RealTimes

2019/2020

ETAS

DRIVING EMBEDDED EXCELLENCE

Dear Readers,

In the automotive world, we mostly focus on the future. For this issue of RealTimes, we also take time to reflect on the past … and for good reason, as you will see!

We have set our sights on the future and are taking off into new worlds in automotive software development. Automotive electronics is undergoing profound changes. The megatrends connectivity and automated driving require completely new E/E architectures and development processes. Powerful vehicle computers with microprocessors as well as the AUTOSAR Adaptive standard are supplementing and, in some cases, even replacing conventional ECUs with microcontrollers. We would like you to join us in shaping this dynamic change.

ETAS already offers developers the "gear" they need to discover this new and exciting world, for instance with the RTA-VRTE platform software framework and the ISOLAR-A_ADAPTIVE architecture design tool.

Our articles on other forward-looking topics such as future-proof test systems, a simulation model for fuel cell systems, and the question of how to quickly comb through large volumes of data, highlight further interesting facets of the work involved in developing the vehicles of the future.

But our focus is not limited to the future. You will also find articles on our established products, such as the MDA V8 and INCA-FLOW, as well as a success story about the SCODE tools. We assure you, these articles are an equally exciting read.

The past plays an important role for us in 2019 in particular, as it is the year in which ETAS celebrates its 25th anniversary. We are very proud of our success over the past 25 years, and we could not have achieved it without you, our customers and partners. Browse the anniversary pages and look back with us to see where we came from.

Last but not least, you'll find our special feature on ESCRYPT with topics such as automotive security as a strategic task, protection of hybrid vehicle networks, and AUTOSAR security – after all, we don't want to venture into new worlds without a "safety net" in place.

We hope you will enjoy this issue of RealTimes as you explore the future and reminisce about the past. Thank you very much for the trust you have placed in us for the past 25 years. Here's to the next 25 years, and true to our anniversary motto: stay wild at heart!

Friedhelm Pickhard Bernd Hergert Christopher White

Left to right:
Christopher White
Executive Vice President Sales
Friedhelm Pickhard
President
Bernd Hergert
Executive Vice President Operations

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New E/E architectures with vehicle computers offer new opportunities

Automotive electronics are set to undergo profound changes driven by the megatrends connectivity and automated driving. These call for completely new E/E architectures in which microprocessor-based vehicle computers (VCs) make it possible to merge domains that are currently distributed. Software based on the AUTOSAR Adaptive standard and the possibility to partition VCs into virtual machines are creating a dynamic that will lead us into new worlds in automotive software development.

Driven by the megatrend of connectivity, communication technology and hardware from the consumer electronics industry are making their way into cars, and modern vehicles are becoming connected with their environment. This opens up a completely new field of possibilities, resulting in an enormous increase in functions and making the services and user experience that end customers have come to expect from their smartphones available in vehicles. This development is introducing an array of tried-and-tested IT (software) technologies into vehicles. A second megatrend is also playing its part: assisted and increasingly automated driving, which in turn means a dramatic increase in functions, such as environmental detection.

These two technological advancements together can hardly be realized in practice with the ECU networks available today. It will take significantly more computing power and more structured architectures than are currently used, as the expected gain in functions would cause a sharp increase in the complexity of today's solutions, which often involve as many as 120 decentralized ECUs.

To understand the scale of this task, consider this comparison: today's automotive software already comprises more than 100 million lines of code – about 100 times more than the software for the space shuttle and more than four times as much as that for commercial aircraft. Experts at Bosch expect the scope of future automotive software to increase by a factor of 10,000, with functionality ranging from hard real-time systems to interactive apps. The car will become a software-dominated system – a "smart device on wheels."
Now, the task at hand is to reliably integrate all these software parts while simultaneously satisfying the highest safety requirements of Automotive Safety Integrity Level (ASIL) D, combined with cybersecurity requirements.

Borderline complexity – new approaches are needed

There is work to be done, and the automotive industry is tackling it with IT and mobile communications hardware: microprocessor (µP)-based vehicle computers (VCs) with high computing power and significantly more (external) storage capacity are supplementing the current microcontroller-based ECUs, allowing manufacturers to transfer functions from conventional ECUs to centralized VCs (Fig. 1 next page).

As a result, domains that were previously distributed can be merged. Mergers of three to four domains on one vehicle computer are becoming conceivable and feasible – also because VCs can be partitioned using a hypervisor. An entire array of virtual ECUs can be integrated and operated independently of each other on the encapsulated domains.

This flexibility, coupled with connectivity to the cloud, opens up the possibility of transferring new functions or updates to the vehicle, even in the field. These over-the-air (OTA) technologies are considered to be the key to new business models that will pave the way for new sales opportunities.

Comprehensive access to in-field vehicle data is another attractive possibility. This would allow manufacturers to provide their customers more targeted advice when they come in to buy a car, such as the ability to offer them tailored drive configurations or insurance rates based on real driving profiles. The data will also make it possible to draw conclusions regarding the service life of vehicle components and to avoid replacing them until it is actually necessary. In short, a huge field of possibilities will open up.

For highly complex cross-domain functions of automated driving, decentralized ECU infrastructures also come up against limits that could be overcome with centralized approaches and a standardized control layer. Much more powerful vehicle computers are needed to enable the enormous volumes of data from environment sensors (radar, video, and lidar) to be merged, compared, and validated with a view to ensuring maximum safety.

Merging domains constructively

E/E architectures with VCs make it possible to do away with domain separation, which evolved over time but is now physically redundant. Decisions will then be made centrally, replacing distributed decision making and coordination between numerous ECUs. This keeps complexity manageable and reduces dependencies between control and drive type, which will create control platforms that can be used to address functional characteristics of a broad spectrum of determinants in detail – for instance, for an efficient recuperation strategy for hybrid and electric drives or for decision making in automated vehicles.

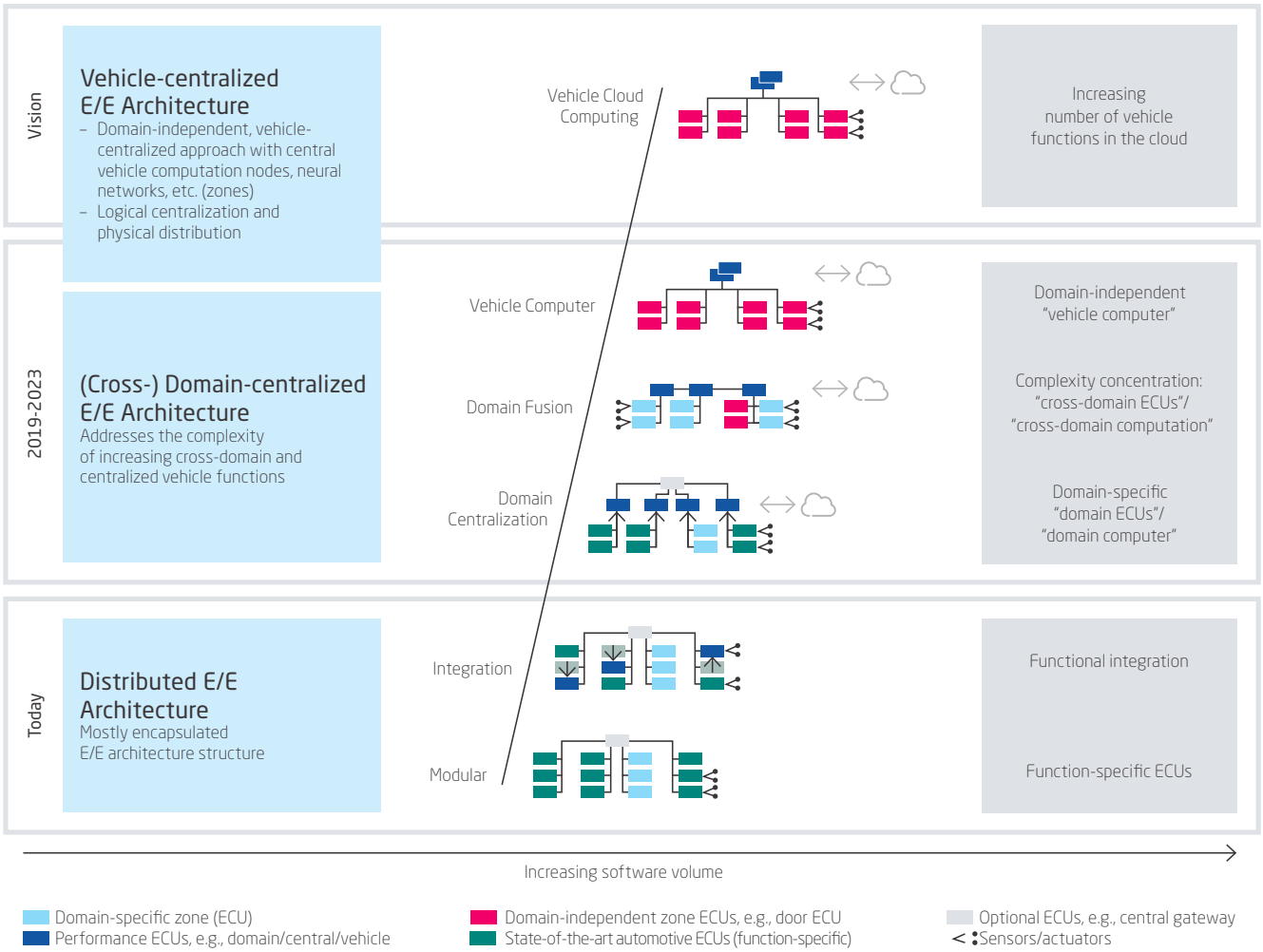


Figure 1: Vehicle computers and cloud connectivity will fundamentally change automotive E/E architectures.

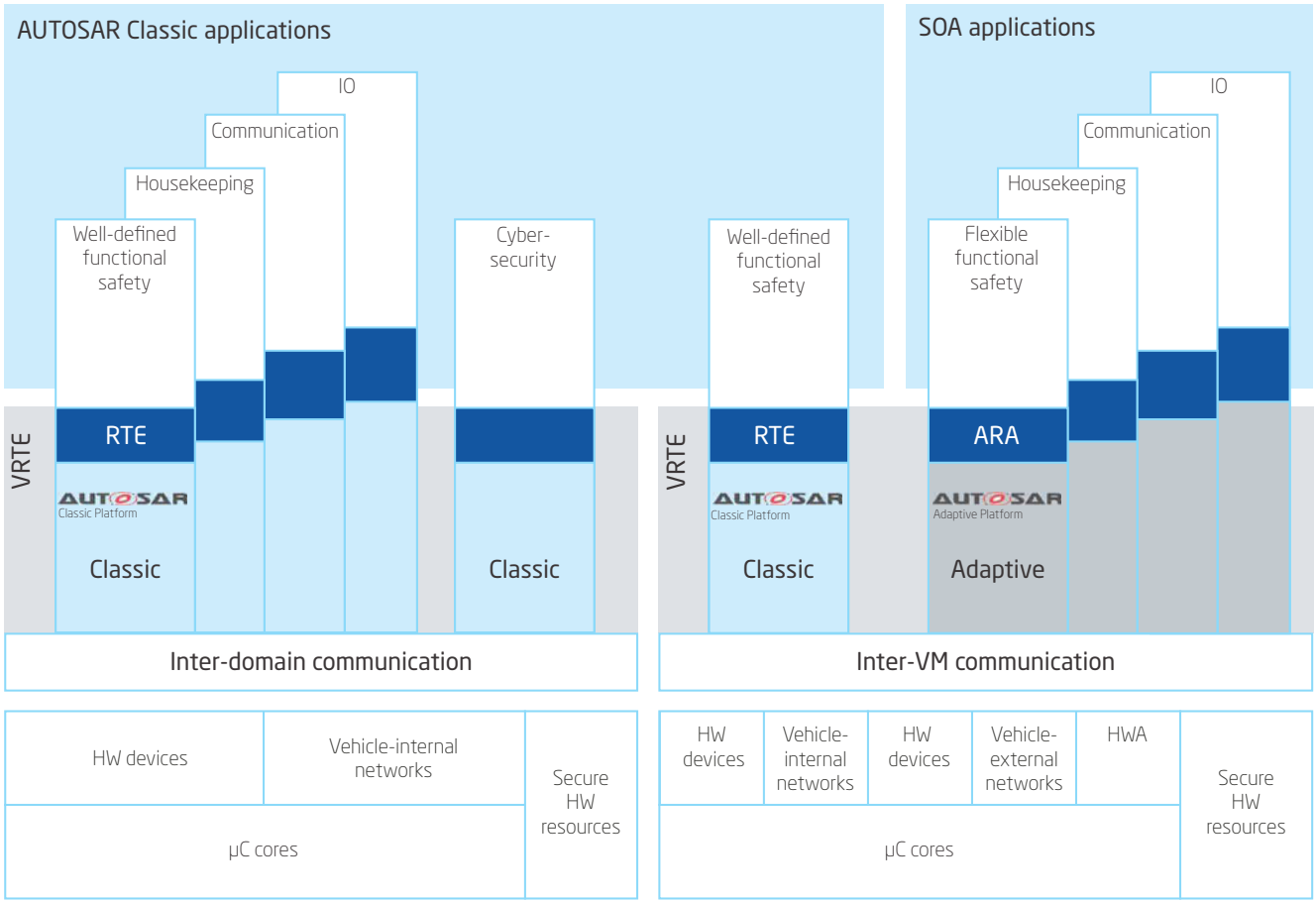
Here's an example to illustrate the scope and benefits of the tasks that lie ahead: to implement automated driving, developers perform calculations in three-dimensional movement trajectories. The actual route is determined in line with various trajectories the vehicle can take on the road. These are highly complex processes into which not only all safety-relevant information flows, but even such parameters as driving comfort and energy consumption. Domain consolidation harbors particular potential here – initially for the drive and chassis functions, including brakes and steering.

The aim here is to functionally integrate these as a software package at the control level and to run this package as a vehicle-motion controller on the VC. This software-based controller receives trajectories, analyzes and optimizes them, and translates the result into commands to the drive, regardless of type, and to the chassis functions. Whether these commands are sent to a combustion, hybrid, electric, or fuel-cell drive is irrelevant.

Separating software development and hardware

Bosch and ETAS already offer solutions for powerful VCs (Fig. 2). At their core is the RTA-VRTE (Vehicle Runtime Environment) platform software framework for µP-based VCs, and software based on the AUTOSAR Adaptive standard. This framework makes it possible to partition the VC into virtual machines that are free from mutual interference and to integrate disparate data and signal transmission structures based on POSIX-compliant operating systems.

Whether domain consolidation, new convenience functions, or security updates – thanks to partitioning and freedom from interference in encapsulated virtual machines (VMs), it is no



SOA = service-oriented architecture HWA = hardware abstraction VM = virtual machine

Figure 2: Basic structure of vehicle computer software with AUTOSAR Classic and AUTOSAR Adaptive components. This structure provides maximum flexibility while maintaining strong safety and security.

longer necessary to update all applications in the course of integration and further development. As in PCs and smartphones, ongoing function upgrades and software updates will be possible. Additionally, software development can be completely separated from hardware.

RTA-VRTE therefore runs on any µP-based hardware, regardless of whether it's a VC or a PC, paving the way for end-to-end virtualization of software development. After all, software that already operates in the vehicle on encapsulated partitions of the vehicle computer – in other words, on virtual ECUs – can be developed on any PC on virtual ECUs. This is made possible by appropriate hardware abstraction layers.

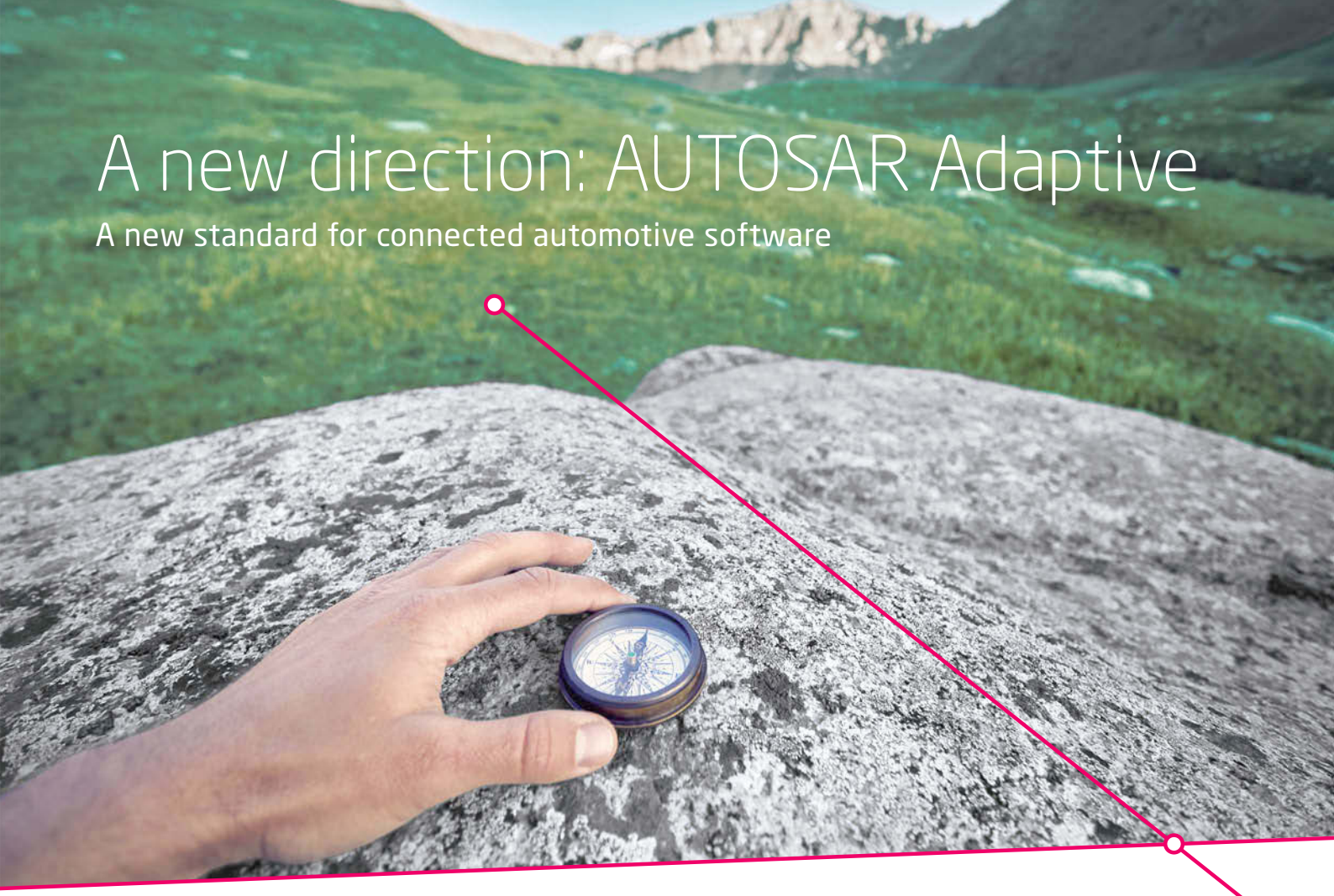
Precisely this approach is the basic idea underlying ETAS' Early Access Program, which, starting immediately, enables early starters to explore future methods and architectures. You can read more about this on the pages that follow, but first we'll take a closer look at the AUTOSAR Adaptive Platform standard.

Authors

Dr. Andreas Lock is Vice President of Systems Engineering, Sector Electric & Electronic at the Robert Bosch GmbH. **Dr. Nigel Tracey** is Vice President of RTA Solutions and General Manager at ETAS Ltd. in York, UK. **Dr. Detlef Zerfowski** is Vice President of Vehicle Computer and Security at ETAS GmbH.

A new direction: AUTOSAR Adaptive

A new standard for connected automotive software



Automotive software is undergoing fundamental changes. New functions and E/E architectures require new software architectures and infrastructures for embedded software. Powerful vehicle computers (VCs) with microprocessors, based on POSIX operating systems, and the AUTOSAR Adaptive standard are supplementing and in some cases even replacing conventional ECUs with microcontrollers. What changes will this bring about in software development and why is becoming familiar with AUTOSAR Adaptive overdue?

When the first AUTOSAR standard was introduced, it was hardly love at first sight. It took nearly a decade before OEMs and suppliers really aligned their development projects with the standard. So it may come as a surprise that ETAS, together with Robert Bosch GmbH, already offers tools, a platform software framework, and services for the integration of the future AUTOSAR Adaptive standard, even though the standardization is still far from complete. Why the hurry? Well, first let's take a look at the standard itself.

What is AUTOSAR Adaptive?

While ECU development has in the past focused on stringent real-time and safety requirements, today aspects such as updatability and upgradability are taking center stage. This includes the dynamic reloading of software components and the use of standard libraries, e.g., for image processing, independent learning of functions, and security updates.

ECUs based on the AUTOSAR Adaptive Platform standard make it possible to easily upgrade applications throughout the entire vehicle lifecycle and to subsequently add new software functions, for instance via over-the-air software updates. It is also possible to develop, test, and update functions independently of each other in distributed working groups and then integrate the functions into the overall system at any time.

This is achieved through "service-oriented communication" within the software applications. Unlike with the AUTOSAR Classic Platform, these Adaptive Applications are integrated into the Adaptive Platform at runtime using metadata in the form of "Manifests" that describe the actual functionality and how the platform can work with it.

The operating system for the Adaptive Platform is POSIX-compliant according to PSE51, defined in IEEE1003.13. POSIX (Portable Operating System Interface) is a standardized programming interface between the application function and the operating system. It makes vehicle software development significantly more flexible. In the vehicle, applications are arbitrarily distributed to the ECUs via the Adaptive Platform. The AUTOSAR OS interface, which is part of the AUTOSAR Runtime for Adaptive Applications (ARA), links the operating system with the application.

The current AUTOSAR Adaptive Platform standard is rated for applications up to ISO 26262 ASIL B. Microcontrollers (µCs) with the AUTOSAR Classic Platform are recommended for more stringent safety requirements. Since AUTOSAR Classic and Adaptive were designed on a common basis, the two standards can be combined to increase the safety class of the overall system. The link between the two AUTOSAR standards can be created directly using the AUTOSAR Classic Platform services. As an alternative, the various signals of classic AUTOSAR ECUs can be automatically mapped to services on adaptive ECUs.

Get started today!

