DRIVING EMBEDDED EXCELLENCE

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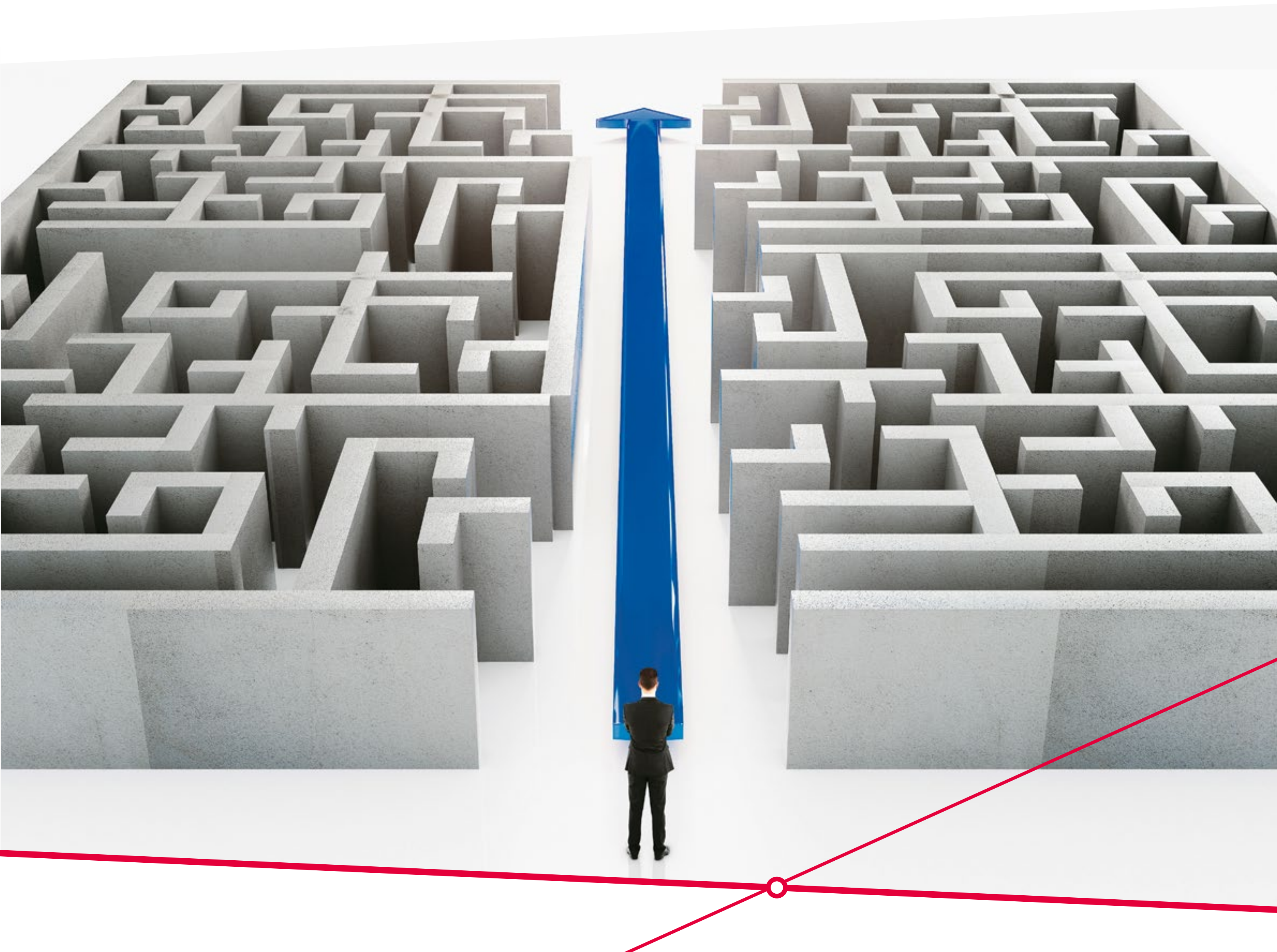
Ready for the future

XiL testing for autonomous driving

From advanced driver assistance systems (ADAS) to highly automated driving, electronic systems are designed to take some degree of control over a vehicle. But before they can be trusted to do that, they need to be rigorously tested. The goal is to verify that a vehicle's software and hardware systems will interact perfectly with the constantly changing environment. This can only be accomplished on time and within budget by using a combination of virtual testing methods, data reuse, and artificial intelligence.



