

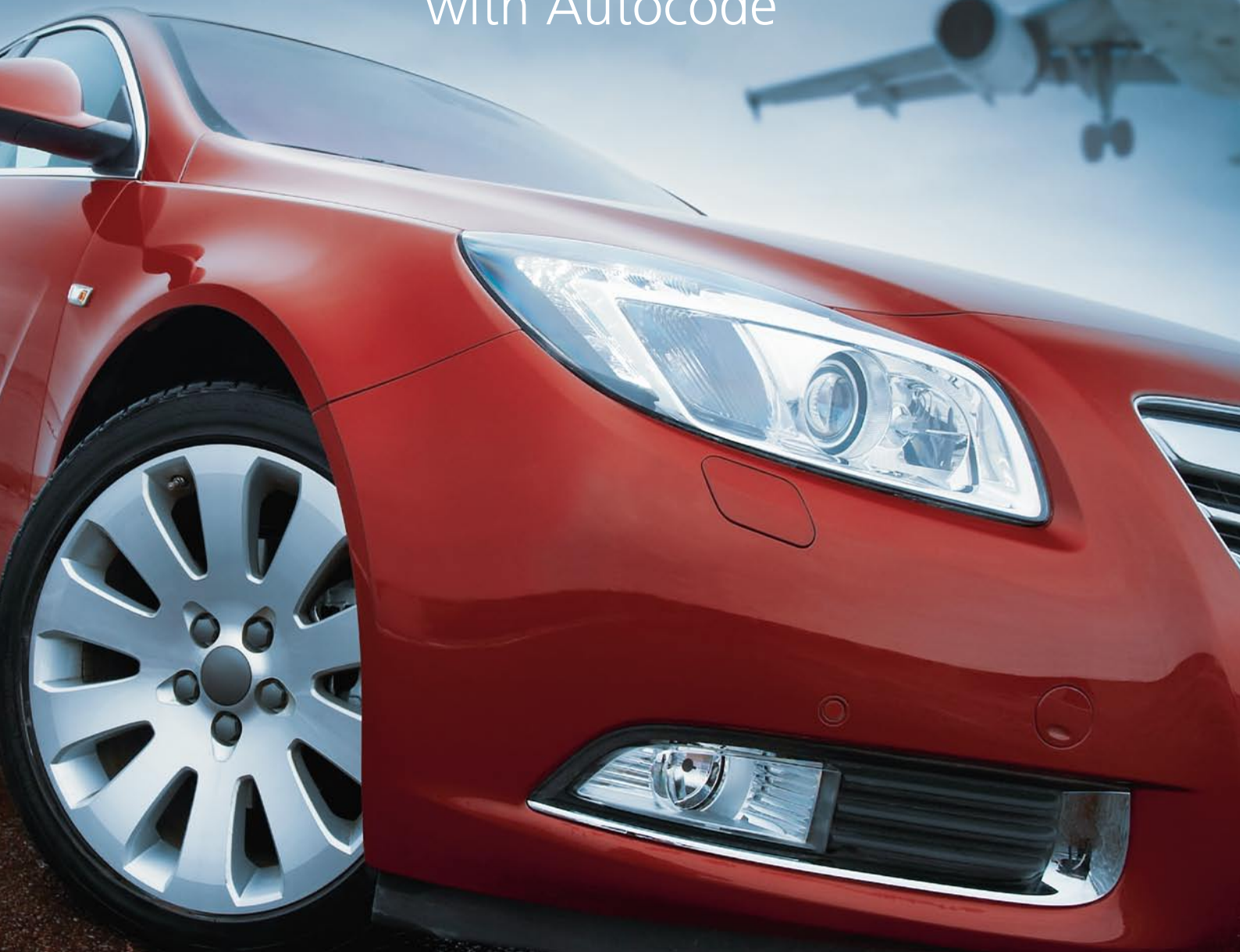
dSPACE

MAGAZINE

SPECIAL EDITION

TargetLink

Driving the Future
with Autocode



TargetLink: A Success Story over the years



Aerospace Industry



Automotive Industry



Buses and Trucks



Off-Highway Vehicles



“TargetLink has become the leading production code generator in the automotive industry.”

*Michael Beine,
Lead Product Manager TargetLink*

When we introduced TargetLink in 1999, production-quality code generation was a brand new technology. TargetLink provided the much sought-after missing link between the prototyped controller model and production code running on the electronic control unit (ECU). TargetLink immediately sparked a lot of interest. As always when new technology is introduced, some customers got on board right away, but many were understandably cautious and asked “Does it really work? Is the technology ready? Is TargetLink mature enough?”

Customer evaluations focused mainly on code efficiency, and the efficiency of TargetLink’s code was the door opener, the key to convincing software engineers to consider code generation.

Today, model-based development and automatic production code generation are established methods in embedded software development. A shift from code-based development to model-based development and

autocoding is in full swing. Companies all over the world are generating their ECU code straight from models, and with success. They are mastering increasing complexity and benefiting from acknowledged advantages such as shorter development times, improved product quality, and lower development costs.

TargetLink has become the leading production code generator in the automotive industry. Code efficiency is no longer an issue of debate – process integration is the key to success. Entire departments have integrated TargetLink into their development processes and tool chains and have significantly improved their development efficiency.

TargetLink code controls engines, reduces emissions, and shifts gears. It steers, brakes, avoids rollovers, controls the distance to other vehicles, and even keeps you awake while driving.

TargetLink’s use also goes beyond the automotive industry. For example,

among other aircraft the Airbus A380 and Boeing 737 fly with TargetLink code onboard. Trucks, buses, harvesters, construction machines, specialty vehicles and fire-fighting vehicles are also equipped with TargetLink code. Simply put, TargetLink code can be found in any kind of application. This issue presents a collection of some of the most interesting applications in the various fields. We invite you to take a closer look. Read what our customers say and what they have achieved with TargetLink over the last decade.

If you aren’t using model-based development and autocoding yet, you should consider doing so to benefit from their proven advantages. Our commitment is to drive TargetLink forward to ensure that automatic code generation helps you to reach your development goals with success.

Michael Beine
Lead Product Manager TargetLink



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Lead Product Manager TargetLink

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Innovation through Software

Functionality realized by software has become an important differentiating factor. Today, OEMs regard software development as a core competence. TargetLink is used to develop functions that give a competitive edge. Mercedes-Benz' Attention Assist and Audi's active sport differential are just two examples. TargetLink is also used when it comes to introducing new technologies: the first production lithium-ion hybrid, the Mercedes-Benz S 400 HYBRID, or putting FlexRay on the road in the BMW X5.

Vorsprung durch Technik – In the Lead with In-House Software Development

AUDI

“In 2003, Audi Electronics Venture GmbH and AUDI AG took their first steps toward using TargetLink. A lot has changed since then. Strategic pilot projects were successfully brought up to production level, and an established method for introducing innovative vehicle functions has evolved at AUDI AG. To ensure that the available human resources are used optimally, AUDI AG set up project teams made up of representatives from the function development departments at AUDI AG and software experts from Audi Electronics

Venture GmbH, and tools like TargetLink are being used. In conjunction with support services that are truly a benchmark for tool suppliers, and correspondingly well-trained application engineers from dSPACE, it was possible to set up a standard development process that completely fulfills AUDI AG’s requirements. Whether in the development of driver assistance systems (Audi lane assist, Audi side assist, Audi adaptive cruise control), in energy management, for the quattro with its sport differential or in the devel-

opment of engine ECU functions – TargetLink is an integral part of the development process. In-house software development has become one of Audi’s core competencies. Since 2008 and the market launch of the new A5, TargetLink code has been a standard component in every new Audi that is developed. The proportion of Audi software will continue to increase, because modularity will also become a firm principle in this area, so that innovative functions can be implemented efficiently in the future.”

Dr.-Ing. Werner Bauer-Kugelmann

*Modeling and Code Generation
Coordinator, Audi Electronics
Venture GmbH*

Sascha Kovačević

*Head of Model-Based Software
Development, Audi Electronics
Venture GmbH*



Putting FlexRay on the Road

Active suspensions greatly enhance ride comfort, for example, by reliably damping the movements of the vehicle body. As published in 2006, the BMW Group developed a new damper control for dynamic stabilization, based on a distributed controller consisting of a central electronic control unit (ECU) and satellite ECUs. Production code for the extensive function model was generated with TargetLink in a largely automated development process and put on the road in the BMW X5, the first FlexRay vehicle.

