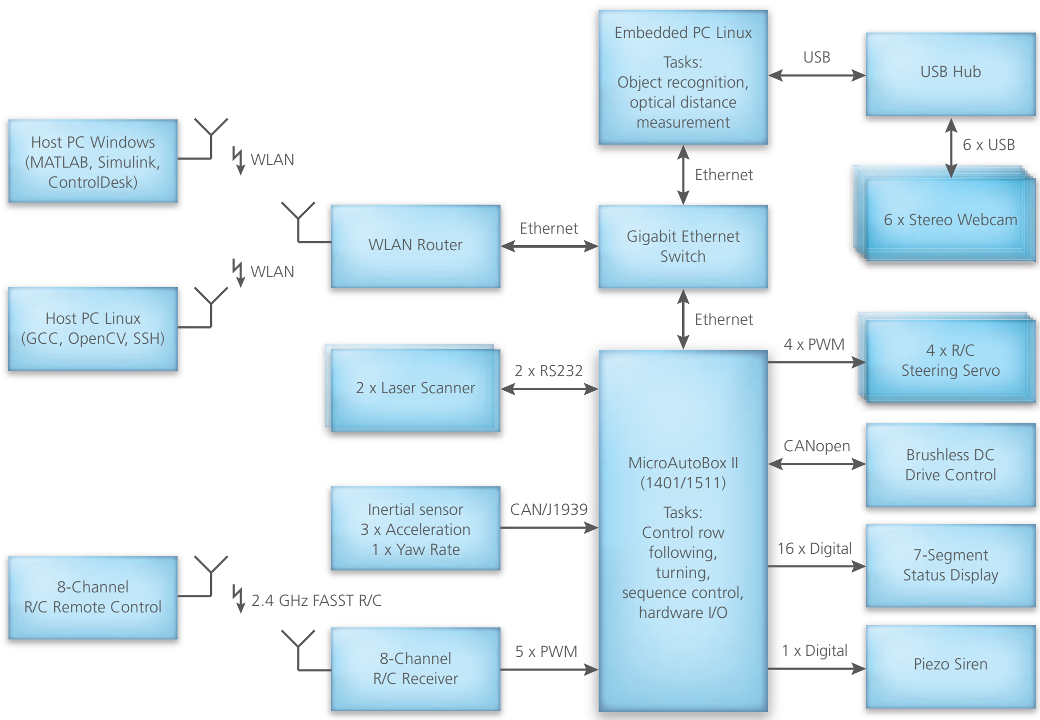
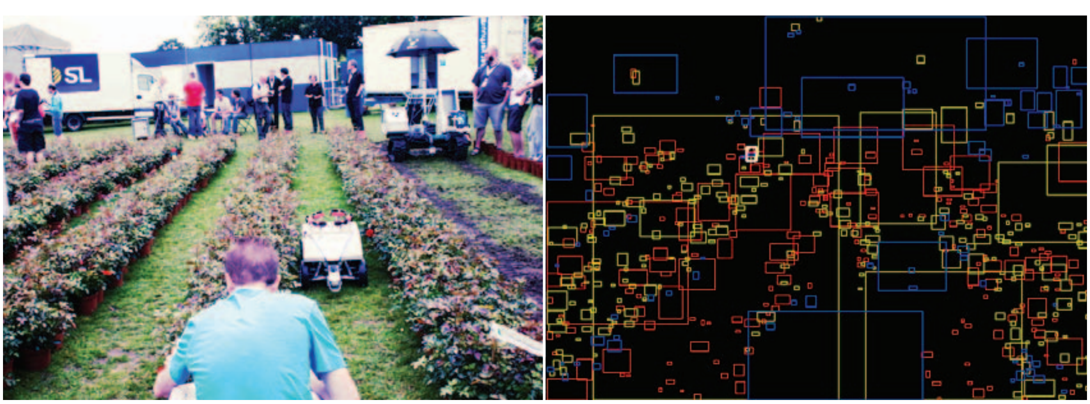


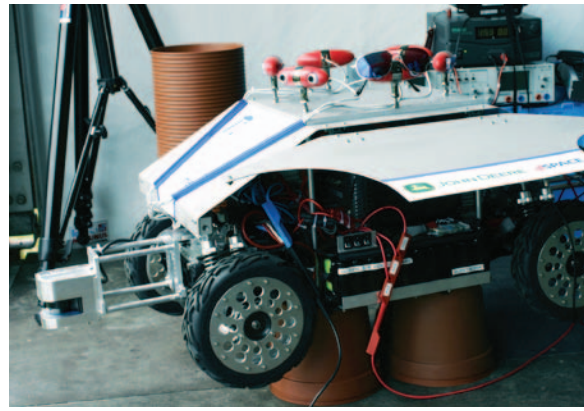
Figure 3: Block diagram of the autonomous vehicle's sensors, signal processing and actuators.

Distributed Signal Processing I: Real-Time Control with MicroAutoBox II

For signal processing and actuator control, the vehicle uses the advantages of two worlds. Hardware-oriented closed-loop control tasks are handled by a MicroAutoBox II in real time. The algorithms for row detection, path tracking and headland turns, plus the sequence control of the entire vehicle are essential parts of the software running on MicroAutoBox II. The multitude of I/O interfaces makes it easy to connect to all different kinds of sensors and actuators (figure 3). MATLAB®/Simulink® provide a proven develop-

Figure 4: Object recognition via OpenCV with a marked plant in the original image (left: cylinder in red, blue and yellow), recognized color regions (right: rectangles in red, blue and yellow) and identified plant marking (right: white rectangle).





ment environment for these tasks; and ControlDesk® enables fast, reliable and convenient system configuration and diagnostics.

Distributed Signal Processing II: Image Processing with Embedded PC

Image processing and machine vision are centrally important tasks for autonomous vehicles. The free C/C++ software library OpenCV has a comprehensive collection of up-to-date algorithms available for various platforms, including Windows® and Linux.
The combination of MicroAutoBox II and Embedded PC make integrating the image processing tasks into the overall system quite easy. The internal Gigabit Ethernet switch and UDP/IP guarantee rapid communication between MicroAutoBox II and Embedded PC running Linux. One particular challenge of the Field Robot Event 2012 was to have the autonomous robot identify a randomly chosen, specially marked rose pot and stop in the immediate vicinity of the pot. The marking selected for the pot was a cylinder with streaks of red, blue and yellow (figure 4). Recognizing the markings is performed sequentially, with the first step being the identification of image areas containing a high proportion of the marking's colors. Next, the arrangement of these areas is used to differentiate between the searched markings from other random image components in the environment. The size of the discovered markings and the depth information of the stereo image serve as the base values for measuring the distance between the vehicle and marked plant. ■

Roland Werner
University of Kaiserslautern

Conclusion and Outlook

The Field Robot Event 2012 was the second stage for the development of the MEC vehicle. In comparison to its debut the year before, the team improved its placement, moving from 10th to 6th place out of 18 teams. In particular, the platform shift to dSPACE MicroAutoBox II was a positive improvement. The reliable, proven development tools allowed the team to focus their attention on function development. Furthermore, the combination of MicroAutoBox II and Embedded PC was especially beneficial because the team could implement the hardware-oriented applications with real-time requirements and a variety of I/O interfaces without having to sacrifice the flexibility of a PC. The next step for the students from the University of Kaiserslautern will be to enter their further optimized vehicle at the Field Robot Event 2013, taking place at the Czech University of Life and Environmental Sciences (CZU) in Prague.

Roland Werner
Roland Werner is research assistant at the Institute of Mechatronics in Mechanical and Automotive Engineering (Chair: Prof. Dr.-Ing. Steffen Müller) at the University of Kaiserslautern and supports the students in their development of an autonomous vehicle.

Perfect Balance

Controlling Li-ion cell voltages during prototyping

To benefit fully from the high energy density of Li-ion batteries, the state of charge of the individual cells must be monitored precisely. dSPACE has developed a battery management system that performs this task throughout the development process, from the first model to in-vehicle testing. Its main focus is on measuring and controlling Li-ion batteries.

Electromobility Needs Powerful Batteries

One reason for the combustion engine's great success in the 20th century is gasoline's high energy density. While one liter of gasoline can run for many kilometers, a modern battery of the same mass or volume takes an electric vehicle only a fraction of the distance. As this comparison clearly shows, developing powerful, high-density batteries is key to the breakthrough of electrical vehicles.

Li-Ion Batteries as the Solution

One type of high-density power storage is batteries based on Li-ion technology. A Li-ion battery consists of numerous single cells with voltages in a typical range of 3.3 … 4.2 V, depending on the battery type. To reach the necessary voltages of sev-

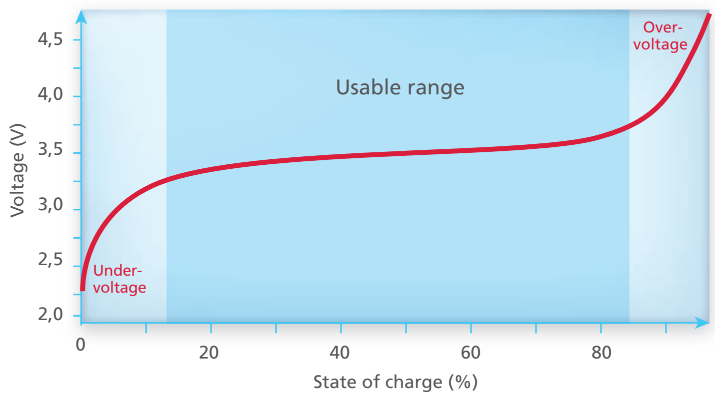


Figure 1: Typical load curve of a Li-ion cell. The usable voltage range is limited to several 100 mV.

eral hundred volts, a large number of single cells are combined to build a cell stack.

