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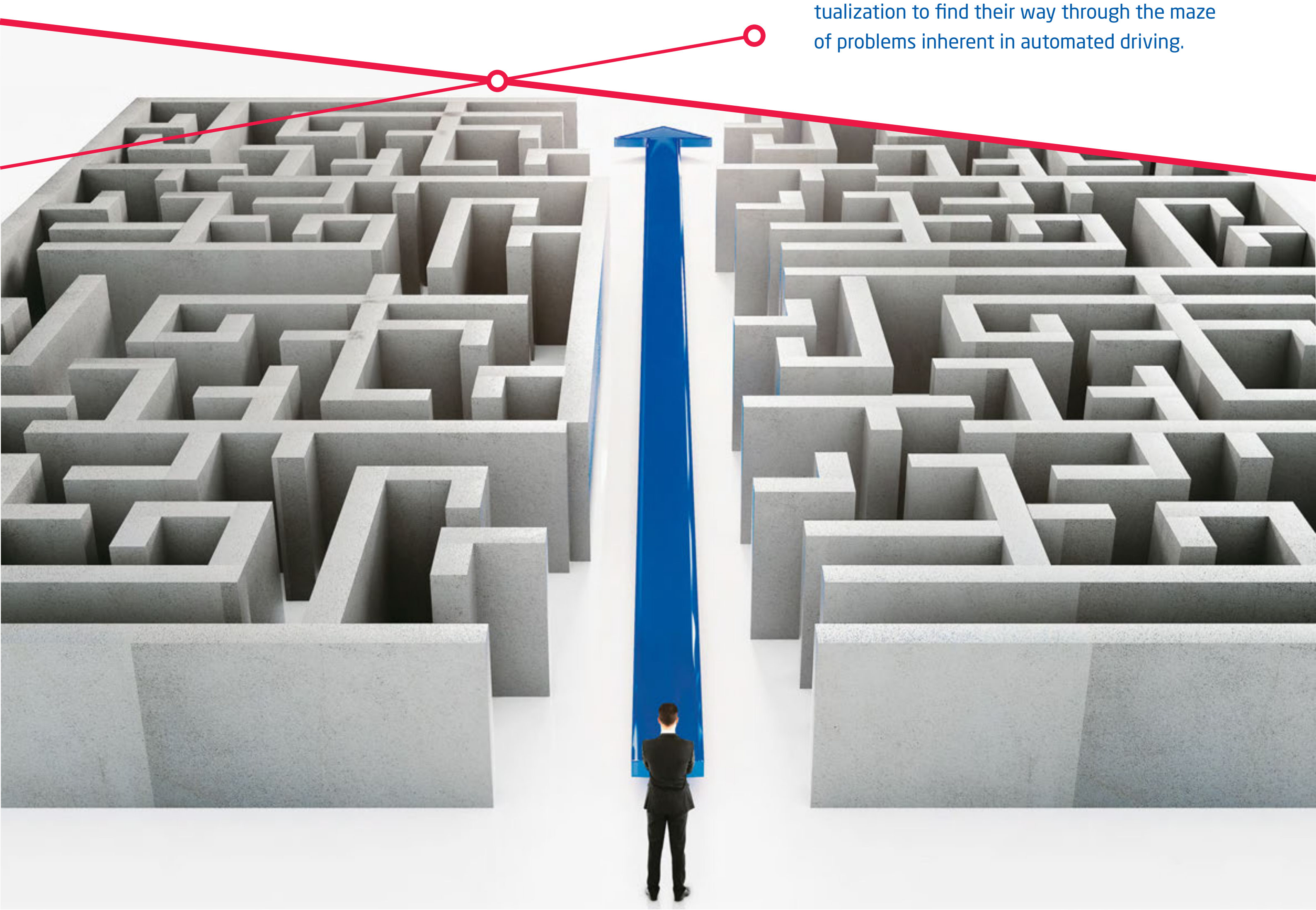
A handle on the future

Virtualized testing and XiL for automated driving

Advanced driver assistance systems (ADAS) have come so far that the step to automated driving is nearly within reach. But before sensor-based electronic systems can actually replace human drivers, they must be fully secured, which means nothing short of verifying error-free interaction between software/hardware systems and a variable environment. This is an enormously complex task that can be accomplished efficiently – in terms of both time and cost – only where virtual testing methods, data reuse, and artificial intelligence come together in one place.