Prototyping and Implementation

The function algorithms that were developed with Simulink® were first tested with a dSPACE AutoBox connected to the FlexRay bus. The tested model was then used directly for production code generation and implementation. To prepare implementation on the target processors, reference traces for the essential functional units were produced by performing model-in-the-loop (MIL) simulation and then in the next step compared with TargetLink code by means of software-in-the-loop (SIL)

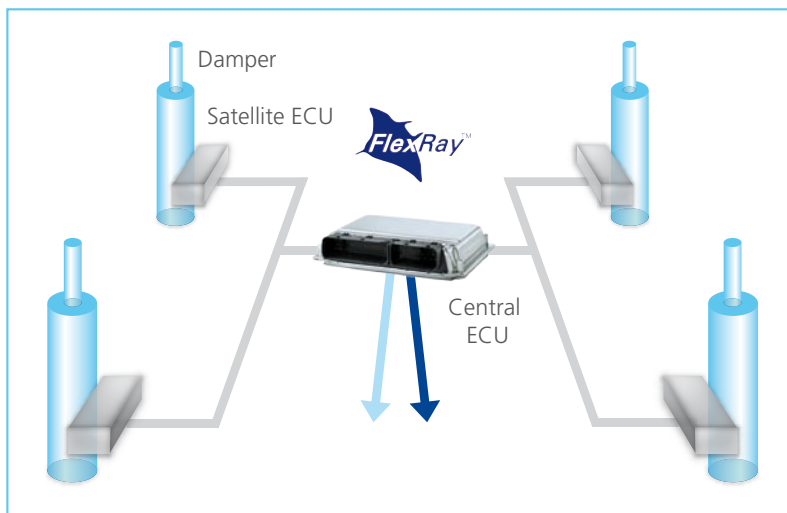


BMW put the high-speed bus technology FlexRay on the road for example with its X5.

simulation. This allows problems such as unwanted fixed-point effects in the satellites to be detected and solved. Processor-in-the-loop (PIL) simulation was used to test the algorithms and the resource requirements directly on the target processors before the ECUs were parameterized. This has the particular advantage that problems with memory management and execution times are detected during early development

phases. These were evaluated with the support of TargetLink's diagnostic functions. The TargetLink code generated for the subsystems was integrated into the BMW Standard Core Software. The BMW Standard Core Software comprised low-level functions from various suppliers, drivers for FlexRay and CAN, and an OSEK operating system. The overall function model was modeled from 12,000 blocks, from which 100 KB of code was generated for the central controller and 11 KB each for the satellites.

Source: BMW: Production Code for Distributed Controller, Florian Büttner, Tobias Schmid, BMW AG, dSPACE NEWS 2/2006



The control system has a distributed design. The intelligent satellites communicate with a central ECU via the FlexRay bus.

Mastering Complexity for Interior Systems

VALEO

"At the VALEO Interior Controls and Switches and Controls divisions in France, we have been using TargetLink as a production code generator to develop software for climate control, and human-machine interfaces since 2004. Earlier projects were carried out with a different code generator, but in 2004 we decided to change to TargetLink, and since 2006 we have successfully completed 10 large-scale production projects. Each of these projects related to a new vehicle from an international OEM. Current projects are the new

Renault Mégane and the new BMW Z4. As development cycles became increasingly shorter, we were repeatedly able to boost our own development speed thanks to TargetLink. In a typical project, there are usually 2-3 developers using the tool in parallel. We are very satisfied with the results, particularly since TargetLink always gives us smooth hand-offs between modeling and coding. Even if models are very complex, TargetLink and the associated dSPACE Data Dictionary ensure they are well-organized and seam-

less. We also appreciate the well-structured code that is produced and the ability to configure what the code should look like. Requirements like multitasking systems and variant management are easy to handle. We utilize the entire scope of TargetLink's functionality including its AUTOSAR features, which we are using in conjunction with SystemDesk in an ongoing project. Overall automatic code generation with TargetLink has proven useful to us since it saved precious time in production projects."

Loïc Hervé

*Software Department Manager,
VIC/VSC division, VALEO Interior
Controls (VIC)/VALEO Switches and
Controls (VSC), France*

Fabien Dias

*Software Design Leader,
VIC/VSC division, VALEO Interior
Controls (VIC)/VALEO Switches and
Controls (VSC), France*





Green Technology with TargetLink



In the face of rising energy costs and imminent climate change, the international car industry is forging ahead with innovative drive concepts such as electric motors and fuel cells. Today several customers use TargetLink for the development of hybrid vehicles, the most prominent example being the Mercedes-Benz S 400 HYBRID. And TargetLink's first production project ever was a green one: Nissan developed a SULEV (Super Ultra Low Emissions Vehicle) emission controller in just 3 months, and the first TargetLink-generated code hit the road in 2000, only a few months after TargetLink had been released.

Nissan 2000MY Sentra CA: Meeting the PZEV Requirements

NISSAN

Back in the year 2000, Nissan launched an engine control component for the 2000 Sentra, the first TargetLink-developed product to go into production – a green application that made strict partial zero emission reduction a reality. Reducing vehicle emission levels had become a big issue. In California, USA, the strict Partial Zero Emission Vehicles (PZEV) standard was introduced. The Nissan 2000MY Sentra CA was the first car ever in series production to meet the PZEV requirements. Having chosen TargetLink for code generation, Nissan shortened the development time down to 60% for the air/fuel controller.



Design Concept

To achieve the required emission levels, Nissan developed a new air/fuel ratio controller along with an efficient catalytic converter. The cleaning effect was activated in a very narrow range of air/fuel ratio around stoichiometrics. Enhanced catalytic performance is usually obtained by dedicated feedback

control of the air/fuel ratio with a corresponding exhaust gas oxygen sensor. Problems in increasing the catalytic converter's performance were caused by the time delay in the feedback loop. The new air/fuel ratio controller installed in the Sentra CA therefore had an observer. This constantly monitored the state of

the catalytic converter. The observer's output was used in a feedforward control to adjust the air/fuel ratio. This new air/fuel controller always got maximum performance from the catalytic converter.

Source: Shigeaki Kakizaki, Nissan Motor Co., Ltd., Achieving the PZEV requirements, dSPACE NEWS 2/2000

*Mr. Shigeaki Kakizaki
Nissan Motor Co., Ltd., Japan*

TargetLink: The Primary Tool of Choice

"We are truly thankful for encountering such an innovative tool. When using model-based development to develop emissions reduction control for the SENTRA CA, we were stumped as to how to produce mass production code from a fully verified model. This was because the time remaining after handcoding was short and code generation technol-

ogy was not considered as good as it is now. However, TargetLink met our expectations admirably and led to our success in obtaining the world's first PZEV certification. Over the 10 years since, like TargetLink, we have expanded applications while continuing to evolve our development process, and more than 50% of our engine controller

binary code is now generated by TargetLink. We are currently planning to actively increase this percentage and are deploying TargetLink in transmission and other controller development as well. We hope that TargetLink will continue to evolve in the coming ten years."

TargetLink for a Hybrid Vehicle

MAGNA STEYR

“To integrate components into a hybrid vehicle drivetrain, extensive modification to the electronic and mechanical systems is required in order to ensure the global optimization of all systems by a hybrid drive strategy. MAGNA STEYR and its cooperation partners integrated new hybrid components in a prototype vehicle and implemented a control system. From the beginning, the function and software development process was geared to achieving a seamless transition to production development, especially to production code generation. At MAGNA STEYR, TargetLink is used for production code generation. TargetLink has, for example, also been used for developing function software for the battery management system.”



Dipl.-Ing. Theodor Schöberl
 Drivetrain Control Systems
 Magna Steyr, Austria

Eco-Friendly Starter-Alternator

VALEO

Valeo Systèmes Électriques, a member of the Valeo group, used dSPACE tools according to the standardized V-cycle to develop a reversible, belt-driven starter-alternator. This innovative concept brings together the features of an alternator and a starter in one product to reduce fuel consumption and CO₂ emissions. During the development process, Valeo first descended the V-cycle using automatic code generation with TargetLink, then ascended the V-cycle using dSPACE tools combined with Valeo facilities and methodologies. Valeo's

micro-hybrid concept combines the functions of a starter and an alternator in one unit: the starter-alternator StARS. The StARS system is made up of an electric machine, an associated control box, and a three-phase cable linking the two, all fitted under the hood. All application components were generated automatically by TargetLink and tested extensively with its test features.

Source: Sébastien Roue, Valeo Systèmes Électriques, Eco-Friendly Starter-Alternator, dSPACE NEWS 2/2007



Battery Management for Mercedes-Benz S 400 HYBRID

JOHNSON CONTROLS-SAFT

25 kilograms: That's the weight of the hybrid battery in the Mercedes-Benz S-Class S 400. The battery consists of 35 cylindrical, rechargeable lithium-ion batteries and delivers a peak power of up to 15 kW (20 HP). The electric and thermal protection of this little bundle of energy is one of the battery ECU's most important tasks. The ECU's algorithms were developed in a joint venture between Johnson Controls and SAFT. dSPACE TargetLink has been used to generate the ECU software.

Model-Based Development

One of the project's greatest challenges was to combine the know-how of battery experts and the requirements of automotive engineers, and develop a system that guarantees high vehicle availability, while protecting the battery cells at the same time. The task was to take theoretical battery models and cell data obtained under laboratory conditions, and shape them into executable software in such a way that they would be viable in practice, yet still provide



sufficient precision. Model-based development and the production code generator TargetLink from dSPACE made it possible to simply integrate existing Simulink® battery algorithms and battery characteristics into the controller model, and to use existing Simulink battery models for validation. Because the aim of this project was to design the first-ever control for lithium-ion technology, the controller software had to be developed entirely from scratch. In-house modeling guidelines based on the modeling guidelines published

by dSPACE helped to prepare the model for the best possible implementation as efficient production code. The function developers for the energy management system (EMM) implemented in the engine ECU also use TargetLink, so working with them ran smoothly and coordination between developers in different companies was much easier.