Li-Ion Batteries Need Monitoring

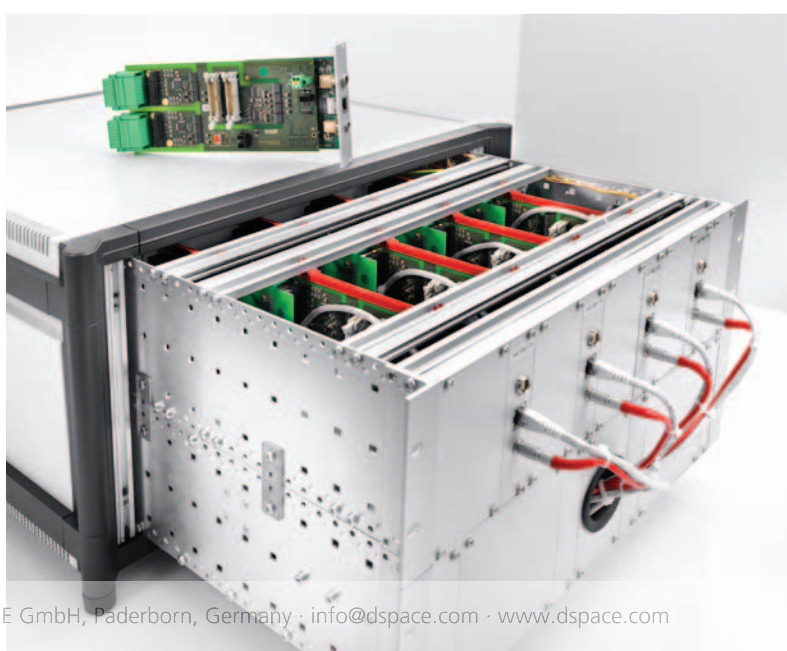
Li-ion batteries have to be constantly monitored and controlled because the usable voltage range of a Li-ion cell is limited to several 100 mV (figure 1). The further the voltage moves out of this ideal range, the more the life span of the cell is impaired. In extreme cases, the cell can even be destroyed. Instances of battery fires in telephones, laptops, and last but by no means least, the Boeing Dreamliner, emphasize just how important it is to monitor the battery state.
Protecting the cells against undervoltage and overvoltage is therefore a top priority. This is where a battery management system (BMS) comes in. This system has the challenging task of measuring cell voltages with galvanic isolation at a precision of only a few millivolts, when the voltage of the overall cell stack usually reaches several hundred volts. A BMS also has to monitor the temperature, because this has a major impact on the cell state.
Using algorithms, the BMS continuously monitors the individual cells to determine values such as the battery's state of charge (SoC), state of health (SoH), and so on. The BMS also performs what is known as 'cell balancing' to keep the voltages of all the single cells at the same level. In passive balancing, superfluous charge is drawn off by switching an ohmic resistance in parallel to any cells whose voltage is too high. The voltage balance between the cells in a stack is one of the most important factors that influence the life span of Li-ion batteries.

The Battery Management System from dSPACE

Because standard solutions fail to meet the requirements described above, at dSPACE we developed our own battery management system for rapid control prototyping, called Battery Cell Voltage Measurement and Balancing. This system lets users measure and control the cell voltages of Li-ion batteries during rapid control prototyping, and also supports the development of battery management algorithms.
Li-ion batteries with a total voltage of up to 846 V can be connected to this dSPACE BMS (battery management and balancing system). The system measures the voltage of each cell with high precision and provides the ability to reduce it, if

> With the battery management system from dSPACE, high-voltage batteries can be managed at cell level with high accuracy.

Figure 2: The modular structure of the dSPACE battery management system allows tailor-made configurations of up to around 200 cells and can also be installed directly in a vehicle.



required, by means of a switchable resistor.

The system is modular and can be assembled to create configurations of between 6 and approx. 200 cells. It can also be installed directly in a vehicle. The modules are connected via Ethernet with a dSPACE prototyping system such as MicroAutoBox II.

One module can measure the voltage and temperature of up to 24 cells and passively balance each cell separately. The balancing resistances are located on a separate carrier board so that different resistance values can be tried out quickly.

Because the voltage and temperature measurement inputs are galvanically isolated, a real battery can also be connected to the system.

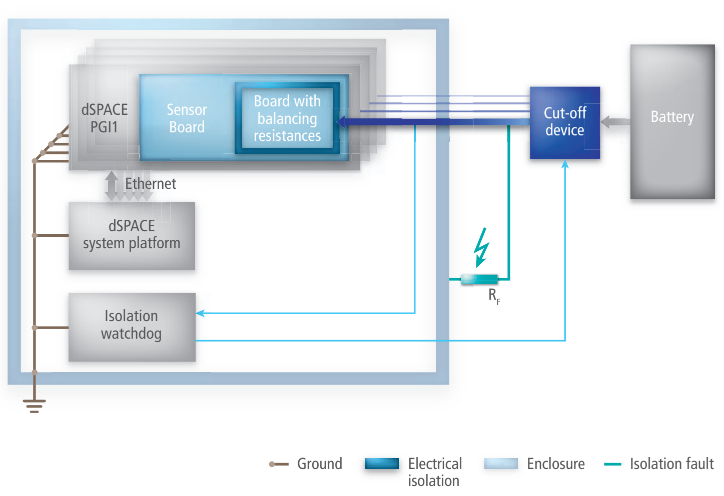
All the properties of a prototyping system have to be more powerful than those of the final product. The dSPACE BMS achieves a precision of ±3 mV at a measurement frequency of up to 1 kHz, regardless of the number of cells. This makes it possible to study the cell chemistry as well. The cell voltage measurement processes in the individual modules can also be synchronized.

Features at a Glance:

Max. no. of cells	Approx. 200
Max. voltage	846 V
No. of cells per module	24
Cell voltage	0 … 5 V
Measurement frequency	Max. 1 kSPS
Precision	±3 mV at 3.3 V ±300 mV
Resolution	0.61 mV
Synchronized measurement	For all cells
BMS IC	Intersil ISL78600
Temperature measurement	For each cell, by thermistor (NTC)
Balancing method	Passive balancing
Isolation	Complete galvanic isolation
Isolation monitoring	Interface for isolation monitoring device
Safety features	Watchdog, diagnostics options, temperature monitoring
Hardware interface	Ethernet
Software interface	Simulink® blockset

In 'manual balancing' mode, the system gives users all the freedom they need to develop battery management algorithms, letting them balance cells individually or collectively, and at any intervals. The 'automatic balancing' mode is a comfort function that performs the less important ask of specifying target voltages and switch-off times so that developers can give their full attention to the more important BMS algorithms.

Figure 3: The isolation concept of the dSPACE battery management system makes it safe to use high battery voltages.



Seamless System Monitoring

To continuously monitor the overall system state, the dSPACE BMS has extensive error detection and alarm features:

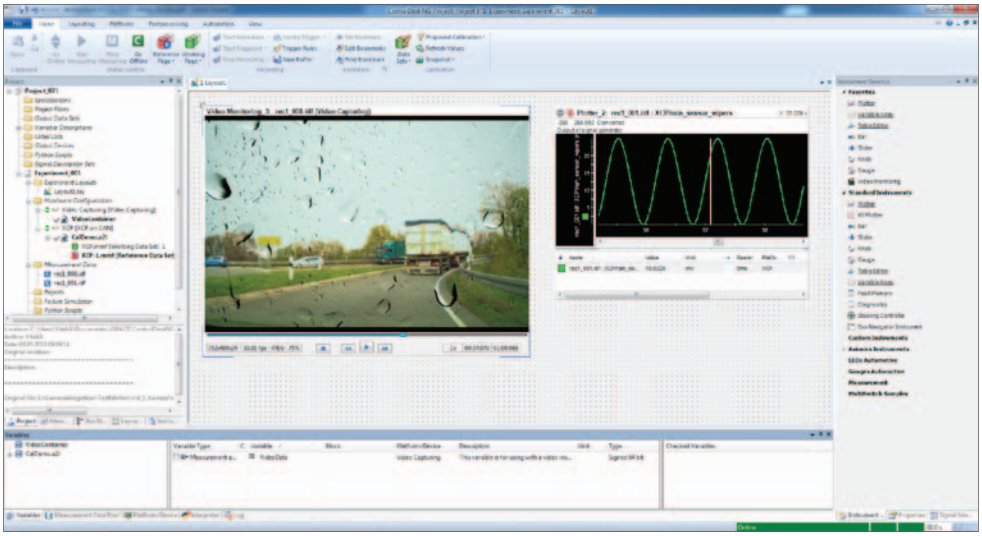
- Warnings on hardware faults and communication/synchronization errors
- Temperature warnings
- Warnings on isolation faults
- Warnings on cell undervoltage and overvoltage

