Virtualisation
Key Technologies to Master Complexity

Advanced Driver Assistance Systems make driving safer. They recognise danger before it happens, and they can actively intervene to defuse critical situations. Such systems operate using a combination of networked hardware and software. Due to the number of involved functions and ECUs, the testing effort is enormous and an efficient approach is required in order to test these systems for functional safety, such as is outlined in the ISO 26262 standard. To manage this effort despite time and cost pressures, testing should begin at an early stage while supplying results that are as realistic as possible. Etas’ Isolar-Eve lets developers generate virtual ECUs, which they can then use for testing the software on the PC in Software-in-the-Loop setups. Thanks to the tool’s openness, testing can proceed seamlessly using Hardware-in-the-Loop simulation.
SCENARIO

Dangerous situations while driving can develop in an instant: The tires may lose grip in a bend. The vehicle in front loses its load. A child runs out onto the street. In such cases, electronic systems are superior to human reactions, as they do not become frightened and they respond with greater speed, rationality, and decisiveness.

Advanced Driver Assistance Systems (ADAS) actively contribute to road safety. With their ultrasonic, radar, lidar, and video sensor systems, they monitor the vehicle’s surroundings and analyse the resulting data in comparison with sensor data from the vehicle. In this manner, the systems are able to determine in advance if the driver is on a collision course, has misjudged a bend, or has failed to notice a traffic signal. If the driver does not heed their warnings, these systems will then intervene automatically to reduce or to mitigate the impact of the situation.

TEST REQUIREMENTS INCREASE WITH SYSTEM COMPLEXITY

Obviously, the reliability of such active systems must be thoroughly tested. The validation of these assistance systems is a challenge in itself. Behind their active interventions lie highly networked, software-controlled processes as well as complex networks of sensors, actuators, processors, and microcontrollers, FIGURE 1. Huge amounts of data from different vehicle domains need to be coordinated in order to ultimately induce an adequate overall behaviour of the vehicle.

Long before production begins, it is important to validate the functionality of the individual ECUs including software along with their interactions, and to document how functional safety is ensured. This places great demands on the testing environment, as it must accommodate these highly heterogeneous, networked systems. The system configurations and architectures of the ECUs used are varied, as is the provenance of the software, of which only a part is based on standards such as Autosar. At the same time high technical requirements have to be met, such as those pertaining to real-time communication and the processing of large quantities of data. This means highly complex systems, high variance and high demands regarding computing power – also for testing and validation.

A further aspect regarding complexity are distributed developer teams involved who are often working across various locations for various development partners. They must cope with constantly increasing system complexity in the face of great time and cost pressures.

VALIDATING ADAS – VIRTUALISATION AS A SOLUTION

To efficiently test and validate sophisticated assistance systems, the effectiveness of test vehicles is very limited. This is because road trials are not suitable for functionality testing in extreme driving situations; especially not when reproducibility is needed. Also, six or seven-digit required test kilometers are becoming more and more incompatible with project planning.

The key to overcoming all these challenges is virtualisation. With virtualisation, ADAS systems can be tested without safety risk while also reducing time and cost pressures, because realistic verification and validation can begin before ECU prototypes are available. In addition, virtual tests can run 24/7 without a break.

Etas’ virtual ECU platform for efficient PC-based development, validation, and verification of embedded software, Isolar-Eve is the perfect solution. The acronym Eve stands for “Etas Virtual ECU”. The virtual ECUs can be configured, generated, and parameterised with calibration data straight from a Windows PC.

New software functions can be integrated quickly and easily into existing ECU code and then run from a PC.
Because Isolar-Eve is built upon the Eclipse platform, developers have access to numerous tools, whether for debugging, code coverage analysis or systematic, automated, and thus perfectly reproducible regression tests. Version control systems and special editors offer further support.

**TIME AND COST SAVINGS THROUGH VIRTUALISATION**

The quick turnarounds for design, implementation, verification, and validation contribute significantly to process acceleration. The direct feedback between development and testing enhances the quality of the software. And since virtual ECUs can be duplicated any number of times on the PC, tests can be carried out in parallel, and therefore many times faster, than in real trials. On top of that, virtual ECUs on a PC can often be run at speeds faster than real time, if required. This acceleration leads to cost savings. The early detection of errors or architectural flaws also contributes significantly to cost efficiency, **FIGURE 2**. This is because the later errors are discovered in the development process, the more complex and costly the correction will be.

These benefits make virtualisation tools the perfect solution for the complex world of ADAS systems. However, there are major challenges on the horizon here. In the future, it will no longer suffice to validate ECUs and software individually. Rather, evidence of functional safety will be required at the system level, especially as it pertains to autonomous vehicles. In an ideal scenario, integrated test environments will be available for validation at the system level in which virtual ECUs can be incorporated into simulations and linked to Hardware-in-the-Loop (HiL) setups from various vehicle domains.