Developers have to rely on simulation and virtualization to find their way through the maze of problems inherent in automated driving.

Intense, falling snow. Snow clings to the clothes of pedestrians and cyclists and quickly blankets street signs and road markings. Will sensor-based, highly automated vehicles be able to cope with this? Will they react appropriately when a child suddenly tears away from its parents' hands and runs into the street, when deer or wild boar spring up out of the dark, or when traffic lights malfunction and police direct traffic using hand signals? When it comes to automated driving, these questions – and theoretically infinitely many others on all conceivable traffic, weather, and environmental conditions – will need to be answered. Given that there are three to four dozen sensors interacting in each vehicle, and that ECUs, microprocessors (μPs), and graphics processors (GPUs) must constantly analyze sensor data under real-time conditions and translate it into driving commands for the vehicle actuators, it becomes clear how hugely complex a task this is. To further complicate matters, all of these things take place, depending on the manufacturer, in completely different, frequently updated hardware and software architectures. And as if all that weren't enough, thanks to over-the-air (OTA) updates, the software is continually modified over its lifetime. If it wasn't clear before, it certainly is now: new, rigorously consistent development approaches are needed.

Virtualization makes complexity manageable

Securing highly automated vehicles is a mammoth undertaking, far beyond the scope of anything we've ever done. Managing such a feat, and doing so on time and on budget, requires intelligent approaches: efficient, largely virtual methods need to be established for the entire development cycle of the software and hardware systems used. Ideally, comprehensive data and workflows will ensure this (Fig. 1). A high data flow rate is key here: for one, so that various data formats can be imported into the virtual tests, and for another, so that previously completed verifications and validations can be reused from one level to the next and thus reliably built on. For this to succeed, interfaces must be standardized, and the chain of security must have an open system architecture that permits development tools from different providers to be used.

ETAS has been rigorously pursuing both approaches for many years and has built up an extensive portfolio of X-in-the-loop (XiL) solutions. These range from the model-in-the-loop (MiL) approach for the basic design of system functions and architecture in the early stages, to software-in-the-loop (SiL) methods for securing software functions that are used very early on in the process, long before ECUs, μPs, GPUs, and other vehicle infrastructure elements are available as hardware. These methods permit any number of virtual ECUs to be used, enabling comprehensive tests and even simulation of future car-to-x communication. They also offer the advantage that tests can be performed in parallel, thus saving time, while also being run through in faster-than-real time, allowing situations to be reproduced as often as necessary. Later, in hardware-in-the-loop (HiL) and vehicle-in-the-loop (ViL) settings, the functions verified and validated in SiL tests can also be tested and validated with the production hardware. Not only do these simulations allow for parallel development processes, but in the ADAS environment, they also facilitate testing of the interaction between vehicle systems and variable environmental conditions, including safety-critical situations.