Source: 25 Kilograms of Pure Energy, Torben Materna, Johnson Controls-Saft Advanced Power Solutions GmbH, dSPACE Magazine, 2/2009





Trucks and Off-Highway

The world's leading truck, bus and off-highway manufacturers rely on TargetLink. Trucks have been equipped with TargetLink code for several years now. Buses, harvesters, construction machines, trucks for defense, and fire applications run with TargetLink code. Daimler's commercial vehicle division can no longer imagine a development process without TargetLink. MAN established model-based development and production code generation as its standard development approach and significantly improved process maturity by using TargetLink. In 10 years, MAN has not had a single production-relevant code generation error.



Well-Established: TargetLink at MAN Nutzfahrzeuge

MAN

“By developing and using innovative technologies, we meet the rising challenges posed by traffic – according to each specific sector and transportation task. This is why we were among the first users of TargetLink ever. Since 1999 we have been using TargetLink to develop the software of our electronic control units and achieve first-class results regarding code and process efficiency, quality, and development time, all of which contributes significantly to our corporate success. At MAN Nutzfahrzeuge, TargetLink has become a permanent component in all our electronics development.

The first projects that included TargetLink, such as dynamic headlight range control and exhaust gas aftertreatment (CRRT) for trucks,

gave us fundamental knowledge and experience in using the production code generator efficiently. Since then we have carried out several projects with TargetLink, establishing model-based development together with automatic production code generation as our standard development process. The percentage of code generated automatically with TargetLink is approximately 95%. The software often extends to up to 700 TargetLink subsystems with thousands and thousands of TargetLink blocks. Up to 25 in-house engineers are involved in each of the complex development projects. With TargetLink, we achieve a code and process maturity that goes far beyond the maturity obtainable by handcoding. What’s more, we can integrate

a multitude of metadata, for example for scaling, and use it automatically – something that could never be managed manually.

TargetLink is our standard tool for automatic code generation. In the 10 years that we have been using it, not a single production-relevant code generation error has ever occurred.”

Stefan Teuchert
 Head of Electric/
 Electronic Systems –
 Vehicle Dynamic
 Functions,
 MAN Nutzfahrzeuge AG





Christoph Bussmann

*Software Developer,
CLAAS Selbstfahrende Erntemaschinen GmbH*

CLAAS

Automated Harvesting Processes

“At CLAAS, we aim to maximize the performance of agricultural machines such as combine harvesters, forage harvesters and tractors by introducing automated functions. An automatic cutting-height control i.e. is applied to compensate for uneven terrain, an automatic steering device follows the contour of the crop edge. Even unloading is supported by adaptive control mechanisms to maintain maximum productivity. To make optimum use of the short testing

window during harvest for developing such functions, it is important for the software to reach a high level of maturity before harvest starts. TargetLink enables us to achieve this maturity: We test the generated production code intensively in the model and then transfer it to the electronic control unit one-to-one. We have been using TargetLink at CLAAS since 2000, and it has been a permanent major component in our development processes ever since.”



OSHKOSH

Rongjun (Ron) Zhang

*Senior Chief Principal Engineer-
Controls,
Advanced Product Engineering
Oshkosh Corporation*

“TargetLink has been the backbone software in our model-based development process for several defense and commercial development programs at Oshkosh Corporation, and we have used it to generate production code to meet the stringent requirements from our customers in the past five years.”



Michael Jesberg

*Software Developer, Daimler Trucks/
Commercial Vehicle Division,
Daimler AG*

DAIMLER

“Time-to-market is a crucial factor for us when we implement new control concepts on an electronic control unit, and TargetLink gives us exactly the productivity we need for the short development times we desire. Since 2001, we have been using TargetLink to rapidly develop and implement control software for our commercial vehicle engine ECUs. TargetLink has all we need to foster efficient, intercompany cooperation within our development team consisting of our supplier Continental and our development partner Detroit Diesel. In all three successfully completed production projects, TargetLink

proved that it is a worthy, reliable tool and was used to program approximately 90% of the application software, made up of 85,000 model blocks. We simply cannot imagine a development process without TargetLink at Daimler’s Commercial Vehicle Division and its partners. With its extensive simulation options we validate functions during the initial development phases. Automatic documentation also considerably reduces the amount of manual work. We’re looking forward to further years of success with our programmer, TargetLink.”

DONGFENG

Automated Manual Transmission



The Dongfeng company (the Chinese name means east wind) is one of the five largest Chinese car manufacturers and the leading manufacturer of Chinese commercial motor vehicles. A research team at Dongfeng developed a new Automated Mechanical Transmission (AMT) based on the EQ4195 truck with a 12-speed manual transmission. The system consists of a 12-speed mechanical gearbox and an automatic shift control system (ASCS). The ASCS includes several sensors and actuators, and a transmission control unit (TCU).

Tools and Development Cycle

The function model developed with Simulink® was first tested in the truck with a dSPACE MicroAutoBox. The developed functions were already optimized and adapted to the mechatronic system during the prototyping phase. To implement the model on the TCU equipped with a Freescale MC9S12DT128B microcontroller, fixed-point object code had to be generated. The automatic scaling features of TargetLink were of great help in fine-tuning the fixed-point code. Automatic scaling was a huge time saver as it took

away the tedious and error-prone task of manually scaling each variable and each operation in the software. The precision of the scaled code was easily judged by comparing model-in-the-loop (MIL) with software-in-the-loop (SIL) simulations; errors like overflows were detected that way. The final object code was generated using the CodeWarrior compiler and merged with custom code.

Advantages of Production Code Generation with TargetLink

When the production code generator TargetLink is used, the definition of the module function is clearer, and implementing and validating the arithmetics is more convenient and takes less time. The model data is completely managed in TargetLink. In addition, the A2L file which is required by the calibration software also can be generated with TargetLink. Overall, the efficiency and quality of development can be greatly improved.

Results

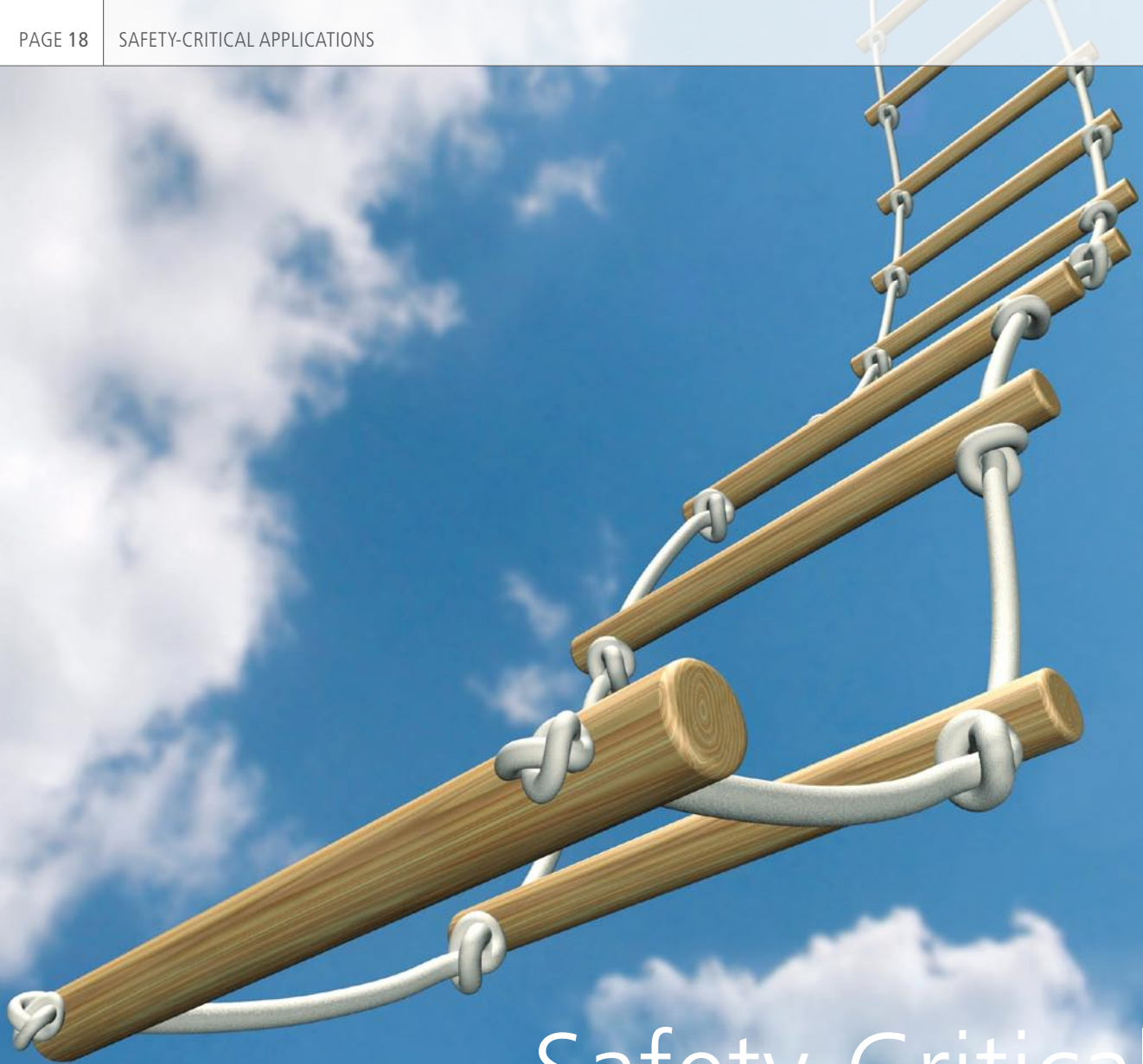
By implementing this automatic shift control system, the Dongfeng research team has succeeded in considerably

reducing fuel consumption and improving powertrain efficiency. For example, the driver has much less work to do than with the predecessor systems.

