



Verification and Validation Strategy for Smart Connected Vehicles

Testing the ADAS Systems



“Autonomous driving” and “Advanced Driver Assistance System” are the big waves of technological developments surging the automotive industry. The industry is investing in these technologies to move vehicle autonomy from level 0 to level 5, where level 5 is the deployment of fully automated driving.

The demand for ADAS will also increase the demand to provide safe, comfortable, and environmentally friendly vehicles. Safety, reliability, and robustness will be the prerequisite features for autonomous driving to achieve market success. Hence, the recent focus of global automotive players is on ADAS for,

- Integrated safety
- Energy efficiency
- Connectivity and autonomy.

ADAS functionalities: A snapshot

ADAS systems are essentially control loops comprising sensors, controllers, and actuators that drive the vehicle in the physical world. Different ADAS functionalities are integrated to achieve a high level of autonomy in the vehicle. To execute these ADAS functionalities, there are a host of sensor components that help measure the environmental parameters around the vehicle and create an intelligent map of the driving environment. These sensors include RADAR, Ultrasound, LIDAR and VISION based sensors which come with varying levels of confidence.

The typical ADAS key use cases are:

- Adaptive cruise control
- Emergency brake assistance
- Front collision warning
- Lane departure warning
- Lane keeping assistance
- Lane change warning
- Parking assistance
- Light assistance system
- Night vision pedestrian detection
- Semi and highly automated driving.

Importance of verification and validation for ADAS

The autonomous vehicle will need competence to recognize the traffic environment, vehicles, pedestrians, road signs and markings, trees, buildings, traffic lights, and many other things that we encounter every day while driving. It is also important to take into account weather and lightning conditions.

For such complex task, there will be an intense amount of testing required to make ADAS as safe and as reliable as the average human. This will require billions of miles of road testing. This seemingly impossible task can only be accomplished with the help of engineering and adopting new testing models. With an evolved system testing practices, thousands of driving scenarios and design parameters can be virtually tested with precision, speed, and cost economy.



The multi-phase V-Model:

For continuous system testing we implement the V-model, which is also known as the verification and validation model. In the V-model, testing is done simultaneously with the development phase. There is a testing phase for each corresponding development phase.

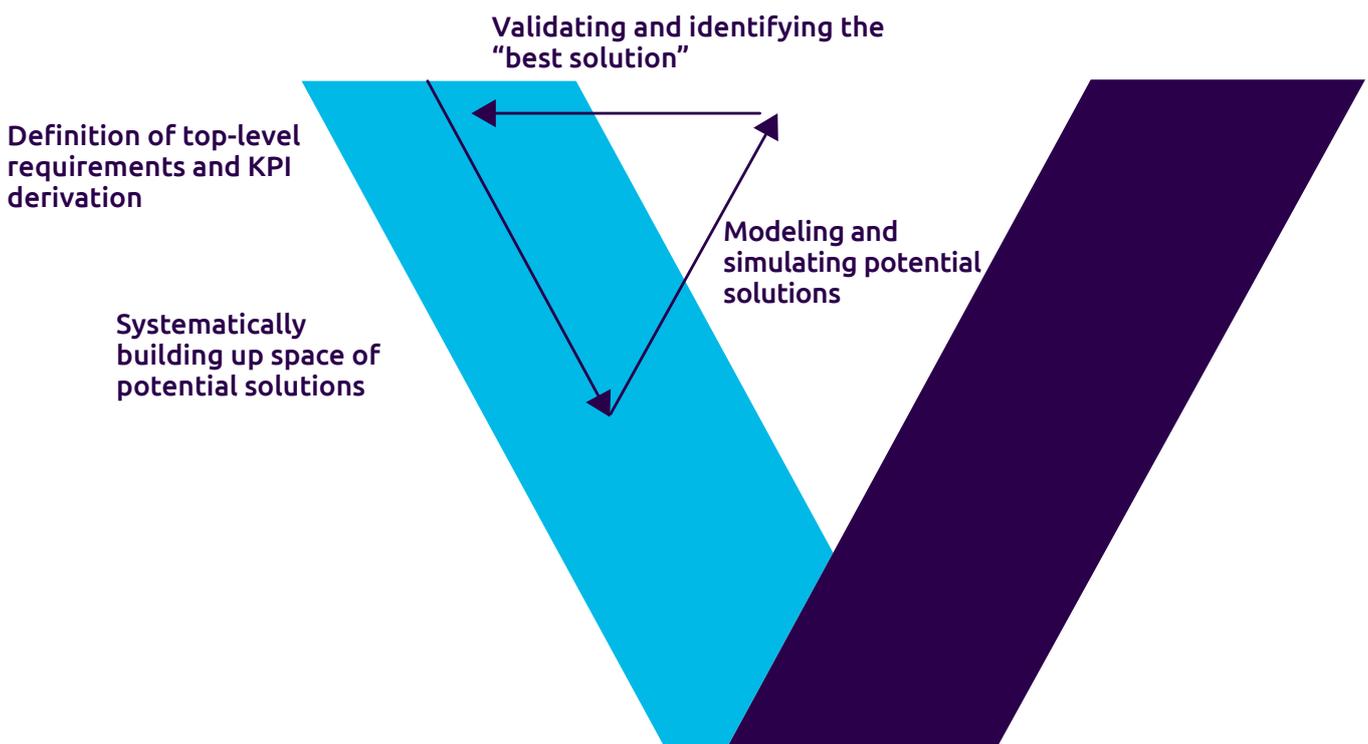
The multi-phase V-model as a modified version involves many iterative and continuous cycles within the V-model.