AUTOSAR Adaptive uses existing software technologies that have been tried-and-tested in other sectors and tailors them for use in vehicles (Fig. 1). To realize software for future connected and automated vehicle systems, developers must explore new avenues and become familiar with the new standard, which differs in key points (Fig. 2). An upheaval like this poses enormous challenges for established players. Not only do methods and tools have to change, but also processes and organizational structures. Companies need to get started today, since this path will not be easy and there is a lot of market pressure, answering the question above as to why the hurry.

This is why ETAS and Bosch developed a basic software framework known as RTA-VRTE (Vehicle Runtime Environment) based on AUTOSAR Adaptive that integrates POSIX operating systems such as Blackberry QNX and Linux. Customers can already use this framework to gain practical experience and thus prepare for the future in good time. Read the next article to find out what ETAS can offer in this regard.

Authors

Dr. Núria Mata is Consultant for Engineering RTA Solutions at ETAS GmbH. **Dr. Stuart Mitchell** is AUTOSAR Expert at ETAS Ltd. in York, UK.

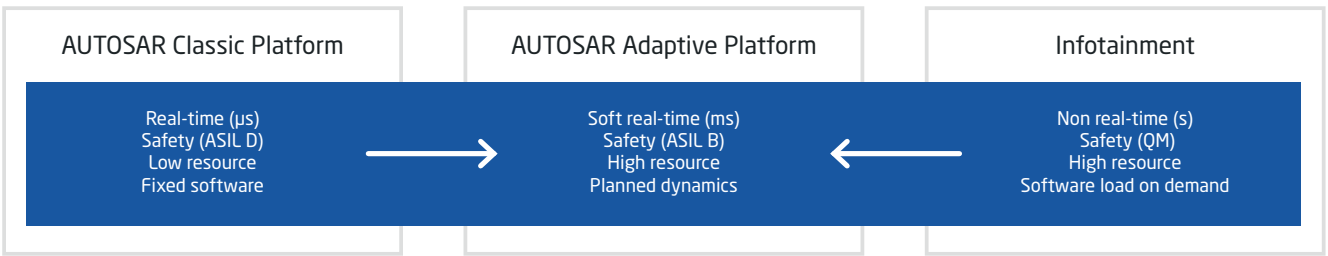


Figure 1: The AUTOSAR Adaptive Platform is an important link between AUTOSAR Classic and infotainment/IT applications.

AUTOSAR Classic Platform	AUTOSAR Adaptive Platform
Single address space (MPU support for safety)	Virtual address space for each application (MMU support)
Statically configured, signal-based communication (CAN, FlexRay)	Dynamically configured, service-oriented communication
Based on OSEK	Based on POSIX (PSE51)
Execution of code directly from ROM	Application is loaded from persistent memory into RAM
Statically defined task configuration	Support of multiple (dynamic) scheduling strategies
Specification	Specification as binding standard, code as demonstrator

MPU = memory protection unit MMU = memory management unit (hardware for virtual addressing)

Figure 2: Key differences between the AUTOSAR Classic and AUTOSAR Adaptive Platform.

Ready for AUTOSAR Adaptive

ETAS offers comprehensive solutions for the upcoming standard

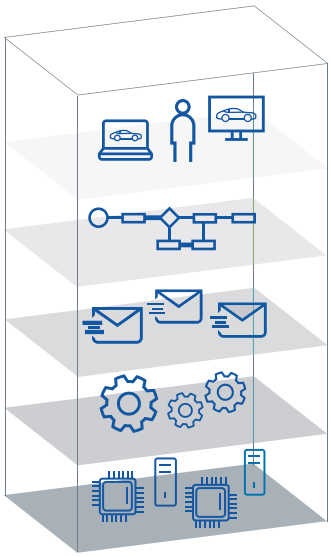
The AUTOSAR Adaptive standard lays the foundation for integrating functions into central vehicle computers and ushers in major changes in ECU development. ETAS' RTA-VRTE platform software framework and ISOLAR-A_ADAPTIVE architecture design tool offer developers the solutions they need to discover the world of new E/E architectures.

The AUTOSAR Adaptive Platform and the introduction of powerful, microprocessor (µP)-based vehicle computers (VCs) will bring about fundamental changes to both software and development processes. These changes will also extend to the platform software and development tools. ETAS is working with Robert Bosch GmbH to develop the RTA-VRTE platform software framework, which is already being used by customers around the world (see page 15).

For customers who want to start their journey now, ETAS offers an AUTOSAR Adaptive Early Access Program (EAP). It includes the RTA-VRTE software and components of the ISOLAR-A_ADAPTIVE software development kit (SDK) as well as consulting and training, giving ETAS customers access to a wealth of experience to help them get started in this new world.

The RTA-VRTE platform software framework

The RTA-VRTE platform software framework includes all the important middleware elements for µP-based vehicle computers (Fig. 1). Levels 1 and 2 include infrastructure software for the relevant hardware and for a POSIX-compliant operating system. Since, unlike conventional ECUs, µP-based vehicle computers allocate resources to applications dynamically, the AUTOSAR Adaptive Platform's execution manager also controls CPU time and memory access in level 2.



Application Services	Functions/Applications
Layer 5 Vehicle-dependent Platform Services	Services managing the ECU grid of the vehicle
Layer 4 ECU-dependent Platform Services	Services managing one specific ECU
Layer 3 Communication Middleware (Service-oriented)	Manages control and data flow between SW components
Layer 2 OS-dependent Infrastructure SW	SW that complements the actual OS kernel (aka scheduler) and abstracts OS-specific properties toward higher layers
Layer 1 HW-dependent Infrastructure SW	SW that interacts directly with HW and abstracts it toward higher layers
Hardware	Microcontroller (µC), microprocessor (µP), virtual machine (VM)

Figure 1: The RTA-VRTE layer model supports key software functions and requirements.

Applications must also recognize other software in the system and communicate with it. The communication middleware in level 3 provides this capability independently of the protocol. This is a core component of RTA-VRTE, managing and controlling the interactions between the levels and ensuring smooth operation of the encapsulated software, including the ECU and vehicle-dependent platform services on levels 4 and 5.

Architecture design with ISOLAR-A_ADAPTIVE

ISOLAR-A has established itself the world over as a tool for creating software architectures based on the AUTOSAR Classic Platform. Because it is based on Eclipse, this tool can easily be integrated into existing development environments, and Eclipse plug-ins also allow ISOLAR-A to be combined with development environments, such as Doors, Subversion, and Git.

ISOLAR-A_ADAPTIVE is the latest addition to the ISOLAR tool family. It lets users develop and integrate application software for RTA-VRTE. ISOLAR-A_ADAPTIVE supports software developers in configuring AUTOSAR Adaptive applications, be it configuring applications, generating Service Manifests, generating Proxies/Skeletons, providing Service Instances, or configuring Service Detection with SOME/IP.

Ready to go!

The RTA-VRTE Early Access Program (EAP) offers a complete software development kit (SDK) for the AUTOSAR Adaptive Platform. The SDK is delivered as a VirtualboxTM* image preinstalled with all tools, together with a set of preconfigured, virtual vehicle computers with RTA-VRTE. It lets users familiarize themselves with the new architecture, run their own prototypes, and debug software. The EAP also includes comprehensive training and consulting.

For maximum flexibility, and in order to prepare for mixed ECU-VC architectures with classic and adaptive AUTOSAR components, the EAP can be configured with ETAS ISOLAR-EVE (sold separately), the virtualization solution for AUTOSAR Classic ECUs. Future enhancements to RTA-VRTE will then provide services that have not (yet) been defined by AUTOSAR but that are vital for developing, debugging, and securing adaptive AUTOSAR applications, such as firewalls or gateway management solutions in the security environment, and connections to measurement and calibration systems.

This gives early starters access to the multitude of software and functions they need in order to develop reliable, functionally safe, and comprehensive adaptive software. It provides a solid foundation on which they can already begin to adopt the processes for future automotive software development.

* Virtualbox™ is a virtualization solution for PCs from Oracle.

Fully virtualized development processes

Partitioning the vehicle computer into strictly encapsulated virtual machines (VMs) also paves the way for highly parallelized, fully virtualized software development processes. As a multilayer platform, the RTA-VRTE is completely decoupled from the VC hardware used later – regardless of whether it comes from NXP, Renesas, Qualcomm, NVIDIA, or Intel. This lets developers familiarize themselves with the AUTOSAR Adaptive Platform on their PC by gaining practical experience with the RTA-VRTE software and ISOLAR-A_ADAPTIVE tools.

The EAP offers preconfigured quick emulator (QEMU) virtual machines (VMs) for x86 64-bit and ARMv8 µP architectures. In the RTA-VRTE, they act as virtual ECUs that developers can run on a desktop PC. All VMs are connected via Ethernet and can thus communicate with each other and, using a Windows Network Bridge, with the outside world.

It's all in the bag

ISOLAR-A_ADAPTIVE, RTA-VRTE, and the EAP provide easy access to a fully virtualized development environment of the future that ETAS customers can already start using on their PCs today. Software development teams now have the opportunity to practice new communication structures, to overcome the previously strictly divided structures, and to establish agile development processes for VC software. Let the future begin!

Authors

Dr. Darren Buttle is Head of RTA Solutions Germany at ETAS GmbH. **Bernhard Reckels** is Product Manager for AUTOSAR Classic and Adaptive tools, including ISOLAR-A_ADAPTIVE, at ETAS GmbH.

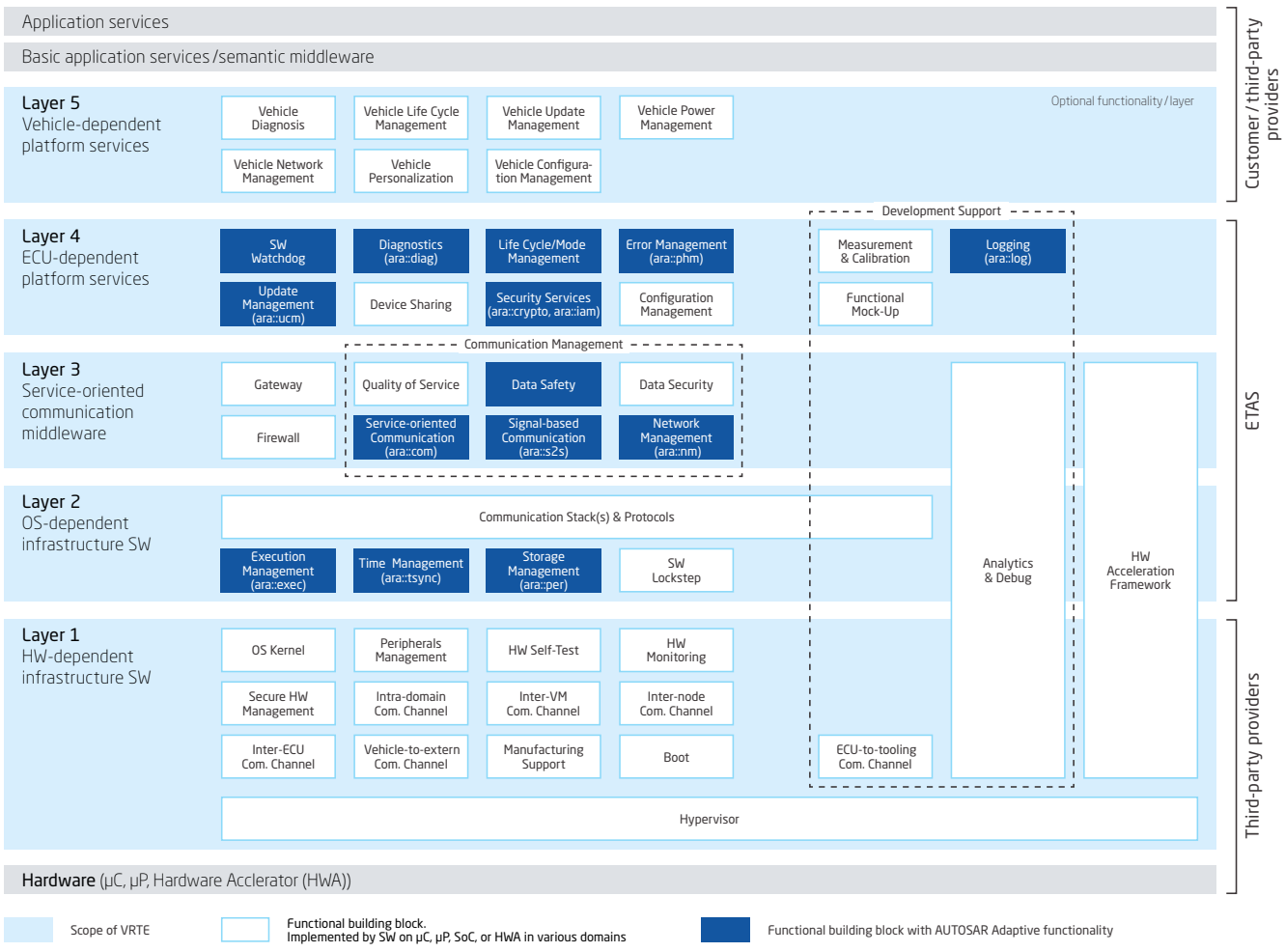


Figure 2: Detailed outline of the software components of the RTA-VRTE software framework.

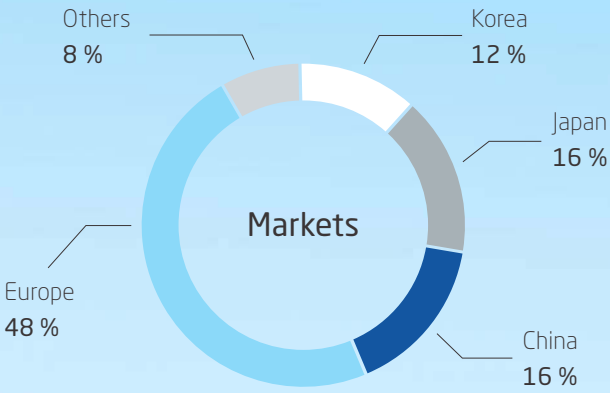
Jointly achieving goals

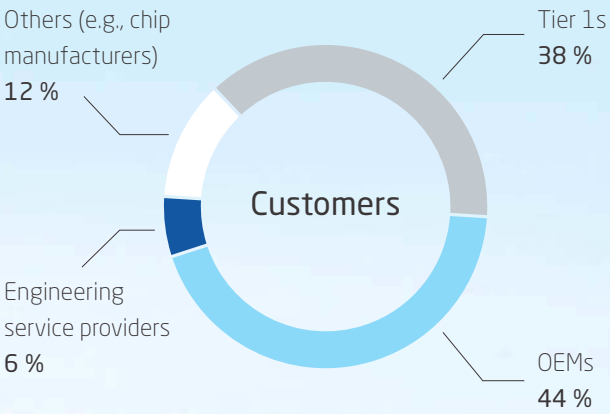
ETAS Early Access Program for AUTOSAR Adaptive in use

The Early Access Program (EAP*) of the platform software framework RTA-VRTE is being well received by users around the world who want to develop software for vehicle computers with the AUTOSAR Adaptive Platform. The following figures show the dissemination in August 2019.

Processors currently requested

Nvidia Xavier	11
Renesas RCAR	6
NXP S32x	8
TI TDA4V	2
NXP iMX6	1
NXP iMX8	1
Xilinx UltraScale	2





AUTOSAR Adaptive training sessions already held

2017	17
2018	111
2019	102 First half-year

The first vehicle computer project with VRTE will go into series production at the end of 2019 featuring a Bosch control unit.

* You'll find more information about EAP on page 12.

ETAS is the AUTOSAR partner for Safe4Rail-2

European project for safe, future-oriented railway applications

The goal of the research project Safe4RAIL-2 funded by the Shift2Rail European rail initiative, is to develop a common platform for E/E architectures and wireless traffic networking (V2X) with high safety requirements for future trains.

Working together with the complementary project CONNECTA-2, Safe4RAIL-2 supports the development of railway demonstrators where next-generation E/E architectures and components for the Train Control & Monitoring System (TCMS) will be integrated. Furthermore, the project addresses how to run the TCMS functions in a simulated environment in order to minimize the need for expensive and time-consuming field tests.

Safe4RAIL-2 aims to reduce the complexity and cost of electronics and thus put European rail suppliers in the lead worldwide. Software prototypes will be developed by 2021 and integrated into railway demonstrators. ETAS, in cooperation with Bosch Engineering GmbH as a third-party, is contributing software architecture expertise and safety consulting as well as components of the RTA-VRTE (Vehicle Runtime Environment) Early Access Program, a ready-to-go AUTOSAR Adaptive development environment that works with POSIX operating systems (see page 12).

The project is led by a European consortium of six industrial partners and two research institutions (see picture). ETAS supports the project partners in building AUTOSAR Adaptive competence. This expertise from other mobility areas is one of the key strengths in the project. Safe4RAIL-2 is financed entirely from EU funds.

"Safe4RAIL-2 is the future when it comes to interoperability in train systems," says Dr. Núria Mata, ETAS Project Leader. "We see a huge potential to improve railway applications and focus on efficient interconnections, standardized interfaces, and an enhanced safety level of distributed train systems and applications."

* Safe4RAIL-2 means "Safe architecture for Robust distributed Application Integration in roLling stock 2"

The Safe4RAIL-2 partners aim to use new technologies to make trains and their transport infrastructure safe and future-proof. You'll find more information at www.safe4rail.eu

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 826073. The information and views set out in this document are those of the author(s) and do not necessarily reflect the official opinion of Shift2Rail Joint Undertaking (JU). The JU does not guarantee the accuracy of the data included in this article. Neither the JU nor any person acting on the JU's behalf may be held responsible for the use which may be made of the information contained therein.

Authors

Ricardo Alberti is Consultant Engineering RTA Solutions at ETAS GmbH. **Dr.-Ing. Núria Mata** is Consultant Engineering RTA Solutions at ETAS GmbH. **Christoph Müller** is Expert Safe Computing Architecture at Bosch Engineering GmbH. **Dr.-Ing. Artem Rudskyy** is Software and System Developer at Bosch Engineering GmbH.

Virtual ECUs in the cloud

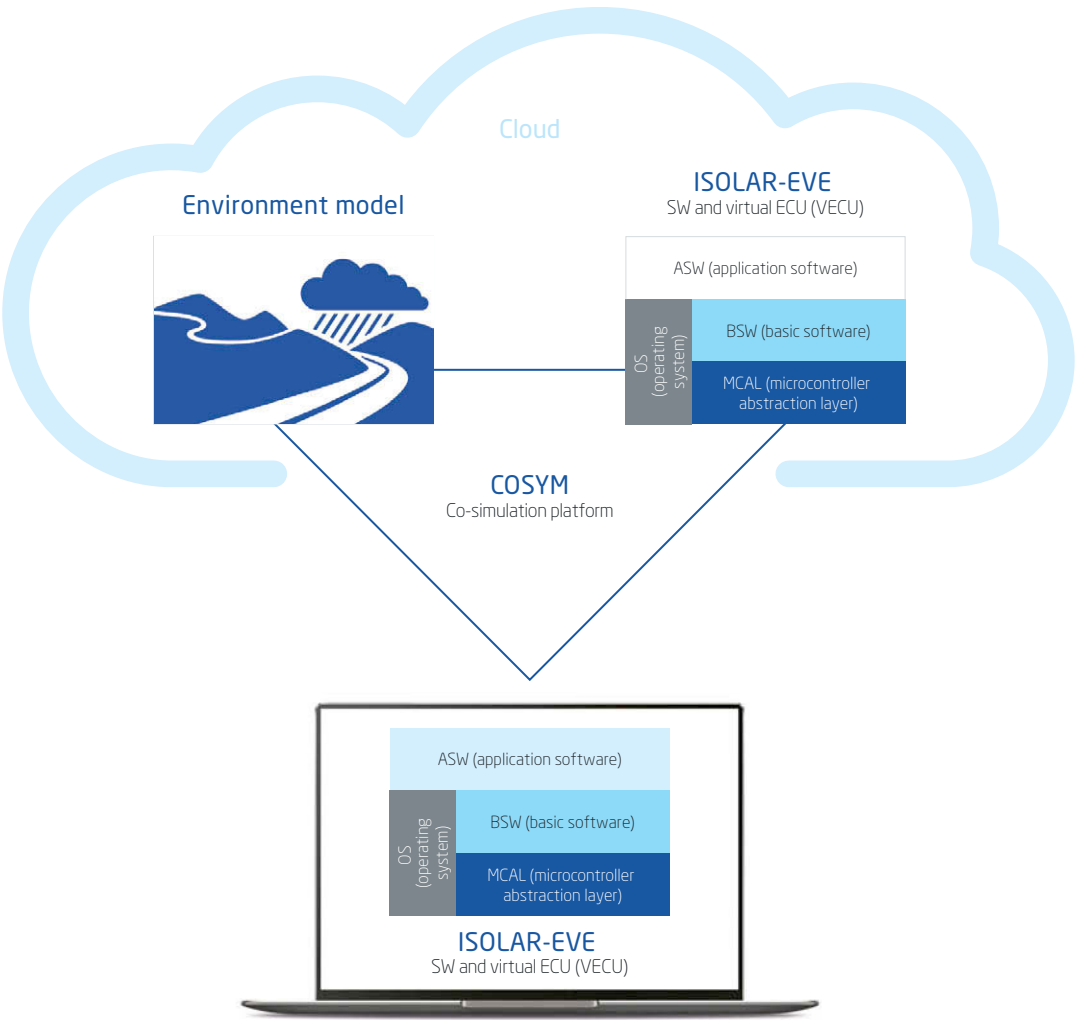
Promising combination of ETAS ISOLAR-EVE and COSYM

ISOLAR-EVE has enabled highly realistic ECU simulations on PCs for several years now. The latest version 3.3.1 adds the ability to execute virtual ECUs in the cloud, where they can be verified as a complete system, using the COSYM integration platform and a simulation of the vehicle communication network. This provides a significant benefit: in virtual test drives, complete systems including their network communication can be verified realistically at a very early stage without being dependent on specific hardware. This is true even when combining AUTOSAR-compliant software with non-AUTOSAR application code and is made possible through physical co-simulation of vehicle components and simultaneous ECU network simulation – in parallel, scalable, and efficient.

"Combining the new version of ISOLAR-EVE with COSYM opens up entirely new possibilities for distributed development of ECU networks," says Dominik Feil, the product manager responsible for ISOLAR-EVE. "This new combination will help customers reach high levels of product maturity faster while reducing costs significantly."

