Siemens PLM Software

Verifying ADAS and autonomous driving performance

Siemens solutions help optimize the mix of virtual and physical testing

Executive summary

According to the European New Car Assessment Program (Euro NCAP) 2020 protocols, testing tomorrow's advanced driver assistance systems (ADAS) solely on a proving ground is no longer feasible. With the increasing level of automation, the number of scenarios vehicles need to react to in a safe and repeatable manner is rapidly growing. Virtual validation and verification is about to become common practice for all original equipment manufacturers (OEMs) that are integrating systems like autonomous emergency braking, lane keeping assist, speed and parking assist. However, virtual results can only be trustworthy if they are confirmed by physical testing. Having consistency in test scenarios, the virtual representation of the environment, the car and sensors is the key to successfully validating and verifying automated driving functions.

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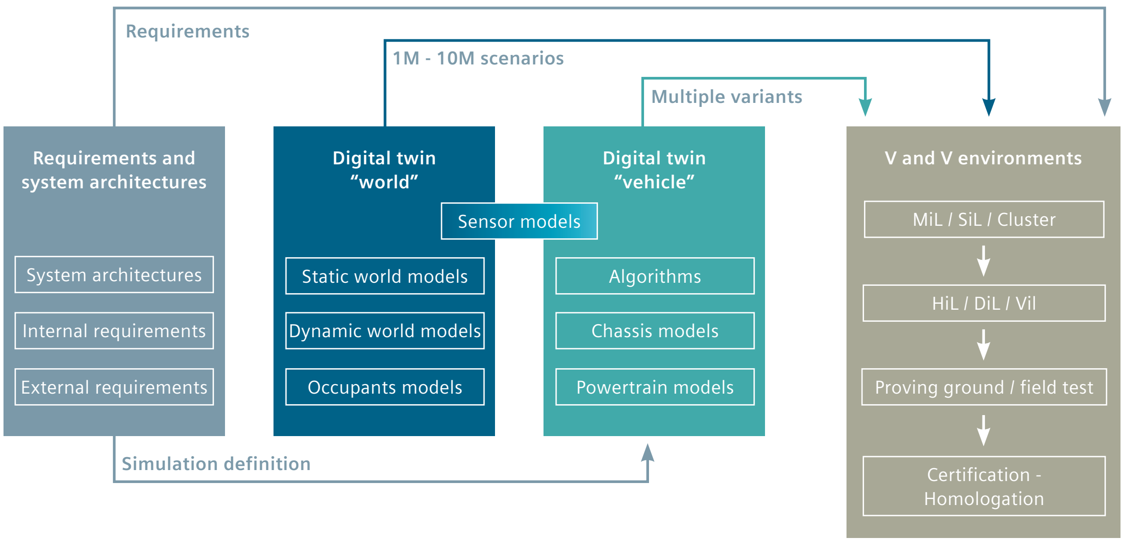
Abstract

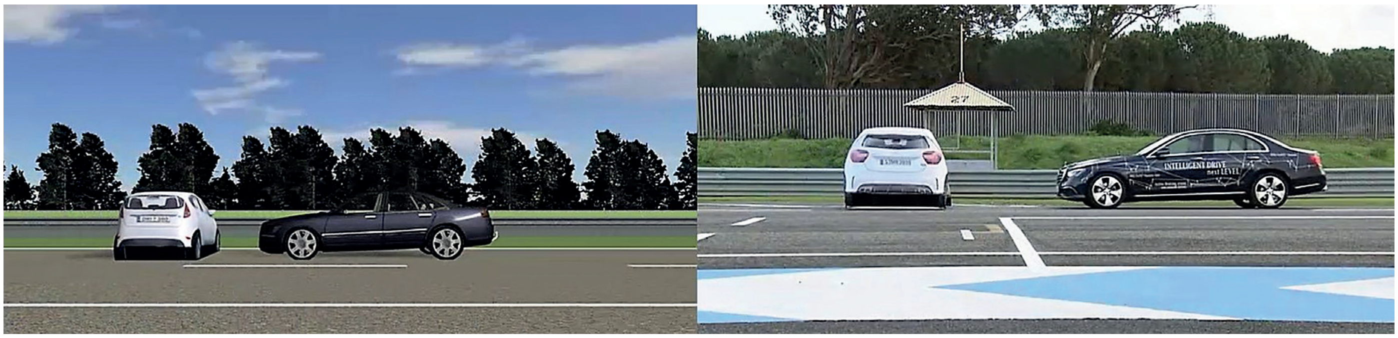


These days ADAS is being standardized in a broad range of vehicles. Not only premium high-end vehicles have pedestrian detection and autonomous braking functionality. It now also comes as standard equipment in small-city cars along with automated parking systems and cruise control. This broad acceptance is indicative of the trend toward fully autonomous driving. Step-by-step more and more control functions of the vehicle will be taken away from the driver, up to the point when fully autonomous mobility-as-a-service offerings will become the norm.