**VIRTUAL ECUS WILL BE A CENTRAL COMPONENT OF FUTURE VALIDATIONS**

Etas has trained its focus on this challenge and is preparing its tools accordingly – and Isolar-Eve has a central role. This virtualisation solution features a deliberately open design, so that its benefits may be utilised throughout the entire development process. Aside from Eclipse integration, Eve supports Autosar software as well as proprietary software. It offers open, flexible interfaces, **FIGURE 3**, and ensures full interoperability with testing and development tools offered by Etas and other vendors. Furthermore, the virtual ECUs can also be easily integrated into existing simulation environments. Isolar-Eve thus supports the generation of Func-
tional Mockup Units (FMU) for co-simulations in various vehicle domains, or integration of vehicle dynamics simulations, such as with IPG CarMaker. Virtual ECUs can also be integrated into Simulink simulations through the generation of S-functions. And rest bus simulations with bus analysis tools, for example Busmaster and CANoe, are supported via the virtual microcontroller abstraction layer (MCAL).

Thanks to Isolar-Eve’s openness, developers can test application software as well as basic software from various vendors. The spectrum ranges from component tests, including Autosar conformity testing, to integration testing and downstream functional validation. Here, the focus on ECU architectures as per Autosar proves helpful: with Isolar-Eve it is possible to generate test interfaces at all architecture levels irrespective of vendor, be it on the level of the application software, the basic software, the real-time environment (RTE), or the microcontroller abstraction layer MCAL. This flexibility provides a considerable benefit, particularly in the heterogeneous world of ADAS systems.

Together with Bosch, Etas is developing a software platform for virtual ECUs. The pilot is based on Bosch Cubas basic software, Etas RTA-RTE, VRTA-OS and a MCAL. The latter will be generated for the PC case by case, individually based on the specific BSW configuration. Since the prototype is based on Isolar-Eve, it immediately profits from the tool’s flexibility and open interfaces. This way, the solution is predestined for the usage in ADAS applications, where the virtual ECU can be used in combination with rest bus simulation, recorded data from test drives, simulations of driver, vehicle, and environment, and different ways of visualisation.

Making the Complexity of Heterogeneous Systems Manageable

Aside from high flexibility, Eve fulfills another central requirement of the ADAS environment: real-time processing and communication. To do this, the virtual ECU can be run on Etas Realtime PCs (RTPC), which are Linux-based. Used together with Etas Multi-RTPC technology, it is possible to run virtual and actual ECUs from various vehicle domains that are interconnected and feature guaranteed synchronised data communication in real time. The system configuration of the Multi-RTPC is highly scalable. In the future, it will also be possible to model the highly complex ADAS networks of autonomous or semi-autonomous vehicles using this technology.

The heterogeneous hardware configurations of ADAS systems are no hindrance to virtualisations using Isolar-Eve, as it supports a wide variety of multicore and multi-ECU architectures.

The Interaction of Virtual Testing and HIL Remains Important

The world of ADAS continues to develop in a dynamic fashion, and this has an impact on system architectures. The intelligence found in function-specific chassis and powertrain control units is now increasingly migrating towards centralised domain control units. These process data about the vehicle’s operating state and pass it on to the subsys-
tems. Today’s powertrain and braking control systems often intervene in isolation to keep the vehicle under control. In ADAS systems, these interventions must be centrally controlled using composite data collected from surrounding sensors. Along with this change come new requirements for virtualised testing environments. Safeguards for the reliability of this centralised ADAS intelligence must be implemented with the utmost care, and in this regard the virtualisation of sensors, actuators, and other components play a critical role.

Active assistance systems are also spurring on the trend towards hybrid architectures with microcontrollers and microprocessors as well as FPGAs (field programmable gate arrays) and ASICs (application-specific integrated circuits). FPGAs and ASICs are responsible for the computationally demanding evaluation of radar and video system data. Currently they cannot be virtualised on a PC, or they can only be virtualised running at very low speeds.

The time outlays involved here can be avoided by using pre-processed data as the input signal into the virtual ECU. The functionality of the ASICs and FPGAs themselves is then tested in the hardware, a procedure for which HiL tests are extremely well suited.

In any event, Software-in-the-Loop (SiL) and HiL tests will complement each other also in other areas in the future as well—with continuous transition. Etas tools such as Isolar-Eve along with RTPC technology featuring real-time capability are the key to bridging the gap between virtual and hardware-based testing. Furthermore, they support developer teams through easy connectivity with established measuring and calibration technologies from the INCA product family as well as from other vendors.

OPENNESS AND FLEXIBILITY ARE CRITICAL

The openness of Isolar-Eve, the easy access to the multitude of plug-ins from the Eclipse and Autosar environments, and the option to integrate them into commercially available simulation environments are the basis for efficient verification and validation. It allows early starts thanks to virtual ECUs, and delivers prompt results to provide reliability in the development of sophisticated assistance systems. In later stages of development, Eve will pave the way to nearly limitless testing environments and setups, be they open- or closed-loop setups, rest bus simulations, or integration of real and/or “synthetic” measurement data.

Because comprehensive expertise is required in the planning and setup of test environments for ADAS configurations, users can call on Etas professionals for assistance. With the right testing design many release tests that can be performed on a virtual ECU. This is because the original function code is unchanged when executed within virtual ECUs.

Through virtualisation, the effort for verification and validation of safety-critical systems becomes manageable. As a prerequisite, the corresponding tools need to adapt to the various requirements originating from the complex technology, the legislation, and the required cross-domain collaboration. Openness and flexibility, as offered by Isolar-Eve, are indispensable for this. This way, developers can focus on the essential: the functionality of the electronic assistance systems. After all, they must be reliable in order to fulfill their lifesaving role in critical situations.
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