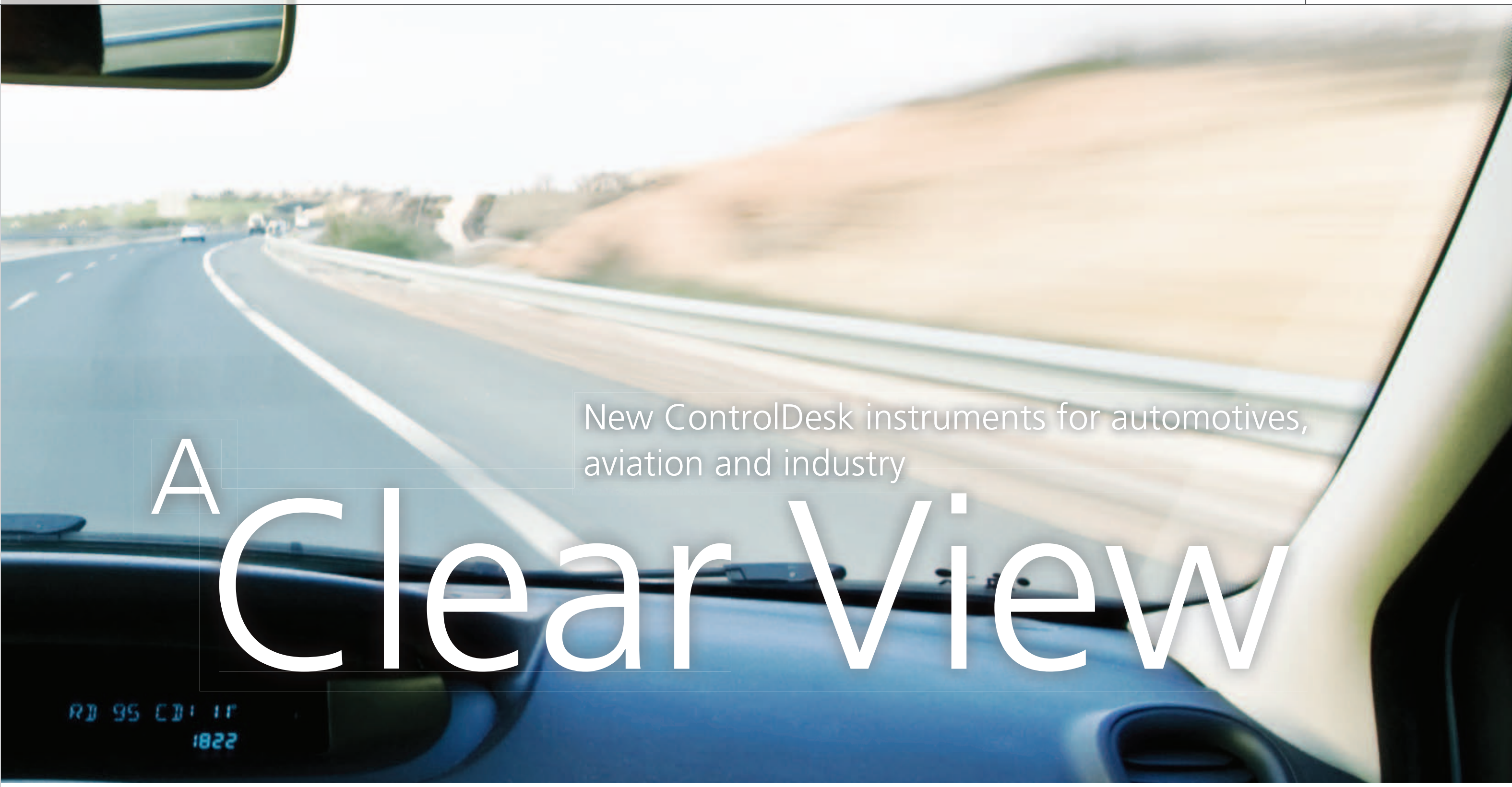
To ensure the safety of the overall system, the isolation resistance is monitored by a separate device that constantly provides information on the state of the isolation and immediately outputs an alarm when it detects an isolation leak.

For safety reasons, dSPACE supplies the BMS only as a turnkey system in an engineering project. ■

As of version 4.3, ControlDesk Next Generation (dSPACE's experiment software) provides major innovations for automotive, avionic and industrial applications. For example, camera images can be recorded with a video instrument via an integrated camera interface and replayed in synchronicity with measurement recordings. And for avionics, there is a new Primary Flight Display (PFD), with Altimeter, Artificial Horizon, Heading Indicator and Airspeed Indicator instruments.

The video instrument and camera interface are used to record and replay video and bus data synchronously (shown here is ControlDesk 5.0 with its new user interface).





New ControlDesk instruments for automotives, aviation and industry

A Clear View

Video Instrument and Camera Interface

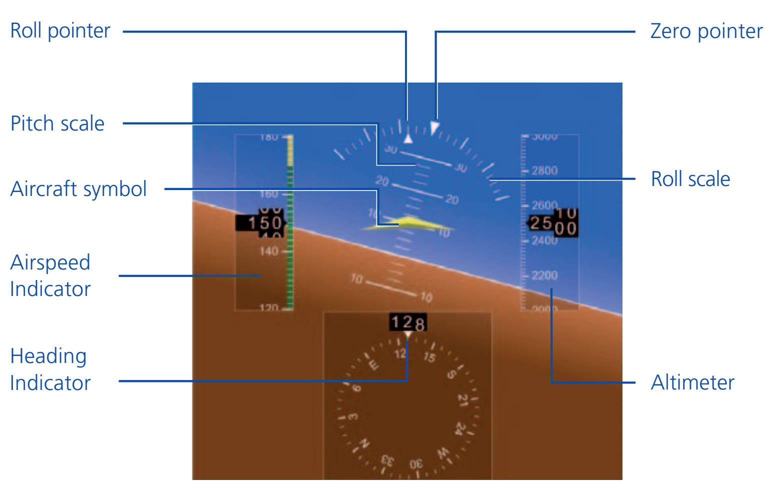
There are numerous applications where it is useful to record camera images synchronously to the measurement values displayed in ControlDesk®. Such images improve the quality with which the real-world effects of control events are assessed and visualized. Users can let their creativity run free. Here are just some of the possible applications:

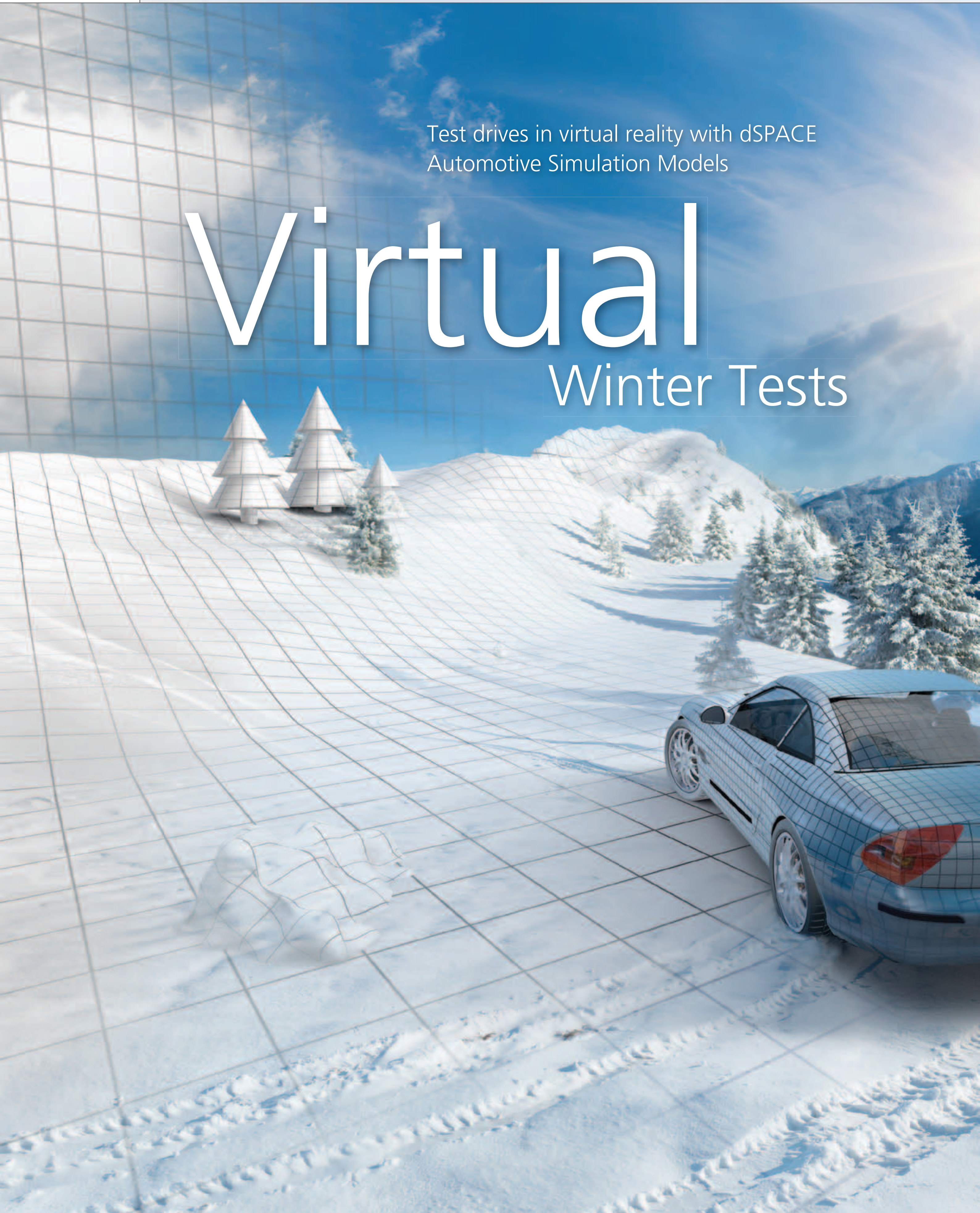
- Validating interaction between windscreen wiper control and the rain sensor
- Visualizing control events in ADAS applications
- Visualizing actions of industrial robots/production machines

ControlDesk provides the camera interface and video instrument that these activities require. Either an industrial-standard camera or a simple USB camera can be connected. And not only can the videos play synchronously to a measurement in real time, they can also be repeated any desired number of times, and exported if necessary. ■

Avionics Instruments

Measurement values from avionics applications can be visualized with the realistic cockpit instruments provided by ControlDesk: the Altimeter, Artificial Horizon, Heading Indicator and Airspeed Indicator. Used on a ControlDesk layout, these give a realistic impression of an aircraft's movements, whether measured or calculated.





Test drives in virtual reality with dSPACE Automotive Simulation Models

Virtual Winter Tests

No modern vehicle ever reaches the market without first undergoing exhaustive tests. And test vehicles alone are no longer enough to test the complex electronic control units. This job is performed by simulation models, which shift ECU development into the virtual reality of a virtual vehicle. Dr. Hagen Haupt, head of dSPACE's Modeling Group, explains how the dSPACE simulation models are meeting this challenge.

What are the Automotive Simulation Models (ASM)?

The Automotive Simulation Models (ASM) are plant models, or in other words, they are a virtual, model-based substitute for a controlled system. They were created in MATLAB®/ Simulink® and support all the essential simulation tasks in the electrics/ electronics development process. dSPACE provides models for combustion engines, electric components, vehicle dynamics and driver assistance systems. We first launched them on the market in 2005, and have been extending them continuously ever since.