Author

Jürgen Crepin is Senior Marketing Communications Manager at ETAS GmbH.



Virtualization is the key to overcoming challenges and ensuring effective project planning when the number of test kilometers is in the six to seven-digit range.

Full control of charge management and more

Future-proof test systems for vehicle control units

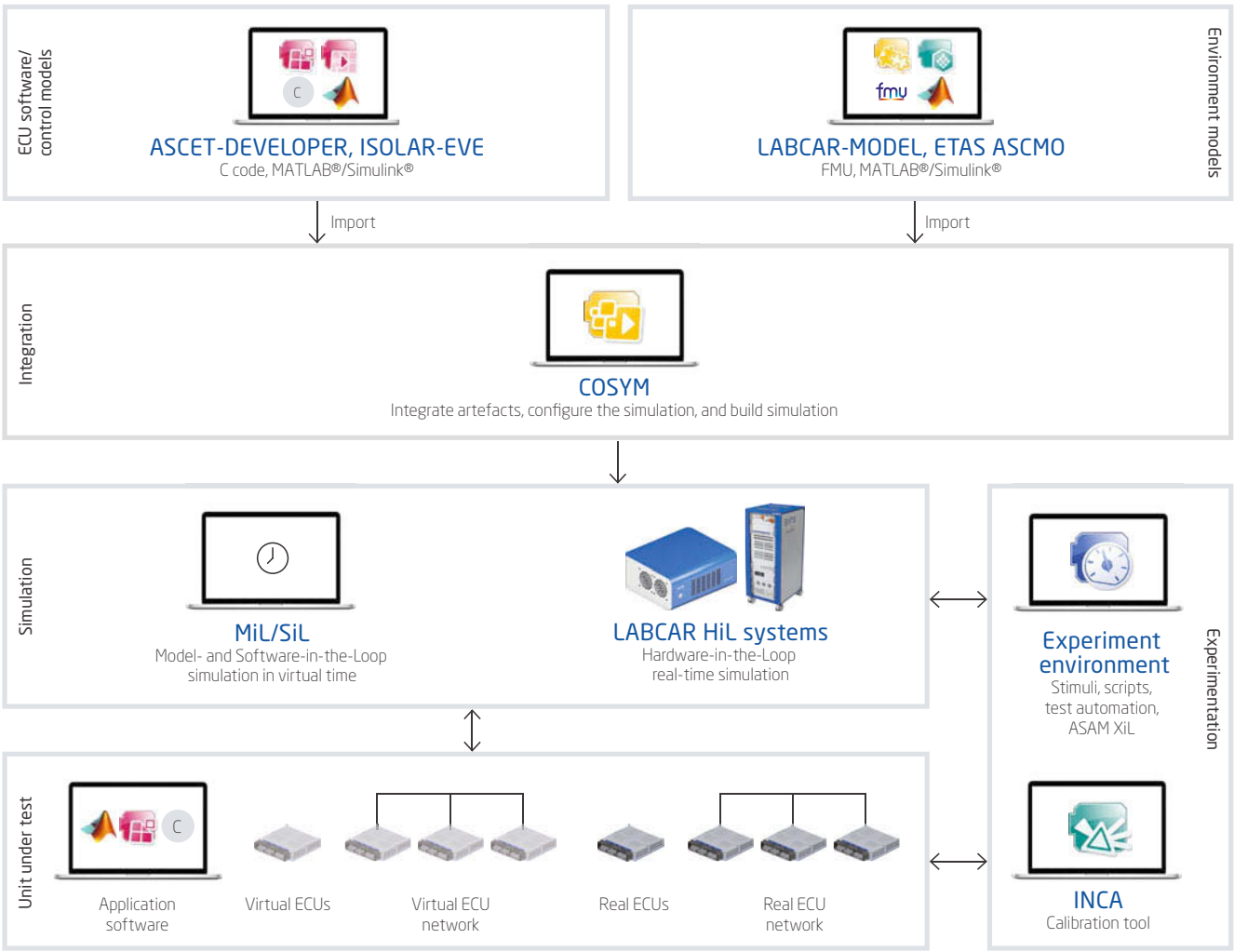
The vehicle control unit (VCU) is set to play an increasingly important role, especially in electrified vehicles. Its performance capabilities make it the perfect choice for complex tasks such as coordinating all the components in the powertrain, including charge management, and handling computationally intensive, cross-domain tasks. Consequently, the VCU places major demands on the test environment, which ideally should be designed for end-to-end virtualization.

From a technical perspective, modern Domain ECUs are significantly more complex than previous ECUs. This increases the scope of testing required in ECU development. At the same time, automakers are under increasing pressure to bring new vehicles to market within the shortest possible timeframe. When it comes to testing, calibration, and validation, this combination of factors pushes purely hardware-based systems to their limits. The future lies in virtual systems.

As a central control unit, the VCU controls and coordinates multiple powertrain components. It also features a connection to the cloud and – in the case of highly automated vehicles – "fail-operational" functions that ensure safe operation of the vehicle in an emergency. At higher configuration levels, the VCU also increasingly offers the performance capabilities required to support computationally intensive, cross-domain functions such as the connection to Advanced Driver Assistance Systems (ADAS).
One of the VCU's core features is the charging interface. This is because more and more vehicles are coming onto the market with battery-electric powertrains, either as the sole source of power or, in the case of plug-in hybrid vehicles, as an auxiliary drive. Consequently, one of the most important tasks facing developers today is to create a smooth and seamless charge management process that ensures the electric drive operates reliably at all times.

One method of testing the VCU charging interface is by using the ETAS LABCAR Hardware-in-the-Loop (HiL) system. It offers the full range of communication interfaces required to adapt all VCU interfaces quickly and efficiently. In the case of charge management, these include authorization (authentication), execution of the charging process (transmission of technical parameters such as charging performance, charging parameters, charging efficiency, and charging schedule), and payment (transmission of billing data). The system includes models for common charging standards (CCS, CHAdeMO, and GB/T), allowing engineers to simulate the charging process for the most common vehicles available today. From the vehicle's perspective, the test system therefore behaves exactly like the real-world charging infrastructure (vehicle to grid).

In the future, test and validation tasks are likely to become increasingly complex and elaborate. In order to continue executing these tasks successfully and efficiently, a shift to replacing traditional HiL tests with virtual solutions is unavoidable.



COSYM is an efficient simulation platform that facilitates seamless transitions between HiL, MiL, and SiL applications.

ETAS test systems are ready for this shift. LABCAR enables a seamless test transition into SiL or MiL environments (Software-in-the-Loop, Model-in-the-Loop) where they can be executed in their entirety on a local PC or in the cloud. This offers multiple benefits, including the ability to perform these tests faster and at an earlier stage of the development process. Thanks to the scalable computing power of cloud computing, the performance capabilities of the test system can be scaled to meet the exact requirements. Virtualization therefore significantly increases the efficiency of VCU development. System testing based solely on HiL systems is not an effective approach.

ETAS offers an open simulation platform that is designed to meet complex future requirements: ETAS COSYM. COSYM is an efficient solution for successfully executing testing and validation tasks for connected, embedded systems – both in a HiL environment and, as an alternative, in SiL or MiL environments. In other words, COSYM facilitates integrated XiL-tests, where XiL refers to "everything"-in-the-loop, meaning either of the three variants. It also supports cloud functionality.

Summary

ETAS test systems are designed with the future in mind, combining HiL testing capabilities with increased virtualization. Testing, validation, and calibration can be transferred seamlessly from a hardware-based environment to a purely computer-based, virtual working environment, and vice-versa. Consequently, ETAS test systems play a key role in the efficient development of even the most complex ECUs, such as the vehicle control unit (VCU), including its charging interface.

Author

Heiko Sutter is Senior Program Manager in the field of Test and Validation at ETAS GmbH.

New domains require new models

LABCAR-MODEL family of products now includes fuel cell model

The twin tasks of significantly reducing greenhouse gas emissions from road transport and developing alternative vehicle drive systems pose a major challenge for the automotive industry. As an emission-free source of energy, the fuel cell is a promising candidate. Following years of research, ETAS has developed a simulation model of fuel cell systems for Hardware-in-the-Loop and Software-in-the-Loop tests. This model offers an efficient means of testing fuel cell ECUs and their operating strategies.

The German government's Climate Action Plan 2050 aims to achieve a 40 to 42 percent reduction in greenhouse gas emissions from road transport by 2030 compared to 1990 levels. This goal covers emissions from cars, light commercial and heavy goods vehicles, and public transport. The development of hybrid and electric vehicles has led to electrification of the powertrain, which favors the use of fuel cells in the automotive sector.

In a fuel cell, hydrogen and oxygen react to produce electricity, heat, and water. This reaction does not produce any greenhouse gases, so there are no harmful emissions. The available energy density, however, is comparable to that of conventional fuels. To achieve the level of performance required by the automotive industry, individual fuel cells are assembled into modules known as "stacks." This allows engineers to prepare fuel cell systems for different performance classes, for example for commercial vehicles or passenger vehicles.

Operating this kind of energy source safely in a vehicle requires a new component control unit known as a fuel cell control unit (FCCU). This maintains efficient fuel consumption and controls

the amount of power generated by regulating the supply of hydrogen and oxygen. Unlike established engine control units, which have decades of development behind them, the FCCU must be made production-ready within just a few years, including development of all the open and closed-loop control and diagnostic functions. To enable rapid development cycles, it is essential to test and validate FCCUs and their operating strategies in a virtual fuel cell system – for example, using Hardware-in-the-Loop (HiL) or Software-in-the-Loop (SiL) set-ups.

As part of a doctoral thesis, ETAS and the University of Stuttgart developed a simulation model for fuel cell systems: ETAS LABCAR-MODEL-FC. Special emphasis was placed on achieving simple parameterization of the complex electrochemical processes within a fuel cell on the basis of easily accessible parameters. The model is geared to the specific requirements of the automotive industry, such as cold start behavior and water management.

Thanks to the use of advanced numerical solvers, the simulation model provides insights into water, temperature, and current distribution within the stack. This spatial resolution also facilitates the observation of non-linear effects, enabling even complex control functions to be tested in the FCCU.

LABCAR-MODEL-FC is specifically designed for use in LABCAR HiL systems and in COSYM SiL virtualization solutions. To enable deployment in these scenarios, the developers paid particular attention to real-time capable implementation. The result of their work, LABCAR-MODEL-FC, represents a realistic model of a fuel cell system for testing and validating an FCCU.

Summary

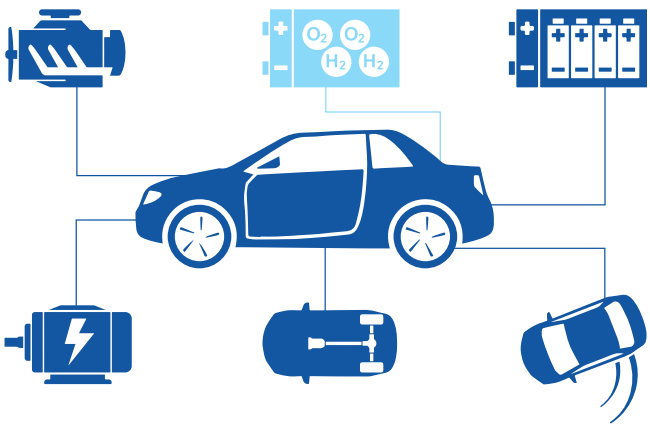
The LABCAR-MODEL-FC fuel cell model from ETAS is a truly cutting-edge product. It provides the perfect solution for performing efficient and reliable testing of ECUs for fuel cell drive systems both now and in the future. This is just one of the tangible contributions ETAS is making toward the development of e-mobility.

Author

Dr. rer. nat. Martin Rosing is Product Manager in the field of Test and Validation at ETAS GmbH.

Scientifically sound: LABCAR-MODEL-FC

Using a real fuel cell to test and validate ECUs for fuel cell drive systems is not only costly and time-consuming, but also potentially hazardous. LABCAR-MODEL-FC is a new simulation model developed by ETAS that specifically caters to the needs of the automotive industry. The model is based on a thesis jointly supervised by ETAS and the University of Stuttgart. It therefore combines a solid scientific basis with a practical focus – a product made by engineers, for engineers.



LABCAR-MODEL-FC is part of the LABCAR-MODEL family of products. Each model in this family can be used to test ECUs from a specific domain.

EATB
A faster way of combing through mass data

An efficiency-enhancing tool for developers and quality management

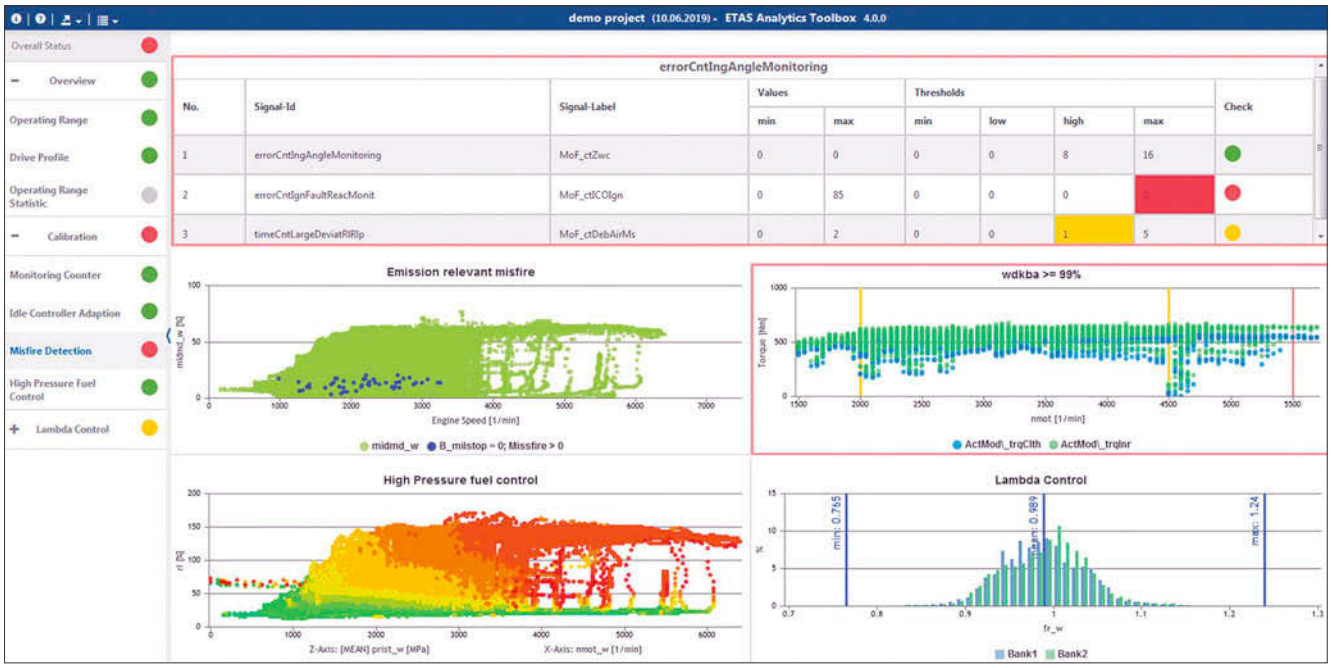
The Enterprise Data Analytics Toolbox (EATB) quickly identifies key points in vast sets of measured data and performs statistical analyses. It also generates reports with compelling graphics for instant use in presentations to management or customers. These time-saving features are a significant advantage to developers in their demanding daily work.

Take, for example, a usage scenario involving a recently road-tested new brake system. Several terabytes of measured data have been uploaded to a server. The next step is to start the workflow that the brake designer has come to know and appreciate. The designer opens the ETAS Enterprise Data Analytics Toolbox (EATB), selects a template with predefined criteria for assessment, and runs the analysis. The program soon identifies all points in this vast set of measured data where parameters need to be adjusted, and generates an interactive graphical report.

The EATB visualizes statistical analyses for both physical and computed signals. It also displays the timeline and threshold events where values exceed the limits. A traffic light provides a clear indication of the status: Green means the calibration is good to go, with no need to take further action. Yellow indicates variance within a certain range of the threshold. Red indicates a deviation extending beyond the threshold value.

The data are evaluated automatically at the touch of a button, in a fraction of the time required for manual analysis. This key function of the EATB addresses the needs of application and validation engineers, project managers, and quality assurance teams. They all receive reliable insight into measured data in a minimum of time, which is a big advantage considering the short development lead times and increasing volume of data in today's development environment.

This report is a great help to the developer, who can then view and edit functions at the parameter level in the Measure Data Analyzer (MDA, see page 36). With this combination of preliminary analysis and focused deep dive, the engineer is able to work quickly, yet with great precision.
The generated reports are flexibly configurable. Another great advantage is that they are interactive. A specialist can easily zoom in on any dataset to see the results in higher resolution. Other tools' PDF reports lack this capability.



Insights at a glance: the Enterprise Data Analytics Toolbox's green, yellow, and red color coding provides a fast, efficient way of analyzing measured data.

With the current status so easily ascertained, these reports also support efficient communication. Generated in lean HTML5 format and stored on a web server, they are readily accessible to everyone with a stake in the project and viewable in any standard internet browser, even on mobile devices. The reports can be integrated into presentations without further editing or formatting.

Developed with users for users, the EATB is born of practical experience. The measurement data format (MDF) can be read and processed directly. The EATB is compatible with data sourced from the ETAS INCA software and other systems.

The templates used by the EATB offer many more benefits. Ideally, a MATLAB® user configures a customer-specific set of criteria for analysis in the given template. Once the know-how needed for key development steps is captured, all developers can benefit from the knowledge archived in the template library. Templates can be adapted for new tasks simply by modifying a few details. The toolbox comes with a manual for creating templates. Template training and services are also available.

The bottom line

ETAS' Enterprise Data Analytics Toolbox is a powerful tool that quickly analyzes even large amounts of measured data. Its trafficlight color coding makes it easy to spot actionable areas. The EATB offers great potential for boosting efficiency. The reports it creates can be embedded directly in presentations. They also satisfy documentation requirements. Many departments at Robert Bosch GmbH already use the EATB. Efforts are underway to ensure future versions of the toolbox will be usable in the cloud and ready for big data use cases. In this way, the EATB fits seamlessly into a fully virtual and accelerated test environment, where it can also deliver on its strengths.

Author

Andreas Klegraf is responsible for the Enterprise Data Analytics Toolbox at the Product Management Integration and User Experience unit of ETAS GmbH.

Vehicle Management Solution reduces costs

Accelerated vehicle development and efficient fleet management

The Vehicle Management Solution from ETAS is an integrated web and cloud-based connectivity solution – a cutting-edge tool designed to enable efficiency in vehicle development. It offers numerous advantages, including the ability to access development vehicles from anywhere and at any time in order to retrieve measurement data, install software versions, and request vehicle status as part of the diagnostics process. This accelerates system development and reduces the cost of field data management and fleet management. The software runs in the cloud, eliminating the need for companies to set up and maintain their own IT infrastructure.

It's a winter morning in Sweden, and the test driver was up early to start his lengthy test drive. Deep in the snow-covered woods, far from the workshop, he receives a message via the remote box. It informs him that various ECU updates with modified steering and braking parameters have been downloaded from the cloud onto the on-board unit via a cellular data connection and are now ready to be flashed. He stops the car at the next opportunity and gives the go-ahead for the update to start.

It takes just a few minutes for the system to install the updates on the ECUs. Soon he is back on the road and, almost immediately, the car begins transmitting current dynamic measurement data as well as status information – all based on the new parameters – back into the cloud via the cellular data network.
A development engineer back at headquarters can immediately access the data from the cloud, perform the next stage of the validation process and prepare further ECU updates if necessary, effectively creating a closed loop (Fig. 1).

This scenario is already a reality thanks to a reliable, secure, and forward-looking connectivity solution known as the Vehicle Management Solution (VMS). Offering a bidirectional communication channel between the vehicle and the cloud, the VMS handles procedures including remote flash, remote measurement, and remote diagnostics. Remote flash (firmware over-the-air, FOTA) involves flashing one or more ECUs over UDS on CAN. The remote measurement function records data on the CAN bus (as described in the example), while remote diagnostics involves running diagnostics from a distance. High data rates and low latencies can be achieved. Preparations are already underway for a cloud-based data analysis feature that will provide further innovative functions and services.

There are two primary components that make up the Vehicle Management Solution. The first of these is a core software module that provides a fast and secure communication interface between the vehicle, cloud, and services. The second is a data management module that organizes, analyzes, visualizes, and prepares the entire flow of data via the cloud.

The on-board unit is the hub of the Vehicle Management Solution in the vehicle. As well as recording measurement data and status information, it also controls data traffic and flashing. The initial VMS configuration includes the powerful new ETAS ES740 On-Board Unit. This is configured to handle highly demanding application scenarios. Nonetheless, ETAS intends to expand VMS compatibility step by step to include modules made by different manufacturers and modules with different performance configurations. One example is the incorporation of the even more powerful ETAS ES820 Drive Recorder.

Two companies have pooled their experience to develop and market this product. ETAS' core competence lies in hardware-related functions and measurement and calibration tasks, while Robert Bosch GmbH offers expertise in backend and cloud services. At the start of 2019, the two companies combined their know-how in a new cooperation.

The VMS is the perfect tool for today's highly challenging market environment. The increasing complexity of modern vehicles requires frequent software releases during the development process, and the subsequent real-world tests are both time-consuming and labor-intensive. This results in very high costs overall. In addition, each development department at an OEM usually has its own test vehicle to carry out its own specific tests, which represents another huge expense.