The recommended multi-phase V-model helps to:

- Stimulate and validate in the global virtual vehicle, similar to a gaming environment
- Move from traditional tool sets used for black-box testing to simulation environment testing.

The simulation environment includes test cases for functional, system, and integration testing. It is applied in early stages to understand the autonomous behavior in different scenarios and to verify decisions about architecture and design.

Continuous cycles within the V-model



Driver-Vehicle-Environment simulation

Simulation-based validation in a virtual environment is one of the preferred and most reliable methodologies to ensure thorough validation coverage of autonomous features. Through this technique, thousands of use cases and scenarios are created and modeled. This creates a virtual environment in which the performance of autonomous features, including safety, reliability, controllability, and response time can be validated. Millions of test cases are generated out of the library of use cases and tested in the virtual simulation environment. Also, we can make the scenarios more realistic by integrating maps and real-world traffic data into the system.

Driving simulators are widely used to analyze driver behavior and responses to various driving scenarios. It is necessary to have a modular software platform that can connect various driving simulators. The platform should also be capable of running as stand-alone simulation software on a single desktop PC.

A comprehensive strategy for autonomous driving simulation includes sensor measurements and simulation, vehicle simulation and modelling, 3D environment modelling, scenario testing, data management, and an open platform to integrate them all.

In addition to the real-time simulations, this platform can also be used for prototype evaluation of driver models in accelerated time. This feature is useful to cover various test cases, including different environment settings and driver behavior.

Driver-vehicle-environment simulation platform



Sensor fusion testing for ADAS

Sensor fusion is blend of data from different sensors to gain a clearer view of the surrounding environment. This is a necessary condition to achieve reliable safety and effective autonomous driving. As multiple sensors come together to provide a better view of the environment around the vehicle, the critical element in making sensor fusion successful is synchronization, which ensures that different sensors are measuring parameters at the same time.

For validation of such a complex system, it is necessary to set up an appropriate test environment to verify the behavior of vehicle systems under similar conditions as the real ones. Product companies are building test systems to perform a “sensor fusion test” in a virtual environment. There is a unique approach of radar characterization and testing with its scalable system to conduct both RF measurements and system simulation. The combination of ADAS sensor fusion with a HIL (Hardware-In-the-Loop) test system is necessary to enable a new level of innovative and automated test solutions. With the help of HIL, individual parts of a holistic system can be simulated and tested in real-time in a virtual environment.