What were the goals, and what has been achieved so far?

From the beginning, we have had two main goals: One was to give our customers the option to obtain all the components needed for HIL simulation from a single vendor, since this provides enormous configuration, operation and maintenance benefits. And the other was to focus on making the simulation process more seamless and efficient by allowing valuable know-how to be used across multiple teams and projects, from function development to HIL testing. We are now able to provide this seamless integration for developing and testing ECU functions in all currently relevant vehicle applications.

What are the main advantages of the models?

What our customers particularly appreciate is the openness of the models. Not only can they trace the implementation of modeled components right down to the level of individual Simulink blocks, they can also adapt the models themselves. The entire process is streamlined by using the same models and parameterizations from function development to HIL tests. Maximum convenience for handling simulations is provided by the graphical tool ModelDesk. This is the central location for configuring and parameterizing models, starting the simulation, and visualizing the simulation results – seamlessly from offline simulation to HIL simulation.

ASM Model Portfolio

Models for combustion engines:
- ASM Diesel/Gasoline Engine (mean-value models)
- ASM Diesel/Gasoline InCylinder (physical models)
- ASM Turbocharger (physical model)
- ASM Diesel Exhaust System (physical model)

Vehicle dynamics models:
- ASM Vehicle Dynamics
- ASM Truck
- ASM Trailer
- ASM Brake Hydraulics
- ASM Pneumatics
- ASM KnC

Environment model:
- ASM Traffic
- ASM Environment

ASM Video Channel

What special features do the models have?
One strong point is that they have standardized interfaces that let users combine models like building blocks, to tailor them precisely to the scope and quality required for each specific application. For example, they can put together models that represent a hybrid drive with a specific battery cell characteristic.

> dSPACE plans to strategically extend the range of models provided for electromobility and driver assistance systems.

This is easy to do in the graphical tool ModelDesk, which is another boost to productivity. Another strong point is that the models match the dSPACE hardware very well. This supports the emulation of cell voltages, the simulation of electrical drives for process-based or FPGA-based calculations, etc. etc.

Which customers use the models?
Even though the market launch of the models was only a few years ago, there are now 800 licenses at 250 customers all over the world. This especially includes major automobile manufacturers and suppliers, and also several universities. Recent newcomers are important departments at Daimler in Stuttgart, Nissan in Yokohama, and Scania in Sweden. Our models are also used by GM in America, Volkswagen in Europe, and Mazda in Asia, to name but a few. The heavy vehicle sector is represented by Caterpillar, Volvo, WABCO and others. These companies particularly appreciate our powerful variant management, which helps them parameterize and simulate vehicle variants.

Why do so many companies rely on ASM?
One reason is that the ASMs provide a complete portfolio from engines to traffic models, enabling entire virtual vehicles to be simulated together with their environment. dSPACE is currently the only vendor to offer such a comprehensive range of models. Another aspect is that many of our customers no longer want to do all the maintenance and development work involved in using their own in-house models. Changing to the ASMs saves them a lot of work. At the same time they remain flexible enough for customer-specific adaptations, thanks to the openness of the ASM. And whenever their

developers face new simulations tasks, they can either quickly find whatever they want from our well-established model portfolio, or further develop the models with our support.

What application fields will the ASMs be tackling next?

The main ones will be electromobility and driver assistance systems. Our customers are very active in these fields, and we will support them with simulation models. The ASM Traffic Model is already facilitating the development of ACC, emergency braking, lane keeping and parking assistants. Car2x is also a very exciting development field, and we will be launching simulation tools for this some time this year. Simulating traffic at junctions, map-based systems, and object recognition are just a few examples. The key to all of this is a flexible, convenient environment simulation – this is where ModelDesk comes in.
In the field of electric drives, we will be adding more precise component models to our portfolio, including FPGA-based ones. We are also advancing classic application fields like combustion engines and vehicle dynamics simulation, for example, by further developing high-resolution cylinder pressure simulation for combustion-based engine controls and enhancing ASM KnC as a virtual suspension test bench.

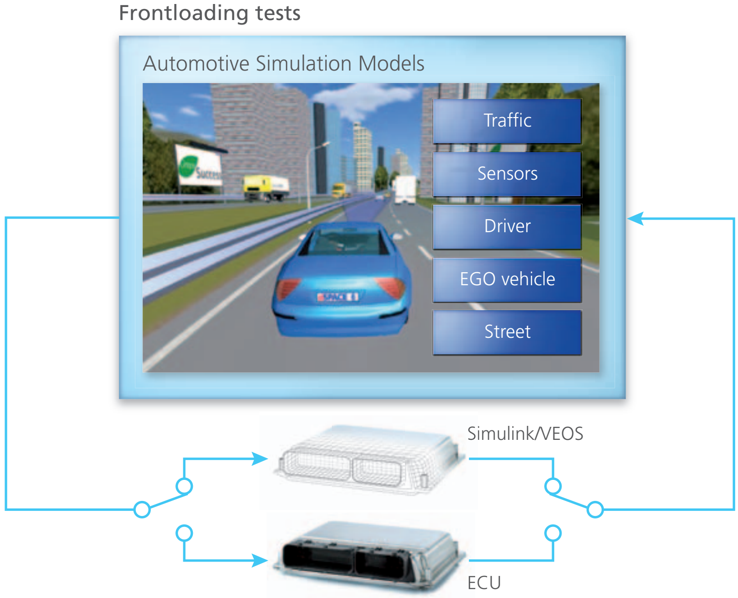
How are you preparing for the development challenges of the future?

Electrics/electronics systems are growing in functionality and also becoming more highly networked. As a result, larger and larger models have to be combined. This leads to new challenges regarding not only the contents but also the handling of the models. To facilitate handling, we will provide highly integrated data management. Connection to dSPACE's data management and collaboration software SYNECT® will play a major role here. Packages built from ASMs and dSPACE VEOS® will offer powerful solutions dedicated to offline simulation.

How do you acquire the know-how for simulations?

When developing the ASMs, we cooperate closely with our users, so whenever new requirements come up, we can include them in our development plan immediately. Some parts of models that were developed in customer projects go straight into the product. And for specific tasks, we work with partners who already have the relevant experience. In the important application fields of electromobility and driver assistance systems, we are actively involved in the Toolbox Speichersysteme, TRAFFIS and Virtual Car2x research projects. Well-founded research results coupled with dSPACE's practical experience and modeling expertise are the ideal foundation for powerful simulation models to perform the simulation tasks of the future.

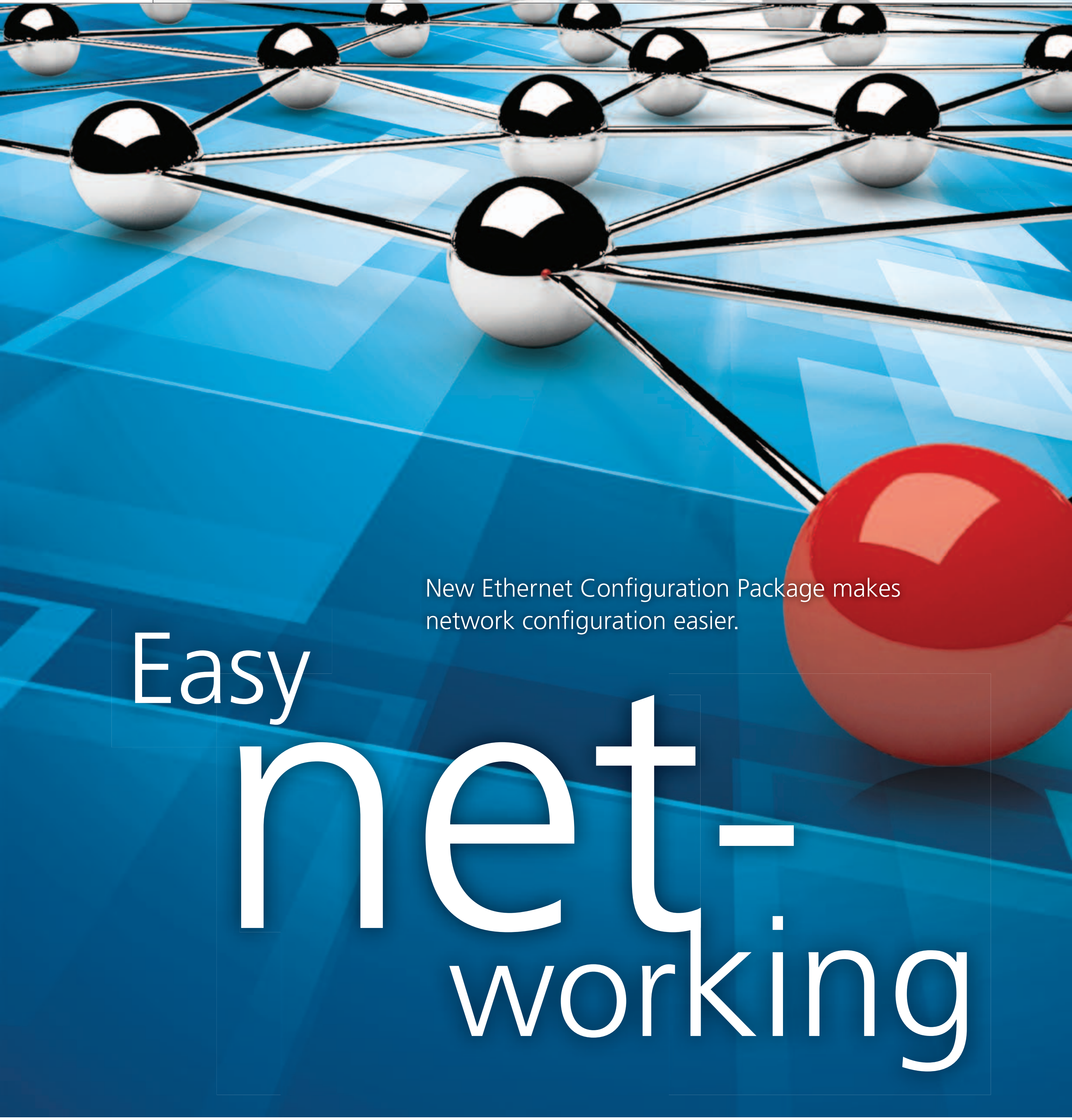
Thank you for speaking with us, Dr. Haupt.