The Vehicle Management Solution helps engineers cope with increasing complexity while simultaneously reducing development costs. Functions such as remote flash and remote measure-

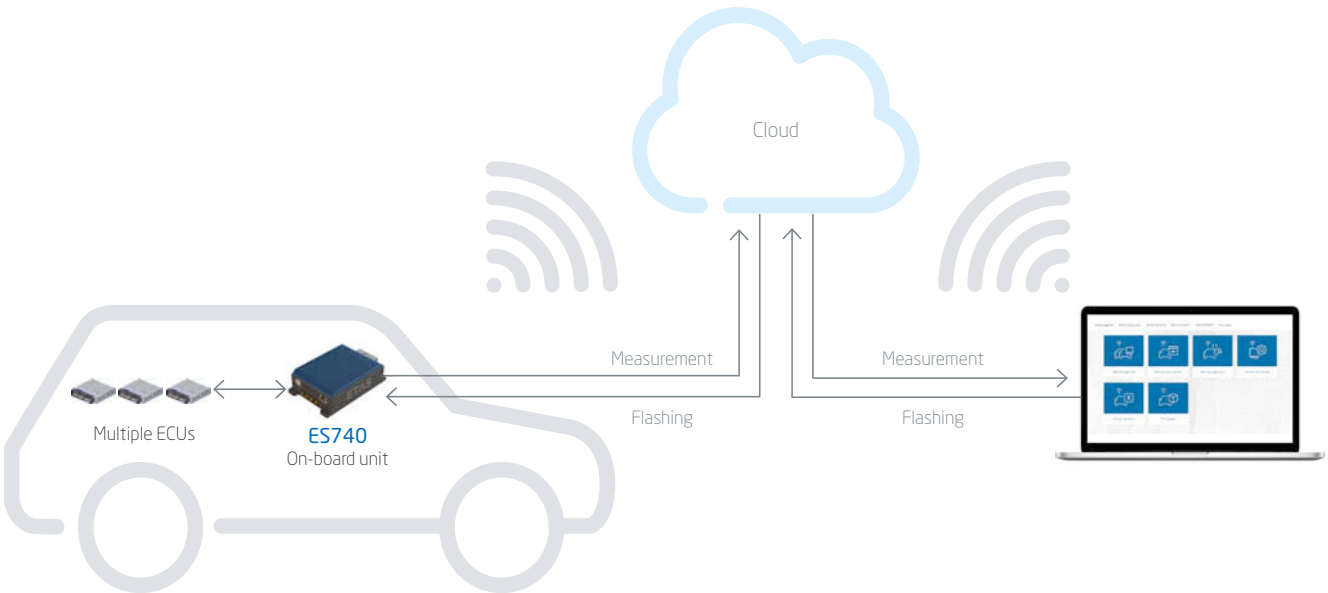


Figure 1: Closed loop – the VMS offers a bidirectional communication channel between the vehicle and the cloud.

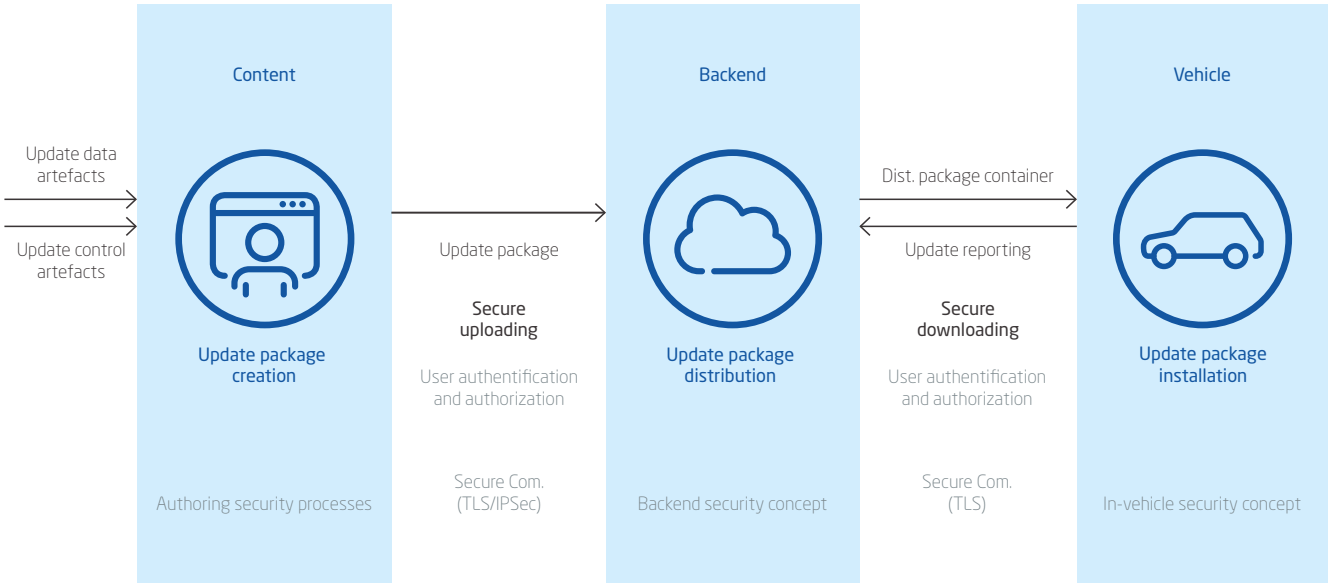


Figure 2: The VMS offers a modular and highly secure environment.

ment provide rapid feedback on modified parameters, reducing the time required to validate software versions. This provides an easy way of ensuring that vehicles are always running the latest version of the software. The VMS enables system experts to remotely supervise several vehicles at once.

Tasks in the vehicle itself are simplified, so that they can be initiated by any test driver. Major cost savings also come from the reduction in fleet size: a single test vehicle can be put to effective use by multiple departments, in some cases even at the same time. As a result of all these factors – and because the vehicle does not have to return to the workshop to be flashed – development times overall are shorter. Thus, the cloud-based system offers maximum flexibility by making development work location-independent.

A fleet management system is included in the VMS that makes it possible to manage, plan, control, and monitor large numbers of different vehicles. By clearly displaying vehicle-specific information, vehicle status, and vehicle position, the VMS ensures that fleet managers and development engineers always have a complete, up-to-date overview. The clearly structured web interface can be used in a standard internet browser.

Security was a key priority for the VMS development team. In-depth security is comprehensively assured along the entire chain, making it impossible for anyone to falsify the data passing through the various transmission paths and stations (Fig. 2).

The modular security concept was developed in collaboration with ESCRYPT, ETAS' wholly-owned subsidiary and a leading provider of IT security solutions.

The Vehicle Management Solution is designed as "software as a service" (SaaS). The model includes operation of the VMS for the customer, and the relevant programs are designed to run on various public clouds. Analyses and evaluations are also executed in the cloud before being sent to the customer. Customers can connect their own applications to the VMS through defined interfaces. The advantages of this model are clear: the VMS software is always up-to-date, customers have no need for their own server, and no maintenance costs arise.

Summary

The Vehicle Management Solution speeds up vehicle development with its location-independent functions and offers significant cost-cutting potential. Regular updates ensure it is always up-to-date. A sophisticated security concept ensures maximum data protection and data integrity. All in all, the VMS is another step forward in the future of automotive development.

Authors

Axel Heizmann is Senior Marketing Communications Manager at ETAS GmbH. **Murat Yeter** is Solution Manager for connected development at ETAS GmbH.

ETAS and National Instruments set up joint venture

Partnership combines software-defined platform from National Instruments with global test and validation solutions from ETAS

ETAS and National Instruments have signed an agreement to jointly design, build, and service pre-integrated Hardware-in-the-Loop (HiL) systems. The companies are pooling their strengths to optimize the testing and validation of automotive electronics software, including ECUs and sensors, to meet current and future customer requirements.

The agreement will establish a closer partnership between two innovators with decades of experience in the automotive industry. By combining the software-defined platform and comprehensive I/O capabilities of National Instruments (NI) with ETAS' expertise in developing and integrating HiL solutions, the partnership will deliver new testing capabilities. The goal is to meet customer needs in the automotive sector, which is evolving rapidly due to electrification and Advanced Driver Assistance Systems (ADAS).

ETAS and NI each own 50 percent of the joint venture, which will be headquartered in Stuttgart, Germany. The new company will become fully operational on January 1, 2020. It plans to employ 50 associates and scale for rapid growth.

"With the formation of ETAS NI Systems, a milestone has been reached for improving test and validation of automotive electronics software, including electronic control units and sensors, to meet current and future customer requirements," said Friedhelm Pickhard, Chairman of the Board of Management of ETAS GmbH.

"We have found a strong partner in NI thanks to its complementary component portfolio, strong brand, high quality products, and cultural fit." "The ETAS and NI teams' capabilities, domain expertise, and global footprint create a unique opportunity to broaden our customer reach and help them solve the development challenges in the automotive industry," said Eric Starkloff, NI President and Chief Operating Officer. "We have made great progress toward getting our partnership operational and look forward to serving customers' needs."

The systems offered by the joint venture will deliver efficient solutions that will enable customers to achieve shorter design cycles, reduced test times, and a faster time to market.

Author

Anja Krahl is Group Manager Brand Management, Media Relations & Digital Communication and ETAS Spokesperson.

Management teams of ETAS and National Instruments together with Leandro Fonseca, Managing Director of ETAS NI Systems (back row, second from left), and Hans-Peter Dürr, Technical Director of ETAS NI Systems (back row, second from right).

RTA-BSW and ISO 26262 go hand in hand

ETAS AUTOSAR basic software is compliant with ASIL-D:2018 applications

The more functions software takes on in a vehicle, the more important functional safety becomes. The increasing complexity of E/E architectures poses a further challenge to the development of functional safety-compliant software. Reliable, tried-and-tested basic software is one of the keys to meeting this challenge. TÜV SÜD tested the suitability of ETAS AUTOSAR software products for safety-compliant use in ISO 26262 ASIL-D applications – and the results confirmed it is compliant.

Functional safety standards such as ISO 26262 focus on defining safety measures to prevent hazards caused by malfunctioning behavior of E/E systems. These safety measures include performance indicators used to certify that software and hardware meet the relevant requirements. But are these indicators sufficient to allow automakers and Tier 1 suppliers to certify the safety of their systems? The answer is most definitely no, and for good reasons.

Getting to grips with complexity saves time and money

We'll start with the example of an average modern premium class vehicle. The software it contains can easily run to 100 million lines of code – more than four times the total amount of software code used in an F-35 fighter jet from 2013. Spurred on by electrification and autonomous driving, automakers have been forced to make an unprecedented array of changes to E/E vehicle architectures. Yet these changes in no way diminish the safety requirements of vehicle users. In fact the opposite is true: as electronic systems take on more and more responsibility, functional safety becomes ever more important.

Meeting safety requirements that extend across all the systems in a vehicle requires a clear strategy and components that are safe by design. Safety standards define what automakers need to do, but don't specify how. This is where certified components can make the process easier and help underpin a strategy for broader system certification.

In addition, automakers are facing new challenges caused by ever shorter development cycles for platforms and increasing pressure to keep costs down. Consequently, each individual step in the process is constantly coming under scrutiny, from procurement and software development right through to production.

Implementing, reviewing and auditing safety-relevant software is an extremely expensive and time-consuming task, yet one that is absolutely indispensable. This is why pre-certified components are often the best solution.

The project

To support customers in developing safety-oriented systems, ETAS commissioned TÜV SÜD to audit the AUTOSAR basic software RTA-BSW. TÜV SÜD is one of the world's leading technical service providers and an acclaimed and trusted partner in the field of functional safety. Tests included checking RTA-BSW's compliance with the relevant certification based on the TÜV SÜD Smart Software Program, including its compliance with functional safety requirements.The TÜV SÜD team also analyzed RTA-BSW's quality and security features, including:

- general safety management,
- software-specific requirements relating to the scope of software deliverables, and
- the software development process.

What is RTA-BSW?

RTA-BSW is a production-ready AUTOSAR Classic basic software collection from ETAS that forms the core of the RTA Classic AUTOSAR product portfolio, called RTA-CAR. The software draws on over 20 years of experience of in-vehicle use with nearly 2 billion ECUs already on the road and zero post-production issues. RTA-BSW supports AUTOSAR R4.x functions and consists of a comprehensive set of AUTOSAR stacks (collections of modules) such as communication, memory, diagnostics, and safety. The modules of the basic software facilitate central ECU communication functions which are generally regarded as a common basis for the development of specific vehicle functions.

RTA-BSW includes everything customers need for functional safety-compliant applications.

The project drew on a number of different safety standards in order to cover passenger vehicles, motorbikes, trucks, and off-highway machines. The following safety standards were applied in the compliance assessment:

- ISO 26262:2018
- IEC 61508:2010
- ISO/DIS 19014:2018
- ISO 25119:2018

Overall, the assessment confirmed that RTA-BSW meets the relevant requirements of the TÜV SÜD Smart Software Program, including those contained in the functional safety module. This represents an important milestone for the ETAS RTA team in the UK, Germany, and Italy. Through RTA-BSW ETAS customers now have access to a solid basis for achieving high safety standards.

Summary

The automotive industry is currently facing numerous changes that affect each and every step in the automotive software development process. The effect of these changes is particularly noticeable in the field of safety-relevant embedded software. Confronted with an urgent need to make more savings, companies are being forced to focus on differentiating factors while relying on off-the-shelf components such as AUTOSAR platforms for other areas. By offering a range of certified AUTOSAR basic software products, ETAS helps customers meet the highest safety standards, ensuring that they are fully prepared for the challenges that lie ahead.

Authors

Luca Baldini is Product Manager for RTA-BSW at ETAS Ltd. in York, UK. **Daniele Garofalo** is Global Head of Product Management RTA Solutions at ETAS Ltd. in York, UK. **Jonathan Manktelow** is Safety Certification Project Manager at ETAS Ltd. in York, UK.

Flexibility through standardization

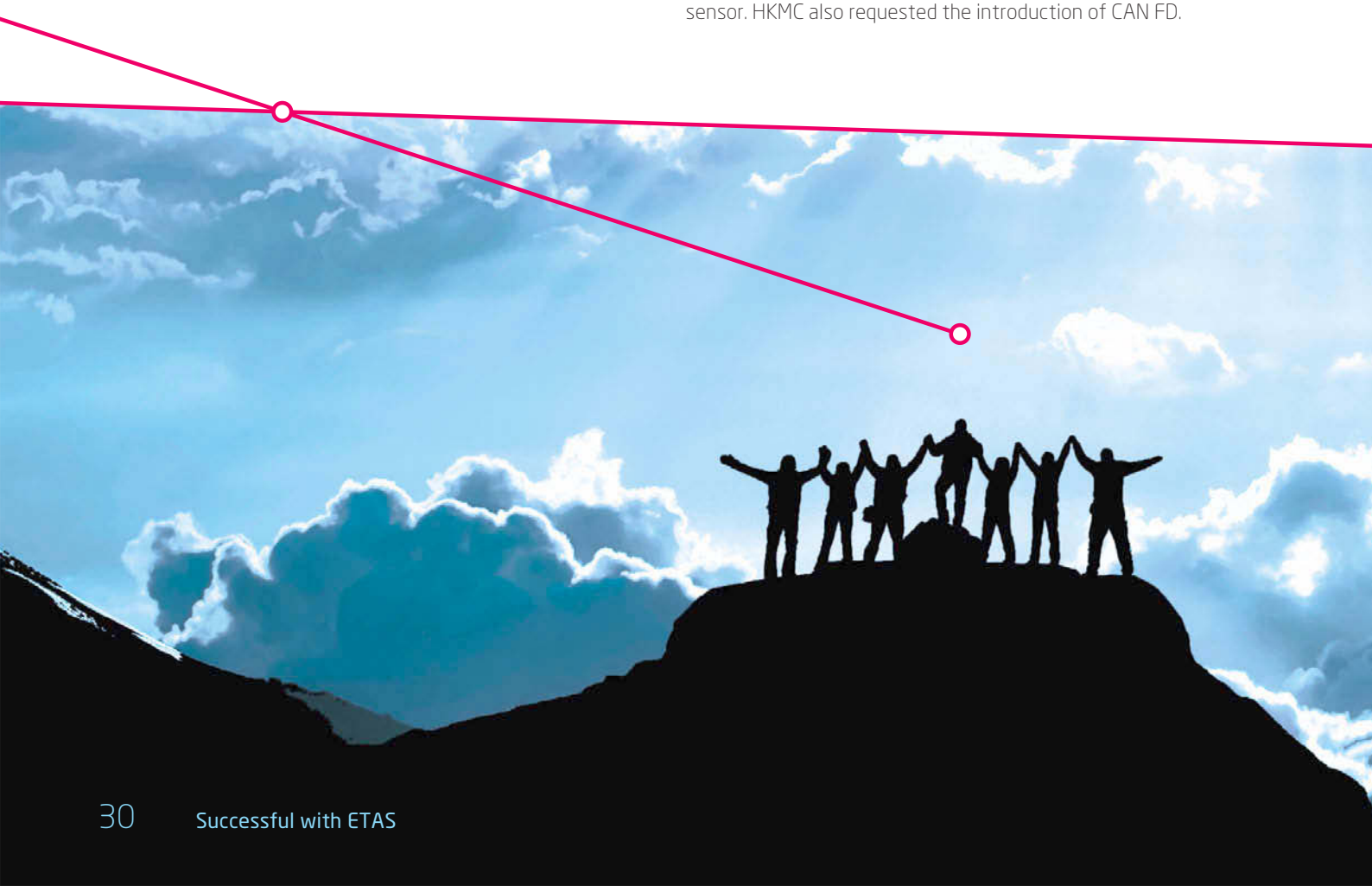
AUTOSAR implementation a team success

It may seem counter-intuitive, but standardization can actually increase flexibility. That's because reliable, standardized basic software speeds up the process of implementing changes and new functions. One company that recently experienced these benefits is the Korean company Motonic, which supplies oil pump units (OPUs) to the Hyundai-Kia Motor Company (HKMC). The engineers introduced CAN FD and AUTOSAR for an oil pump control unit and quickly achieved their goals thanks to ETAS' solutions. Here we take a closer look at how they accomplished this.

Meeting an ambitious goal

In the past, traditional hybrid vehicles typically incorporate two types of oil pumps to produce oil pressure for automatic transmissions: a mechanical pump for the combustion engine, and an electric one for the electric motor. In contrast, modern hybrid vehicles require just one electric pump, which reduces the volume of the system and improves fuel efficiency. Here, a permanent magnet synchronous motor (PMSM) was chosen instead of a brushless direct current motor (BLDC).

There are numerous parameters involved in controlling an oil pump, including torque transmission, lubrication/cooling/slip compensation, and leakage compensation. Base torque transmission in this case relates to the vehicle operating status (stationary/driving), using the line pressure of the automatic transmission and the oil temperature as input data.
An additional goal of the new system was to introduce a sensorless control algorithm for PMSM to improve motor performance and reduce the risk of failure posed by the Hall effect position sensor. HKMC also requested the introduction of CAN FD.



The previous control system was heavily dependent on a specific microcontroller unit (MCU). As a result, the incorporation of new MCUs was an extremely time-consuming process. To solve this problem, Motonic introduced the ETAS RTA basic software based on the AUTOSAR platform, making it possible to run the application software independently of the microcontroller.

Challenges along the way

A new standard development process for MCU firmware was established by developing a specific motor complex device driver (CDD) based on AUTOSAR. ETAS provided support in the form of a global team of experts from Korea, the UK, Germany, and Italy who assisted Motonic with the introduction of the AUTOSAR platform and the new functions.

The Motonic team used ETAS ASCET to develop the software for diagnosis and fail-safe and for the coordination control algorithm. The sensorless control algorithm, however, was hand-coded. The key challenge was to ensure AUTOSAR-compliant implementation of the control timing in line with the specifications. The team's efforts paid off, resulting in an optimized execution and synchronization control algorithm for the new motor. The flash bootloader (FBL) and diagnostic specification satisfied HKMC, too.

The ETAS engineering team performed the AUTOSAR BSW prototype configuration for the OPU FBL development using the basic software RTA-BSW, the operating system RTA-OS, the runtime environment RTA-RTE, and the flash bootloader RTA-FBL. Local technical support and training were also included. The developers also used the integrated AUTOSAR architecture and basic software configuration tool ISOLAR-A, the configuration tool ISOLAR-B, INCA for calibration, diagnostics, and validation, and the CAN FD Bus Interface ES582.

Benefits

Motonic began production of the new OPU with a flexible and reliable firmware platform built on AUTOSAR basic software that has been tried-and-tested in millions of vehicles on the road. This new sensorless control algorithm reduces the risk of failure. The project gave Motonic in-depth insights into the AUTOSAR platform, resulting not only in better technology, but also key improvements to the development process. Motonic has achieved its goals and now has a solid basis on which to build a successful future.

Authors

Haejin Kim is Senior Research Engineer at Motonic in Korea. **Seungyun Ryu** is System Application Engineer at Infineon Technologies Korea Co., Ltd. **Hojeong Yoo** is Field Application Engineer at ETAS Korea Co., Ltd.

Ten versus 1,000,000,000

Experiences with SCODE at Bosch Powertrain Solutions

Hardly any other software system is as complex as the air system of a combustion engine. Numerous factors have to be considered, many of which influence each other. If the relationships between these factors are looked at incorrectly when starting development, things can quickly become very expensive. The SCODE tools were developed in order to correctly understand and describe complex systems right from the beginning. But do they actually do what the development team expected?

The SCODE development team stepped up to get the steadily increasing complexity in software development under control. After five years in actual use, we can now take stock of function development for Robert Bosch GmbH diesel engine air systems.

The challenge

The characteristics of modern diesel engines depend largely on the air system. A complex software with many thousands of calibration parameters yields optimized performance characteristics and greater comfort while simultaneously ensuring that increasingly ambitious emissions targets are met – for instance, for real driving emissions (RDE) test cycles.

At Bosch, this is not restricted to just a single engine. The software includes, for example, power ratings, transmission variants, emission standards, and individual market adjustments. A triple-digit number of calibration variants for the same engine is not uncommon. In addition, there are strict time and cost requirements to be observed. This kind of complexity can hardly be realized with conventional methods – let alone provide a flexible response to potential changes.