Outlook

The system is currently undergoing second-cycle development. Meanwhile, improvements are also being made to the development process. A real-time operating system (such as OSEK), well supported by special blocks in TargetLink, is used in the new development, and multi-rate implementation will be realized by using TargetLink's multi-rate features.

*Source:
Hongfei Ni
Dongfeng Research and Development
Automated TM, dSPACE NEWS 1/2008*



Safety-Critical Applications with TargetLink

More and more safety-related systems have been – and will be – introduced into modern vehicles. The aerospace industry looks back at many years of designing electronic systems under safety aspects. TargetLink has proven its maturity for safety-related applications in both the automotive and the aerospace industry. For example, the Airbus A380 and the Boeing 737 are equipped with code from TargetLink, and the upcoming Boeing 787 Dreamliner will be. In the automotive industry, several SIL 3 and ASIL D applications have been successfully developed with TargetLink. In 2009 TargetLink was certified by the German certification authority TÜV SÜD for ISO 26262 and IEC 61508.

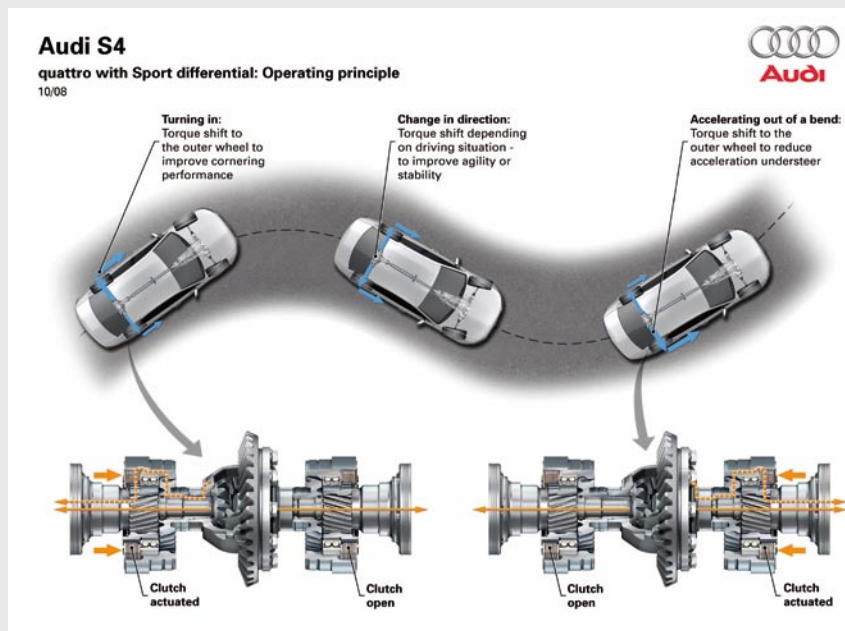
quattro® with Sport Differential

AUDI

“With the active sport differential, Audi has elevated the vehicle dynamics of cars with quattro permanent all-wheel drive to a new level. The innovative control system distributes the torque from the engine in continuously variable proportions between the rear wheels. This greatly increases the agility, driving pleasure and active driving safety. A precisely controlled torque flow steers the car even more responsively and directly around corners and retains the directional stability even longer. Understeer is a thing of the past. Improving the vehicle dynamics by variably distributing the drive torque via an actively controlled rear-wheel differential is a safety-relevant task.

Function and Software Development

The function model of the Audi vehicle dynamics controller results from a rapid prototyping project that used dSPACE AutoBox. The first task was to transfer the Simulink® prototype model into an implementation model that was suitable for automatic code generation. Our decision to use a 32-bit floating-point processor, the Infineon TriCore 1766, in the production ECU simplified this transition and allowed production code to be generated at an early stage. The focus of software development is no longer only on customer-oriented functions. For the active sport differential, it is expanded to include the requirements of production software development regarding safety-related functions and verification methods.



What's important is a modular setup of the entire function model. This makes it possible to work incrementally: creating and executing separate tests based on module specifications, function specifications, and the system specification for each individual implementation step. In addition, precise impact analyses can be performed, and the influence of parameter changes on modules and functions can be evaluated. Only modules and functions that were affected by a change have to be re-examined. Using processor-in-the-loop simulation, resource analyses were performed for the various software versions of the vehicle dynamics controller. TargetLink's code size report, and the integrated execution time and stack measurement, were the basis for these analyses.

Summary

Together with the dSPACE Support Team and a dSPACE Resident Engineer, we successfully met the requirements for a safety-relevant, in-house software development. We achieved the best possible code optimization and also ensured protection of our intellectual property towards the supplier as an external system integrator."

*Thomas Bock,
Software Project Manager,
Alexander Schmitt,
Technical Coordinator Software Test,
Audi Electronics Venture GmbH,
Ingolstadt*



Cabin Pressure Control

Since 2000, Nord-Micro has been using the dSPACE production code generator TargetLink to develop cabin pressure controls for a wide range of aircraft types. In Nord-Micro's development processes, the auto-coded software effortlessly fulfills the strict requirements of aircraft manufacturers such as Boeing and Airbus, and also those of the FAA and EASA aviation authorities.

Cabin Pressure: Safety First

Automatic cabin pressure control in aircraft is not only important for comfort, but also a safety-critical

functionality. An error in the cabin pressure control system could cause the crew and passengers to lose consciousness.

Successful Use of TargetLink since 2000

Nord-Micro has been using TargetLink to develop and autocode controller software since 2000. Thus, numerous aircraft, from regional jets to the Airbus A380, have cabin pressure control systems on board that contain controller software developed and autcoded with TargetLink. The controller software meets the rigorous requirements defined by aircraft manufacturers and aviation authorities, including certification up to DO-178B level A.

Reduced Test Workload

In the development process at Nord-Micro, TargetLink is not only used for autocoding, but also in other process steps such as automatically generating documentation, defining software requirements, model design, auto-

matic scaling, code review, and software integration testing. Amongst the TargetLink features that considerably reduce the test workload at Nord-Micro are the good readability of the TargetLink code, traceability between the code and the model, and deterministic code generation. Moreover, the flexible configurability of the source code enables Nord-Micro to integrate several TargetLink models into the real-time software without much difficulty. The efficiency of the source code always fulfills the real-time requirements. Integration with other development tools such as IBM Rational® DOORS® and Rational® Test RealTime ran smoothly.

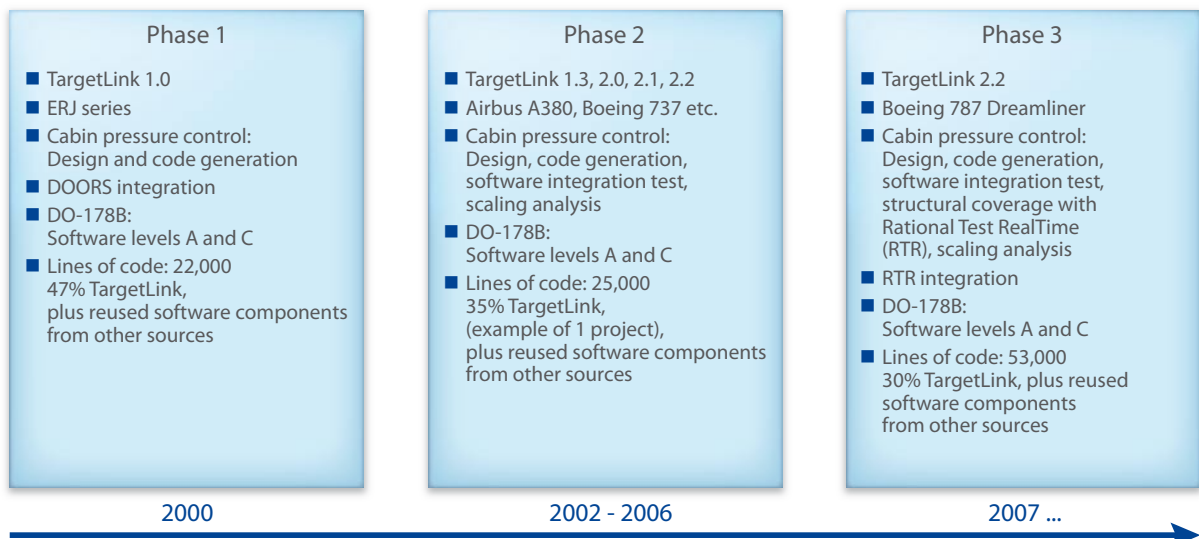
TargetLink for Future Projects

Following positive experience with TargetLink, Nord-Micro will continue to use the tool for developing cabin pressure control systems in new aircraft in the future.