The ASMs enable early, integrated testing in the automotive E/E development process.

> dSPACE is the only model vendor who covers the entire scope of automotive simulation from engines to road traffic.

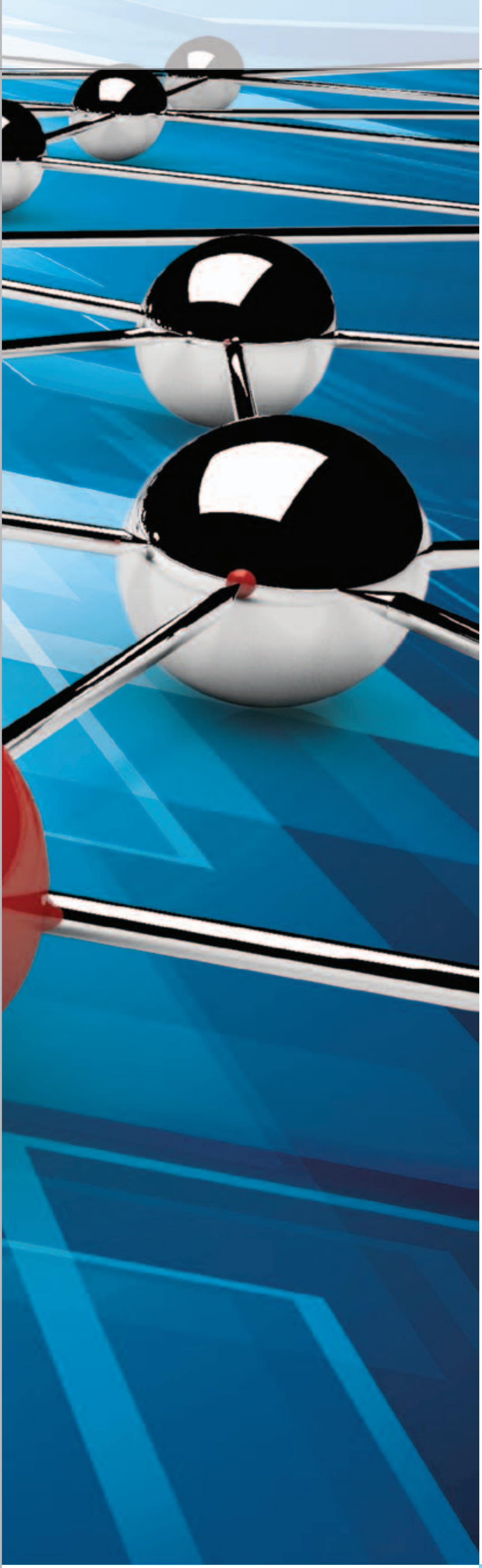
Dr. Hagen Haupt is in charge of simulation model development at dSPACE GmbH.



New Ethernet Configuration Package makes network configuration easier.

Easy net-working

With the new Ethernet Configuration Package, dSPACE is the first provider to enable service-based communication in Ethernet ECU networks in real-time systems.



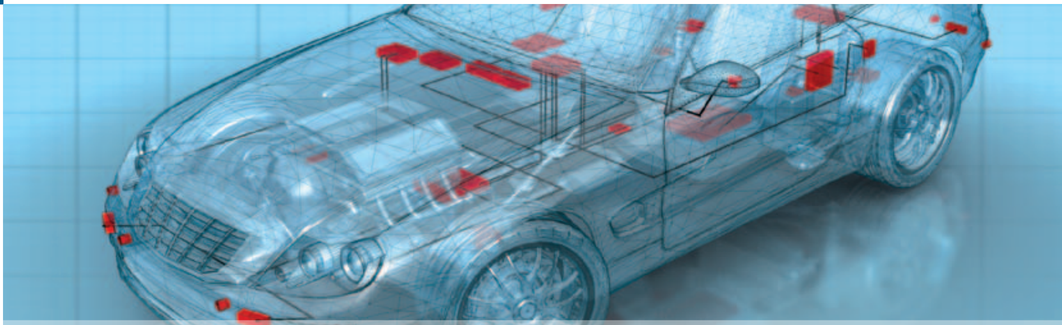
Why Automotive Ethernet?

Following FlexRay's successful introduction into vehicles just a few years ago, Ethernet is now about to go into production use as an automotive communication bus. With its flexible layer model, high bandwidth and cost-effective, independent implementations, Ethernet has numerous potential uses in vehicles. Ethernet networks will therefore play a decisive role in modern driver assistance systems, new comfort and entertainment functions, ECU flashing, and other functions. Because the Ethernet networks have often been optimized for automotive use, development is also focusing on many other aspects of the communication system. For example, the OPEN Alliance Special Interest Group (OPEN Alliance SIG), which dSPACE is also a member of, is promoting the widespread introduction of Ethernet-based networks with single pair, unshielded twisted cables. Activities in the fields of ASAM MCD-2-NET (FIBEX) and AUTOSAR include ones aiming to standardize communication descriptions and harmonize middleware layers. There is already a broad base of users and interested parties who are planning to introduce automotive Ethernet. dSPACE supports these customers with the new Ethernet Configuration Package.

> Ethernet networks will therefore play a decisive role in modern driver assistance systems.

dSPACE and Ethernet

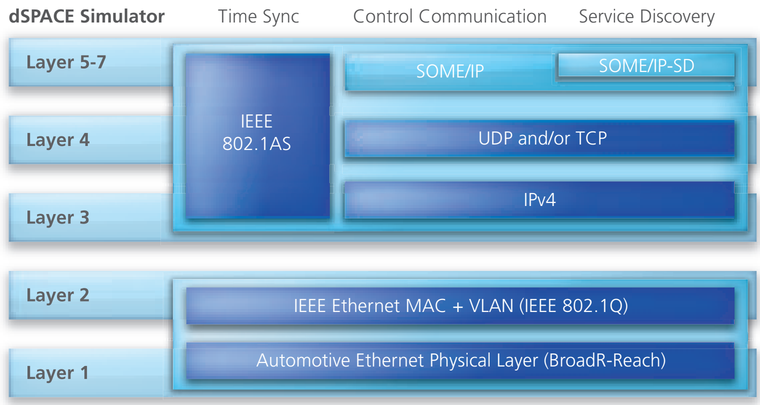
For many years, dSPACE has been providing products and solutions for connecting Ethernet to real-time systems. Two examples are the DS1006 Processor Board for hardware-in-the-loop simulation and the MicroAutoBox for rapid control prototyping with blocksets designed for MATLAB®/Simulink®.
These products focus mainly on the User Datagram Protocol (UDP) and the Transmission Control Protocol / Internet Protocol (TCP/IP) via Ethernet. However, the current Ethernet/IP discussion is addressing the layers above UDP and TCP/IP and aims to implement service-based communication (figure 1). The serialization protocol SOME/IP for service-based communication and the service discovery protocol SOME/IP-SD are playing a key role here.
A version of the FIBEX standard called FIBEX 4, published by ASAM [www.asam.net] back in September 2011, meets the need to describe the additional elements required for service-based communication via Ethernet. The experience gathered from the initial application phase will lead to FIBEX 4.1, which is due to be released soon. FIBEX 4 is the first step towards a data exchange format for Ethernet-based in-vehicle communication networks. More



Ethernet Configuration Package

Features

- Enables the simulation of service-oriented, event-based Ethernet communication in real-time systems.
- Supports FIBEX 4 communication descriptions.
- Supports SOME/IP middleware.



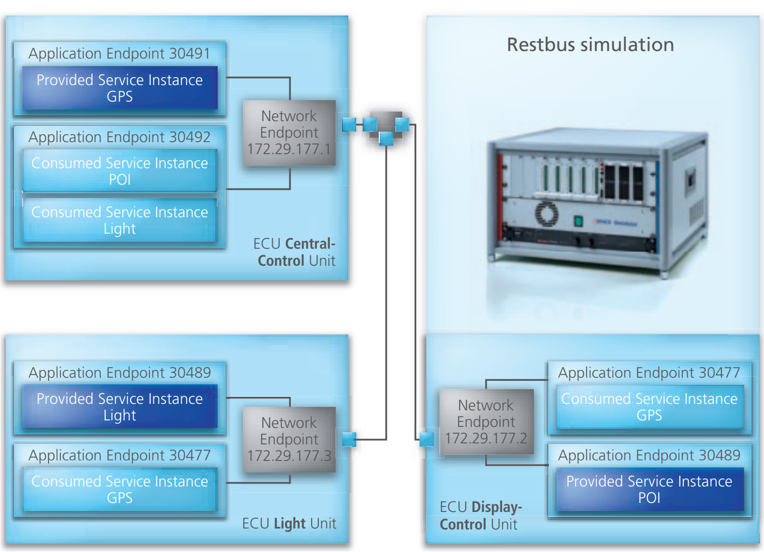
ISO/OSI layer model of service-based communication via Ethernet

communication descriptions for service-based communication via Ethernet will follow, especially ones for AUTOSAR. The main idea behind this IP- and service-based communication is explained below with excerpts from the FIBEX 4 format.