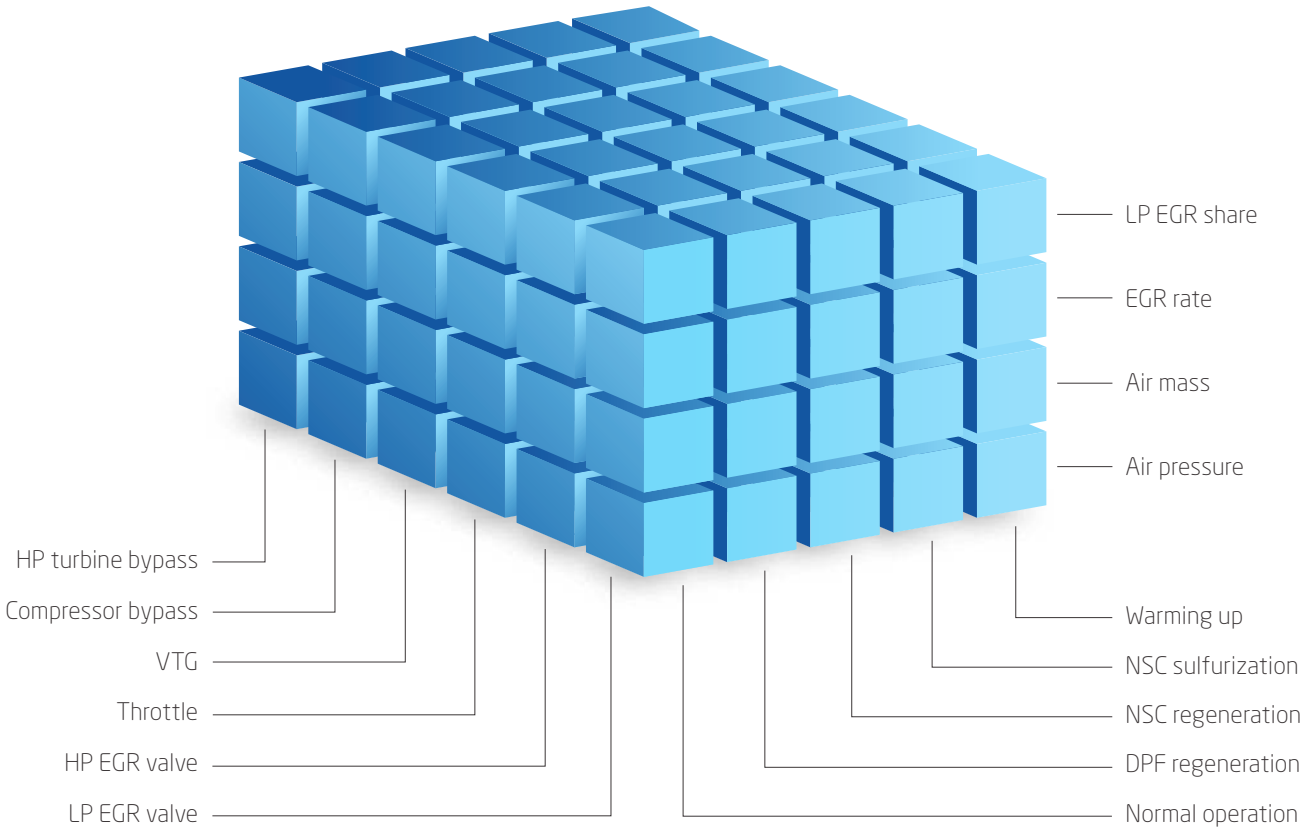
The solution

To get this system under control, we at Bosch gradually replaced static maps with physical models some ten years ago. These models describe system behavior using formulas stored in the ECU and calculate the control model at discrete times.

Now SCODE-ANALYZER lets users describe and validate the complex relationships in control systems. With SCODE-CONGRA, they can then describe these systems using physical formulas, display and validate them as an interactive graph, and transfer them to program code. Integration in MATLAB® and Simulink® environments is possible. The tools are based on functional morphology, which is the study of the structure and relationships of the functions to each other, and on cognitive automation, which is the redesign of information in a behavior-influencing system.

SCODE-ANALYZER adds priorities and structure to system description. The tool first asks what is required from each switch and uses this information to describe the entire problem space. Then the process uses morphological analysis as early as the function development stage to break the

> The new tools have proven highly successful in practice and have even exceeded our expectations.



Target values, air system actuators, and operating modes: increasing complexity in three dimensions.

problem space down into logical subspaces known as modi, such as the exhaust gas return rate in normal operation and the air mass for particle filter regeneration – or the simultaneous control of both parameters for NO_x catalytic converter regeneration. This creates a total of about ten specific subspaces to address, rather than the one billion plus that are theoretically possible.

Each mode fully covers all requirements. The ANALYZER eliminates undesired and impossible combinations, and every combination in the problem space is assigned to exactly one mode. The result is a completely and clearly described subspace that covers all requirements and includes nothing that isn't essential.

Concrete benefits

SCODE significantly reduces the complexity of the physical models within the software, and thus the calibration effort. An additional benefit is that this process simplifies software design. Using the tools reduces development time for comparable functions by 25 to 30 percent on average. The same is true for calibration effort. Other benefits include design safety, resulting from the clear and precise description and the far greater ease of reusing existing elements. A positive side effect of this is that the process improves documentation all along the control flow by presenting each mode in an extremely compact form.

In conclusion, the new tools have proven highly successful in practice and have even exceeded our expectations. After premiering it in diesel engines, Bosch is now establishing the process as a standard for gasoline engines, too, as well as for electric and hybrid drives.

Author

Dr.-Ing. Thomas Bleile is Senior Expert in air system function development at Robert Bosch GmbH.

Contact at ETAS GmbH:
Dr. Markus Behle (Senior Product Manager for software engineering tools and one of the co-inventors of SCODE), Markus.Behle@etas.com

INCA-FLOW – success through cooperation

Guided calibration and automation increases efficiency

INCA-FLOW is an intuitive tool that allows engineers to model calibration procedures with a graphic design editor and then execute them on the connected infrastructure. Offering major improvements to calibration efficiency, INCA-FLOW is well established in the market and currently used by around one hundred automakers and suppliers. It represents a major success for the partnership between ETAS and IAV that began in 2009.

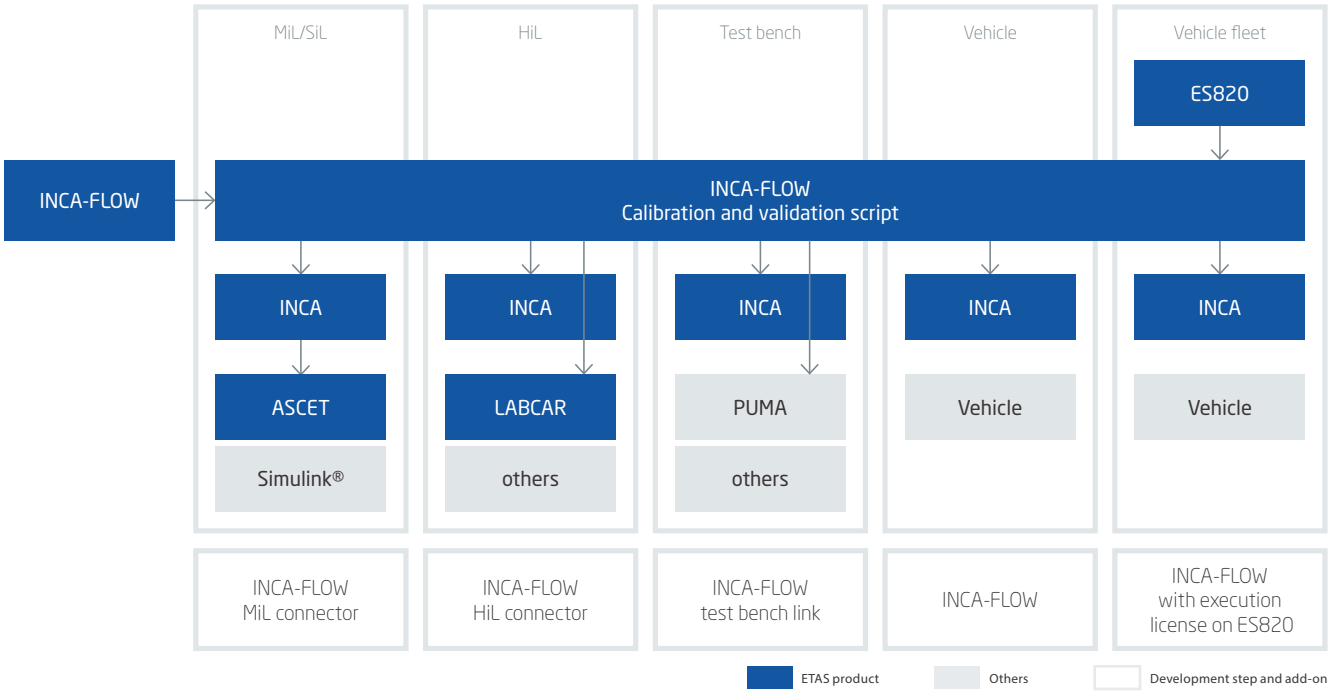
The increasing number and complexity of driving functions requires development tools that relieve the pressure on calibrators through automation and, at the same time, make proven processes and know-how available company-wide. To address this need, INCA-FLOW supports manufacturers, suppliers, and service providers in their efforts to standardize calibration tasks. Automakers and ECU suppliers can use INCA-FLOW to introduce identical ECU function calibration procedures worldwide that deliver reproducible results.

The product of a highly successful partnership, INCA-FLOW was developed by IAV and has been marketed exclusively by ETAS since 2009. "The outstanding growth we have enjoyed over the past decade has created a solid customer base," says ETAS Product Manager Thomas Kruse. "One of the keys to this success has been our willingness to constantly adapt INCA-FLOW to the industry's evolving requirements." Sven Meyer, a Senior Solution Expert at IAV, agrees, adding: "INCA-FLOW contributes to the fact that application and validation are standardized and automated in many companies today. This leads to shorter development times, reduced costs, and improved, reproducible calibration quality." Depending on the development environment, Meyer puts the efficiency gains at between 30 and 80 percent compared to manual parameterization.

Today's ECUs have some 60,000 parameters, where previous ECUs had just 2,000. This means the development process can no longer be performed using manual methods. INCA-FLOW makes it easy to define an automated parameterization process without requiring any in-depth programming skills. Working in INCA-FLOW's graphical user interface, the calibration engineer starts by writing a script – for example, to perform measurement, evaluation, and calibration tasks directly in INCA itself. This frees up experts to focus all their attention on their core competencies: efficiently parameterizing ECU functions to minimize emissions, ensuring robust onboard diagnostics (OBD), and optimizing consumption, performance, and driving behavior. In this way INCA-FLOW automatically documents examples of best practice, making them accessible company-wide.

These features make it suitable for calibration engineers and function developers as well as software developers and project managers. The two latest add-ons pave the way for INCA-FLOW to be used in an even wider range of ECU calibration applications. The new "Engine and Transmission Driveability" add-on (EDT and TDT) replaces calibration criteria that were previously determined on a subjective basis with objectively measured values. This makes the tuning process simpler and faster and more comparable. Using this add-on also allows engineers to improve the driving characteristics of the engine and transmission in real time. Take, for example, a situation where transmission jolting is occurring during acceleration. The recorded information appears directly in the INCA-FLOW interface, and the calibration engineer can work directly in this interface to iteratively modify the parameterization until the transmission jolting has been minimized. The second add-on – a connection to different types of test benches – is also very well received by customers. It provides a manufacturer-independent interface for connecting test benches to INCA and INCA-FLOW via CAN or ASAP3. "This is a cost-effective and efficient solution," says Kruse. Once created, a script can be used on any test bench, and the design of experiments (DoE) approach reduces the number of tests.

The partnership between IAV and ETAS has also resulted in another product, INCA-RDE. This software monitors in real time whether a journey complies with RDE (Real Driving Emissions) regulations and displays the emission data in various graphical forms in the INCA environment. Currently, measurements are generally recorded and then evaluated at a later point in time. Since INCA-RDE brings together both the ECU parameters and the Portable Emission Measurement System (PEMS) data, they can be clearly visualized and viewed in the INCA experimental environment and the measurement data saved to a measurement file. For the future an even more advanced feature is planned, which will allow the software to identify possible causes of peaks in emissions in order to make adjustments to the parameterization of characteristics such as exhaust-gas recirculation and fuel injection already during test drives – rather than afterwards at a desk.



Deployment of INCA-FLOW in all calibration infrastructures.

Summary

The partnership between IAV and ETAS is a genuine success story. INCA-FLOW is already firmly established in the market – and the launch of INCA-RDE means customers now have access to another product that offers equally impressive benefits. By boosting efficiency, both tools considerably make automotive developers' work easier and thus strongly meet customer requirements.

Author

Axel Heizmann is Senior Marketing Communications Manager at ETAS GmbH.

Quick and intuitive analysis of measurement data

Measure Data Analyzer (MDA V8): clearly structured user interface and innovative evaluation instruments

Large measurement files with numerous signals present an enormous challenge for data analysis. That's why ETAS developed MDA V8 – a brand new solution that is designed to meet future needs. Already regarded as a standard tool in the automotive industry, this new version of MDA combines a clearly focused range of functions with outstanding performance and a user-friendly interface.

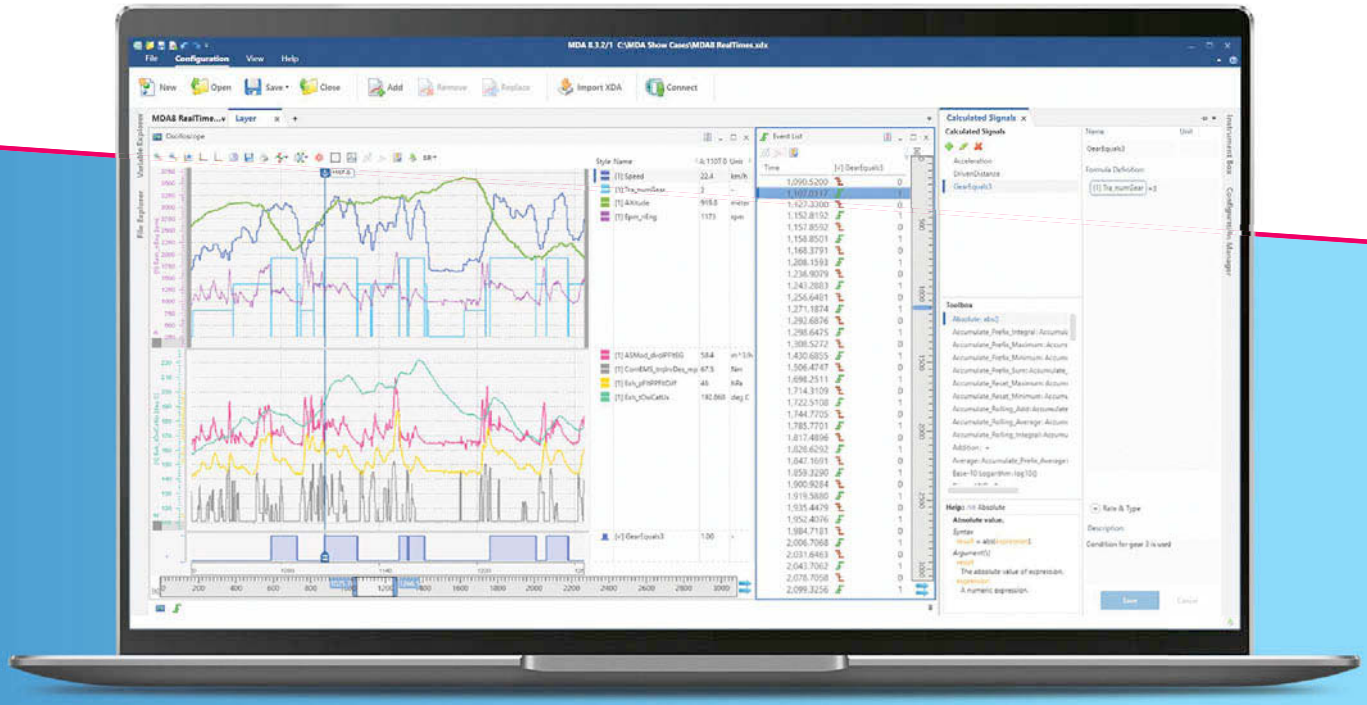
Let's take a look at a typical example of MDA V8 in action. A calibrator receives a large measurement file with recordings covering several hours. The file is from a test drive during which some strange behavior was observed that now has to be investigated in more detail. With previous tools, this would mean painstakingly working through a series of complex steps. But MDA V8 allows the calibrator to define simple search criteria to identify problems, such as a harsh downshift, in particular speed ranges. Results that match the search criteria are immediately displayed in the event list. The list is automatically updated if the criteria are modified or revised. With the areas of interest now defined, the user can more quickly determine the influencing parameters.

MDA V8 is a completely new version of the proven Measure Data Analyzer from ETAS. It uses highly efficient algorithms and has been designed with future requirements in mind. Thanks to the high processing speeds in MDA V8, measurement files with several hundred thousand signals in many different measurement grids can be opened and processed quickly.

To ensure MDA V8 can be used as efficiently as possible, the developers have based the software around the key functions of the previous version, MDA V7, while deliberately avoiding rarely used special functions and add-ons. Working with MDA V8 is an intuitive and efficient experience thanks to this user-friendly design and a completely revised graphical user interface (GUI).

Using the event list instrument, the calibrator can navigate quickly between results, modifying or expanding the search criteria as necessary. This is where key functions of MDA V8 come into play, such as the calculation of derived signals. Using the formula editor, the calibrator can define calculation rules in just a few easy steps and combine them with existing functions as necessary.

Another very useful feature is the ability to synchronize instruments. This allows the user to synchronize the event list display with all the other windows by a single click. The same holds for the redesigned virtual oscilloscope instrument, which can plot signal information in stacked sections, called strips, for easier viewing and analysis. The time axis of the oscilloscope instrument has been extensively developed to allow intuitive, sliding navigation of the complete time range. Dynamically changing

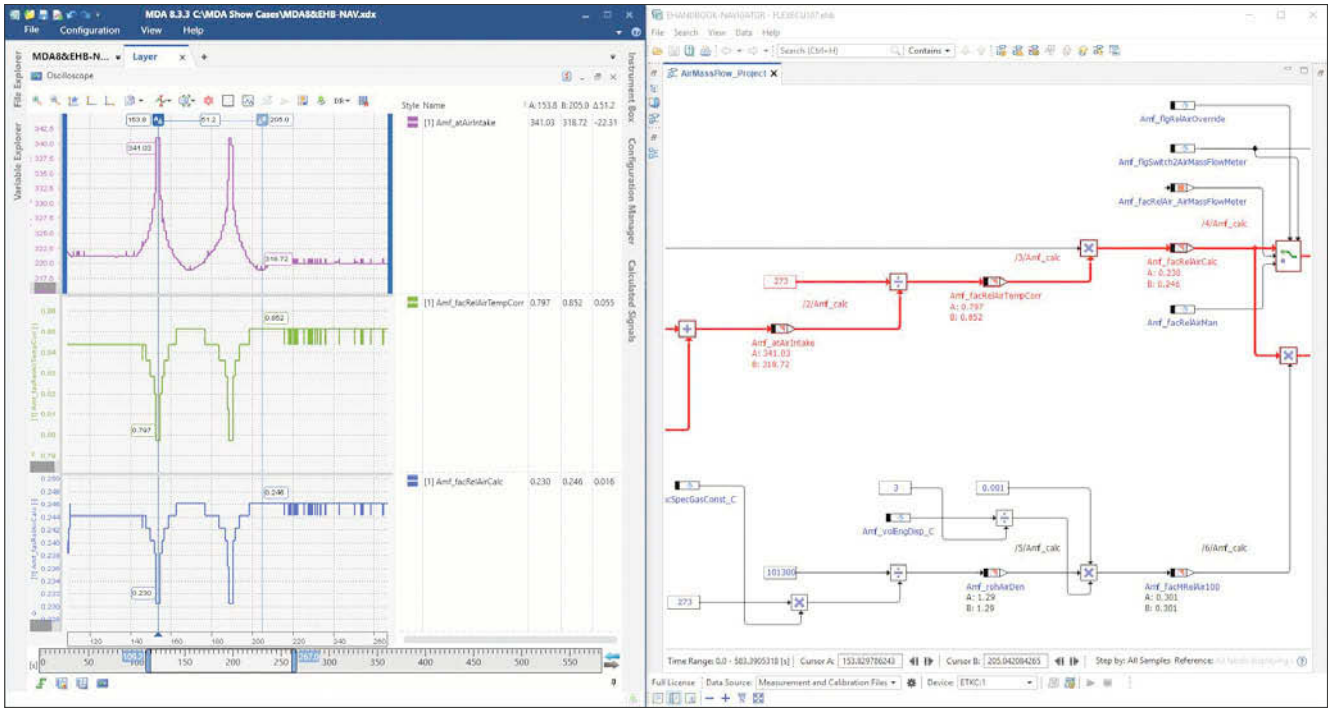


Using a search criterion defined as a calculated signal (right), the event list (center) allows users to navigate from one result to another. The selected signal is displayed in the virtual oscilloscope (left).

Key highlights of MDA V8:

- A powerful tool that offers fast processing of large measurement files
- Clear focus on the most important functions
- New, intuitive, and clearly structured user interface
- Easy to create and use calculated signals
- Oscilloscopes offer multiple configuration options for displaying signal curves
- Direct connection to interactive documentation in EHANDBOOK-NAVIGATOR
- Import of MDA V7 configurations simplifies migration
- Numerous individual settings for signals, instruments, and other items are saved automatically to minimize configuration effort
- Easy to integrate in customer environment, for example with support for customer-specific text-based measurement data file formats
- Write, read, and convert all versions of the measurement data format (MDF)
- Support for indexed and compressed measurement data files in compliance with ASAM specification MDF V4
- No new license needed – the V7 license covers V8 as well

regions allow the calibrator to move quickly through the signal data and zoom or pan with ease. Exact time intervals can be specified and, when viewing a very small interval, a magnified region appears to allow very accute navigation of the data. The ability to connect MDA V8 to EHANDBOOK-NAVIGATOR (EHB-NAV) from ETAS makes it easy to perform further analysis if the defined search criteria prove to be insufficient. EHB-NAV provides direct access to the ECU software documentation, enabling users to quickly identify correlations between individual measured values. This makes it easier to understand cause and effect relationships. EHB-NAV's interactive documentation can also display measured values that are synchronized with the current cursor positions in MDA V8, offering an additional means of identifying the cause of an error.



When MDA V8 (left) is connected to EHANDBOOK-NAVIGATOR (right), the cursor time is automatically updated in the EHANDBOOK-NAVIGATOR interface.

The new MDA V8 is based on highly efficient algorithms and perfectly designed to meet future needs.

The table instrument provides a detailed view of the individual signal values with the exact timestamp values. When comparing signals sampled at different frequencies, the calibrator can choose whether to only display the actually measured values or to have gaps in the measured values filled with interpolated data. This makes it quicker for the calibrator to complete the analysis.

MDA V8 is already in use at many OEMs and component suppliers. Customer feedback testifies to the great popularity it enjoys, in part thanks to the ability to adapt MDA V8 to the customer's environment. For customers with ASCII-formatted data files, MDA V8 allows creation of a simple description file to enable reading and writing of user-specific file formats. MDA V8 also offers plenty of support to users migrating from the previous version: in addition to reusing existing configurations from MDA V7, short instructional videos are available on www.etas.com/mda (menu „Downloads"). A comprehensive help menu, as well as written user guides and tutorials, aid in learning the new functionality and enhancements of MDA V8.