The trajectory to autonomously driven cars is marked by the need for the vehicle to recognize and react to an increased number of complex scenarios. This is also recognized by authorities like Euro NCAP. In future protocols, large numbers of virtual tests will be required to complement the proving ground tests.

Siemens has a wide scope of virtual and physical testing solutions for ADAS and autonomous driving, with optimum fidelity level modeling solutions for sensors, environment, chassis systems, powertrains and controllers. This simulation-based solution framework enables massive model-in-the-loop (MiL) and software-in-the-loop (SiL) testing. But it also supports the re-use of test definitions and models in real-time environments like electronic control units (ECUs), system components or hardware-in-the-loop (HiL) and full vehicle-in-the-loop (ViL) tests. However, this is not where it ends; having a long history and a broad set of capabilities in proving ground testing and model validation services, Siemens closes the loop and combines the results in the virtual environments with those of the proving ground tests.

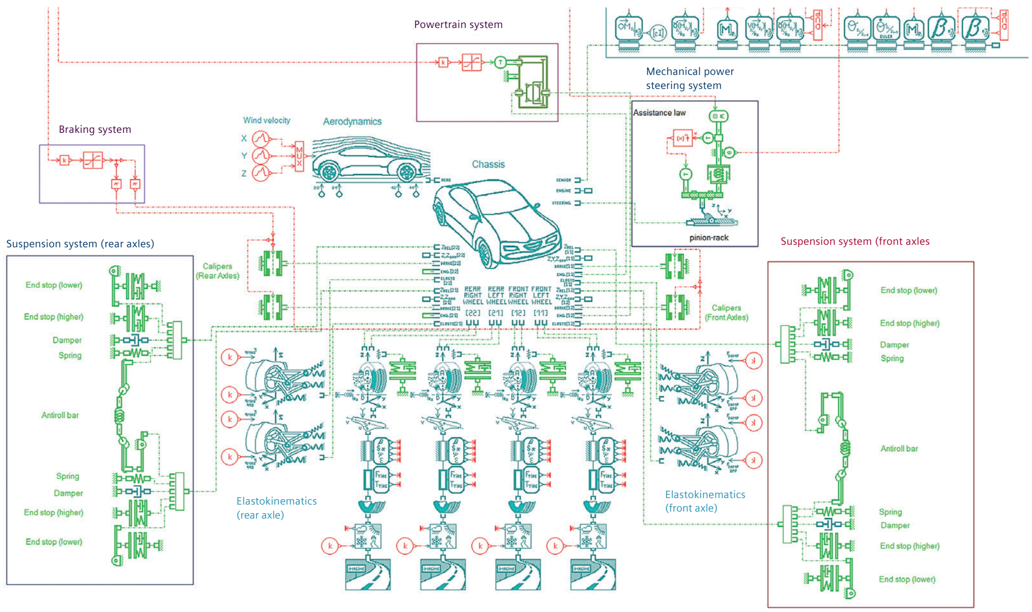
Challenges in validating ADAS in the full vehicle



Typically, ADAS systems are supplied by one or more Tier 1 suppliers to the OEM. In this case the controller software is part of the system and not developed in-house. Alternatively, the OEM system engineering teams develop the ADAS system, including developing the controls by using components supplied by the Tier 1 and Tier 2 suppliers. Independent of the supply chain structure, these systems are typically developed in a vehicle-agnostic manner to support installation in multiple vehicle platforms. Only in the very last stage are more detailed, vehicle-specific controls developed.

In both cases the vehicle performance teams need to validate and verify the performance of the systems in specific vehicle configurations. Today's practice is to perform a series of standard proving ground tests and complement them with extensive test drives on the public roads of a variety of countries. Not only is this a costly approach, it cannot be reproduced and repeated.

