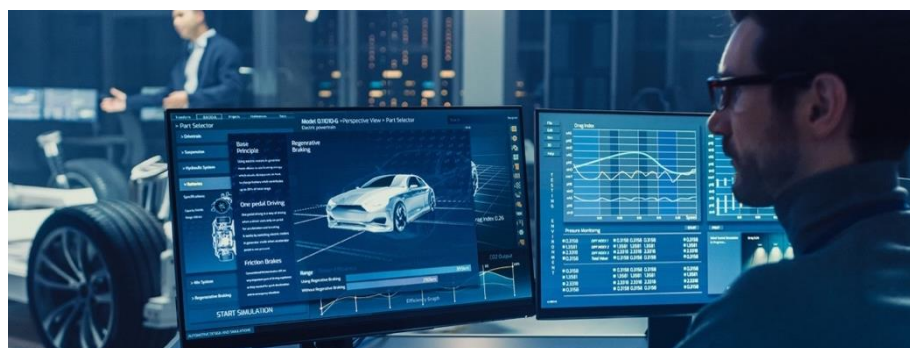


Create the trust your customers need

Develop safe transport solutions
that protect human lives with
Autonomous Vehicle Development.

The growth of the autonomous vehicle market is forecast to be worth \$7T of new economic activity by 2050. With changing consumer demands, advances in technology and intensifying competition, automotive original equipment manufacturers (OEMs), which have been built on more than 100 years of engineering expertise in traditional car making, are now forced to scrap the ways they've developed cars for completely new and untested methods.



Consumer demands drive competition

As consumers become more aware of and enjoy the benefits of advanced driver assistance systems (ADAS) and autonomous vehicles (AV), demand grows. AV manufacturers are competing with current and new entrants to the market such as technology companies like Amazon, Google and Apple, start-ups and foreign governments that are now front and center for the future of transportation. From features such as lane assist and automated parking to fully autonomous driving, the demands placed on vehicle manufacturers for a safe, reliable, connected and secure mode of transportation is now a requirement for new vehicles.

Today's ecosystem of OEMs and tier suppliers are using linear engineering toolchains to build automated driving functions. These homegrown systems take a siloed approach to ADAS and AV development, using individual toolsets and environments to develop and test vehicles.

Traditionally the automotive verification programs for ADAS systems have been driven largely by regulatory requirements. New Car Assessment Programs (NCAP) for example contributed greatly to setting the norms for testing autonomous emergency braking systems. With the development of AVs, higher levels of automation are required, driving the need for new approaches to verify ADAS and autonomous driving systems. Currently this process consists of driving thousands of miles while encountering and capturing numerous occurrences with the aim to optimize the automated driving system. In addition, multiple initiatives are published to create shared scenario databases for testing ADAS and autonomous vehicles. The automotive industry has great interest in these shared databases and supports global standardization of the format, which eventually will help with limiting liability cases.

Centralized architecture and partnerships are key

The traditional vehicle architecture is under pressure. In the race to develop new ADAS and AV systems and with new technology players entering the market, software, chips and electronics have become the heart of the vehicle, replacing the traditional role of combustion engine and chassis. With this new vehicle architecture an integration of individual systems is required, such as the braking and steering systems, but also the different sensor and control systems, which have increased complexity. The inability to deal with this complexity will potentially result in losing the race in the development of AVs.

Most of the standard engineering processes in the automotive community are not well suited for new levels of interoperability because they rely on a strict separation of interests between the OEM and the system suppliers. The siloed approach, the communication cascade of information and uniting domains together to deliver vehicle results becomes a challenge at all levels, from the tools and skills of the engineers, to the difficulty of communication across teams and between OEM and supplier, as well as the communication protocols within the vehicle.

While OEMs are pushing the limits to develop higher levels of driving automation, the AV systems need to be tested, optimized and validated as well. Although current efforts cover basic scenarios, driving thousands of miles in the real-world and leveraging shared scenario databases, the number of variants necessary to validate autonomous driving systems is infinite. Through these traditional methodologies the number of critical use cases necessary to sign off these systems and determine they are safe and robust enough to go to market will not be reached.