Source: Andreas Alaoui, Maximum Safety, dSPACE Magazine, 1/2009



Using TargetLink



TargetLink Certified for IEC 61508 and ISO 26262

The German certification authority TÜV SÜD has certified TargetLink. The certificate provides evidence to engineers that TargetLink is suitable for developing safety-related software according to ISO 26262, IEC 61508 and derivative standards such as EN 50128. IEC 61508 is the internationally recognized generic standard for the development of safety-related electronic systems. The upcoming automotive standard ISO 26262, which is derived from IEC 61508, is the new definite standard for the development of safety-

related systems in road vehicles. EN 50128 is the relevant standard for railway software. The development of safety-related software has to fulfill more requirements than with non-safety-related software, as there are also safety standards to be met. Therefore the certificate comes with a reference workflow for the development of safety-related software using TargetLink. The reference workflow has been prepared by dSPACE and approved by TÜV. It provides guidance for meeting the safety requirements of ISO 26262



and IEC 61508 to develop software up to and including ASIL D and/or SIL 3. In addition, the certification is based on the examination and assessment of the TargetLink software development process, the software modification process and customer problem reporting.

TargetLink for Safety-Critical Applications

FORD

“At the Ford Research Center in Aachen, TargetLink has been used for automatic code generation in model-based software development. Even safety-critical applications were developed with TargetLink since 2005. To cope with safety-critical aspects, a development process was introduced that covers all of the development phases from implementing the requirements up to testing the individual work products. Since TargetLink can be used throughout all phases, verification is possible on several levels. The behavior of the model is tested against the requirements by using functional tests. Model checking via the BTC EmbeddedValidator and EmbeddedTester is used to formally

prove that the model meets the safety-critical requirements without any errors. Automatic comparison of the model with the generated code checks whether the parameterization of the code generation attributes is correct. TargetLink proved that it is ideal, especially for safety-critical applications, since the availability of validation and verification tools ensures a high product quality at a tolerable test level. To validate the generated code, we also perform in-vehicle tests with dSPACE Micro-AutoBox. The wide diversity of variants of the software to be generated poses a further challenge during development. Functional variants, configuration variants for vehicle

platforms, and code generation variants need to be supported. During all of this, it must be possible to adapt the software to the specific ECU requirements of different suppliers. This specifically is where TargetLink has shown its exceptional flexibility, because the dSPACE Data Dictionary facilitates the definition and management of several data variants. Automatic switching between the variants can be done via script.”

Thomas Rambow
 Research Engineer
 Hybrid Vehicle Technologies/
 Electronics & Control
 Ford Powertrain Research & Advanced Engineering, R&A Europe



Supporting Standards

TargetLink itself is a technology leader that sets and supports standards. From the beginning, TargetLink has supported the automatic generation of ASAM MCD-2MC (ASAP2) variable description files. MISRA-C compliance documentation and the official MISRA TargetLink guidelines, MISRA AC TL, provide guidance for modeling and code generation with a special focus on functional safety. TargetLink was also the first code generator to provide AUTOSAR support, and as a result the first AUTOSAR production projects with TargetLink already started in 2007.

AUTOSAR-Compliant Function Development

DAIMLER

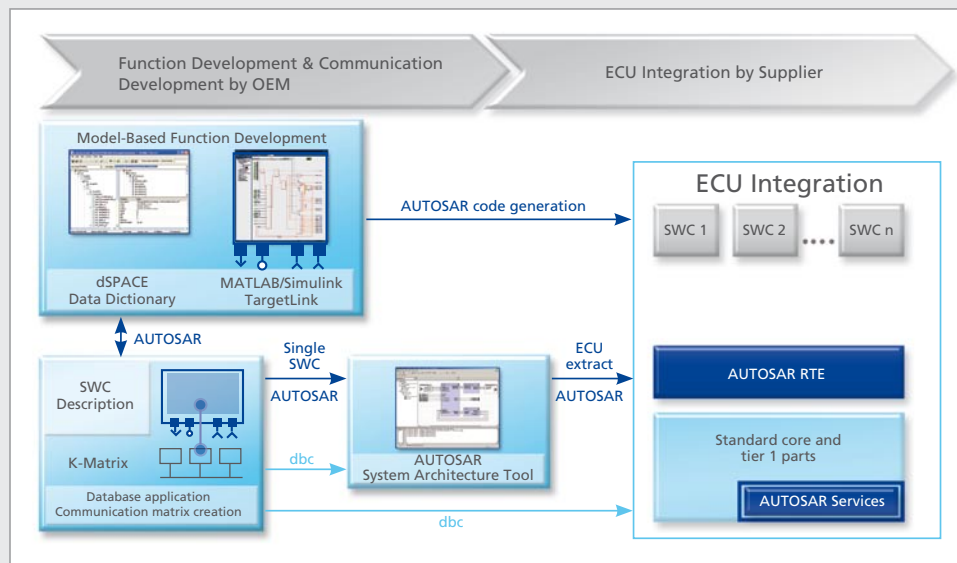
The AUTOSAR standard defines a software architecture, software interfaces and interchange formats for creating function libraries that are independent of ECU suppliers. Daimler AG is introducing AUTOSAR in the fields of comfort and vehicle interior functions as part of its activities for standardizing function library software modules. This process includes using the autocoder TargetLink for modeling AUTOSAR software components and generating code from them.

Model-Based Development of Vehicle Interior Functions

For some years now, Daimler AG has used modeling to develop vehicle functions, especially for comfort and interior functions. Model-based development for the vehicle interior focuses on the main functions of the central body computers, each of which has integrated multiple functions. Model-based development was introduced on a large scale for the current C-Class (204 series). The model-based approach is systematically applied to the series currently in production development, and the number of functions to be integrated is constantly increasing.

AUTOSAR Tool Chain

An existing tool chain was extended for developing AUTOSAR-compliant vehicle functions. The common object pool for storing AUTOSAR interfaces and SWC descriptions is a major component of the development environment. It was implemented as an extension to an existing database application used for creating communication matrices. The pool not only contains AUTOSAR modeling elements; in it, parameters and



AUTOSAR tool environment for generating AUTOSAR software components (SWCs). Data exchange between tools is based on AUTOSAR XML and DBC files.

NVRAM variables can also be described and given values. Because of its similarity to the communication matrix, AUTOSAR interfaces can be generated elegantly from the data in the communication matrix and subsequently updated. The tried and tested release concept used for communication matrix development can also continue to be used. The SWC descriptions can be imported and exported via the AUTOSAR interchange formats. This supports the connection to the dSPACE Data Dictionary and to system architecture tools.

The model-based development of AUTOSAR-compliant function models is supported by model-in-the-loop (MIL) and software-in-the-loop (SIL) tests, both integrated in the development environment. Finally, AUTOSAR-compliant production code together with a consistent AUTOSAR SWC description file is generated.

Conclusions and Outlook

As we see it, AUTOSAR is capable of evolutionary introduction into the development process as it is known today. With a stepwise approach to introducing AUTOSAR, we can continue using existing function models as well as proven processes and tool chains, and optimize them step by step. Due to its success, using function modeling to develop comfort functions and interior functions has become a standard method at Daimler AG. Much of the experience gathered in these projects can be transferred to AUTOSAR-compliant development and will make it possible to replace manual steps by automated and standardized process steps in the future.

Source: Christian Dziobek, Dr. Florian Wohlgemuth, Mercedes-Benz Cars Development Dr. Thomas Ringler, Group Research & Advanced Engineering, Daimler AG, Germany, AUTOSAR in the Development Process, dSPACE Magazine, 1/2008

Complex electrical systems like that in the Audi S5 require efficient architecture concepts and development tools.



AUDI

Shock Absorber Control the AUTOSAR Way

Audi implemented a shock absorber control that complies with the AUTOSAR concept. This project provided important insights on setting up a tool chain in which TargetLink, dSPACE's production code generator, is used for modeling and generating AUTOSAR-compliant ECU software. To gain experience with using the AUTOSAR concepts, they were implemented in prototype form as part of a development project. The objective was to convert an entire existing shock absorber control system into AUTOSAR-compatible software components by means of TargetLink, and to test it on a production-close vehicle as the prototype development platform.

The control consists of four body acceleration sensors, four distance sensors, and four continuously controlled shock absorbers. A central ECU evaluates the sensor signals and calculates the shock absorber control, taking into account further vehicle dynamics variables such as the steering angle, yaw rate, brake signal, lateral acceleration, vehicle speed, and engine torque. The ECU receives these variables from the vehicle's CAN bus. The ECU communicates with the active shock absorbers via a FlexRay bus.

Workflow with TargetLink

TargetLink supports AUTOSAR-compliant modeling with AUTOSAR

blocks, which make it easy to define AUTOSAR runnables and model the communication interfaces. The AUTOSAR-specific data for SWCs, runnables, interfaces, etc., is stored in the dSPACE Data Dictionary and linked to the actual model. Thus, the entire workflow established for model-based design with TargetLink can also be applied to developing AUTOSAR software.

Once an AUTOSAR function model has been designed, it can be simulated and tested with TargetLink at the model (MIL) and the software (SIL) level. As well as generating the AUTOSAR-compliant code, TargetLink automatically produces the AUTOSAR software component descriptions.