A validation and verification framework for ADAS and autonomous driving

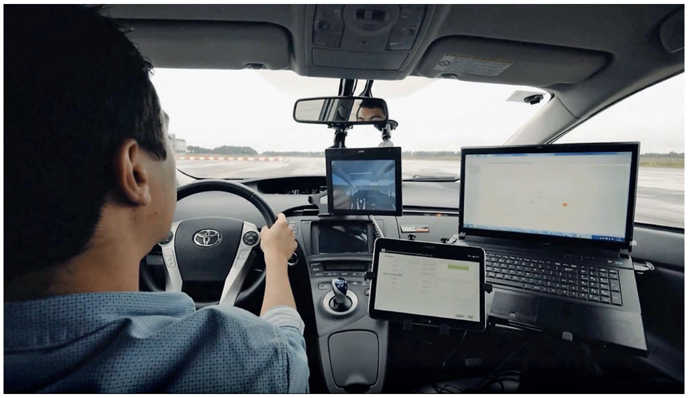


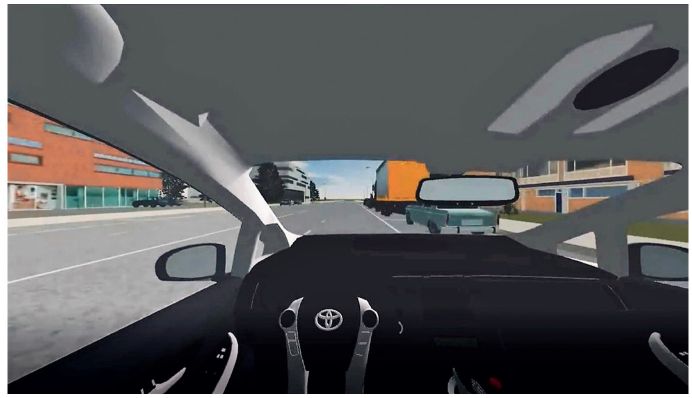
In order to efficiently answer the new need for virtual validation data, it is important to rethink the entire vehicle development process. Transitioning toward a model-based system engineering (MBSE) ensures the creation of digital twins for all relevant elements of the vehicle.

Not only a controller and traffic scenario simulation solution are needed for full vehicle virtual validation and verification. Specific vehicle behavior must be simulated accurately enough to deliver trustworthy predictions: for example, decelerations, tire slip angles, vehicle roll and pitch angles. That's because these values impact safety performance. This means accurate models are required for chassis systems, powertrain and tires so the correct fidelity level of vehicle dynamics simulations can be run, reflecting specific vehicle behavior. Simcenter Amesim™ software contains large libraries of chassis systems and components with varying levels of fidelity, making it possible to efficiently generate accurate representations of a specific vehicle configuration. These models do not only have value in ADAS performance verification; we suggest you broadly adapt model-based engineering processes, developing these models in the respective departments. In that way models can be used to first optimize designs, and subsequently to validate and verify programs up to the point when true multi-attribute balancing comes into play for optimizing factors like comfort, energy efficiency and safety.

Siemens supports this transition and is currently working on a validation and verification framework for ADAS and autonomous driving. Starting from requirements and vehicle-level system architecture, the Simcenter™ portfolio makes it possible to generate endless numbers of virtual scenarios, combining world models with vehicle models connected through sensor models.

For each requirement, test cases are managed, potentially covering hundreds or thousands of scenarios. By using Simcenter Prescan™ software you can take multiple approaches to automatically generating these test cases. Typically, it is done with script-based modeling functionality. Simcenter Amesim software is the environment most commonly used for creating vehicle models capable of exchanging component or system models of different fidelity levels, optimizing accuracy and processing time. Simcenter Prescan representations contain the reflective properties for physics-based radar, camera, lidar and ultrasonic sensors. The sensor models can therefore also be scaled from basic ground truth information up to full wave propagation modeling for detailed sensor evaluations.





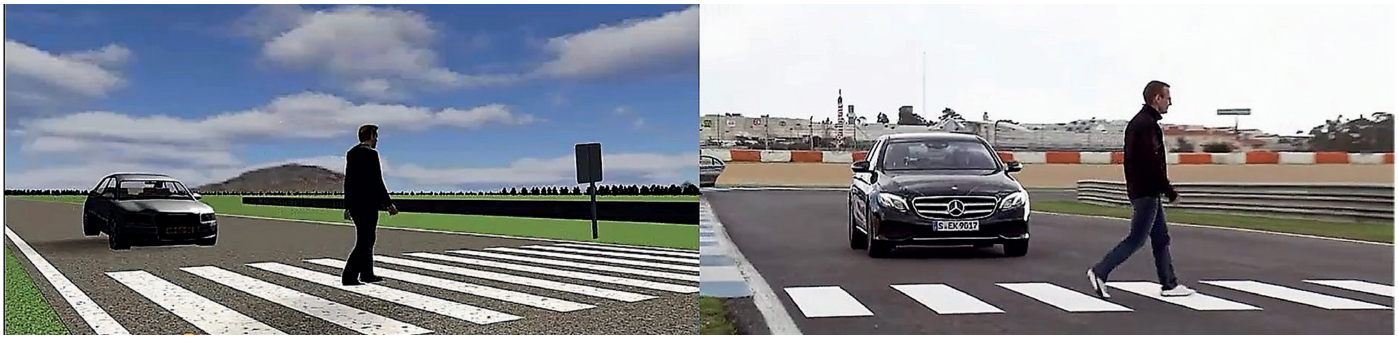
Full virtual validation and verification