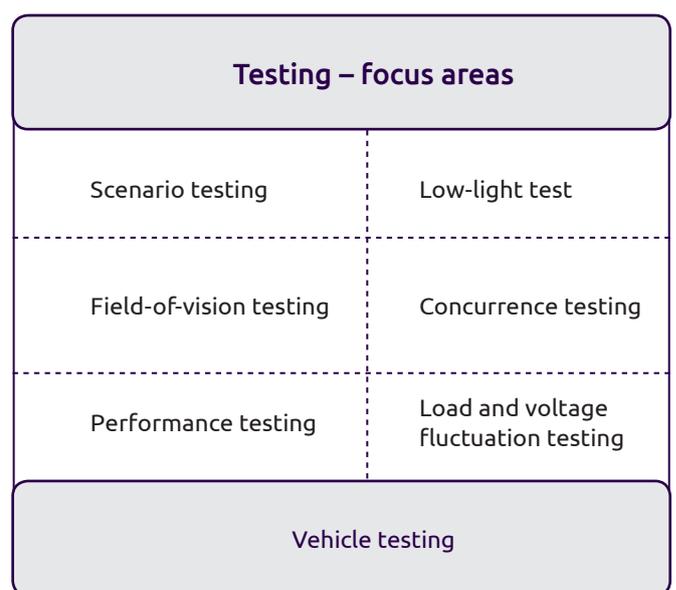
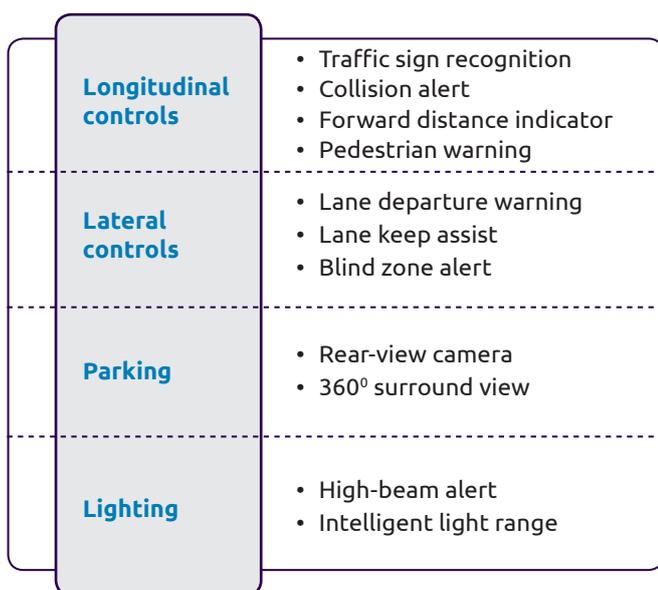
Test engineers need to use the right combination of different sensors to validate sensor fusion across multiple scenarios, for example, to check the effect of temperature and environmental conditions on the sensor, or to simulate reflections and shadows from engine.

Test strategy

Autonomous vehicles will have to be driven hundreds of millions of miles to demonstrate their reliability. As per industry standards, the percentage of effort required for verification and validation coverage ranges between 45-55%, depending on criticality levels. There are numerous reported numbers for the drive cycle or mileage accumulation to test and validate ADAS systems in the range of 10⁴ to 10⁷km.

It is essential to leverage the strength of simulated environment testing to augment physical road testing. The simulated environments with real-world features for Model-In-the-Loop (MIL), Software-In-the-Loop (SIL), Processor-In-the-Loop (PIL), Hardware-In-the-Loop (HIL), Driver-In-the-Loop (DIL), and Vehicle-Hardware-In-the-Loop (VeHIL) validation. This new verified virtual techniques need to be part of systems development lifecycle.