The shock absorber control is subdivided into several AUTOSAR software components, each comprising several runnables. In this specific case, communication between inter-runnables was used intensively, though the AUTOSAR standard currently supports this only for scalar variables. Thanks to an Audi-specific TargetLink extension, however, the function developers can also work with vector signals, which TargetLink converts into code patterns for scalar variables. This simplifies the modeling process and also ensures compliance with AUTOSAR.

Implementing the AUTOSAR Software

As part of SWC implementation on the ECU, the AUTOSAR operating system was configured and the runtime environment (RTE) was generated by EB tresos. To generate the RTE, the software component descriptions generated by TargetLink were imported into EB tresos, and the RTE was generated on the basis of the information in them. The last step was to configure the FlexRay drivers, which are in the basic software.

The Infineon TriCore microcontroller family was used to set up the prototype hardware because of its good performance and broad-based connections to typical automotive peripherals. These so-called "engineering device" microcontroller derivatives provide a powerful data interface for the necessary tests and for instrumentation tasks.

Successful function implementation on the production-close ECU was verified both in test drives and in tests on the simulator. These also clearly showed that the AUTOSAR-compliant code generated by TargetLink meets the production requirements on size and run-time behavior.

Source: Dr. Karsten Schmidt, Frank Gesele, AUDI AG, Systematic AUTOSAR Migration, dSPACE NEWS 1/2008



Stephan Hemberger
Function Developer, Daimler AG

Tool-Supported Entry into the World of AUTOSAR

DAIMLER

"In 2007, we were looking for an automatic production code generator to develop an AUTOSAR-compliant anti-theft alarm. Other departments in our company recommended dSPACE TargetLink. Valuable advantages for our development process resulted from using it.

The tasks involved in the anti-theft alarm project are split up as follows: We are responsible for function development. Our supplier provides the basic software and RTE (run-time environment), and implements the functions on the ECU after we develop them.

Before TargetLink was introduced, each supplier had to start function development from scratch, using our specification. Now that we use TargetLink, suppliers have an executable specification in the form of the function model that we create. This means we achieve a high level of maturity much earlier. Moreover, it is easy for us to coordinate modifications and exchange models with suppliers at short notice.

Even though TargetLink was a new tool for us, normal Simulink skills

were enough to make the switch-over smooth. We quickly obtained fully functioning results without having to bother with software details. The TargetLink AUTOSAR Module is one of the components we use for modeling, so we do not have to grapple with the AUTOSAR specification on top of everything else. We just use predefined blocks. The ability to reuse the results of earlier development projects also helps streamline our processes: By using libraries from other AUTOSAR projects, we can integrate already validated functions with very little effort.

One classic example of TargetLink's user friendliness is the HTML documentation generated along with the code. It is a good help in reviews and for directly comparing the code and the model.

Although we just started using TargetLink a short time ago, our overall impression is already extremely positive, because we have never had problems with the code quality or performance. We will definitely be using TargetLink again in upcoming development projects."

Customer Testimonials





MITSUBISHI ELECTRIC

The Essential Development Tool

"We have been using TargetLink now for 10 years. The volume of automatically generated code increases every year, and today TargetLink has become an absolutely essential tool in development.

We are sure that functional improvements and reliability will be even better in the future, and hope to use TargetLink for a long time to come."

Yamada Motomi
Mitsubishi Electric Corporation

DAIMLER

Excellent Support

"dSPACE's excellent local support in the US enabled us to successfully achieve our challenging timelines."

Dr. Marcus Heller
Manager, E- Motors & Power
Electronics, Mercedes-Benz
Hybrid LLC

Efficient Variant Handling

"At DEUTZ AG, dSPACE's production code generator TargetLink has been in action since 2007. With TargetLink's help, we can implement software on different ECUs from different suppliers quickly and efficiently. Because of the many different types of ECUs, the flexible API functionality that TargetLink provides, and its user-friendliness, are very important for us at DEUTZ AG.

To automate code generation for the various ECUs even more, DEUTZ AG developed its own software sharing tool, which utilizes the TargetLink API. In this way we can make changes to Simulink models and the data dictionaries very quickly. One major advantage of this fully automatic development environment is that once a function has been developed, it can be integrated on various ECUs without much effort at all. Interpolation routines and/or

DEUTZ

diagnostic functions are adjusted in the code by the respective ECU functions. Duplicate version control is no longer necessary, as only the Simulink model has to be versioned as the reference. And because the development environment adapts completely automatically, it also reduces errors in switching from one ECU to another.

DEUTZ AG has been using TargetLink for approximately 2 years and has implemented several functions in various ECUs. The time that TargetLink has saved, and the intellectual property protection that it offers, have helped DEUTZ AG reduce costs considerably."

Abderrahim Qriqra
Electronics Advance Development,
DEUTZ AG

CHRYSLER

The Premier Tool

"After 10 years TargetLink continues to be the premier tool for automatically generating production software from Simulink models. We have found TargetLink to be reliable, efficient and highly adaptable to our production software requirements. TargetLink has proven that automatic code generators can approach the efficiency of hand code."

Thomas H. Pruett
Senior Engineering Specialist,
Powertrain Core Electronics
Chrysler LLC



Paving the Way for SPICE Certification

"Magneti Marelli has been using TargetLink from the year 2001. Since then we have brought several production projects to market where TargetLink code accounted for more than 90% of the application software. In all of them, TargetLink played a key role in launching the products on time. TargetLink is also proving useful in obtaining SPICE certification for our developments. Automatic consistency between the code, the specification and the documentation is a major factor in this respect. Another is traceability between the model and the code, which can be carried out in any direction by a click. The integrated model testing support gives us com-

prehensive test capabilities in all development stages. We can test the model and the production code on the PC, and the production code on the actual controller, within one development environment, and perform back-to-back testing efficiently. TargetLink is essential throughout the development process at the Magneti Marelli Powertrain Division. With TargetLink's comprehensive feature set, we are well prepared to handle upcoming production projects efficiently and reliably."

Giacomo Gentile

*Director Methodologies & Tools
System Development, Magneti Marelli
PowerTrain S.p.A*

MAGNETI MARELLI

FORD

Efficient Code and Excellent Support

"For a major production-level autocoding application, we selected TargetLink as the auto-code generator. With that project now approaching production, we are very pleased with our decision. The generated code is efficient and we had very few issues in deployment. Where we did have issues the support from dSPACE was excellent. We also found that when we needed to generate user documentation from our Simulink/Stateflow models, dSPACE had a solution that was much closer to meeting our needs. We appreciated their willingness to support us in this development."

Craig Stephens

*Manager, Gasoline Systems
and Software Integration,
Ford Motor Company*



TargetLink at Porsche

"Since 2005, we have been using TargetLink successfully for production code development, especially for powertrains and vehicle dynamics. By using TargetLink, we can convert the sport functions, characteristic of our Porsche brand, directly into ECU code without any transfer losses.

Our first project was the Porsche Dynamic Chassis Control (PDCC) system. It was first introduced in the Cayenne and brought us excellent customer feedback. Since then, TargetLink has become an important factor in our software development process. Its versatile

PORSCHE

test possibilities and excellent dSPACE support are a great help. TargetLink's high code efficiency also enables us to generate code for the highly dynamic control systems of our sports vehicles. We're eagerly waiting to see how TargetLink performs in the future for inputting data into models and for scalability."

Dr. Matthias Schumann, Roland Pfeifle

*Development Electronics Software Architectures, Porsche AG,
Germany*



Reliable Code

"Using practical tools like TargetLink, reliable code can be quickly generated, especially if it is described in accordance with the guidelines. We could even customize TargetLink in order to generate code for our special requirements. We thank dSPACE for its support."

Shinya Iizuka
Yamaha Motor Co., Ltd.

YAMAHA



MITSUBISHI MOTORS

Ensuring Software Quality with TargetLink

"With the growing role of software an enormous amount of effort is required to ensure software quality. In this context, TargetLink offers a large number of user-oriented functions and settings, and has now become essential for efficiently ensuring software quality.

In the future, we expect to install highly reliable code generated by TargetLink in new types of electronic control units (ECUs) such as those used in electric vehicles."

