

# ADAS and Autonomous Vehicle Development

**Requires Engineering Solutions that Foster Trust**

**19 October 2023**

## Key Takeaways

- Successful adoption of ADAS and AV requires trust—trust by consumers and trust in the tools and solutions used by engineers to design, develop, and validate the vehicles.
- As ADAS / AV engineers explore operational scenarios based on experience and fundamental physical knowledge—electrical, mechanical, chemical, thermal, optical, human-machine interface—and more comprehensive scenarios, trust grows.
- Techniques like SOTIF (Safety Of The Intended Function) improve robustness insights by exposing design weaknesses with expansive simulations orchestrated by virtualized scenarios.
- Only a well-integrated design and simulation toolset managing expanding scenarios can sustain an AV / ADAS automaker for tomorrow—one that starts Integrated and stays Integrated and remains connected across all disciplines as scenarios are continuously evaluated.
- Siemens Digital Industries Software (Siemens) solutions enable collaborating, improving decision-making across the lifecycle, and keeping the right information available all the time.

## Introduction

Advanced Driver Assistance Systems (ADAS), from automated lane correction to acceleration / deceleration during cruise control, are now commonplace. More advanced features like collision avoidance with proactive steering control are emerging in most automobiles. Automakers will continue to add features which improve safety and automation for the consumer. The convergence of affordable sensors proliferation, increasing onboarding computing capacity, and advanced electrical propulsion and control systems is hastening the pace of ADAS feature development and deployment.<sup>1</sup>

Autonomous vehicles (AVs) require even more sensing, data management, and new ways of engineering to foster consumer trust. As autonomous vehicles remove human control of the vehicle, computer-based decision systems must be as good, or even better, than a human operator. This is the inherent safety a human operator brings—their driving experiences in all types of conditions, from traffic, to weather, to malfunction of traffic and vehicle systems. Humans can quickly judge and apply their learnings to operate the vehicle safely. As AVs come to market, the automated judgement and application of experiences must be trustworthy for mass market adoption. Having a comprehensive set of tests, user scenarios if you will, based on extensive simulations is essential.

Embedded software and associated electronics are often developed using agile, continuous release processes which are fundamentally different from expensive (i.e., capital investment) hardware driven mass production release processes. These differences demand a continuous verification and validation process that software developers have refined with agile practices. A new or refined requirement might be addressed with field upgradable software. But the need for thorough testing remains.

Competition is increasing in the automotive industry as the fundamentals of transportation are moving toward electrified propulsion with more capable position and obstacle detection leading to higher levels of autonomy. As new markets develop and consumers change their preferences, time to market for new products and feature upgrades becomes the battleground for all automakers—established and start-ups.

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<sup>1</sup> Research for this paper was partially supported by Siemens Digital Industries Software

Innovative AV and ADAS development continue with more customers making product choices based on these automation features. A few metropolitan areas are developing frameworks and platforms in which autonomous vehicles operate within a city and take advantage of traffic monitoring and broader position, motion, and obstacle sensing. Challenges remain to engineer successful AVs, requiring engineering solutions that improve product trustworthiness. Co-operative sensing and integration of features across vehicles and cities is needed. AV and ADAS engineering were summarized and discussed in a July 2021 CIMdata eBook, *Autonomous Vehicle Development Requires Closed Loop Solutions*,<sup>2</sup> including the expansion of scope beyond a single vehicle.



Recently, Siemens published an AV eBook<sup>3</sup> that explains the challenges automakers continue to encounter as ADAS features expand and the AV operational uncertainties are realized. Siemens understands these challenges and is developing capabilities based on the ADAS and AV narratives summarized in this white paper.



CIMdata summarizes accelerated product development driven by electrification as:

*"Embedded computers and attached optical, radar, and environment sensors expand and improve measurements during operation and bring insights to automakers previously only obtained from prototype testing. Merging findings from customer usage with validation results before initiating mass production provides product usage insights which will lead to upgrades. These upgrades can occur anywhere at any time."*<sup>4</sup>

Electrification is making ADAS features not just possible while accelerating their introduction into the marketplace. Understanding the operational scenarios and even expanding scenarios to comprehend performance domains not yet measured will improve trust in vehicle designs as engineers evolve ADAS features.