Picture the scene: a heavy snowstorm, so fierce that it's difficult to see signs and pedestrians, or even make out the lane markings on the road. Can highly automated vehicles really cope with that kind of situation? How should they respond to a ball being kicked into the road or a policeman directing the traffic? In theory, self-driving vehicles must be able to deal with an endless array of different scenarios. To help them do that, ECUs, microprocessors (µPs), and graphic processors (GPUs) continuously analyze data from three to four dozen sensors under real-time conditions and translate it into driving commands for the vehicle actuators. All of that has to happen in whatever hardware and software architectures the vehicle manufacturer has chosen for each particular model. Additionally the complexity is compounded by frequent over-the-air (OTA) updates to vehicle software. Validating and verifying these highly complex systems is a mammoth undertaking that goes beyond anything this industry has seen before.

Virtualization makes complexity manageable

The time and investment this task requires could easily spiral out of control. That's why experts are looking for efficient methods, many of them virtual, that can help make this complexity manageable without neglecting safety considerations. Ideally, these methods would offer consistent workflows and data streams throughout the entire development cycle of a vehicle's software and hardware systems. The key is to get the data moving freely from one stage to the next, enabling developers to import a range of data formats into the virtual tests and allowing them to build on whatever verifications and validations they have already performed as they continue through the process.

For that to work, they need standardized interfaces for software and development tools and open system architectures that permit the use of development tools from different providers. Both these aspects are fully integrated in the X-in-the-Loop (XiL) solutions from ETAS. These encompass the Model-in-the-Loop (MiL) approach for the basic design of system functions and architecture in the early stages as well as Software-in-the-Loop (SiL) methods for subsequently validating and verifying software functions. ETAS XiL methodologies facilitate comprehensive testing, including the simulation of future Car-to-X communication, long before the ECUs, µPs, GPUs, and other hardware are available. Developers can run these kinds of tests on a computer with as many virtual ECUs as they like. That saves time because the tests can be run in parallel and in faster-than-real time, and can be reproduced as often as necessary. This produces verified and validated functions that can subsequently be tested and validated in Hardware-in-the-Loop (HiL) and Vehicle-in-the-Loop (ViL) settings using the production hardware. It also gives developers an entirely safe environment where they can run through safety-critical scenarios as often as they choose.

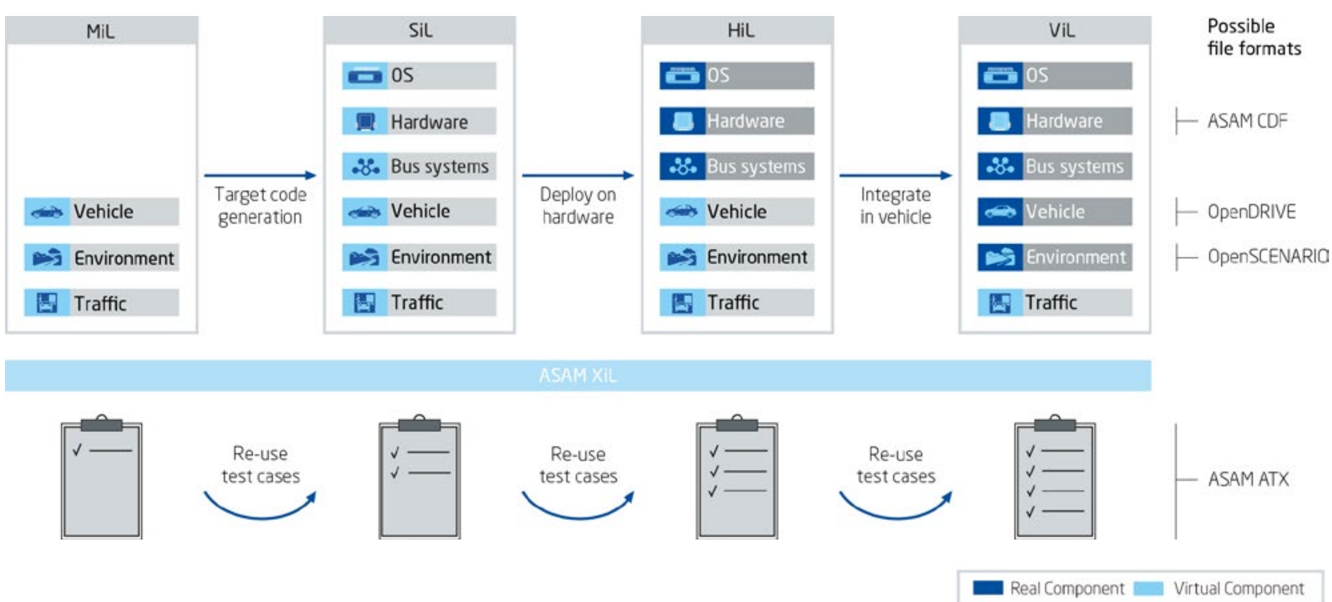


Fig. 1: Schematic diagram of components at the various XiL levels

Making smart use of the existing tool chain

To validate highly automated vehicles, this XiL toolchain must be opened up to new data formats and prepared for simulation tasks with rapidly increasing amounts of data. Its scope must be widened to include not just in-vehicle systems, but also 3D data from environment sensors, traffic simulations, driver behavior, and the tasks involved in autonomous vehicle control. Depending on the architectures used in each case, developers need the option of connecting ECUs using either today's automotive buses or future Gigabit Ethernet cables. Equally important is a function that allows developers to input suitable stimuli into their simulation for each sensor and each ECU – from stereo video cameras to radar and lidar sensors.