Service-Based Communication with FIBEX 4

Ethernet is specified in IEEE 802.3 and covers the first two layers of the ISO/OSI model. Because the network nodes share the physical transmission medium, collisions can occur. These can be avoided by point-to-point connections with switches as coupling elements. The fibex4ethernet schema extends the FIBEX topology with the elements that are needed for describing Ethernet in the data link and physical layers. Network endpoints and application endpoints were integrated into the fibex4it schema and elements for the IP and transport addresses (such as ports) were added. The FIBEX specification was extended by two basic concepts for communication via Ethernet. The first of these is typical signal-based communication like that used with CAN. This involves mapping protocol data units (PDUs) to Ethernet. The network and application endpoints for the PDUs are then modeled in FIBEX. Because Ethernet provides more features than just transmitting simple signals via UDP, etc., the second basic concept allows the specification of complex service interfaces that contain methods for describing communication on higher layers. Generic data types can be used for the parameters of the methods to transmit information that is more structured than with simple signals. The fibex4services schema contains the elements for modeling service-based communication. Underneath the application endpoints are the service interfaces that are instantiated as either provided services or consumed services.

Figure 1: Example of service-based ECU communication



Tool Support

The dSPACE Ethernet Configuration Package supports the simulation of

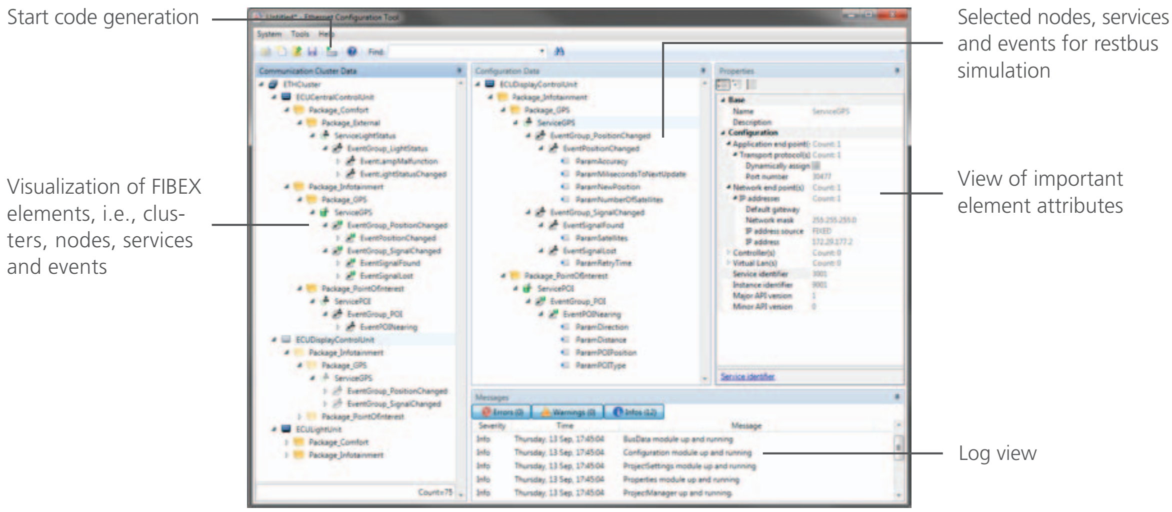


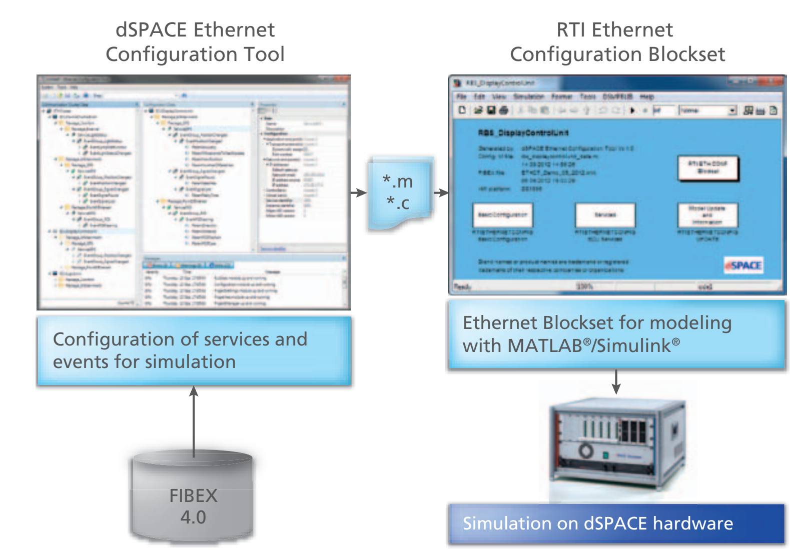
Figure 2: Ethernet Configuration Tool

service- and event-based communication as described in FIBEX 4. The first version of the dSPACE Ethernet Configuration Packages is available for systems with quad-core DS1006 Processor Boards. Like the dSPACE FlexRay support, the dSPACE Ethernet Configuration Package consists of two parts: One is the dSPACE Ethernet Configuration Tool for configuring a dSPACE system as a simulation node in a service-based Ethernet network. The other is the RTI Ethernet Configuration Blockset for modeling service-based communication in MATLAB/Simulink (figure 3).

The Ethernet Configuration Tool

A FIBEX 4 file can be imported and visualized with the dSPACE Ethernet Configuration Tool. FIBEX elements such as clusters, ECUs, services and events are represented in a clearly organized tree (figure 2). Users can select ECUs, services and events for the simulation simply by drag & drop. A structured view displays the most important attributes of the FIBEX elements. The selected services and events serve as inputs to automatic communication code generation. A transmission file is generated as a basis for service-based model frame generation in MATLAB/Simulink. The result is a Simulink interface model with preconfigured service and event blocks that build on the RTI Ethernet Configuration Blockset. The Simulink interface model provides subsystems for the simulated ECUs with the relevant service instance interfaces. With the help of the parameterized event blocks, users can design functions in the function model, for example, to try out the new communication via Ethernet/IP or to perform restbus simulation. The new dSPACE Ethernet Configuration Package is the first tool for restbus simulation on real-time systems for service-based in-vehicle Ethernet communication.
The latest version, Ethernet Configuration Package 1.1, was released in June and also supports dynamic service discovery. Further versions will follow. ■

Figure 3: Architecture of the Ethernet Configuration Package



Success in Action

SCALEXIO in customer projects

Launched two years ago, the SCALEXIO hardware-in-the-loop (HIL) test systems from dSPACE have already proven their value in numerous customer projects. They are now being used across the globe, in countries such as China, France, Germany, Italy, Japan, the UK and the USA.

Broad Range of Applications

SCALEXIO® covers a broad range of applications in the area of commercial and passenger vehicles. The ECU test systems implemented so far are for electric motors and combustion engines, car body and transmission electronics, and battery management systems.

What SCALEXIO Users Say:

"We are very satisfied with the SCALEXIO system. Our special application requires a compact and robust HIL system that is easy to transport. SCALEXIO meets these requirements. Moreover, SCALEXIO has also proven itself on the test track. But what also convinced us was the ability to reconfigure the hardware with ConfigurationDesk. Other systems would require hardware conversion."

Wolfgang Schindler, Daimler AG

"The flexible SCALEXIO hardware can be adapted quickly to different test variants for different ECUs, which has reduced our setup times. SCALEXIO has replaced our previous self-defined HIL signal conditioning system."

Thomas Wolf, WABCO

"For us, the great advantage of SCALEXIO is that we can use the same models whether we run a test on a complete HIL system or just on a processing unit with no I/O hardware connected. Being able to test the I/O hardware configuration in advance of HIL testing means we are very flexible."

Robert Walesch, Dr.-Ing. Maximilian Miegler, AUDI AG

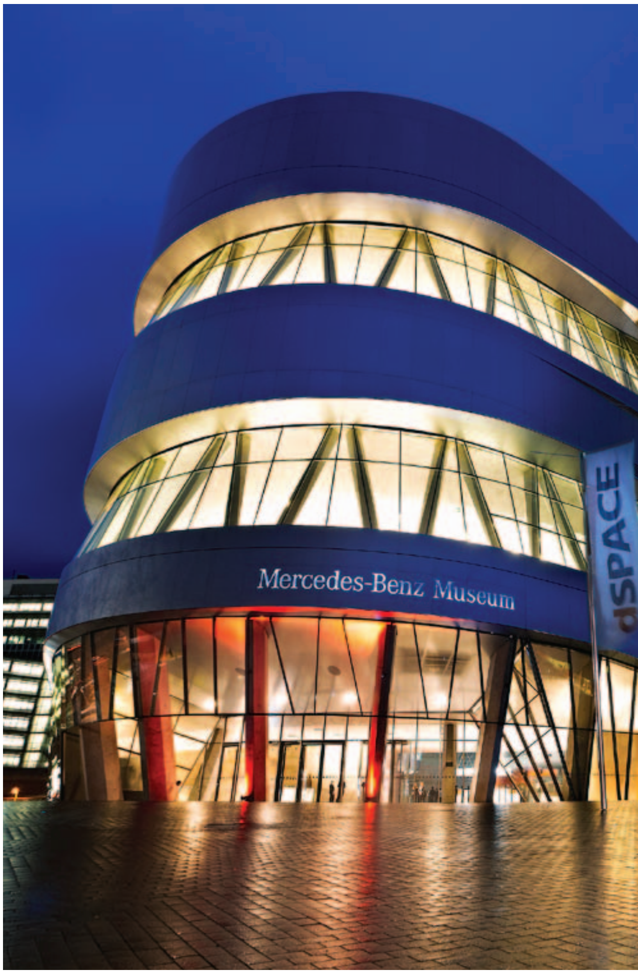
"By separating the model and the I/O, the SCALEXIO concept makes system creation and configuration easier for us. We will be using our systems for testing combustion engine and car body electronics for at least the next 8 years, so we chose to use the technology of the future."

Markus Ritzer, AUDI AG

Driven by Innovation

On January 29, 1886, Carl Benz applied for a patent for his 'vehicle powered by a gas engine'. Exactly 127 years later, on January 29, 2013, representatives from German car manufacturers and suppliers met at dSPACE's 7th German User Conference. There they discussed the latest development topics and trends – and revisited the roots of automotive engineering at the Mercedes-Benz Museum.