Summary

ETAS has taken a major leap forward with Version 8 of MDA. It is geared to the present and future needs of vehicle development, and its plentiful advantages make it the perfect tool for meeting whatever challenges the automotive industry may face in the years ahead.

ETAS plans to continue enhancing MDA by integrating additional evaluation functions and further improving the synchronized display of measurement data and the calibration data valid at that particular point in time. So calibrators have plenty to look forward to!

Author

Dr. Matthias Gekeler is Product Manager MDA & INCA Experiment Environment at ETAS GmbH.

Learning INCA

Introductory INCA seminar for aspiring engineers at the Werner-Siemens-Schule

"Why is it so important to ensure the correct positioning of a throttle valve in a vehicle? As a calibration engineer, what tools can I use to achieve that?" Students from Werner-Siemens-Schule – a vocational college in Stuttgart – got to grips with these and similar questions in a four-day INCA seminar tailored specifically to their needs. They are currently working on completing a fast-track mechatronics course before they embark on their technical studies at Esslingen University of Applied Sciences. Known as "E-MobilityPlus," this cooperative model of instruction in automotive mechatronics combines vocational training and university studies in a dual framework.

It's eight o'clock on a Monday morning, and 18 students are sitting in the electronics lab at Werner-Siemens-Schule. They have come together for a four-day INCA seminar. The idea for the seminar stemmed from a long-term partnership between Werner-Siemens-Schule and ETAS, and both the content and the structure of the seminar have been tailored to the students' needs. The course developers were particularly keen to get the right balance between theory and practice, ensuring that the students get a gradual, step-by-step introduction to the topic of calibration and calibration tools. The seminar also includes regular breaks and plenty of time to reflect on what they have already learned. Each theoretical session is followed by a hands-on task that allows the students to immediately apply what they have learned, locking the knowledge in place and giving participants a clearer understanding of each individual step. The instructors also explain the theoretical background of each practical task in detail because, unlike traditional seminars with experienced engineers, the students are not yet familiar with how the various aspects of calibration tie together. Questions about why things have to be done in certain ways are explained and discussed based on use cases from the automotive industry. The hands-on final test allows everyone to successfully demonstrate their knowledge once again by creating a measurement chain in INCA and evaluating measurements using MDA (Measure Data Analyzer) – both of which are easy to do if you are familiar with the appropriate tools and know-how to operate them correctly.

Author

Klaus Fronius is Group Manager Market and Competitive Intelligence and University Liaison Manager at ETAS GmbH.

It is important for ETAS to support young people – because today's students are tomorrow's engineers. Seminars like these are an investment in the future.

INCA seminar at the Werner-Siemens-Schule.

Thinking outside the box

ETAS ASCMO speeds up modeling work in Brazil

Students from the University of São Paulo have been partnering with ETAS for many years. This successful partnership was recently expanded to the domain of vehicle dynamics.

Tires can give teams a crucial competitive edge on the race track, whether that involves braking a split second later while overtaking or accelerating to victory. The "scuderia" with the best grasp of how these key components behave is always going to be one-step ahead, which is why this continues to be such an active area of research. Now a group of students from the University of São Paulo (USP) has decided to tackle this challenge head-on with support from ETAS. The students are part of the Equipe Poli Racing team that represents USP's Engineering School at the Formula SAE Brazil engineering design competition for students, which is known as Formula Student in Europe. Formula SAE has achieved huge success in Brazil, attracting 65 teams and over 1,300 engineering students.

This talented team of future engineers has been partnering with ETAS for many years, using INCA and "blue boxes" for measurement and calibration tasks to gain a competitive edge in powertrain design and validation. This successful partnership was recently expanded to the domain of vehicle dynamics with even more impressive results, using ETAS ASCMO for tire modeling tasks with the assistance of ETAS experts. ETAS ASCMO is a tool for data-based modeling and model-based calibration. It enables users to accurately model, analyze, and optimize the behavior of complex systems based on only a few measurements and using advanced, state-of-the-art statistical learning procedures (Gaussian processes). Acclaimed as a leading solution in the realm of engine calibration, ETAS ASCMO can also be applied in any situation that requires engineers to describe complex systems, establish correlations, and elaborate a model.

The students began with a huge dataset comprising over half a million measurement points – and an even bigger challenge. How could they tap into the non-linear behavior of tires that was so deeply concealed within the enormous amount of available data? Fortunately, ETAS ASCMO fits this challenge like a glove, allowing the students to establish input based on relevance, select 800 training points, and generate a global, multi-input regression model incorporating all the relevant information in a single characteristic hypersurface. It took just seconds for the team of suspension designers and track engineers to obtain reliable predictions of tire response that would otherwise have taken weeks to generate using conventional methods. The preliminary results were published in a paper at the XXVII International Symposium of Automotive Engineering (SIMEA) in São Paulo in August 2019. At this event, the ETAS team achieved a notable result: it received the "Honorable Mention" Award in the "Design and Vehicle Technology" category.

But the race is far from over; the team hopes to implement even more ambitious applications next season to unleash even greater vehicle potential on the race track!

Author

André Pelisser is Field Application Engineer at ETAS in Brazil and former Team Captain of Equipe Poli Racing.

Successful collaboration with Kookmin University

Kookmin University draws on support from ETAS and ETAS ASCMO to make it to the top in the Formula category of the race car design competition run by the Korean Society of Automotive Engineers.

With the aim of offering practical education in specialized areas, Kookmin University is dedicated to the development of Korea's top-tier Automotive Engineering College. It established the Department of Automobile and IT Convergence in 2014 to cultivate future-oriented talents with consolidated knowledge in computer programming, electrics/electronics, and basic mechanics such as dynamics, thermodynamics, and statics.

on optimization of maximized engine torque and minimized BSFC (Brake Specific Fuel Consumption). KORA generated an ETAS ASCMO model from the measured data, proceeded with global optimization, and extracted calibration maps (injection duration, injection timing, ignition advance), each in accordance with ECU map size. The team then applied, validated, and tested them. Two weeks before the competition, a validation test was con-

KORA is motivated for the Formula SAE.

Since the signing of an MOU (Memorandum of Understanding) with Kookmin University in 2014 for the advancement of the domestic automotive industry, ETAS Korea has closely collaborated with the University, contributing its solutions such as LABCAR and ETAS ASCMO as well as the AUTOSAR portfolio. In 2018, the ETAS ASCMO collaboration achieved a tangible result. ETAS supported Kookmin University students with ETAS ASCMO for their racing competitions at home and abroad. The KOOKMIN RACING (KORA) team, the automotive engineering club of Kookmin University, competed in KSAE (Korea Society of Automotive Engineers) Formula and Formula SAE (Formula Society of Automotive Engineers; short FSAE). FSAE, held by SAE, is the world's biggest student engineering competition. Since the competition judges both performance and energy efficiency, engine calibration simultaneously focused

ducted at the Daegu proving ground. The test proved that the optimized map helped reduce lap time by up to 4 seconds and cut fuel consumption by 0.1 liters over a driving distance of 11 kilometers. The vehicle with the ETAS ASCMO optimized calibration map won first prize in the Formula category in KSAE Formula in August 2018 and ranked third in the Acceleration category (11th in 2017) in FSAE in May 2018.

Authors

Wonseok Chang is Specialist Field Application Engineer at ETAS Korea Co., Ltd. **Youngeun Kim** is Marketing and Communication Manager at ETAS Korea Co., Ltd.

Milestones in

It all started with the "young mavericks at Bosch" ...

It all started with the "young mavericks at Bosch." On June 1, 1994, a team from the pre-development department and colleagues from the Bosch divisions "Diesel Engine Systems" and "Gasoline Engine Systems" became the 42 associates of the new company called "ETAS Entwicklungs- und Applikationswerkzeuge für elektronische Systeme GmbH & Co. KG."

1994

Germany
ETAS GmbH & Co. KG founded in Stuttgart

LABCAR*
MAC2*
VME System*
ASCET V1.0.0*
ETK*
VS100*

*adopted from Bosch

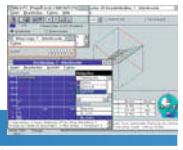
1995

France
B2i becomes distribution partner in Rungis

1997

USA
ETAS Inc. founded in Ann Arbor

Korea
Jehin Eng. becomes distribution partner in Seoul



INCA
Measurement, calibration, and diagnostic software

2009

Brazil, Italy, Russian Federation, Sweden
ETAS sets up its own sales organizations

2007

India
ETAS Automotive India Pvt. Ltd. founded in Bengaluru

2006

XETK
ECU interfaces

VCI
Vehicle communication interface

ES400
Micro measurement modules

ES900
Prototyping and interface modules

2010

ES720
Drive recorder

EHOOKS
Tool for software hook insertion

ES5340
PCIe-based simulation board

2012

escrypt

ETAS acquires Bochum-based ESCRYPT

ETAS ASCMO
Model-based calibration

ISOLAR-A
AUTOSAR authoring tool

ISOLAR-EVE
Virtual ECU platform

2019

25 years later, ETAS is a global company with over 1,400 associates

The joint venture ETAS NI Systems is founded

RTA-VRTE
Platform software framework for vehicle computer

ES886
ECU and bus interface module

2018

ES830
Rapid prototyping module

ETAS history

From the very beginning, ETAS was a magnet for highly qualified and motivated associates – and more – a large playing field full of creative development opportunities. Over the past 25 years, this dedicated entrepreneurial spirit has developed and grown, producing a global company with over 1,400 associates at 23 locations in 12 countries around the world.

1998

Japan
ETAS K.K. founded in Yokohama

Brazil
Unit becomes distribution partner in São Paulo

2000

ES1000
Rapid prototyping system

LABCAR-OPERATOR V1.0.0
Experiment environment

2001

France
ETAS S.A.S. founded in Rungis

United Kingdom
ETAS Ltd. founded in Birmingham

2002

ES600
Measure-ment modules

ES690
Interface module

2003

ETAS acquires LiveDevices and Vetronix

Korea
ETAS Korea Co., Ltd. founded in Seoul

2004

INTECRIO
Prototyping environment

LABCAR-RTPC
PC-based realtime simulation target

2005

China
ETAS (Shang-hai) Co. Ltd. founded in Shanghai

ES500
Interface modules

2013

EHANDBOOK
Documentation solution

2014

RTA Solutions
ECU software development

2015

ES800
ECU and bus interface modules

FETK
ECU interfaces

2016

Canada
ETAS Embedded Systems Canada Inc. founded in Waterloo

ES5300
PCIe-based LABCAR

2017

Germany
Integration of cybersecurity expertise from the Bosch Group

ETAS acquires TrustPoint Innovation Technologies, Ltd.

SCODE
Tool for the description of complex systems

RTA-LWHVR
First automotive hypervisor

ISOLAR-B
Tool for configuring BSW

COSYM
Co-simulation platform

ES820
Drive recorder

Years ETAS – Still wild at heart
Anniversary wishes to ETAS

We are proud to be able to look back on a quarter century of ETAS history. We would like to thank our dedicated and highly motivated associates who continuously advance and refine our mission to "drive embedded excellence." And of course we would also like to thank our customers and partners for their trust and long-standing cooperation. Only together could we achieve where we are today.
Friedhelm Pickhard, Bernd Hergert, and Christopher White, Board of Management ETAS GmbH

Congratulations on your first 25 successful years, ETAS! I wish you continued success in "driving embedded excellence" for the next 25 years!
Uwe Hillmann, former member of the Board of Management ETAS GmbH

ETAS always offers quality service in regards to INCA enquiries. We appreciate this very much. Please continue!
Eva Biemans, Data Analytics & Development Calibration, Continental

Happy 25th birthday! Thank you for continuously supporting my teaching!
Prof. Dr.-Ing. Hanno Ihme-Schramm, Professor of Thermodynamics and Combustion Engines at Hamburg University of Applied Sciences (HAW)

I can't imagine life without ETAS. I think I've got blue blood running through my veins!
Alfredo Gomez, Senior Project Manager, ETAS GmbH

Throughout the years we've maintained a fantastic sense of cooperation and an open door culture. This is what makes ETAS stand out.
Liane Schumann, Headcount Controlling, ETAS GmbH

May the growth and the profitability of ETAS in the next 25 years be as sweet and big as your giant cake for this year's "25 years ETAS" celebration!
Stefan Duss, former member of the Board of Management ETAS GmbH

The enthusiasm for technology and to create a globally marketable product from the newly developed ETK system brought me to ETAS in 1994. The start-up feeling and the highly motivated colleagues were very inspiring.
Burkhard Triess, Head of Engineering Technology, ETAS GmbH

I'm proud of all the years I've spent working at ETAS. I would definitely opt for ETAS if I was faced with the same choice again.
Roland Rothbächer, Senior Manager Technical Functions, ETAS GmbH

I get tremendous satisfaction from providing the best possible working environment for my colleagues. I like to see it as my contribution to preserving the unique ETAS spirit.
Andreas Oehler, Facility Management, ETAS GmbH

Dear ETAS colleagues, I feel privileged to have been a part of the first 13 years of ETAS' history and the thought always fills me with pride and joy. Nearly as many years have passed since then and the ETAS success story has endured. Your ideas, your motivation, your creativity, and your determination will continue to be the foundation for satisfied customers and success for the next 25 years. I wish you all the best!
Dieter Wohlfarth, former member of the Board of Management ETAS GmbH

ETAS – the year in pictures

1 ETAS and ESCRYPT presented development solutions for automated driving and cybersecurity at their booth during the 2019 embedded world trade fair in Nuremberg. Spread over a total area of 200 square meters, new exhibits, job opportunities, workshops in the ETAS Open Lab, and presentations in the ETAS Academy drew numerous visitors to the booth.

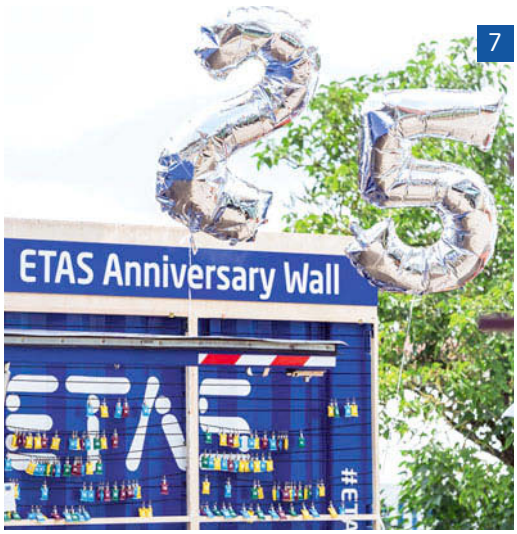
2 ETAS at Formula Student Germany 2019 at Hockenheimring. The custom-converted container – the big #ETASbluebox – was a hit with the teams and visitors alike.

3 ETAS at the Automotive Testing Expo Europe 2019, with demos on virtualization, data acquisition, and vehicle management solutions.

4 The ETAS team at the Bosch TestFest in Ludwigsburg. Participants were invited to attend workshops at the ETAS booth.

5 ESCRYPT received the Cybersecurity Leader Award (CLA) for its role as a thought leader in information security. ESCRYPT was awarded first prize in the SME (small and medium-sized enterprises) category for establishing a comprehensive portfolio of solutions and services for the IT security of connected vehicles.

6 „A new era for mobility engineering in Brazil" was the motto of this year's SIMEA (International Symposium of Automotive Engineering) in São Paulo. ETAS Brazil was there to present an unconventional application of ETAS ASCMO in vehicle dynamics and received honorable mention.



7 “25 Years of ETAS. Still wild at heart” – this is the motto for ETAS’ anniversary, as well as for the anniversary party for associates and their families.

8 ETAS showcased its expertise at the Automotive Electronics Congress in Ludwigsburg, where it presented AUTOSAR Adaptive with the RTA-VRTE (Vehicle Runtime Environment).

9 The Stuttgart International Symposium Automotive and Engine Technology, which draws more than 800 participants, is one of the biggest conventions on vehicle and engine development. At its booth there, ETAS showed how data can be processed using GETK for automated driving applications.

10 ESCRYPT in the US organized the 6th annual escar USA event. Over 300 attendees from the automotive industry, government agencies, and universities participated in the two-day program.

11 At the Automotive Testing Expo Korea 2019, ETAS Korea presented virtual test and validation solutions (COSYM) and new solutions for rapid prototyping, among other interesting topics.

12 The ETAS Symposium 2019 took place in Tokyo. With guest speakers from all over the world and more than 400 participants, the conference focused on the future of vehicle software development.

Ready, set, go!

The ETAS website has a brand new look

ETAS has been working hard on the new website – and on July 16, 2019 it finally went live! The new website is available in six languages and boasts more than 17,000 individual pages.

The website relaunch incorporated a comprehensive list of requirements stemming from the team's multi-tiered approach to the project. The overarching goal was to give a brand new look to the old website, revise how the content is structured, and bring the content management system (backend) fully up to date. The result for users is a great surfing experience and simpler navigation. To achieve their goal, the team put a clear emphasis on design and technology aspects and on making the site easy to use.

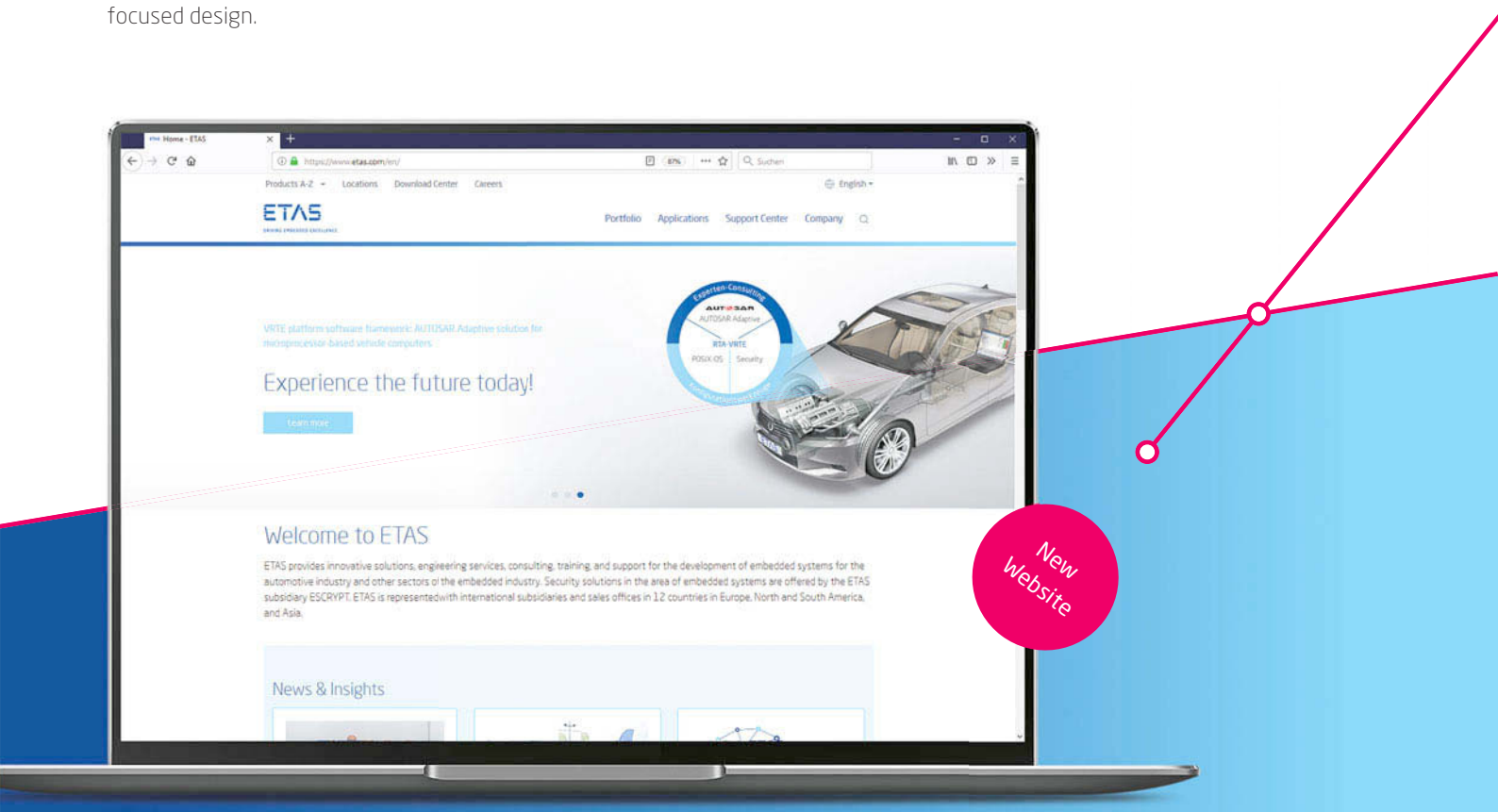
The designers have completely revamped the website, taking the new corporate design, which ETAS rolled out in 2018, as their basis and orientation. In line with the principles of "Less is more" and "Content first," the team resisted the urge to fill all the available space with content. Instead, they have left plenty of breathing room and white space to create a clear and focused design.

The use of responsive web design on the new ETAS website ensures a seamless experience for everyone, irrespective of whether they are accessing the site from a PC, tablet, or smartphone.

We hope you enjoy exploring and surfing the new ETAS website (www.etas.com) and we look forward to your feedback! Contact: webmaster.de@etas.com

Author

Lisa Scheftschik is Online Marketing Manager Digital Communication at ETAS GmbH.



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INTRUSION DETECTION

IDS and automotive firewall as complementary solutions

HARDWARE SECURITY MODULE

Next-generation HSM firmware

Security Special 2019/2020

www.escrypt.com

"Cybersecurity is becoming a prerequisite for type approval"

Dr. Moritz Minzlaff on automotive security as a strategic task

Increasing security requirements for vehicles are manifesting themselves in a wave of new standards and regulations. In this interview, Dr. Moritz Minzlaff, Senior Manager at ESCRYPT in Berlin, explains what the automotive industry has to adapt to.

Mr. Minzlaff, efforts to create binding standards and regulations in the field of automotive security are now in full swing. Which developments deserve special attention here?

There are two initiatives that everyone is watching right now: first, ISO/SAE 21434, which sets standards at the process level; and second, the activities of UNECE WP.29, which will make cybersecurity a prerequisite for the type approval of vehicles. Both the UNECE regulations and the ISO specifications will come into force within the next three years. So there's really not much time to prepare.