Siemens has identified narratives which build on the recommendation that automakers must adopt a system of systems design approach, including integrated requirements, continual system evaluation, and closed-loop, multi-level verification and validation. CIMdata agrees with this focus and will examine these new narratives in this whitepaper.

**System of systems development practices will foster future development of autonomous vehicles**

By bringing design and empirical data together, trust in the resulting product develops faster. Moving a learning development cycle from use of physical prototypes to virtual engineering allows discovery in

<sup>2</sup>CIMdata eBook. *Autonomous Vehicle Development Requires Closed Loop Solutions*. July 2021. Available via login at: <https://www.cimdata.com/en/resources/complimentary-reports-research/white-papers>

<sup>3</sup> See Siemens eBook: *Autonomous Vehicle and ADAS Development* at: <https://www.plm.automation.siemens.com/global/en/industries/automotive-transportation/autonomous-vehicles.html>

<sup>4</sup>See CIMdata White paper: *Accelerating Product Development*. March 2022. Available via login at: <https://www.cimdata.com/en/resources/complimentary-reports-research/white-papers>

days instead of months. With advances in digital twins and economical computer-based simulation, testing cycles can become continuous. This allows ADAS features to be evaluated every day, instead of waiting for physical prototypes to be built and then used in road trips for product evaluations. Laboratory testing with physical samples and managed scenarios improves the issues discovery and resolution process. Keeping laboratory procedures and scenarios in synch with simulation procedures allows the exploration of un-measured, but logically likely scenarios. The management and discovery of scenarios used to analyze features in the context of the product operation are essential.

## Siemens Solutions Focus on Data

Siemens has defined a data-centric view which is the foundation of their refined narratives speeding ADAS features and AV products (see Figure 1). Data, from product information to usage insights, must be considered together as decisions are made. Some usage and durability insights occur after a product is mass-produced and they will drive product upgrades, especially when a new feature is delivered via an over-the-air software upgrade. These product features must be tested and validated with the same rigor as was done for a mass production certification.

**Data improves safety, comfort, and efficiency**

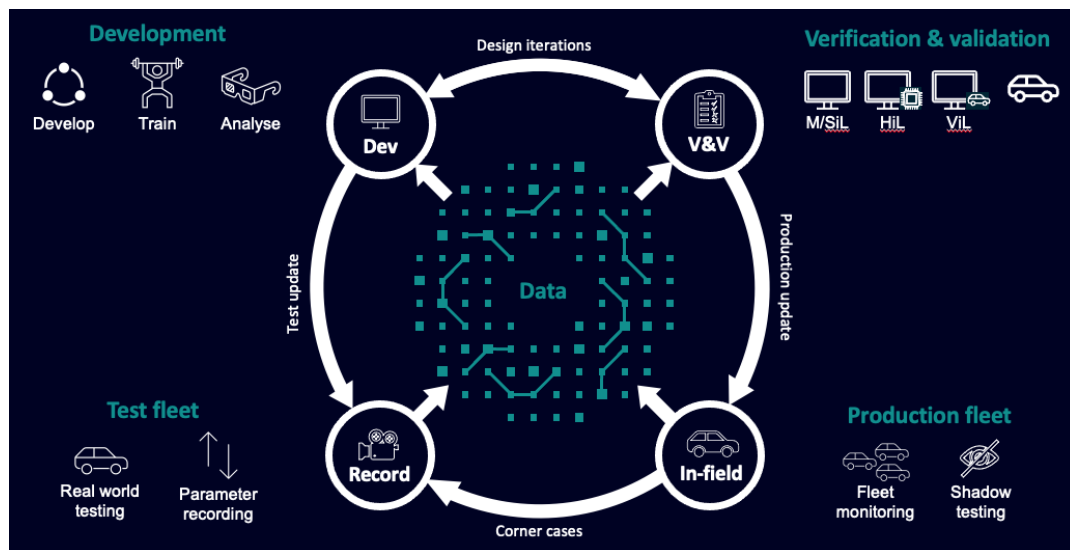


Figure 1—Data Enabling Safety, Efficiency, and Comfort  
(Courtesy of Siemens)