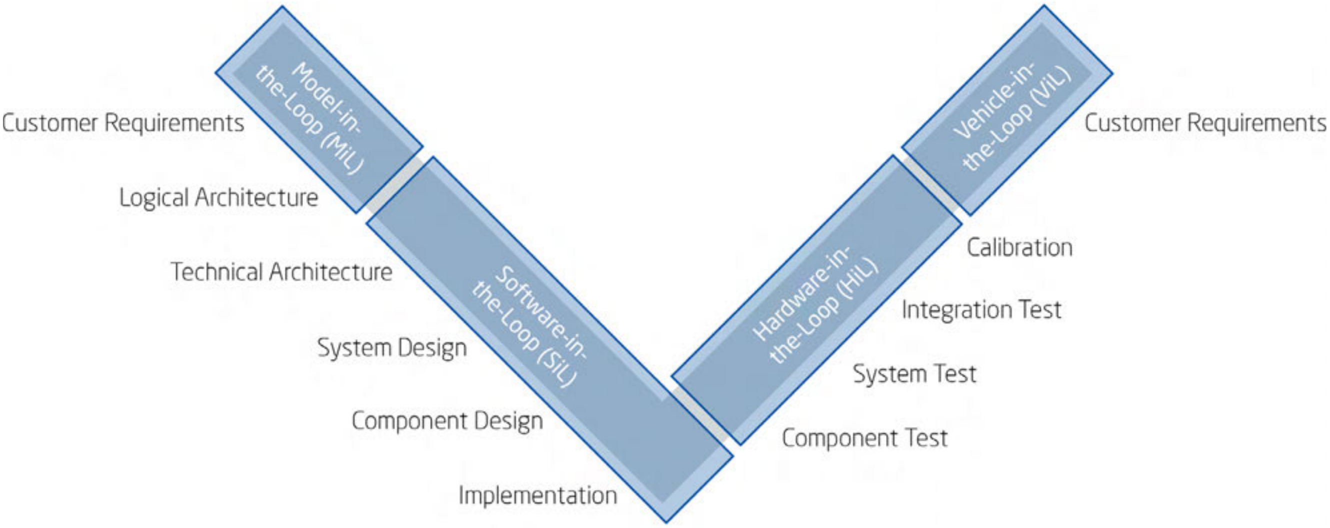


Fig. 1: Comprehensive testing is an important key to success

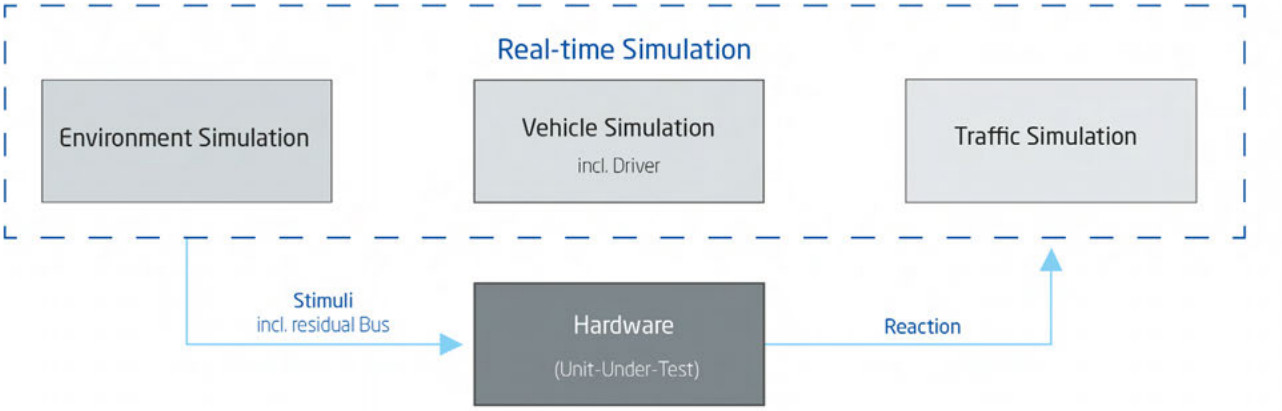


Fig. 2: Simulating traffic situations in the HiL environment is a crucial element of successful ADAS testing.