OEMs and suppliers present technological trends
at the 7th dSPACE German User Conference


Mercedes-Benz Museum
dSPACE


Pioniere
Pioneers

Keynote speaker Thomas Lieber, Volkswagen AG and Dr. Herbert Hanselmann, dSPACE

Auditorium with 180 attendees at Liederhalle, Stuttgart

Patent number 37435 issued in 1886 can be regarded as the birth certificate of the automobile. Newspaper reports on the first public outing of the three-wheel Benz Patent Motorwagen Type 1 appeared in July 1886. These events changed people's mobility for ever. Since its beginnings, the car has evolved from a purely mechanical construction to a complex mechatronic system. Technological progress plus changes in public expectations and environmental requirements are presenting manufacturers with one challenge after another. This often involves electronic systems and their software, which are playing an increasingly important role in today's vehicles.

127 Years of the Car: Current Challenges and Ideas

Hot topics from the development of vehicle electronics and software were on the agenda at the 7th German User Conference 2013. Thomas Lieber, Head of Electric Traction, Volkswagen AG, kicked off the two-day lecture series with his keynote speech on 'Electromobility as a Trend and Its Effects on the Value Added Chain'. He painted a clear picture of how OEMs are handling challenges such as dwindling resources, metropolization and emission laws, and of the strategies, concepts and development tasks that result.

> "In the last decade, we completely networked the vehicle. This decade, the vehicle will network seamlessly with its environment."
>
> *Thomas Lieber, Volkswagen AG*

Other exciting projects in the fields of electric drives, driver assistance systems and safety-critical applications provided further insights into current development trends. The concept of boosting efficiency with development tools and methods was a particular focus of the papers. Of particular interest was the early positive user feedback on dSPACE's brand-new tools, SYNECT® (ABB, Audi) and VEOS® (Volkswagen). And as several presentations demonstrated, numerous customers have already given SCALEXIO®, the new simulator system, a firm role to play in their development processes.

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Seminars and Networking

On the third day of the conference, the visitors could choose among seminars that investigated current topics in more detail. Product experts from dSPACE presented workflows and methods for the successful handling of data management, virtual validation, compliance with application, and system architectures. With long breaks between papers, the conference provided an ideal platform for conversation and networking. This was much appreciated by the attendees, who made full use of the opportunity. The Mercedes-Benz Museum was a stunning venue for the evening event, taking everyone on a journey through the history of the automobile as they talked and made new contacts before ending the action-packed day with a delicious buffet.

dSPACE sincerely thanks all the speakers, the exhibitors BTC, DMecS, Elektrobit, MathWorks, MES, and all the attendees for their contributions, which made this event such a success. You have inspired us to hold more conferences like this in the years to come! ■

Speakers:

1. ***Robert Walesch, AUDI AG,***
2. ***Richard Bergmann, AUDI AG***
   Robert Walesch and Richard Bergmann described the HIL strategy at Audi AG and their use of SCALEXIO in ECU software validation.
3. ***Steffen Stauder, TU Kaiserslautern***
   Steffen Stauder showed how a mechatronic HIL driving simulator designed by dSPACE is advancing model-based controller and function development for mechatronic steering systems
4. ***Thomas Wolf, WABCO Fahrzeugsysteme GmbH***
5. ***Dr. Oliver Schütte, WABCO Fahrzeugsysteme GmbH***
   Thomas Wolf and Dr. Oliver Schütte explained the objectives of the automated test process at WABCO, in which SCALEXIO and the Automotive Simulation Models (ASM) are playing a major role.
6. ***Christoph Freier, Volkswagen AG***
   Christoph Freier reported on a groundbreaking project on completely virtual ECU validation at Volkswagen AG, in which dSPACE VEOS was evaluated as a test platform.
7. ***Stefan Riegl, MAN Truck & Bus AG***
   Stefan Riegl showed how an engineering data backbone benefits the automation of integration tests with dSPACE simulators.
8. ***Alessandro Recca, ABB Switzerland Ltd.***
   Alessandro Recca presented the automatic testing of drive software for rail vehicles and showed how ABB is successfully using dSPACE's data management software SYNECT in its processes.
9. ***Gerhard Kiffe, Audi Electronics Venture GmbH***
10. ***Thomas Bock, Audi Electronics Venture GmbH***
    Gerhard Kiffe and Thomas Bock presented their project for organizing the continuous improvement process in embedded software development at the Audi Software Group (EnProVe), which also involves strategic cooperation with dSPACE on developing the SYNECT data management software.
11. ***Dr. Mouham Tanimou, Robert Bosch GmbH***
    Dr. Mouham Tanimou described a method that supports the easy exchange of data specifications between OEMs and suppliers, based on ASAM MDX (Meta Data eXchange Format). For MDX generation, Bosch is relying on dSPACE TargetLink® and the TargetLink Data Dictionary.
12. ***Dr. Florian Wohlgemuth, Daimler AG***
    Dr. Florian Wohlgemuth provided insights on an AUTOSAR-compliant development process for comfort and interior functions. Daimler is using the dSPACE TargetLink production code generator to generate the production code for the AUTOSAR ECUs.
13. ***Dr. Heiko Zatocil, Siemens AG***
    Dr. Heiko Zatocil presented an ISO 26262-compliant, model-based development process. Siemens is successfully using the production code generator dSPACE TargetLink for this.
14. ***Philip Markschläger, Dr. Ing. h.c. F. Porsche AG***
    Philip Markschläger presented early insights on the driving efficiency system Porsche InnoDrive and showed how dSPACE MicroAutoBox is used for prototypical energy management predevelopment.

SYNECT: Central Data Management Has Major Extensions

dSPACE has added yet another new module to SYNECT®, the data management and collaboration software first launched in the fall of 2012. There are now three SYNECT modules in all: Test Management, Variant Management, and Signal & Parameter Management.
SYNECT focuses on the consistent, central management of development data, and is ideal wherever software and ECUs are developed and tested by model-based design. Data can easily be reused either within the same team, or across different teams, process phases and projects.
SYNECT Test Management is a convenient way to manage tests, link them to the underlying requirements, combine them to make execution plans, and utilize them directly for test execution (for example, in HIL testing with AutomationDesk® or SIL/MIL/PIL testing in the context of Simulink® and TargetLink®). Clear, well-organized analyses of tests, test coverage and test progress can be generated quickly and simply by using the test results stored centrally in SYNECT, and then used for planning further tests. The module can be combined with SYNECT Variant Management for close interaction between variant management and test management.
The latest module is SYNECT Signal & Parameter Management. This gives users the capability to manage signals, parameters and parameter sets centrally throughout the entire development process. SYNECT Signal & Parameter Management supports numerous file formats for exchanging signals and parameters and using them with other tools in the development process. For example, Simulink users can flexibly exchange parameter values, and signal and parameter definitions, between their function or plant model and SYNECT's central data management facility. TargetLink users can exchange variables, scalings and type definitions between the file-based TargetLink Data Dictionary and SYNECT. Parameters for ECU calibration can be imported and exported in DCM and PAR files. With SYNECT Variant Management, users can specify dependencies between parameters and variants, and create and manage parameter sets for different variant configurations.

Yet another SYNECT module, for model management, is planned for the end of 2013.

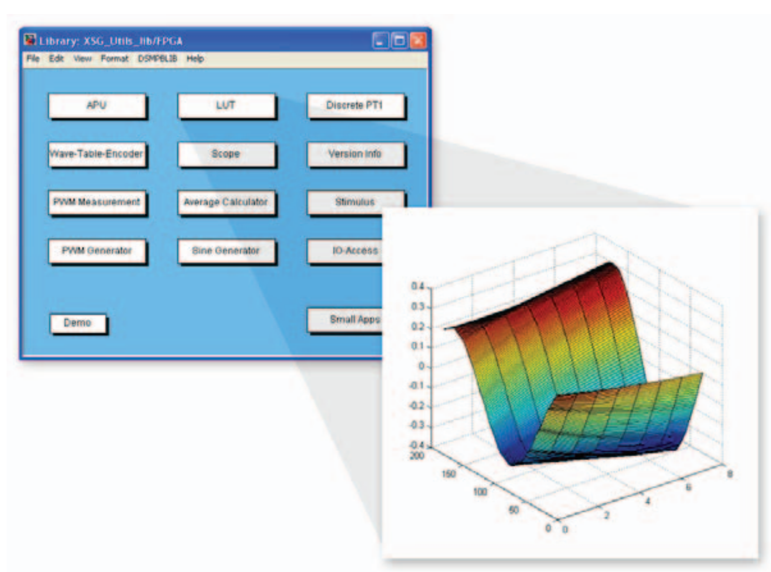
MicroAutoBox II with Multistage Watchdog Mechanism

dSPACE has now equipped its MicroAutoBox® II with a multistage watchdog mechanism. Its run-time monitoring, with configurable time-out behavior, yields a higher level of security for prototype vehicles used in road and fleet tests because the system can immediately respond to critical situations appropriately and as defined by the customer. The system watchdog is implemented via FPGA in the hardware independently of the MicroAutoBox II processor, while the individually configurable software watchdogs enable targeted monitoring of the software tasks in the user model. As soon as the user software generates a timeout in the system watchdog, the configured behaviors kick in. This timeout behavior includes examples such as backing up data, setting defined output values, or a complete system reboot. The new watchdog mechanism comes with the dSPACE 2013-A software release. For simple, block-diagram-based programming and integrating the new watchdog into existing Simulink control models, dSPACE provides a new dSPACE Real-Time Interface Blockset (RTI) as an interface. This new Watchdog Blockset supports all MicroAutoBox II variants. At least 20 tasks (more is possible, depending on the memory resources being used) can be monitored simultaneously and independently from each other. In addition, individual timeout behavior can be assigned to each respective task. ■

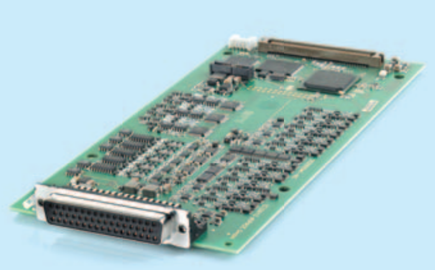
Implement FPGA Models Faster with XSG Utils Library

The XSG Utils Library from dSPACE gives users of real-time FPGAs a large number of extended function blocks for implementing their own projects. These range from extended I/O, scope functions and look-up table functions to an average calculator, a sine generator and a wave-table encoder. The function blocks can be used in rapid control prototyping projects with dSPACE MicroAutoBox® II and also for hardware-in-the-loop simulation with the DS5203 FPGA Board.