The following sections examine each narrative that is driving Siemens solutions to assist in enabling tomorrow's ADAS features and AVs:

- Frontload Vehicle and Systems Design to Maximize ADAS Features
- Continuously Optimize System Behavior
- Continuous Verification and Validation

All three narratives take advantage of data from across the lifecycle, well beyond historic product development. This closed-loop use of lifecycle data is innovative and needed as ADAS features and AV products grow in complexity while assuring safe transportation.

## Frontload Vehicle and Systems Design to Maximize ADAS Features

Especially for ADAS and AV, comprehending embedded software considerations upfront at conceptual modeling is critical. Understanding the needs, agreeing to needs as requirements, and assigning requirements to subsystems implemented by different engineering disciplines requires having a comprehensive system analysis of the problem space. Concept exploration including embedded software allows better educated trade-offs when making implementation decisions for the most effective and scalable solution. Consideration of human factors, economic factors and environmental factors upfront can also bring a sustainability view during development of ADAS features that not only deliver safety but also efficiency (e.g., start-stop where engine automatically shuts down at traffic lights).

**Frontloaded virtual development of products is faster**



**Figure 2—Frontloading Design by Exploring Motion**  
(Courtesy of Siemens)

Frontloading vehicle and systems design requires solutions that allow the team of experts from every needed discipline to see what will happen based on a proposed feature in the operational context. No longer will they wait for an evaluation ride with prototype vehicles. Rather, repeatable laboratory procedures will drive evaluations. As simulation techniques become less and less expensive, both in time and cost, they can replace some physical laboratory and road testing. Augmenting this simulation data and presenting the performance insights earlier in product decision cycles, hastens new feature introduction.

Imagine for a moment the decision improvements that occur when motion is considered during design. Visualization with moving parts and subsystems improves engineering understanding, which then contributes to better product decisions. Better product decisions lead to improved product trustworthiness. Of course, more complicated physical interactions, including approaching unexpected

obstacles while moving, make frontloading even more essential. All this must be managed with traceability compliance to regulations.

## Continuously Optimize System Behavior

The speed of traversing the path from measurement to insight then decision, see Figure 1, is faster when using computer-based simulations and tests. The next challenge is managing the evolution of scenarios, both measured and formulated, and then using them to evaluate design choices.

Understanding how to address changing requirements, whether consumer-driven or regulatory, is faster and easier using computer-based design and simulation solutions. Software-based ADAS features, from data collection and analysis using machine learning inside the product to improved controls based on actual usage patterns, provide a new opportunity to optimize the vehicle while in the hands of consumers.

Automaker leaders have done this for some features to improve mechanical durability of rotating parts, but adding new features that could generate new revenue streams, because trust is improved, is a new frontier. Trust must be earned and maintained, and this is possible with a virtual engineering ecosystem that allows for exploring system options and weaknesses in the context of usage patterns.

**Scenario management, both learned and projected, must be applied when optimizing performance**



**Figure 3—Scenarios Expand beyond Single Vehicles**  
(Courtesy of Siemens)

Figure 3 shows multiple vehicles, one changing lanes, one accelerating, and one braking. A few seconds earlier, the actions being taken by each vehicle were different. By evaluating a proposed steering/braking control system upgrade in the context of this time-elapsing scenario, in a controlled test (virtual in this case), an engineer can decide more quickly what are the key parameters of the proposed vehicle control feature upgrade. And if it is done with existing mechanical subsystems, including sensors and actuators, then it can be delivered as billable improvement with an over-the-air electronics program update enabling lifetime product upgrades.