Making smart use of the existing tool chain

The key is to use the XiL tool chain efficiently, opening it up to new data formats and simulation tasks, and at the same time, preparing it for the rapidly growing volumes of data. Whereas the focus to date has been primarily on in-vehicle systems, now tests must also incorporate three-dimensional data from environment recognition and traffic simulations, as well as driver behavior and the tasks involved in autonomous vehicle handling (Fig. 2). Depending on the architecture, this will require various ECUs and processors to be connected to the automotive data buses commonly used today, and to future gigabyte Ethernet links. The more difficult task will be to inject suitable stimuli for each of the sensors and ECUs incorporated in the simulations, as those for stereo video cameras differ from those for radar or lidar sensors. The challenge begins with the fundamental question of how to generate corresponding data files for the multitude of test cases – and how to store them in a way that enables developers to access them quickly and selectively. In current development projects, this first step is proving to be a major obstacle. There is a lack of powerful tools for the requisite data acquisition. The ECU needs data rates of 500 MByte/s, and this figure will soon shoot up to 1.5 to 3 gigabyte/s and higher. ETAS recently introduced its new high-performance GETK-Px interface series for this, and powerful dataloggers that will be connected to the interfaces via a 10 GByte/s Ethernet switch are also available. Removable storage with volumes in the terabyte range facilitates the workflows.

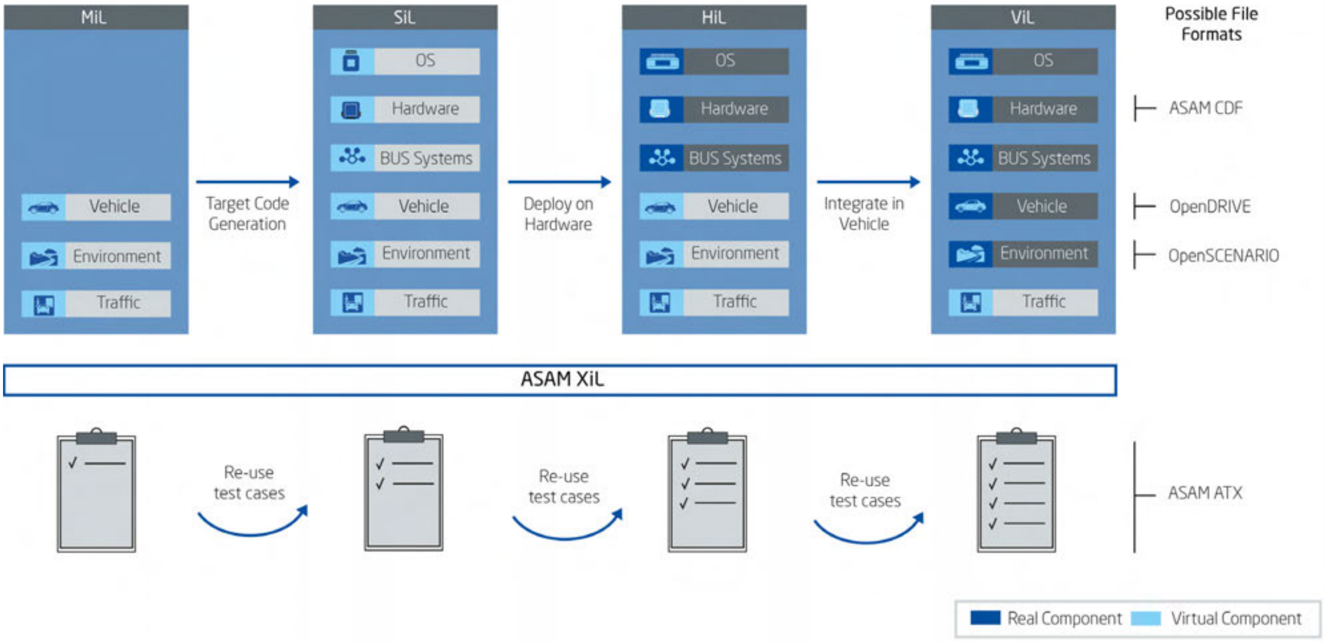


Fig. 3: Schematic diagram of the components involved in the various XiL levels.

Standardization is a must …

If developers are to actually use these solutions, it must be possible to seamlessly integrate them into familiar workflows, and the only way to ensure that is through standardized software protocols, data formats, and interfaces. That's why ETAS rigorously follows existing standards and participates in many standardization bodies. In the automated driving environment, this philosophy is now also reflected in the possibility for users to use ETAS solutions in the automotive data- and time-triggered framework (ADTF).