Testing thousands of scenarios is easier said than done. With the Siemens validation and verification framework for ADAS and autonomous driving, the majority of tests are executed in a fully virtual MiL manner. This means the vehicle, environment, sensors and controller are put together as virtual representations, as close to the reality as required to generate trustworthy results.

In practice this means the starting point is the generation of the scenario variants. There are multiple possible sources for scenarios. There are scenario databases like GIDAS and CIDAS (German and Chinese accident databases, respectively), many OEMs and Tier 1s record traffic data and generate OpenSCENARIO format descriptions out of that data, and there are software solutions to generate scenarios synthetically. Simcenter Prescan has all the common scenario interfaces to support massive simulation in cluster environments. The execution of these large numbers of test is handled in HEEDS™ software.

Mixed reality validation and verification

During the vehicle development process, hardware and software components become available. Since the large majority of the Simcenter models run in real time, it is straightforward to bring hardware and software into the loop, replacing the virtual components. Typical examples of this are the ECU in loop testing, real-time SiL testing and sensor-in-the-loop testing. Siemens works with its customers in engineering services engagements to create these HiL and SiL setups, while enabling re-use of the models and test-case definitions from the MiL stage, preventing unnecessary work and providing consistent results. These tests can also be run for MiL validation work.



Another real-time application is driver-in-the-loop (DiL) and ViL testing. In the first, a driving simulator becomes part of the test setup; for example, making it possible to do subjective assessments and human machine interface research. In the ViL setup, the entire vehicle is driven through a virtual scene. The sensors of the physical vehicle are disconnected from the vehicle controllers while the sensor data is being generated in real time in the vehicle. It is then sent as inputs to the vehicle controller instead. In this way, complex tests with multiple traffic participants can be executed with the complete vehicle on an empty proving ground; for example, getting exact results for braking distance or lane-keeping performances. ViL tests are valuable for preparing future Euro NCAP tests that require mixed virtual results and proving ground tests since it makes it possible to rerun virtual scenarios in a one-to-one comparable execution on a proving ground.

Proving ground and real-life testing

The last stage of the verification and validation process will always take place outdoors with the preproduction vehicle. When the first cars become available for testing, both model validation tests and full performance verification tests can be executed. It is especially important that continuity is guaranteed for validation tests.

With Simcenter Prescan, virtual test scenario definitions can be translated in driver robot set points, making it straightforward to run the exact same scenario in virtual conditions as well as on the proving ground. This capability makes it possible to accurately prepare proving ground testing, especially when proving grounds are virtualized in detail, recording the friction coefficients and pothole locations of the tarmac. As a result, test campaigns can be optimized and executed efficiently. Siemens has simulation partnership agreements with the leading proving grounds for autonomous driving to streamline this process, such as the American Center of Mobility at Willow Run, Michigan.

TASS International, a Siemens business, is a Euro NCAP-accredited test laboratory, running full-scale crash tests and active safety assessments for speed assist, lane support and emergency braking. The hands-on test experience on the proving ground is translated into the virtual components of the validation and verification framework.

Conclusion

Verifying the performance of automated driving functions is particularly complex due to the infinite number of possible scenarios the car will encounter during its lifetime. A closed-loop validation and verification framework ensures measurable test coverage and enables continuous improvement of the scenario database. Siemens partners with the automotive industry to bring continuity throughout the development and validation and verification processes, from a pure virtual representation to when the physical vehicle hits the road. And it doesn't stop there. Data collected during the lifetime of the vehicle can be used to further improve the vehicle with over-the-air software updates. Having an established virtual and physical validation and verification framework enables this new way of working. Siemens is guiding its customers and partners in this paradigm shift and helping to prepare the automotive industry for a new reality.

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