This means that in the near future the IT security for vehicles will truly be relevant for type approval!

That's right. In the future, according to UNECE specifications, OEMs will be able to approve vehicle types in markets such as the EU or Japan only if they can demonstrate appropriate risk treatment. ISO/SAE 21434 will be the key to overcoming this hurdle by offering common security standards for the automotive industry. At the same time, further regulations and laws are constantly being developed at the regional level, which must also be kept in mind.

What are the specific challenges facing automakers and suppliers?

The big challenge is that in the future, security must be approached comprehensively right across the supply chain and life cycle. It is no longer enough to provide two or three central ECUs with security functions. Vehicle manufacturers will have to identify and secure critical elements for the entire platform – all the way through to phase-out. This means life cycle management will be a decisive topic in the future. In other words, how do you provide adequate risk-based protection after start of production for connected vehicles that face many years of exposure to a constantly changing threat landscape out on the road?

As an OEM or supplier, what should I do now to make vehicle protection a permanent fixture in my corporate actions and my organization?

You need to act on two fronts. First, you should determine the security requirements of your product: vehicles and components with different degrees of connectivity, different functionalities, different safety relevance, and different degrees of automated driving each require tailored protection. To achieve the security level identified in this way, you'll need to involve all participants: from development and production through quality assurance to sales and customer communication, responsibilities and roles must be clearly defined within the company and along the supply chain.

At the same time, you can carry out an "inventory," in other words a standard audit or assessment. Which areas are you well positioned in? Which aspects of future regulatory requirements do you already meet? And which existing processes can you build on? A gap analysis of this kind will point out where investments in the further development of security will have the greatest impact.

Does it make sense to get a security specialist like ESCRYPT on board?

Yes, because our independent perspective and our global, industry-wide know-how is the ideal complement to your in-house expertise. The only way to achieve continuous protection of connected vehicles is by working together and taking a holistic approach. That's why, at ESCRYPT, we've already combined classic enterprise IT security with embedded security. Because the only way to master cybersecurity in the future is across domains, from vehicles to apps to clouds.

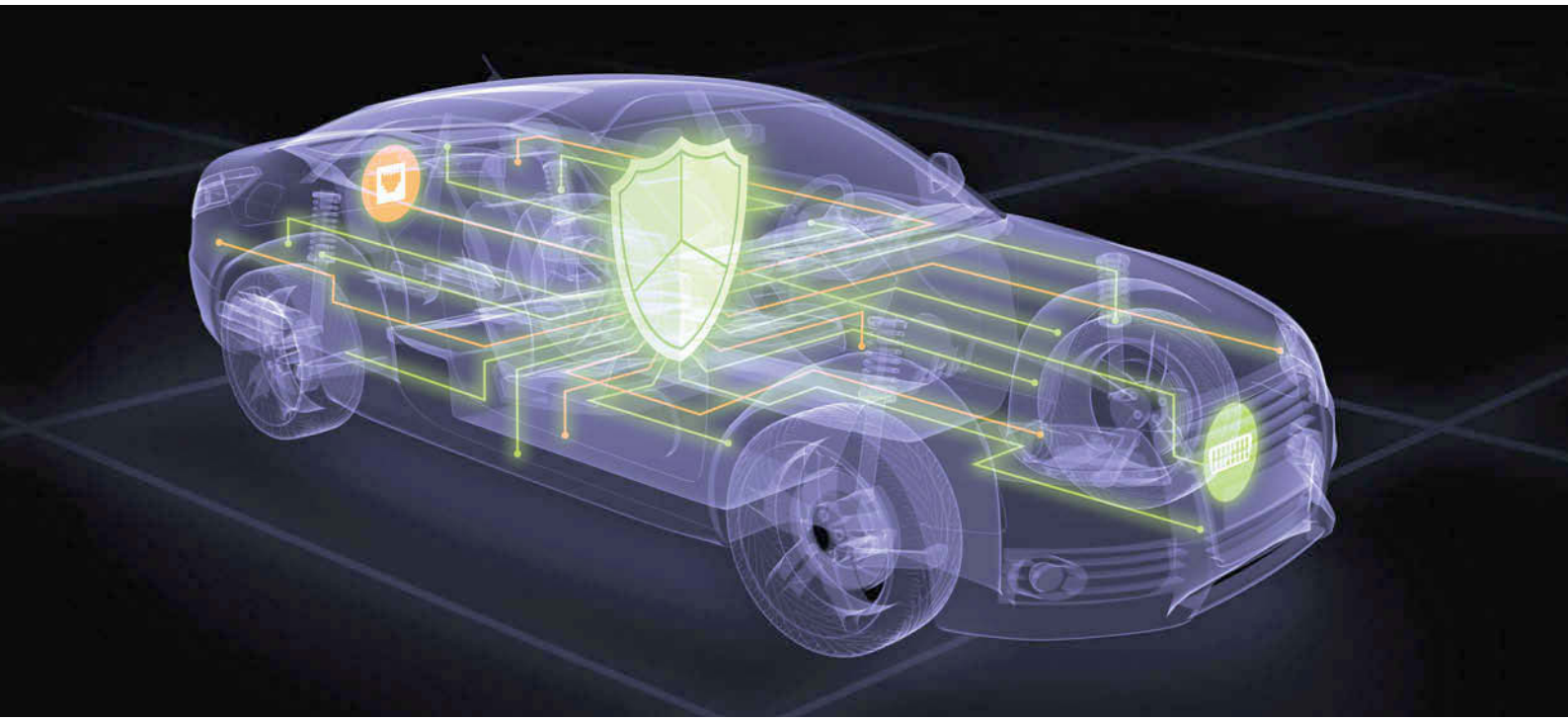
Dr. Moritz Minzlaff
Senior Manager at ESCRYPT

Due to our diverse project experience with manufacturers and suppliers in all major markets, we can also offer benchmarking. We identify exactly those aspects of security as currently practiced that should be further developed, and we help identify the necessary investments in cybersecurity. Time is short and the risk is too great not to achieve type approval according to UNECE specifications or to do so only with a delay or cost overrun. Thanks to our in-depth engineering experience, at the end of the day we at ESCRYPT know how to bring automotive security into series production. All this massively increases the chance of successfully mastering the challenges ahead. ■

"The only way to achieve continuous protection of connected vehicles is by working together and taking a holistic approach."

Intrusion detection for hybrid CAN-Ethernet networks

Tailoring security measures to both worlds



Today's decentralized E/E architectures are no longer up to the challenges of connected, automated vehicles, which is why vehicle computers and automotive Ethernet will complement conventional ECUs and CAN buses. These kinds of vehicle networks require protection in the form of tailored attack detection and data traffic monitoring.

The direction of development is clear: vehicle computers (VCs) and broadband automotive Ethernet will complement today's vehicle electrical systems with dozens of ECUs connected by CAN, LIN, and FlexRay data buses. The latter remain in demand where high real-time requirements and cyclically recurring functions need to be implemented. In other instances, microprocessor-based central computers partitioned into virtual machines will take over, because they are better equipped to meet the challenges of connected, automated vehicles.

But how can hybrid CAN-Ethernet architectures and their data processes be effectively secured? Fundamentally, there are two principles: communication shielding and partitioning. Seamless monitoring of communication is required in order to detect cyber attacks at an early stage; domain-specific virtual subnets (VLANs) minimize the penetration depth in the case of an attack. Both are feasible in hybrid electrical systems, but require different methodical approaches for the CAN and Ethernet worlds.

Efficient attack detection for CAN

An intrusion detection system (IDS) can be integrated into gateways or ECUs to monitor the CAN buses. It detects anomalies in CAN data traffic by comparing it with the "normal behavior" specified by the OEM. The embedded security component looks out, for example, for anomalies in cyclical messages and abusive diagnostic requests, which it classifies as potential attacks and logs or reports (Fig. 1).

The performance of the CAN IDS (CycurIDS) depends directly on the quality of its configuration. This is why efficient initial rules from the OEM should be continuously supplemented by new detection mechanisms based on analyses of current attack vectors in order to achieve a high detection rate with as few false alarms as possible. The implementation stands and falls with the quality of the toolbox, which is used for the initial configuration and the continuous development of the rule sets. As ready-to-use software, such an IDS (CycurIDS) can be used as a CAN attack detection system in hybrid electrical systems at any time.

Automotive firewall in the Ethernet switch

In contrast, an automotive Ethernet firewall (CycurGATE) is advisable for secure, smooth Ethernet communication in hybrid electrical systems. This is implemented directly in the Ethernet switch, allowing it to monitor the complete packet flow without risking any interference with ECUs or the host controller. Balanced hardware and software co-design means that the firewall can make use of the hardware acceleration on the switch. As a result, most of the data packets are processed at wire speed. The main task is to defend against denial of service attacks. But by maintaining partitioning in all network layers, the firewall also supports secure data exchange between partitioned domains. To this end, a packet filter filters the incoming and outgoing data, checking each by way of stateful packet inspection and deep packet inspection.

So, the automotive Ethernet firewall (CycurGATE) not only protects the electrical system against unauthorized access and manipulation – it also serves to control onboard communication (Fig. 2). It completely covers the Ethernet/IP including the common automotive protocols (e.g., SOME/IP), and it monitors access to networks and VLANs at MAC level. Communication is filtered by means of whitelists or blacklists that can be updated at any time, which ensures fast, effective reactions to new attack patterns.

```
…
0.010000 1  100  Rx  d 8 8A FF FF 0C 42 5F FD 97
0.011000 1  110  Rx  d 8 03 3E 3E E2 10 FF 4A 3F
0.012000 1  120  Rx  d 8 03 F7 30 27 C7 7E D9 9C
0.020000 1  100  Rx  d 8 11 F4 00 3E E2 60 6C B9
0.021000 1  110  Rx  d 8 1F AA 00 00 00 00 C0 00
0.022000 1  120  Rx  d 8 02 AA 00 00 00 00 C0 00
0.031000 1  110  Rx  d 8 86 4A 2F 01 81 05 80 7F
0.031500 1  110  Rx  d 8 E5 2B 41 0C 00 00 00 00
0.032000 1  120  Rx  d 8 02 04 78 00 FF 00 00 30
0.041000 1  110  Rx  d 8 6E 7B FF FF 3F FF 1F 8B
0.042000 1  120  Rx  d 8 00 5A 00 00 0F 55 02 00
0.043000 1  7DF  Rx  d 8 02 10 03 00 00 00 00 00
0.044000 1  7E8  Rx  d 8 02 50 03 AA AA AA AA AA
0.051000 1  110  Rx  d 8 FE 4B 2F 01 81 07 80 7F
0.052000 1  120  Rx  d 8 68 05 78 00 FF 00 00 30
…
```

Timings
- Frequency deviation
- Message infiltration
- Time-outs

Diagnostics
- Type of service
- Service conditions

Figure 1: The CAN IDS detects anomalies in cyclical messages and any abuse of diagnostic requirements.

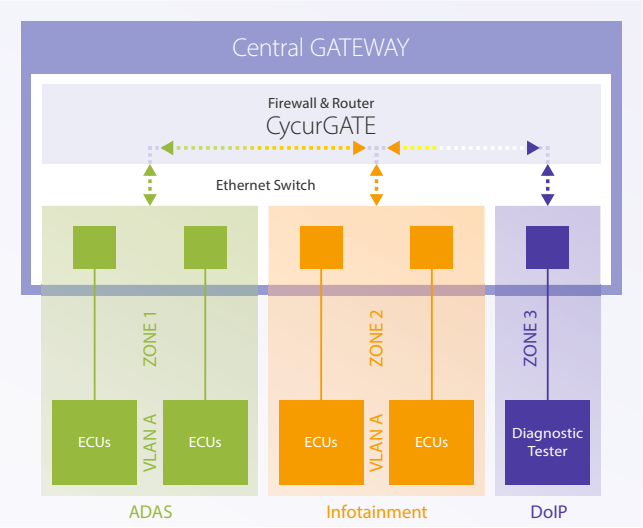


Figure 2: Automotive Ethernet firewall assumes gatekeeper and router functions.

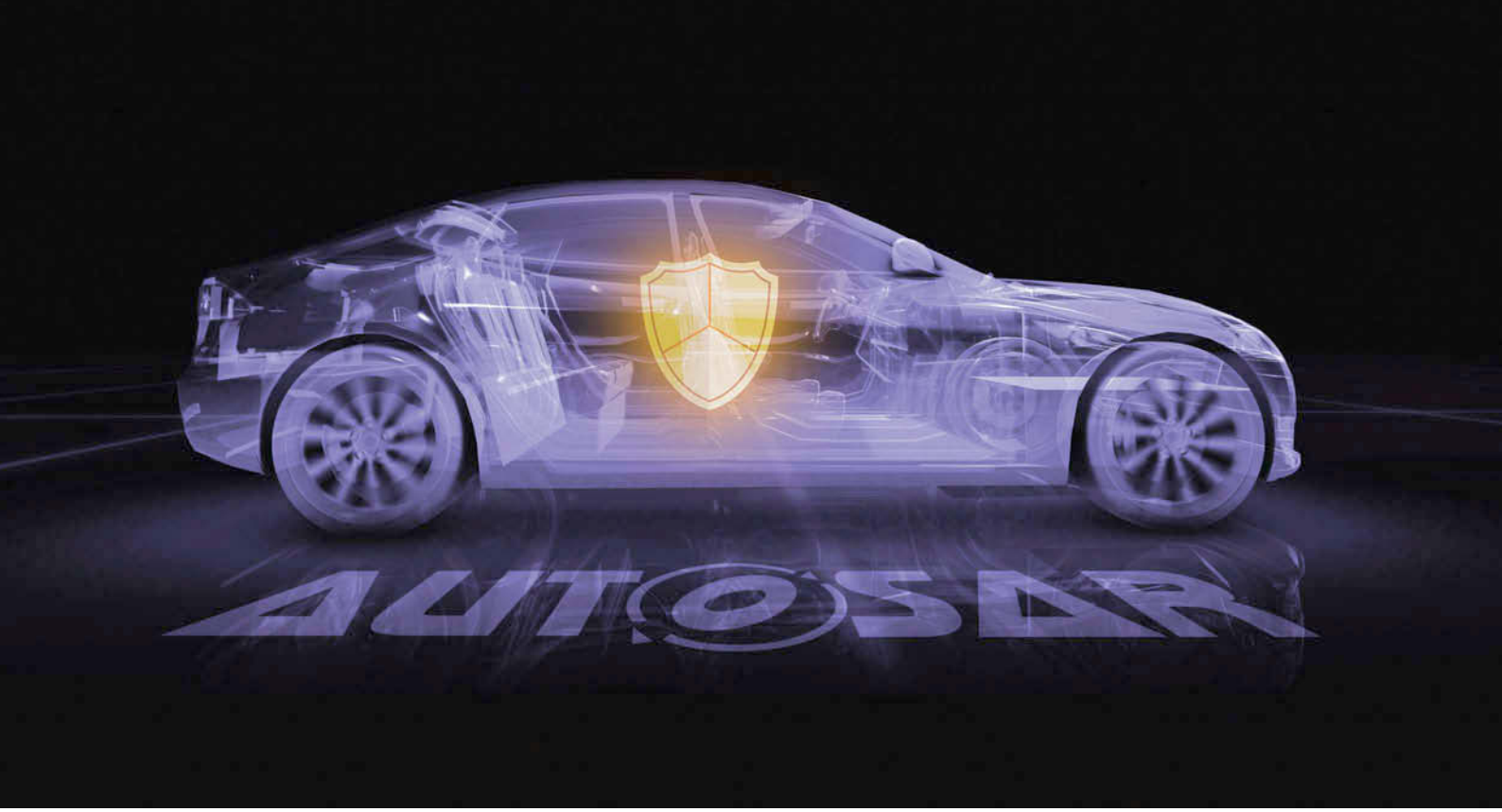
Intelligent load distribution

In addition to implementation in the central Ethernet switch, it is also possible to integrate host-based firewalls directly into ECUs. This requires high-performance solutions. The firewall must be powerful enough to check in real time and decide whether and where to route individual data packets. However, it cannot cover complex attack detection patterns, such as the frequency of stateful SOME/IP communication. Here, an additional Ethernet IDS is required that detects patterns of anomalies based on the message frequency, sequence, payload, data, and services and logs or reports them as attack attempts. For optimum performance, this approach requires intelligent load distribution between switch and microcontroller. Firewalling and intrusion detection can take place partly in the switch and partly in the target controller.

Together, CAN IDS, automotive Ethernet firewall, and Ethernet IDS can protect hybrid E/E architectures reliably and without noticeable latencies. Embedded in integrated security concepts, they are central components of risk prevention and functional safety in the connected and increasingly automated vehicle of the future. ■

Authors

Dr. Jan Holle is Product Manager for Intrusion Detection Systems at ESCRYPT. **M.Sc. Siddharth Shukla** is Product Manager for Automotive Firewall at ESCRYPT.



AUTOSAR security

Adaptive platform must focus on holistic vehicle protection

Automated driving functions and increasing connectivity call for more flexible software architecture – and a high degree of IT security. AUTOSAR delivers on this. With the adaptive platform and the deployment of critical security components.

AUTOSAR Classic, the standard middleware for most vehicle platforms, still meets the usual requirements. But in the future, vehicle computers will shape E/E architectures as central applications and the vehicle will become a software-dominated system. This is why AUTOSAR Adaptive will successively replace AUTOSAR Classic in many areas as the new future-oriented set of rules – setting new standards for automotive security in the process.

Security modules in AUTOSAR

AUTOSAR already incorporates various IT security applications, for instance for securing in-vehicle communication or protecting confidential data. However, Classic and Adaptive AUTOSAR currently offer partly identical and partly different security applications due to their different architectures (Fig. 1).

- **Crypto Stack:** Determines the cryptographic procedures and keystores implemented and provides the necessary key material to the various applications via uniform interfaces. The applications then access only the interfaces provided, independent of their crypto implementations, and remain portable to different ECUs. In addition, the AUTOSAR crypto stack can support multiple crypto implementations in parallel.
- **SecOC, TLS, and IPsec:** As an AUTOSAR Classic-specific protocol, SecOC specifically secures CAN communication. SecOC ensures authentication and freshness of the messages, but not their confidentiality, and allows OEMs to fine-tune their specific security levels. On the other hand, with automotive Ethernet in vehicles, TLS and IPsec are becoming increasingly important. Both standards support authentic and confidential communication; TLS is also suitable for external communication.
- **Identity and Access Management:** The AUTOSAR Identity and Access Management module ensures that only authorized applications access certain resources. These access rights can be freely configured in AUTOSAR and updated at any time.

- **Secure diagnostics:** AUTOSAR supports the logging of IT security events in secure memories. It also monitors authorized access to this data using the UDS services 0x27 (SecurityAccess) and 0x29 (Authentication). For example, the diagnostic test apparatus gains access to logged security incidents only if it has previously carried out a challenge-response communication or authenticated itself using a certificate.

Security engineering process

The decisive factor is to apply the security modules contained in AUTOSAR and adapt them individually to the security requirements of the vehicle platform. In other words, AUTOSAR must be integrated throughout the security engineering process. This involves three crucial steps: risk analysis, configuration, and testing. Taking the example of SecOC, this would be as follows (Fig. 2):

- **Risk analysis:** A risk analysis of all messages identifies those that need to be protected by SecOC. If different security profiles are stored, the message is assigned to the correct profile.
- **Configuration:** In the next step, SecOC and the crypto stack are configured for all ECUs involved in the data exchange according to the risk assessment and security profiles. Care is required here: a misconfiguration in a single ECU may result in secured messages not being verified and thus discarded.
- **Testing:** From a security perspective, several tests must be carried out before an ECU can be released for production – code review of the security critical components (e.g., SecOC module, CryptoStack), penetration test of the ECU, functional test of the SecOC module.

AUTOSAR Adaptive must follow an integrated security approach

On the way to connected, automated driving, the number of safety-relevant in-vehicle functions is increasing. This means it is becoming more important than ever to have more elaborate security measures and a high security level in place for vehicle platforms. In the future, OEMs will also increasingly establish new business models based on high connectivity that will need to be secured. This gives the further development of AUTOSAR Adaptive a clear mandate to integrate security applications much more strongly than before.

AUTOSAR configuration according to security needs

Example: Authentic ECU communication

- ✔ Identify security-relevant messages
- ✔ Configure messages in SecOC
- ✔ Select keys and algorithms in the Crypto Stack
- ✔ Align configuration across the vehicle
- ✔ Code review of security-critical components
- ✔ Penetration test of the ECU
- ✔ Function test of the SecOC module

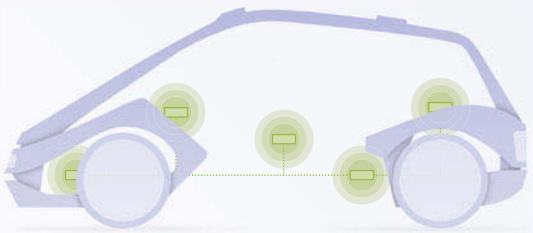


Figure 2: AUTOSAR configuration according to security requirements using SecOC as an example.

The guiding principle for AUTOSAR Adaptive must be an integrated automotive security approach: additional IT security components such as hardware security modules and the possible implementation of intrusion detection and prevention solutions will therefore have to be taken into account in the further development of AUTOSAR Adaptive. ■

Authors

Dr. Alexandre Berthold is Team Leader for Consulting and Engineering at ESCRYPT. **Dr. Michael Peter Schneider** is Project Manager AUTOSAR Security at ESCRYPT.

	Crypto Stack	SecOC	TLS	IPSec	Secure Log/Diag	Identity & Access Mgmt
AUTOSAR Classic 4.4	✔	✔	✔	✖	✔	✖
AUTOSAR Adaptive R19-03	✔	✖	✔	✔	✖	✔

Figure 1: Security application in AUTOSAR Classic and Adaptive (as of August 2019).