This development environment acts as a bridge between visualization in the vehicle and sensor and ECU testing in the lab – and many leading manufacturers and suppliers are now using it in their ADAS. Standardization is also a prerequisite for ensuring that all raw data measured in vehicles can be imported into and replayed in the XiL tests. This data replay is an integral part of the validation strategy, as smartly combining virtual and real data makes it possible to validate the various "layers of perception" in the ADAS ECUs – and through these, ultimately also previously used simulation data. In the future, the task will be to iteratively refine this inference between simulation and reality in order to take full advantage of the efficiency of virtual testing. Only then will the various results also be valid in subsequent development steps.

… and paves the way for artificial intelligence

The data foundation for this can come from virtual testing performed in previous projects and from test drives. Thanks to continuous, synchronous recording of measured data, coupled with intelligent analysis of that data, previously unused data can be refined with the help of big-data algorithms. This would enable developers to selectively access suitable sequences in databases. ETAS is actively developing solutions such as Enterprise Automotive Data Management (EADM) to facilitate this and other tasks. Reusing data makes it possible to systematically train neural networks – for instance to recognize objects, calculate clearance, and make decisions in real traffic situations.

Any future-proof test methodology must permit seamless reuse of artifacts, as this is the only way to manage the exponential increase in the amount of testing while keeping testing time and costs within reasonable limits. This applies to individual projects, where reuse further reduces the amount of testing with each development level, all the way through to calibration, and it applies across all projects, because the efficiency of virtual validation steadily increases with the growing base of artifacts and measured data. That's why ETAS created ETAS COSYM, an integration platform that enables efficient consistency in simulation and testing.