The scenarios needed require several activities to provide reuse and automation, including scenario definition, scenario use by simulation and testing, scenario variability driven by real-world testing, scenario prioritization, scenario updates, regulatory compliance, human-in-the-loop testing, and feedback driving scenario learning. CIMdata will explore these topics in a future commentary on continuously optimized system behavior.

## Continuous Verification and Validation

Mastering systems thinking, traceability, and continuous verification and validation is critical across the lifecycle, including operational use, for the success of future ADAS and AV engineering. Being able to explore choices and decide faster requires a continuous verification and validation ecosystem that bridges disciplines and eases process evolution using all data sources, especially those originating with product's use as soon as it is recorded.

Continuous verification and validation (V&V) of Advanced Driver Assistance Systems (ADAS) and Autonomous Vehicles (AVs) is a critical process to ensure the ongoing safety and performance of these systems throughout their operational lifecycle. It involves a systematic approach to continuously assess, test, and validate the functionality and safety of ADAS and AV systems as they evolve, adapt to new conditions, and receive updates. Here are key aspects

**Scenario management includes varying environmental conditions to assess sensor reliability**

of continuous verification and validation for ADAS and AV systems: data collection and monitoring, scenario-based evaluations, software and algorithm validation, dynamic updating, regulatory compliance, machine learning and AI model validation, user feedback and incident analyses, redundancy and fail-safe mechanisms, all with appropriate documentation and reporting. A future CIMdata commentary will describe these aspects in more detail.



**Figure 4—Environmental Variation Can Be Simulated**  
(Courtesy of Siemens)

Consider the effects on sensor reliability to accurately view conditions when fog or limited daylight is present, as shown in Figure 4. What worked well in ideal conditions will not work as well in these varying conditions. V&V will use these broader environmental boundary conditions as variations when judging the completeness of a product with ADAS features. Under extreme conditions the system may require human driver intervention. The transitions from automated to semi-automated to manual driving is

another set of scenarios to be continuously evaluated as the operational algorithms are engineered and exercised.

This is even more of a challenge for AV operations—the product must work safely in all environments in which it is used. Assessing AVs based on knowledge gained from increasing use will provide customers with the most trustworthy transportation experience. In other words, validation continues to be refined as the product is used. Fortunately, computing is affordable for the execution and evaluation of test suites driven by scenarios that comprehend and simulate these actual experiences.

Simulations correlated with laboratory and field measurements provide reliable insights leading to better products. Faster product upgrades can and will be based on direct customer feedback and their measured experiences. Validation scenarios improve when trained by the latest real-time measurement data and this can be done continuously as the design changes, making continuous validation practical. Exploring safety margins with a correlated digital twin is possible—see Siemens' executable Digital Twin (xDT) technology, another capability making continuous V&V possible.<sup>5</sup>

Continuous V&V is a fundamental part of the development and deployment process for ADAS and AV systems. It helps identify and rectify issues promptly, enhances system robustness, and builds confidence in the safety and reliability of these technologies, which are essential for their acceptance by both users and regulatory authorities.

## Conclusion

Fast-paced ADAS and AV features development and optimization are key to success. Keeping and building trust with customers is crucial. Siemens is developing a growing set of capabilities for data capture, scenario-based analysis, critical scenario creation,<sup>6</sup> algorithm development, sensor and vehicle integration, and seamless system optimization. This in turn enables frontloading the engineering of AV/ADAS features, continuous system behavior optimization, and continuous verification and validation of compliance and performance.

**ADAS features and AV development will use more virtual engineering with scenarios driving evaluations**

Siemens' focus on the narratives, shown in sky blue in Figure 5, can improve many development tasks of ADAS and AV development and operations—from data capture to scenario analysis to algorithm development to sensor integration to system optimization all confirmed by continuous V&V—shown in yellow in Figure 5. A closed-loop view through all phases of the ADAS and AV product lifecycle—from design to manufacturing and including customer use—is crucial. Advances in computing make continuous verification and validation affordable while comprehending new scenarios derived from customer usage.