Digital vaccination for the ECU

IT security for networked vehicles starts with ECU production

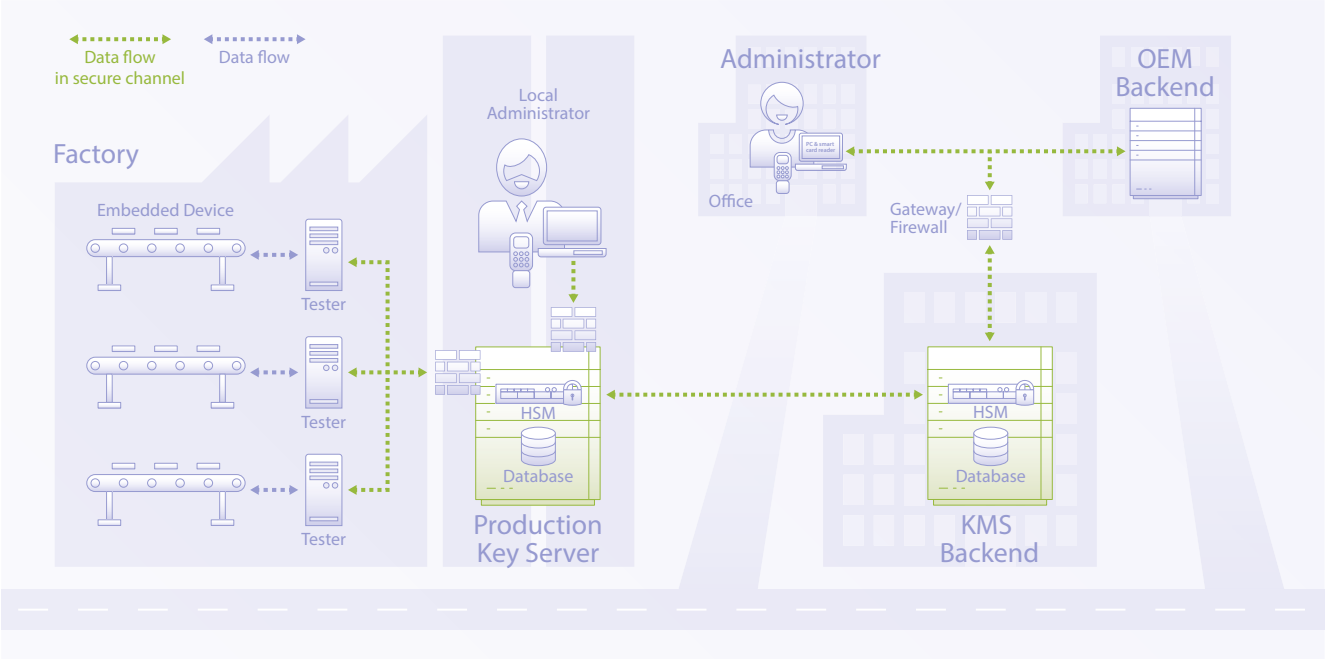
How can the cryptographic key material necessary for secure data exchange be introduced into the ECUs securely and according to requirements? The answer is an integrated solution consisting of a central key management backend and decentralized production key servers.

When it comes to protecting against cyber attacks, the control units in the vehicle play a key role – in the truest sense of the word: only cryptographic keys enable ECUs to authenticate themselves and thus legitimize data exchange within the electrical system as well as with the outside world. The special challenge here is that the ECUs for the various vehicle platforms must initially be supplied with OEM-specific key material and certificates – and ideally during their production by the ECU manufacturer.

Secure distribution of OEM key material

The effective solution combines a classic key management solution (KMS) as the central backend with decentralized production key servers (PKS) that are installed in the production facilities and communicate with the KMS. This is of benefit to the OEM because it means the process of equipping the OEM's specific ECUs with its own key material can be fully integrated into the ECU supplier's existing production infrastructure.

First, the KMS is fed the data packets with the key material provided by the respective car manufacturer. The key material is stored centrally, distributed via secure data transfer as needed among production sites, and stored on production key servers in readiness (see Figure).



Integrated key distribution and injection with key management solution and production key server.

Key insertion via end-of-line tester

The key material is introduced into the ECUs on site during production by connected end-of-line testers. These then retrieve the individual key packages from the production key server in the plant and "inject" them – like a "digital vaccination" – into the individual ECUs during production. At the same time, the PKS logs which cryptographic keys have been introduced into each ECU. Finally, on request, the PKS sends back what are known as verification files from production via the central KMS backend to the OEM. This gives automotive manufacturers certainty that the ECUs are correctly equipped with key material.

The solution combines high security and availability.

Secure storage without permanent online connection

A particular advantage of the solution is the symbiosis of high security and availability. The production key servers are protected against unauthorized access both by a robust and powerful hardware security module (HSM) and by their own security software. In addition, the PKS make contact with the backend only from time to time to synchronize data, carry out any updates, and create sufficient buffers with cryptographic data. This means that they are not dependent on a permanently stable internet connection, which means they are largely immune to potential online attacks.

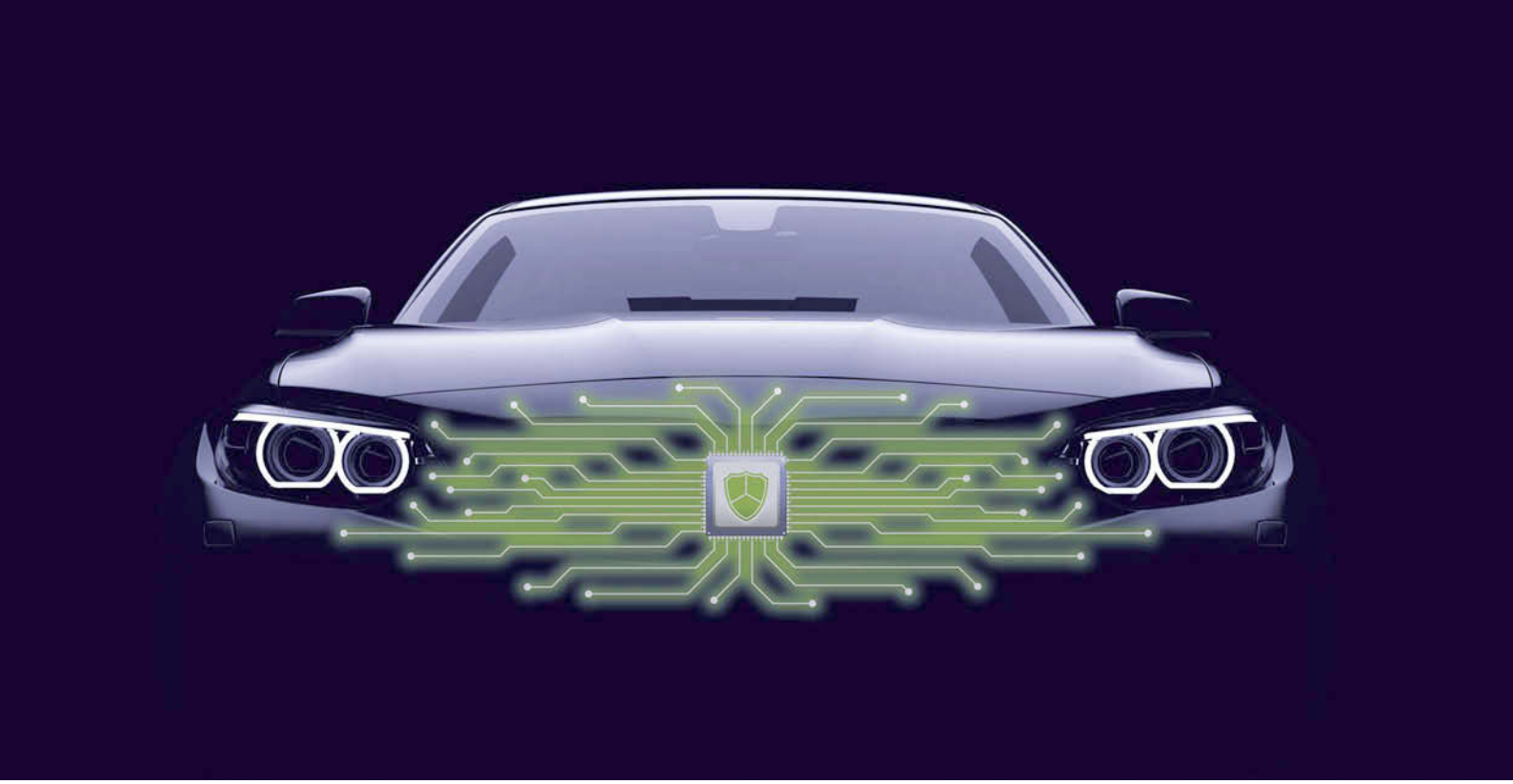
Users can freely determine how often contact should be made with the KMS backend as required. If the stock falls below a predefined minimum quota, new keys are automatically requested from the server. This ensures that there is always enough key material available for equipping the ECUs in production, which precludes a potentially costly production outage due to an interrupted network connection. The production key server always remains operational.

In use worldwide in ECU production

Secure and precise ECU data assignment with cryptographic keys forms the basis for almost all other in-vehicle IT security functions. The integrated KMS-PKS solution makes it possible to master the complex delivery mechanism for OEMs' cryptographic material, from secure key management to secure storage and injection of the key material into the ECUs and, finally, logging and verification. For good reason, today this process is used worldwide in ECU production for various automotive manufacturers. ■

Authors

Christian Wecker is Product Manager PKS at ESCRYPT.
Michael Lueke is Senior Program Manager KMS at ESCRYPT.



Performance boost for hardware security modules

New service-oriented HSM software secures future electrical system architectures

In vehicle architectures of the future, much of the software will be centralized on domain controllers, and automotive Ethernet will provide broadband onboard communication. This requires new approaches to IT security. Next-generation hardware security modules (HSMs) are becoming a central component, because they combine multi-app capability with real-time communication.

Vehicle computers (VCs) are about to merge vehicle domains and their software-controlled functions. The ECUs in the periphery will increasingly develop into input/output devices whose actual applications will be running on the VC. The advantages for OEMs are far-reaching. IP is shifted to the central computers. The complexity of E/E architectures is reduced, as is the engineering effort. Instead of purchasing specific ECUs and software for each vehicle generation, OEMs can pool the development and interaction of the software applications on the vehicle computers – saving time and money.

However, centralization drives an increase in onboard communication. Rather than decentralized processing in ECUs, the domain controller must collect data, process it, and distribute it in the vehicle. Because real-time requirements often apply, the data traffic will run via automotive Ethernet. Meanwhile, in subnetworks, signal transmission will still be done via CAN bus. IT security must be adapted to these hybrid architectures.

Security by design

With a view to increasing connectivity, security by design and update by design should be firmly anchored in hybrid in-vehicle networks – especially in light of the new possibilities opened up by the decoupling of hardware and software as well as the relocation of many software applications. IT security functions can also be managed centrally in the centralized in-vehicle network. At the same time, the protection of the ECUs in the peripherals must be guaranteed.

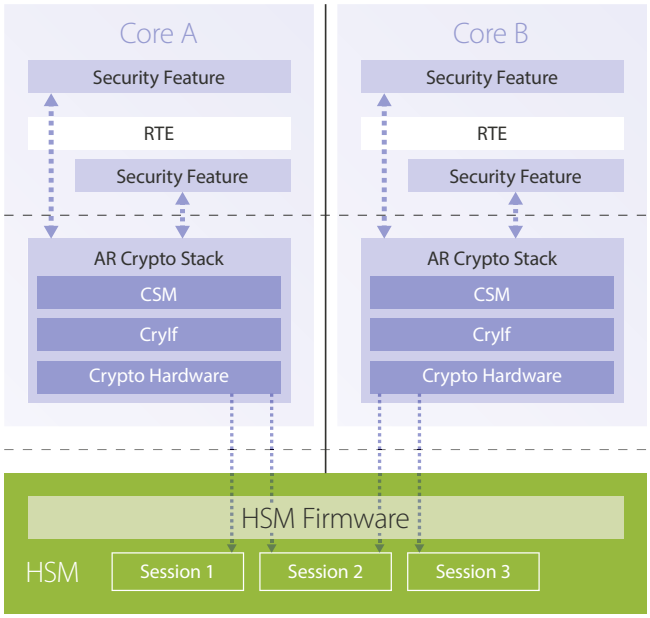


Figure 1: Requests from multiple host cores are processed by the HSM firmware in parallel sessions.

Hardware security modules (HSMs) are indispensable for completely secure onboard communication (SecOC). These help to ensure the authenticity of all data converging here and prevent attackers from gaining access to the central processor or even to the in-vehicle network by bypassing security-relevant ECU interfaces. But the challenges in centralized in-vehicle networks go beyond that: the demands on the security components also increase whenever central vehicle computers, often partitioned into many virtual machines, take over the software applications and functions of several ECUs. A new generation of hardware security modules has already been prepared for this.

Job preference and the real-time operating system

The IT security functions of the HSM are physically encapsulated in an HSM core on the microcontroller of the respective processor. There, they are activated and operated via the HSM software stack. The computer's host controller can thus devote itself to its actual tasks, while the HSM core processes security requirements: secure onboard communication, runtime manipulation detection, and secure booting, flashing, logging, and debugging. This makes HSMs much more powerful than purely software-based IT security solutions.

If software applications and ECU functions are combined on vehicle computers, it is foreseeable that there will sometimes be many applications competing simultaneously for the HSM's security functions. In this case, the HSM must provide the necessary IT security functions and manage the data streams of multiple applications in real time. This pushes standard HSMs to their limits; purely software-supported security solutions even more so. But a new generation of hardware security modules with a real-time operating system and an intelligent, flexible session concept is up to the task.

Multi-core/multi-application support

In future architectures, if several cores make parallel requests, the new HSM's firmware ensures that the HSM core processes these in up to 16 parallel sessions, with a configurable number of sessions in the modern HSM software stacks. The secret of this multi-core and multi-application support lies in the special architecture of the HSM firmware driver. This allows different virtualized applications to integrate the driver independently, paving the way for the independent development of various software parts: During integration, the "linker" step ensures that the driver's various instances use a common structure in the shared RAM of the hardware. Here, each instance creates its own structures (sessions) so that the driver can always manage several requests from the strictly encapsulated applications in parallel (Fig. 1).

A central security component in this setup is the host-to-HSM bridge. As the element separating the hardware security from the host, it takes over the "inflow control" to the HSM. In the bridge register, the queue of requests from the host cores is set up and processed in a way that ensures optimum utilization of the HSM as a limited resource to execute the requested security functions as quickly as possible. The next generation of HSM software turns the HSM's multi-app and multi-core capability into reality. OEMs can access it in a fully tested, production-ready form (Fig. 2).

Bulk MAC interface provides real-time performance

A further challenge is how to secure the massive increase in communication. Dealing with the juxtaposition of CAN buses and automotive Ethernet in the centralized electrical systems and secure

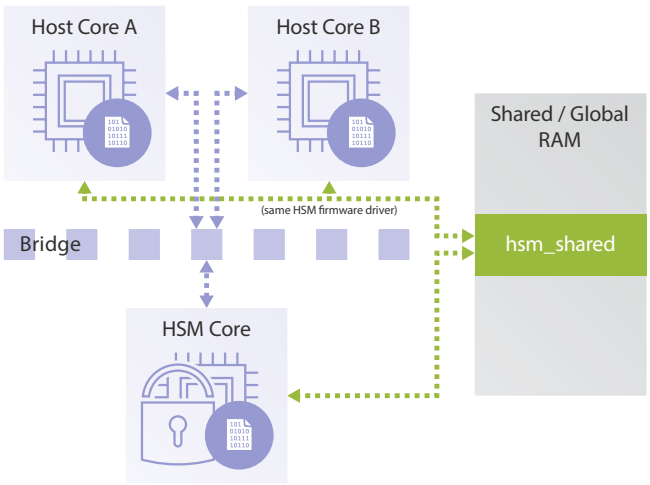


Figure 2: Multi-core/multi-application support – job requests are processed via bridge register and shared RAM.

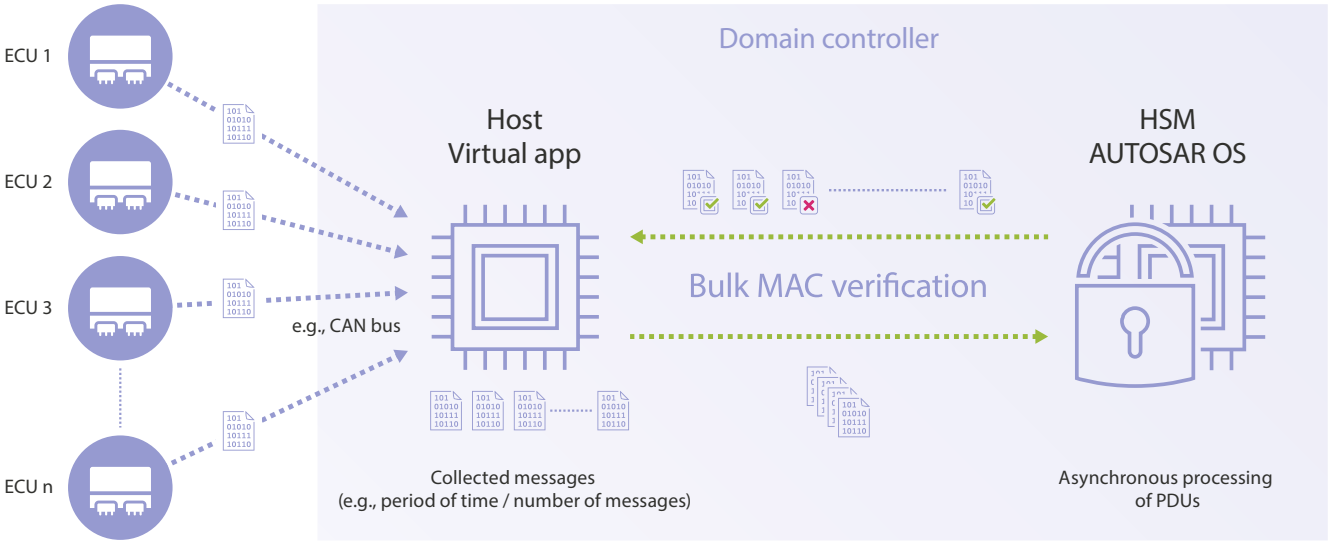


Figure 3: The bulk MAC interface provides secure real-time communication.

in-vehicle data exchange with protection for all communication protocols is demanding. The innovative HSMs also offer a solution for this, although their performance is limited in itself. Limits are set less by the HSM's hardware crypto engine than by the bridge register, because it doesn't permit data exchange in any quantity and at any speed. One solution is something known as a bulk MAC interface: first, the host collects all messages over a predetermined period of time; then it posts them en bloc as a request to the HSM via the bridge register. This way, one (!) single data transfer is sufficient. The HSM firmware processes all collected messages on the HSM hardware unit at once and transmits the results to the host (Fig. 3).

This delivers a huge gain in performance. Even if each data transfer between host and HSM takes only 10 µs, the delay adds up to 1 ms for a hundred messages. This is problematic for real-time systems. Using a bulk MAC interface, those hundred messages can be handled in one-hundredth of the time. For OEMs who set up networks with central computers and domain controllers and define many PDUs in the process, a bulk MAC interface offers definite advantages. By ensuring sufficiently fast authentication of large numbers of different messages, it maintains secure real-time communication in the vehicle network. In the next HSM software generation, this bulk MAC setup is already integrated ready for production.

Future-proof hardware security firmware

As in-vehicle networks are being transformed into centralized platforms, they are driving the decoupling of hardware and software. Hardware security modules play a central role in ensuring the IT security of these platforms. Not only do they protect the data streams from peripherals, where CAN buses will continue to dominate, to the central controllers against access and manipulation (SecOC). They are also able to cover security use cases at the highest network level and secure running software applications with a high data load and real-time requirements. A new HSM generation, designed for multi-core and multi-application tasks, ensures real-time communication even with high data loads and heterogeneous formats using a bulk MAC interface.

Next-generation hardware security firmware can be mapped in dedicated OEM product variants.

In view of increasing connectivity and the trend toward automated driving, OEMs are increasingly setting their own specific security standards for E/E architectures. Next-generation hardware security firmware can be mapped in dedicated OEM product variants – and flexibly integrated into central security concepts. It runs on the latest microcontrollers and provides its host driver as source code. This gives OEMs and Tier 1 suppliers a wealth of opportunities for reuse and customization. Thanks to this flexibility and their performance, hardware security modules with the latest firmware are a fundamental component for securing the centralized, hybrid in-vehicle networks of the future. ■

Authors

Tobias Klein is Lead Product Owner HSM at ESCRYPT.
Dr. Frederic Stumpf is Head of Product Management Cybersecurity Solutions at ESCRYPT.

Preliminary plan of Mark 51°7, Bochum. © skt umbaukultur – Partnerschaft von Architekten mbB – Bonn

ESCRYPT to build new headquarters

By early 2022, a new headquarters will be built for ESCRYPT on the site of the former Opel factory in Bochum. Construction work on the new building, designed in line with the latest structural and energy standards, will begin in summer 2020. It will ultimately offer an attractive working environment for up to 500 associates.

"By selecting this new location, we are consciously putting ourselves closer to the region's vibrant university and research landscape," says Dr. Uwe Müller, responsible Division Head for ESCRYPT within the Bosch Group. Moreover, ESCRYPT's new building on the former Opel site is symbolic of the automotive industry's new identity, based on digitally connected, automated, and electrified mobility. ■

Dr. Uwe Müller,
Head of Application Field Cybersecurity Solutions,
ESCRYPT (Bosch Group)

"By selecting this new location, we are consciously putting ourselves closer to the region's vibrant university and research landscape."

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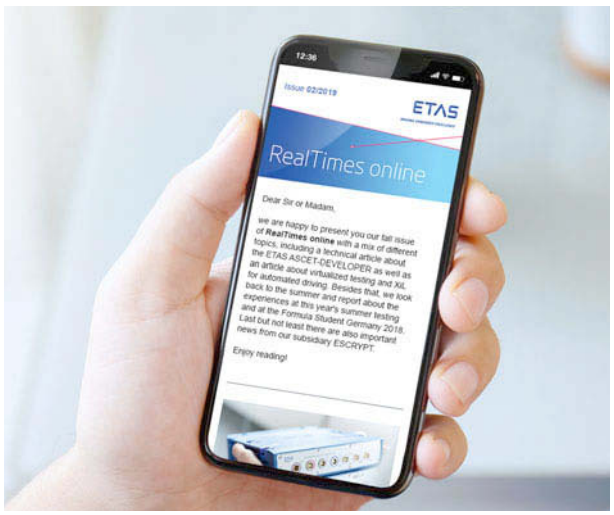

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Managing Editor Selina Epple
Editorial Team Corbin Bennett, Nicole Bruns, Jürgen Crepin, Martin Delle, Christian Hartig, Claudia Hartwell, Axel Heizmann, Anja Krahl, Silke Kronimus
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