Masakazu Mizutani
Mitsubishi Motors Corporation

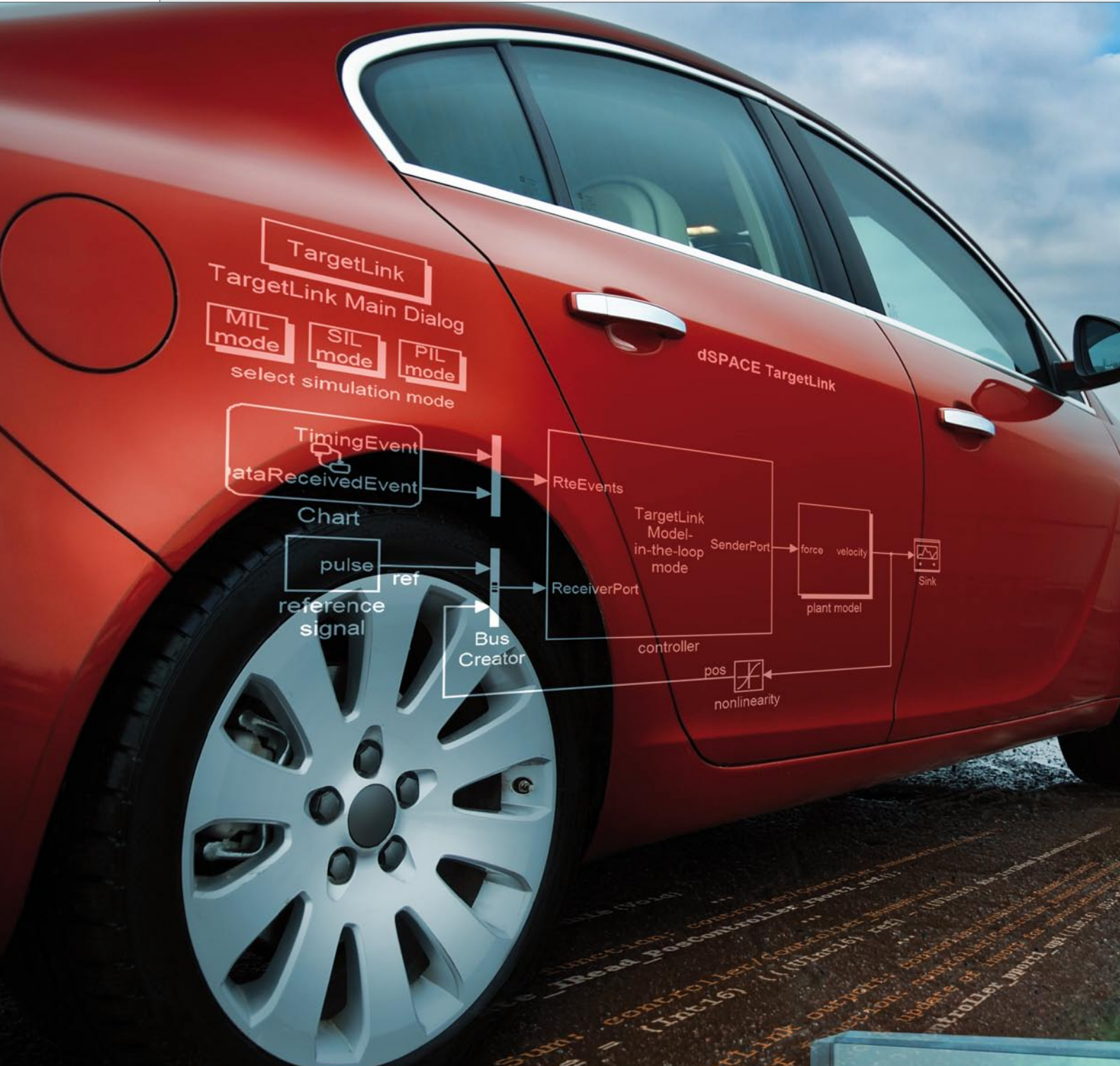


HONDA

Indispensable for Transmission Software

"Congratulations on the 10th anniversary of TargetLink. TargetLink was indispensable for the development of our transmission software. Please continue to give us the more and more evolution, improving quality, and strengthening of support organization."

Kenji Hagiwara
Honda R&D Co., Ltd.



10 Years of TargetLink

2008



Automatic production code generation is one of the decisive phases in developing electronic control units and embedded software. Since its launch in 1999, the automatic production code generator TargetLink has gone from strength to strength. Come with us on a short journey through time as we show the milestones since 1999!

Milestones in a Success Story

Safety-critical application: cabin pressure control for the A380.

Daimler's engine ECU development department relies on TargetLink.

TargetLink supports AUTOSAR software components.



1999

The Revolution: Straight from Simulink® Model to ECU

With its launch in fall 1999, TargetLink revolutionizes the development of electronic control units (ECUs): Production-ready code can be generated from the controller model and transferred directly to the ECU at the touch of a button. Handcoding is now obsolete. The first production projects begin before the year ends. With TargetLink, Daimler completes a research project for a hybrid truck in only 3 months.

2001

Top Benchmark Results Impress the Entire Industry

TargetLink's excellent benchmark results cause a sensation. International automotive manufacturers and suppliers are impressed. Moreover, the production code generator now has an added attraction as the "missing link" between function model and ECU: It closes the major gap in the development process and ensures seamless integration. TargetLink is also valued in the off-highway sector: An international manufacturer of agricultural machines uses TargetLink to develop tractor transmissions and other control components.

2003

Entire Departments Rely on TargetLink

TargetLink is now a valuable tool in large project teams, where it blends seamlessly into the development process. The new "programmer" is now a full team member, for example, at Daimler. The company has switched its entire engine ECU development department over to automatic production code generation with TargetLink.

```
atic Void FuelRateCalculation(Void)
```

```
/* SLLocal: Default storage class for local variables | Width: 32-bit
```

```
Int16 Sa3 F A / 1999 2000 2001 2002 2003
```

```
Description: F/A
```

```
LSB: 20-17 OEB: 0 MIN/MAX: -0.25 0.2999923706055 +/-
```

2000

On the Road: TargetLink Code in Production Vehicles

TargetLink attracts widespread interest in the automotive industry. OEMs and suppliers worldwide begin evaluation and pilot projects, and use the results in actual production.

Nissan launches an engine control component for the 2000 Sentra, the first TargetLink-developed product to go into production. The results of this project and others are impressive.

2002

The First Safety-Critical Aviation Application

The aviation industry has particularly strict safety requirements. TargetLink has made its mark on aviation – in projects like the cabin pressure control from Nord-Micro:

- Code certified according to aviation's highest safety standard, DO178B Level A
- Development time cut by 50%

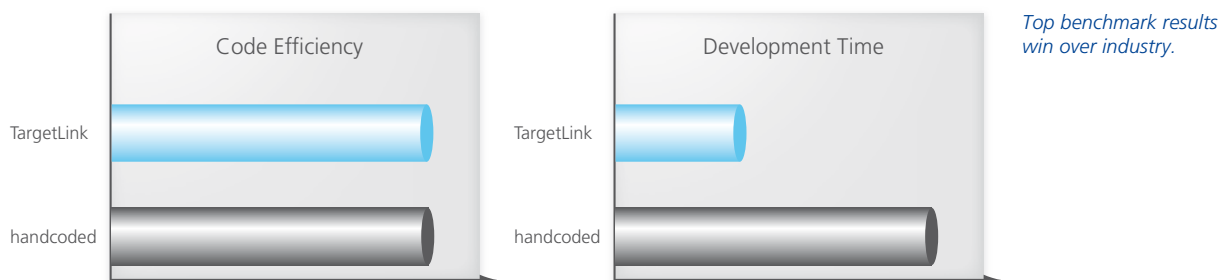
The new cabin pressure control is installed in a number of passenger planes, including the Airbus A380.

2004

New Features: More Than Just a Code Generator

Now with powerful new extra functions, TargetLink is setting new standards.

- dSPACE Data Dictionary for managing the data sets of complete ECU applications
- Production-level implementation of OSEK and multirate modeling
- Code coverage analyses and incremental code generation



2005

The Best in Test

Model-based development is gaining ground, and so is automatic production code generation. TargetLink wins over new users and new application fields at an impressive rate. BMW is yet another major OEM who chooses TargetLink after evaluating the various production code generators on the market.

2007

MISRA Modeling Guidelines for TargetLink

The Motor Industry Software Reliability Association (MISRA) publishes official modeling guidelines for TargetLink. TargetLink is the first autocoder ever to have such guidelines, reinforcing its position as the world's leading production code generator in the automotive industry. The guidelines particularly address aspects of functional safety.

2009

The No. 1 for Professional Code

Ten years of success. TargetLink is being used in numerous industries all over the world. The automotive industry regards it as its established code generator. TargetLink also looks back on several successful years in developing safety-critical aerospace systems (see the customer report "Maximum Safety", dSPACE Magazine 1/2009), and has been certified by the German certification authority TÜV SÜD for ISO 26262 and IEC 61508.



2006

TargetLink Supports AUTOSAR

For the first time ever, a code generator bridges the gap between model-based design and production-ready, AUTOSAR-compliant ECU software. TargetLink provides extensive support for modeling, simulating, and generating code for AUTOSAR software components.

2008

TargetLink 3.0: The Winning Combination

The best of both worlds: With its newly designed blockset and its tried and tested features, TargetLink 3.0 provides even closer integration with MATLAB®/Simulink®, so that numerous Simulink third-party tools can be used for TargetLink models. TargetLink 3.0 also supports model referencing to facilitate modular, distributed development processes.

TargetLink is highly valued in the off-highway sector.