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<sup>5</sup> CIMdata highlight. Siemens: Making the Digital Twin Executable - Predictively Aligning Its Real-World Counterpart. Available at: <https://www.cimdata.com/en/resources/complimentary-reports-research/commentaries/item/16725-siemens-making-the-digital-twin-executable-predictively-aligning-its-real-world-counterpart-highlight>

<sup>6</sup> Critical Scenario Creation – methodology to identify and create unknown, unsafe scenarios for improving product robustness - Patent Registration Number WO 2022/179759 A1

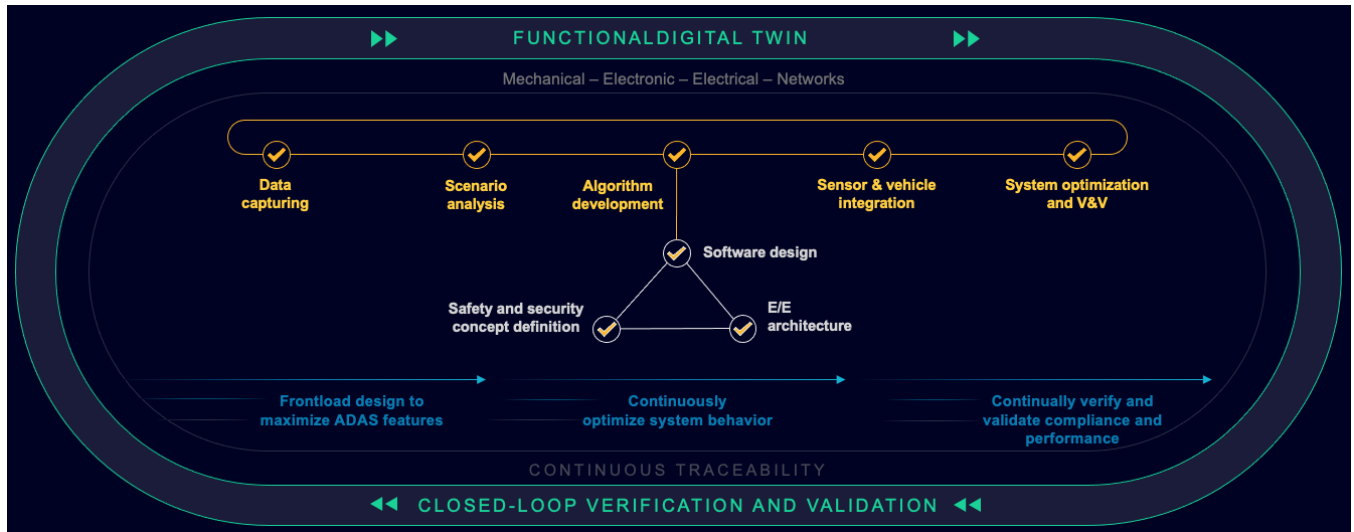


Figure 5—Yellow Tasks Simultaneously Done During ADAS & AV Development  
(Courtesy of Siemens)

CIMdata believes these narratives will encourage ADAS features and AV product development in new ways<sup>7</sup>expanding virtual engineering and evolving development practices. When combined with the ADAS/AV scenarios management, virtual engineering broadens and grows trust—the trust needed for a completely autonomous transportation future.

## About CIMdata

CIMdata, a global strategic management consulting firm, provides services designed to maximize an enterprise's ability to design, deliver, and support innovative products and services. For more than forty years, CIMdata has provided industrial organizations, providers of digital technologies and services, and investment firms with world-class insight, expertise, and best-practice methods on a broad set of product lifecycle management (PLM) topics and the digital transformation they enable. CIMdata also offers research, subscription services, publications, and education through certificate programs and international conferences. To learn more, visit [www.CIMdata.com](http://www.CIMdata.com) or email [info@CIMdata.com](mailto:info@CIMdata.com).

<sup>7</sup>See CIMdata White paper: Accelerating Product Development. March 2022. Available via login at: <https://www.cimdata.com/en/resources/complimentary-reports-research/white-papers>