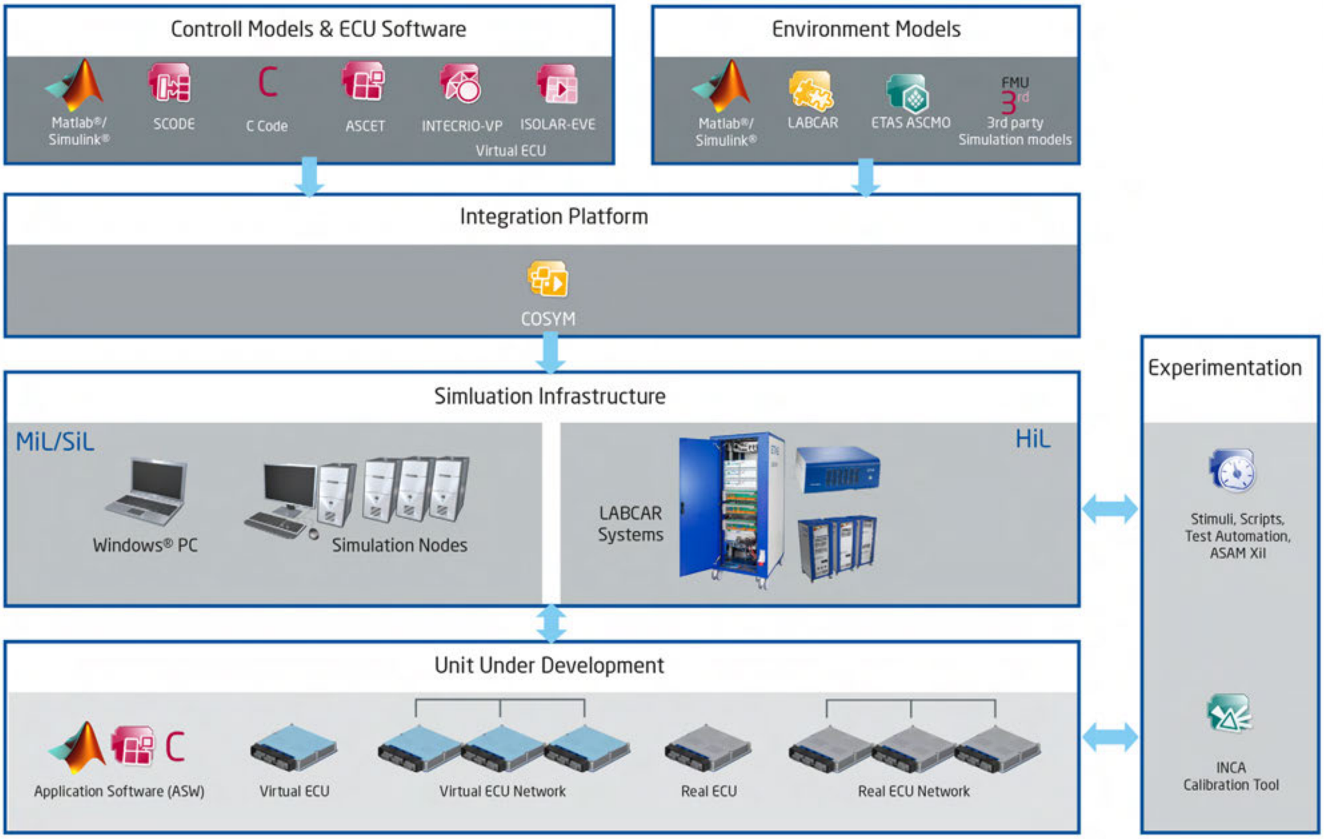


Fig. 4: Overview of the components of a consistent XiL approach using ETAS COSYM as the integration platform.

Virtualization is the key to reasonably minimizing risk despite the theoretically infinite number of parameter combinations. It enables quick switching of parameters and rapid execution on virtual ECUs running in parallel. This methodology exposes potential errors or system weaknesses early on and minimizes the need for expensive test drives.

Even in late development stages, where testing can be continued with, for instance, ETAS' LABCAR family of comprehensive HiL solutions, tools such as ETAS EHOOKS ensure complete flexibility. This tool allows engineers to set bypass hooks in the software and thus to test functions in an encapsulated environment – regardless of who supplied the ECU. In this way, developers can integrate and test algorithms directly in the ECU software. Bypass hooks ensure streamlined workflows during calibration, too, by making it easy to override weak signals.

Consistency across every stage of XiL testing

Efficient virtualization in the ADAS environment not only requires expertise and solutions for individual levels of XiL testing; it calls for well-thought-out end-to-end solutions with standardized interfaces and data formats that allow test cases to be easily reproduced across all development stages. Uniform access to the relevant unit under test (UUT), as well as the models and data files used, can be realized with established standards such as ASAM CDF, ASAM XiL, and ASAM ATX, in addition to new approaches such as OpenSCENARIO. Only with this kind of standardization will it be possible to advance the seamless verification and validation of software for self-driving vehicles from troubleshooting in simplified models to testing with real hardware components – and to reuse test descriptions, datasets with parameters, stimuli for sensors, and evaluation modules from one stage to the next (Fig. 3).

Key features

Achieving automated driving requires virtual testing, smart data handling, and artificial intelligence. The only way to manage this is to use efficient test methods and to reuse artifacts and measured data wherever possible. The more mature the virtual testing, the lower the risk that errors or unforeseen system weaknesses will occur in the late development stages. A suitable XiL solution along the tool chain makes it possible to get a handle on the enormous tasks involved in making automated driving a reality.

Conclusion

To efficiently secure that benefit, and highly automated driving, comprehensive virtualization is indispensable. The complexity and the sheer number of testing tasks is already skyrocketing due merely to the plethora of different vehicle sensors and software/hardware architectures. The far more complex interaction of these systems with the environment and with all other road users must be secured, as well. The only way to manage this is to use efficient test methods and to reuse artifacts and measured data wherever possible. Standardized interfaces and data formats are of crucial importance.

In addition, high-performance solutions are needed for in-vehicle data acquisition and recording, and the data thus obtained has to be made usable for ADAS development in order to gradually close the gap between test drives and simulation. The more mature the virtual testing, the lower the risk that errors or unforeseen system weaknesses will occur in the late development stages. ETAS' portfolio of solutions along the virtual XiL test chain helps achieve this. One thing is certain: intense, falling snow must not and will not compromise the safety of self-driving vehicles.

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