For further information, visit our website at www.dspace.com/go/xsg-utils ■



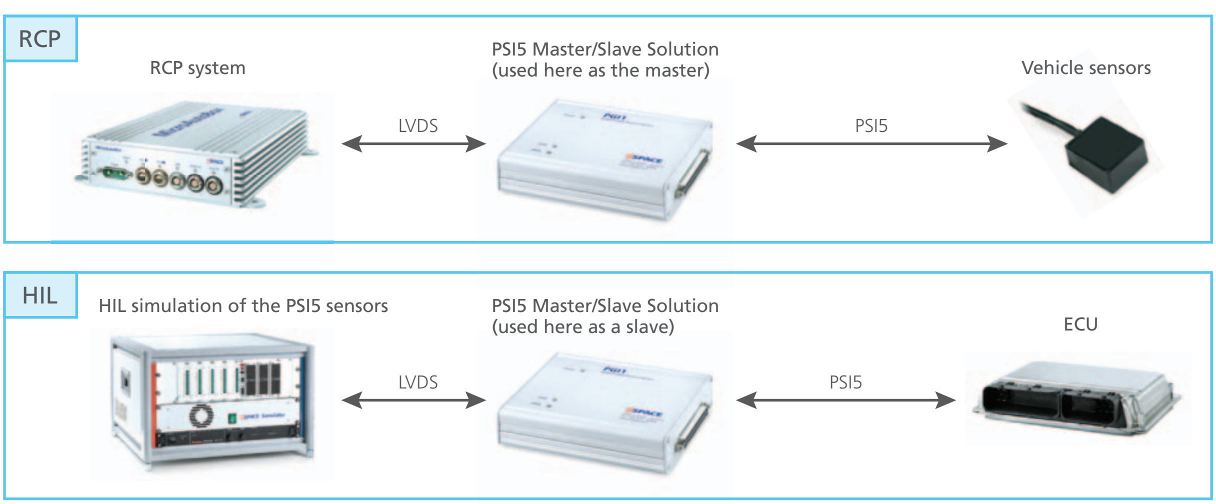
SCALEXIO Solutions for Electric Motor Applications



SCALEXIO® now has a special new board for HIL tests of electric drive ECUs: the DS2655 FPGA Base Module. The board includes a freely programmable FPGA and is given the necessary number of I/O channels through additional I/O modules. The DS2655 makes it possible to simulate electric motors with the short simulation cycles they require – for hybrid vehicles, electric motors, wind energy converters, etc. dSPACE also offers simulation models for electric drives and their power electronics: the XSG Electric Component Models.
The FPGA is configured graphically with the RTI FPGA Programming Blockset and dSPACE Configuration-Desk. The FPGA program itself can be tested in an offline simulation before being implemented on the real-time hardware. This gives users the ability to react flexibly to new requirements, for example, when new interfaces are added or if the execution of model parts has to be sped up. ■

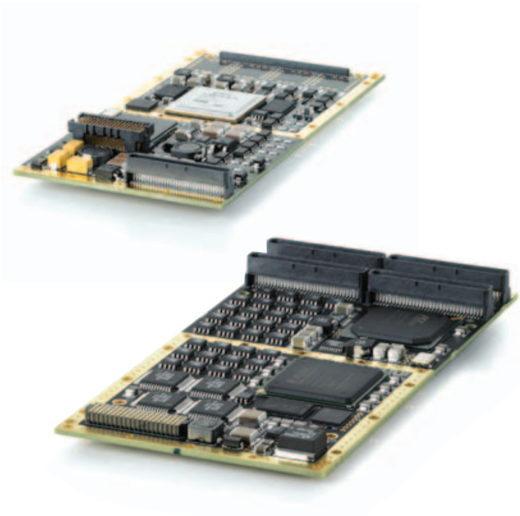
Integrating PSI5 Sensors

PSI5 (Peripheral Sensor Interface 5) is a widely used open standard for connecting vehicle sensors to electronic control units. The new PSI5 Master/Slave Solution from dSPACE provides an easy way to simulate PSI5 sensors in hardware-in-the-loop tests or to connect them in rapid control prototyping with **MicroAutoBox/AutoBox**. The PSI5 Master/Slave Solution consists of hardware based on the dSPACE Programmable Generic Interface (PGI1) and an RTI blockset for easy graphical configuration. It can represent 10 slaves and 4 masters. ■



Top: The PSI5 Master/Slave Solution connects the RCP system (here: MicroAutoBox) to the real vehicle sensors.
Bottom: The HIL simulator simulates the vehicle sensors, while the PSI5 Master/Slave Solution provides the connection to the ECU via the PSI5 bus.

SCALEXIO Solutions for Aerospace Applications



dSPACE has added the first I/O interfaces for aerospace applications to its SCALEXIO® hardware-in-the-loop (HIL) system. The new interfaces provide access to ARINC-429 and MIL-STD-1553 networks, and are based on tried-and-trusted PMC/XMC modules from Avionics Interface Technologies (AIT). These modules use the PCI(e) interfaces in the SCALEXIO Processing Unit to ensure the optimum bandwidth for data exchange with the real-time model. To guarantee real-time capability, dSPACE developed dedicated QNX drivers for this application case. ■

MicroAutoBox II: FPGA-Based Cylinder Pressure Indication for Vehicle and Laboratory

With the new Cylinder Pressure Indication Blockset, the MicroAutoBox® II 1401/1511/1512 with an inserted DS1552 Multi-I/O Module can now be used for FPGA-based cylinder pressure measurement and indication (MABXII Cylinder Pressure Indication Solution). The solution supports angle-synchronous pressure measurement with 0.1° max. resolution. The evaluation of the pressure values can be controlled by several algorithms in real time, such as released heat, mass fraction burned, the indicated mean effective pressure, etc. ■

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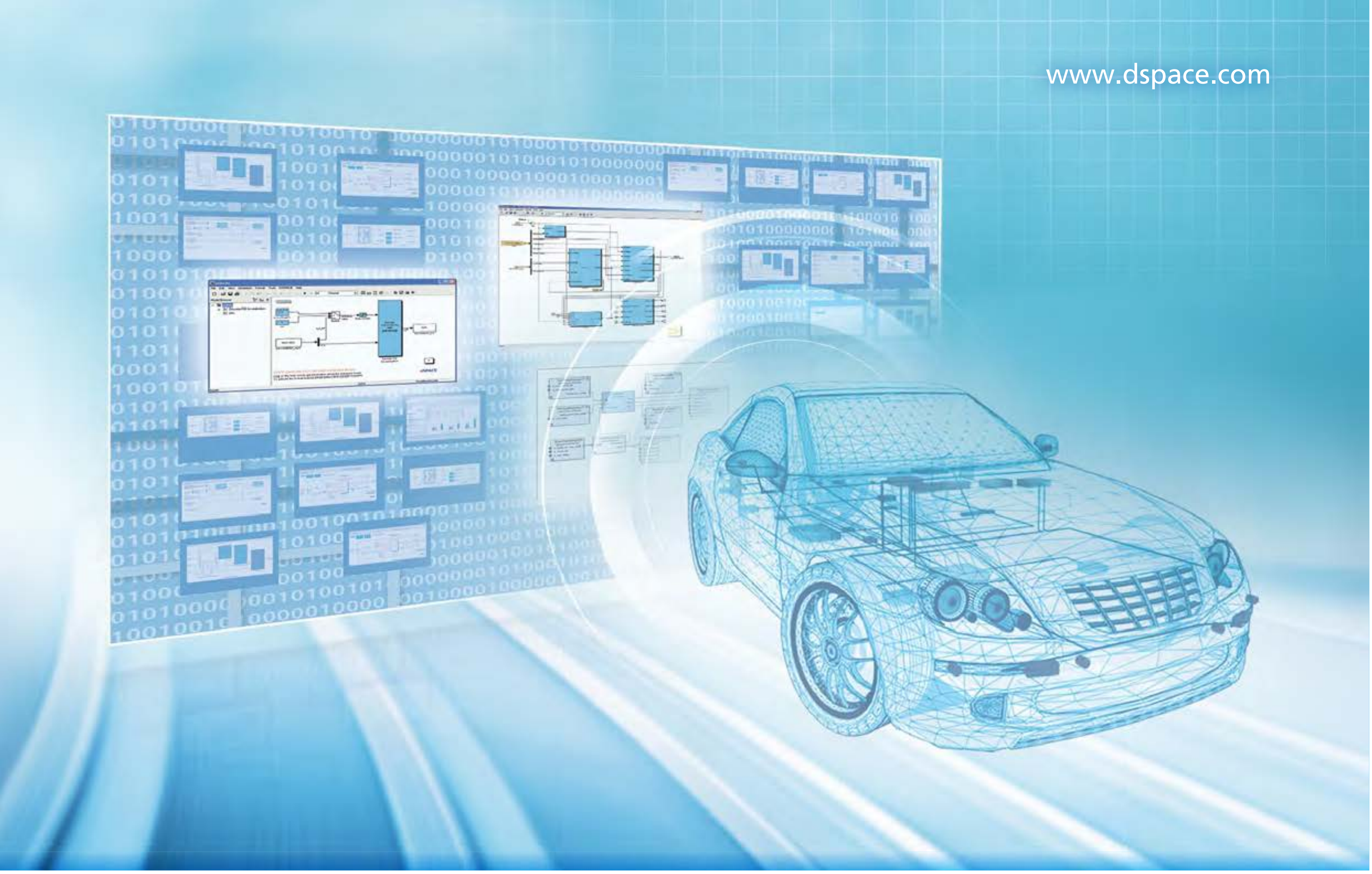
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