A further challenge is the sheer quantity of data captured by sensors and domain controllers. It is rare to find tools that can capture 500 Mbyte/s from an ECU, yet the ADAS environment – and especially the development of highly automated vehicles – requires data speeds of several gigabits a second. ETAS has now filled this gap in the market with its new high-performance GETK-Px series of interfaces. Combined with powerful data loggers that dock to interfaces using a 10 Gbits/s Ethernet switch, plus removable media with terabytes of capacity, these interfaces are the perfect choice for future-proof workflows.

Standardization is a must ...

Developers will only be willing to adopt new solutions if they can be seamlessly integrated in their standard workflows. That's why ETAS rigorously adheres to existing standards for interfaces and data formats and plays such a proactive role in numerous standardization bodies. It also supports well-established solutions for highly automated driving, such as the Automotive Data- and Time-Triggered Framework (ADTF). Its ultimate goal is to ensure that all the raw data measured in the vehicle can be imported into and replayed in XiL tests. This data replay is a key pillar of future verification and validation strategies: a clever combination of virtual and real data can be used to validate the various "layers of perception" of the ADAS ECUs used in the vehicle. Comparing the simulation with reality helps validate the simulation data used in the process. This opens up the full potential of virtual testing, allowing the results to be reused at later stages of development, too.

... and paves the way for artificial intelligence

Previously unused data can be enriched through a combination of continuous, synchronous recording of measurements and intelligent analysis using big data algorithms. This enriched data provides training material that can teach neural networks to identify objects, calculate clearances, and make decisions. Providing developers with defined access to suitable sequences is key, so ETAS is actively involved in developing solutions such as Enterprise Automotive Data Management (EADM).

To keep pace with future developments and enable engineers to meet strict deadlines and budgets, the test methodology also needs to ensure that all suitable artefacts can be reused. Within an individual project, reuse steadily decreases the amount of testing required from one development step to the next, right the way through to calibration. From a broader perspective, reuse boosts the efficiency of virtual validation across all projects by increasing the quantity of available artifacts and measurement data. Ensuring this consistency in the simulation and testing process is one of the key future goals of the ETAS COSYM integration platform.

Ultimately, virtualization is the only way of minimizing risk in an environment that has an infinite number of parameter combinations. By conducting time lapse testing with virtual ECUs and running through a wide range of different parameters, it is possible to expose bugs and system weaknesses early on, minimizing the need for expensive test drives. This approach offers benefits at every stage of development, including HiL testing with solutions from the ETAS LABCAR. Outstanding flexibility is also a core feature of products such as ETAS EHOOKS, a tool that engineers can use to integrate bypass hooks into the ECU code without requiring detailed information about the software. That allows them to test functions directly in the ECU software without the assistance of the ECU manufacturer and to bypass unstable signals at the subsequent calibration stage.

Consistency across every stage of XiL testing

Efficient virtualization in the ADAS environment calls for welldesigned holistic solutions spanning the entire XiL chain. Standardization is a pre-requisite for reproducing test cases throughout all the stages of the development process. Access to the relevant unit under test (UuT) and the models and data files used for testing is essential and must be safeguarded through established standards such as ASAM CDF, ASAM XiL, and ASAM ATX and new approaches such as OpenSCENARIO. This strategy paves the way for seamless verification and validation of software for self-driving vehicles – from troubleshooting in simplified models to testing with real hardware components. It facilitates the reuse of test descriptions, data sets and parameters, stimuli for sensors, and evaluation modules from one stage to the next.

Conclusion

Comprehensive virtualization has a key role to play in the efficient validation of highly automated driving. The sheer complexity and breadth of the testing process calls for well-designed, across-the-board solutions that include established test methods high-performance data capture tools, and the option to reuse artifacts and measurement data. The aim is to gradually close the gap between test drives and simulation. ETAS offers a range of XiL testing solutions that are specifically designed to accommodate future developments. With its successful mix of established ethodologies, XiL development, big data and AI, ETAS can help make self-driving vehicles a genuinely reliable option – even in a heavy snowstorm.

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