ADAS features and test focus areas

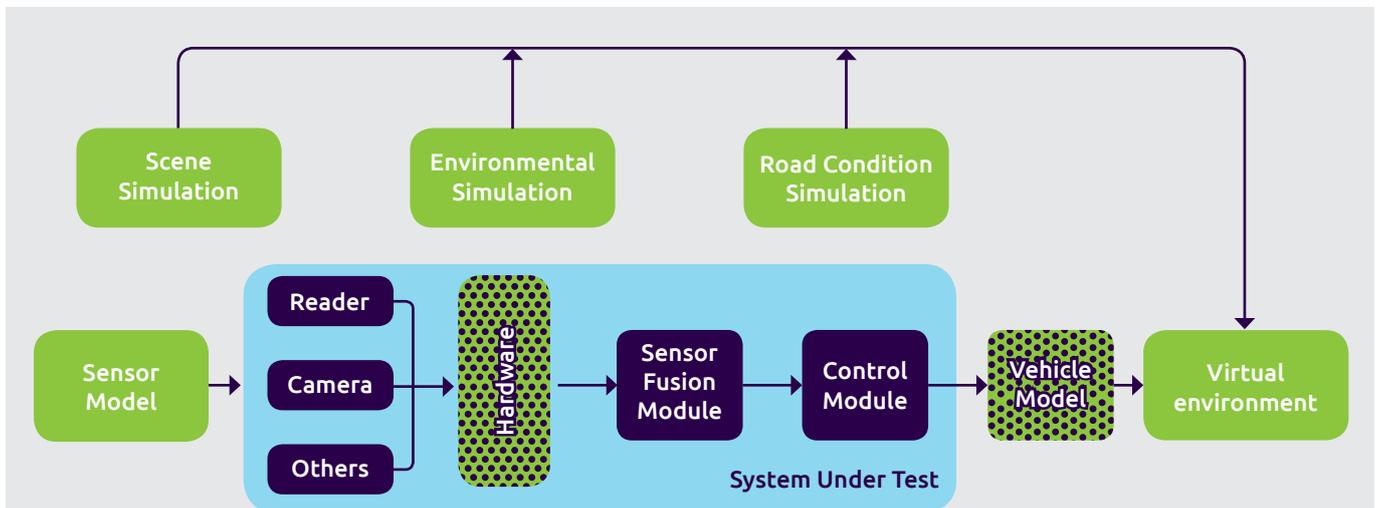


Test setup and automation

With an all-inclusive solution of sensor fusion testing on a single platform, one can move all safety-critical systems from the road to the lab. One recent example of an HIL test system using the platform-based approach to sensor fusion testing was demonstrated by a consortium called ADAS IIT - Innovations in Test.

This group is a collaboration between NI alliance partners S.E.T., Konrad Technologies, measX, and S.E.A. The group demonstrated an ADAS test setup that can synchronously simulate radar, lidar, V2X communications, and camera signals for an ADAS sensor. The setup was able to simulate a virtual test drive using IPG CarMaker and NI VeriStand software.

Example of HIL test system using the platform-based approach to sensor fusion testing



■ Model (Virtual) ■ Physical



Moving ahead with Verification and Validation for ADAS

It is a challenge for the automotive industry to ensure zero incidences of malfunctioning during autonomous drives and to make self-driving vehicles mainstream. Achieving acceptable levels of safety and reliability will need substantial verification and validation activity. To make the journey towards autonomous driving successful, verification and validation is one of the most important factors to be worked on.

Today, the key challenge is the paradigm shift of the skills needed in test engineers. There is a need to move from traditional tool sets used for black box testing to simulation environment testing and next generation of testing techniques. It is important to continuously improve the accuracy of models and extrapolating it in a more realized way.

It is important to continuously improve the accuracy of models and extrapolating it in a more realized way. To achieve accuracy in virtual simulation testing companies should invest heavily in:

- Research and development of technology nuggets - algorithms, AUTOSAR integration framework, validation framework
- Partnership with hardware manufacturers, sensor manufacturers, semiconductor vendors, and platform providers
- Adoption of new digital technologies such as AI and machine learning across the Verification and Validation phases.

Conclusion

Extensive verification and validation before the actual launch can assure performance of autonomous vehicles on the road. For approximately 60% of the development time there is no real prototype available for testing. Hence it is difficult to achieve early-stage vehicle evaluation and validation.

To meet the challenges of increasingly complex use cases and scenarios there must be an ongoing development of controlled environments. Physical testing will continue to be critical but OEMs will have to limit the dependency on physical testing. Hence, new methodologies for verification and validation using virtual techniques in early phases of development are necessary. This will also reduce cost, risk, and time to market. To achieve this, a simulation-based validation in a virtual environment is one of the best and most reliable methodologies available.

A good driver experience with an autonomous vehicle at first launch is very important and the automotive industry should not shy away from investing in the enabling technologies and ecosystems.





About Capgemini

A global leader in consulting, technology services and digital transformation, Capgemini is at the forefront of innovation to address the entire breadth of clients' opportunities in the evolving world of cloud, digital and platforms. Building on its strong 50-year heritage and deep industry-specific expertise, Capgemini enables organizations to realize their business ambitions through an array of services from strategy to operations. Capgemini is driven by the conviction that the business value of technology comes from and through people. It is a multicultural company of over 200,000 team members in more than 40 countries. The Group reported 2018 global revenues of EUR 13.2 billion.

Learn more about us at

www.capgemini.com

About Capgemini's Digital Engineering and Manufacturing Services

Capgemini's Digital Engineering and Manufacturing Services brings together deep domain expertise to lead the convergence of Physical and Digital worlds through technology, engineering and manufacturing expertise to boost our clients' competitiveness. A recognized leader with over 10,000 engineers across the globe and 30+ years of experience, Capgemini's comprehensive portfolio of end-to-end solutions enables global companies to unlock the true potential of their product portfolios and manufacturing efficiencies.

To know more please contact:

marketing.dems.global@capgemini.com

People matter, results count.

The information contained in this document is proprietary. ©2019 Capgemini.
All rights reserved.