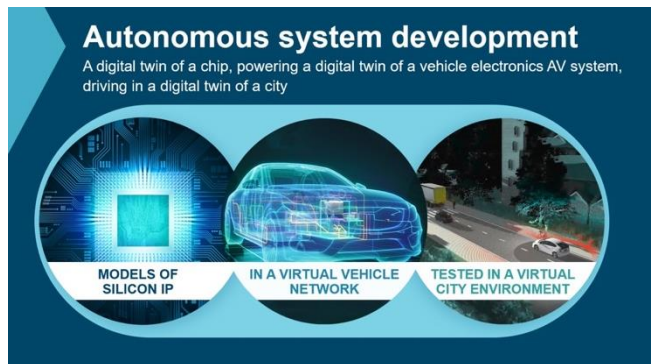


Consumers become more aware of and enjoy the benefits of advanced driver assistance systems and autonomous vehicles.

From chip to city

Delivering on the demands of consumers requires a comprehensive, modern solution that enables OEMs and suppliers to not only continue focusing on the core aspects of vehicle development they have pioneered and mastered, but also to branch out and utilize advanced methods for simulating their vehicle programs across domains to deliver safe, reliable and secure AVs.

OEMs and suppliers must transition to data-driven validation and verification programs for AV systems development: a comprehensive digital twin that provides a mirror image of the AV system on the level of the chip, electronics, vehicle and city infrastructure (from chip to city). The transition requires an integrated solution of simulation, test and engineering services.



Using performance data to drive decisions

Performance information can be fed back at multiple levels into the development process to optimize the behavior or dynamics of the vehicle. The data can also be fed back to modify the system's designs on a continual basis. This closed-loop approach drives physics-based data back into the design process, which leads to faster, more optimal and efficient system design that can have an impact on functional performance.

As an example, an automotive company using the digital twin to verify a lane departure warning system in a simulation environment can reduce a significant amount of time on road testing. When accurate and realistic lane markers including wear and tear are incorporated in the simulation, results of the simulated scenarios will match the outcome of testing in real life, ultimately optimizing the vehicle's sensor system design.

Setting up partnerships for higher levels of integration

It is no longer feasible to write a specification for an automatic emergency braking (AEB) system and request quotations from multiple suppliers and then integrate the system with an adaptive cruise control (ACC) and a parking system from other suppliers. OEMs and suppliers need an integral approach and a more centralized architecture, exchanging architecture information and simulation models. Suppliers

and OEMs must set up tight partnerships to achieve higher levels of integration, making the development process more efficient.



Massive scenario simulation for AV systems validation

Massive virtual simulation is required to develop, test and validate autonomous driving systems. Existing scenario formats allow for leveraging numerous use cases that algorithms will encounter during their operational lifetime. It is only through massive simulation using a comprehensive digital twin of the AV systems on the level of the chip, electronics, vehicle, and city infrastructure. Numerous variations of use cases can be generated (weather conditions, road friction levels, traffic characteristics, speeds, directions, etc.), eventually leading to the creation of critical scenarios or corner cases. This model-based approach, using artificial intelligence (AI) techniques, helps to generate and identify these corner cases that are used to train and optimize the AV system by identifying system failures. With simulation this can be achieved early in the design process, accelerating the systems design significantly. Most importantly, simulations affect the safety and comfort of the vehicle's occupants and other road users.

Find confidence that your autonomous vehicle will perform safely and reliably

Autonomous vehicles represent a huge challenge and opportunity for the industry as consumer demand and disruptive innovations continue to increase. To take the lead in the development of autonomous vehicles, an integrated solution of simulation, testing, virtual validation and engineering services is required, supporting a closed-loop development process, all brought together in a comprehensive digital twin. In this pursuit, partnerships will be key to leveraging advanced methods for simulating vehicle programs while delivering safe, comfortable and reliable autonomous vehicles.