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"AUTOSAR-Compliant Function Development"
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"Utilization of TargetLink for Delphi
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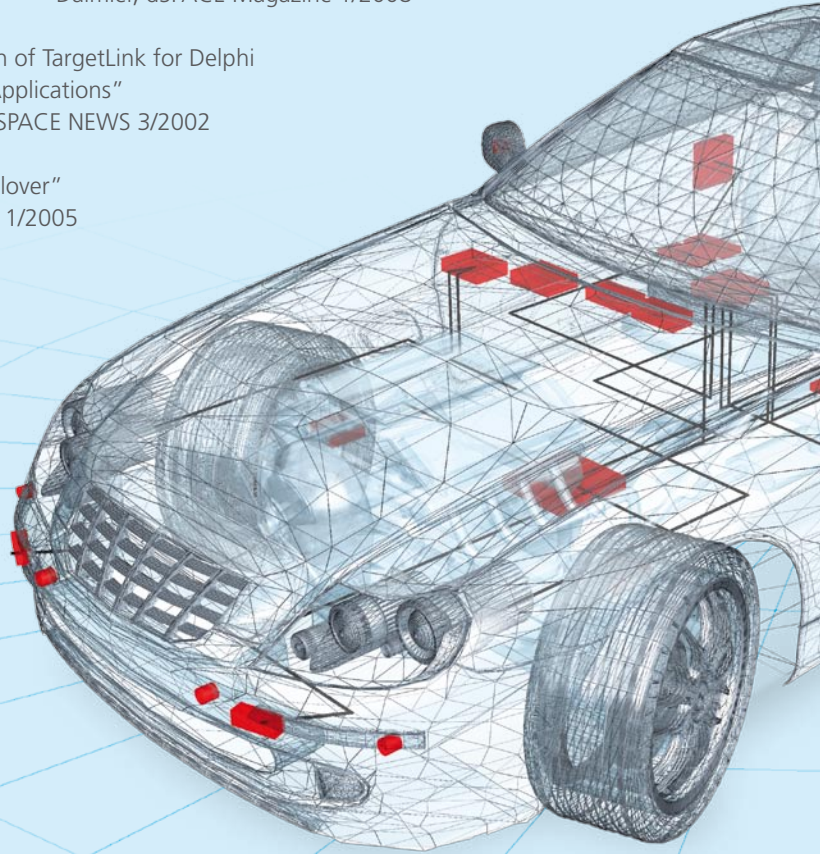
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troller", BMW, dSPACE NEWS 2/2006

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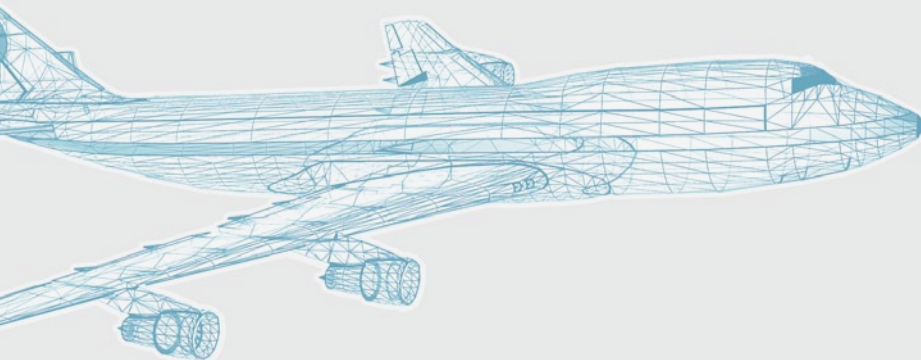


Aerospace Industry

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"Barracuda's Maiden Flight"
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"C Code Reaches New Heights
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"TargetLink Goes Off-Road"
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"Cool When It's Hot"
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"Audio Playback Control Development"
Parker Engineering / Delphi / Purdue University,
dSPACE NEWS 3/2007

"Coming Soon: Steer-by-Wire at ZF Lenksysteme"
ZF Lenksysteme, dSPACE NEWS 1/2001

"Magneti Marelli's Design of a GDI Engine Controller"
Magneti Marelli, dSPACE NEWS 3/2002

"DaimlerChrysler Relies on TargetLink for Engine Controls"
DaimlerChrysler,
dSPACE NEWS 2/2003

"Jiexun – A Hybrid Hero"
ChangAn Automotive,
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"Eco-Friendly Starter-Alternator "
Valeo, dSPACE NEWS 2/2007

"The European Research Project BRAKE"
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"TargetLink for ESP Controller Development"
Unisia Jecs, dSPACE NEWS 2/2001

"25 Kilograms of Pure Energy"
Johnson Controls-Saft,
dSPACE Magazine 2/2009

"How MAN Controls Emissions with TargetLink"
MAN Nutzfahrzeuge, dSPACE NEWS 2/2002

"Production Code Generation: Three Months from Modeling to Implementation"
Daimler, dSPACE NEWS 2/1999

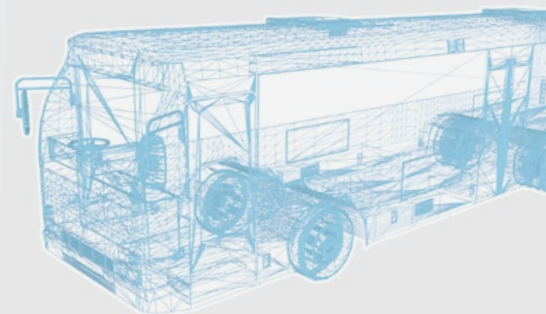
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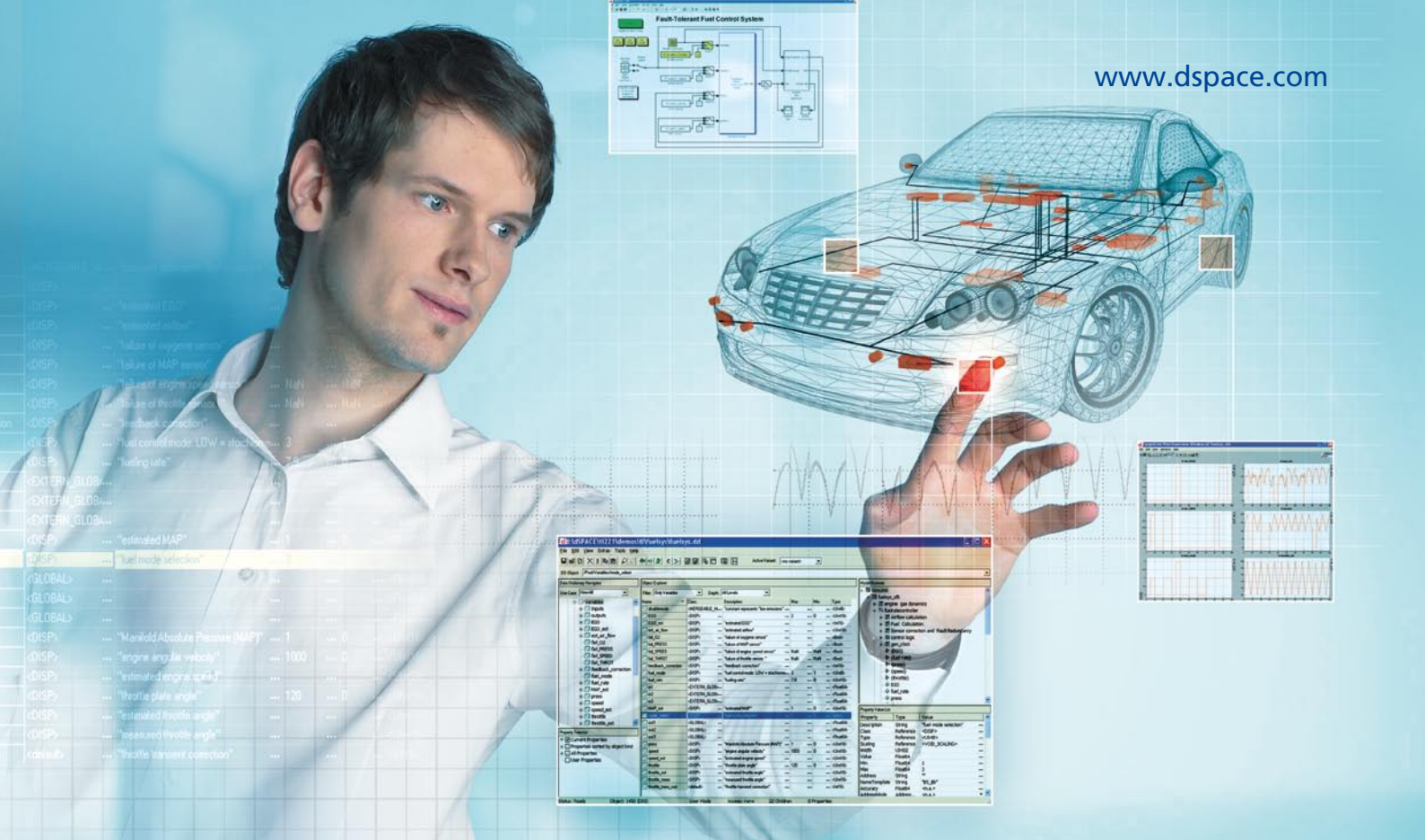
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Trucks, Buses & Off-Highway Vehicles





System Architecture

Rapid Prototyping

ECU Autocoding

HIL Testing

ECU Calibration



TargetLink 100% Efficiency, 200% Speed

Since its launch in 1999, dSPACE's autocoder TargetLink has been a true success story. Today it's the world's number one autocoder, and the list of companies using it reads like a Who's Who in the automotive and aerospace industries.

What makes TargetLink so successful? The fact that it generates production-ready code directly from a graphical development environment, to go straight from the controller model to the ECU. This reduces development time – frequently by more than half.

TargetLink also offers impressive code efficiency. Broad configurability. AUTOSAR support. And it has been certified by the German certification authority TÜV SÜD for use in the development of safety-related systems.

TargetLink: the quickest route from function model to ECU.