AUTOMOTIVE JOURNAL

ni.com

Q4 + 2020

Flexible Test to Meet the Challenges of Change

Change is abundant throughout the automotive industry. As technology convergence continues to expand the horizon of possibilities, we must ensure consumer trust increases along with the rate of technological development. For example, autonomous vehicles will only be as successful as the level of trust between the consumer and the vehicle, or even the manufacturer. Consumer trust will be a differentiator, and we view test as the key route to deliver on that differentiation and assist you in achieving your aspirations for autonomous mobility. We will help you transform test into a strategic advantage.

The critical choice is to embrace the change and understand that the amount and pace of change are steadily increasing. The pace of change requires designing flexibility into the product development process so that you can modify test at the same rate. Do you feel confident that your test strategy can keep pace with the imminent changes from regulation, regionalization, and evolving consumer expectations?

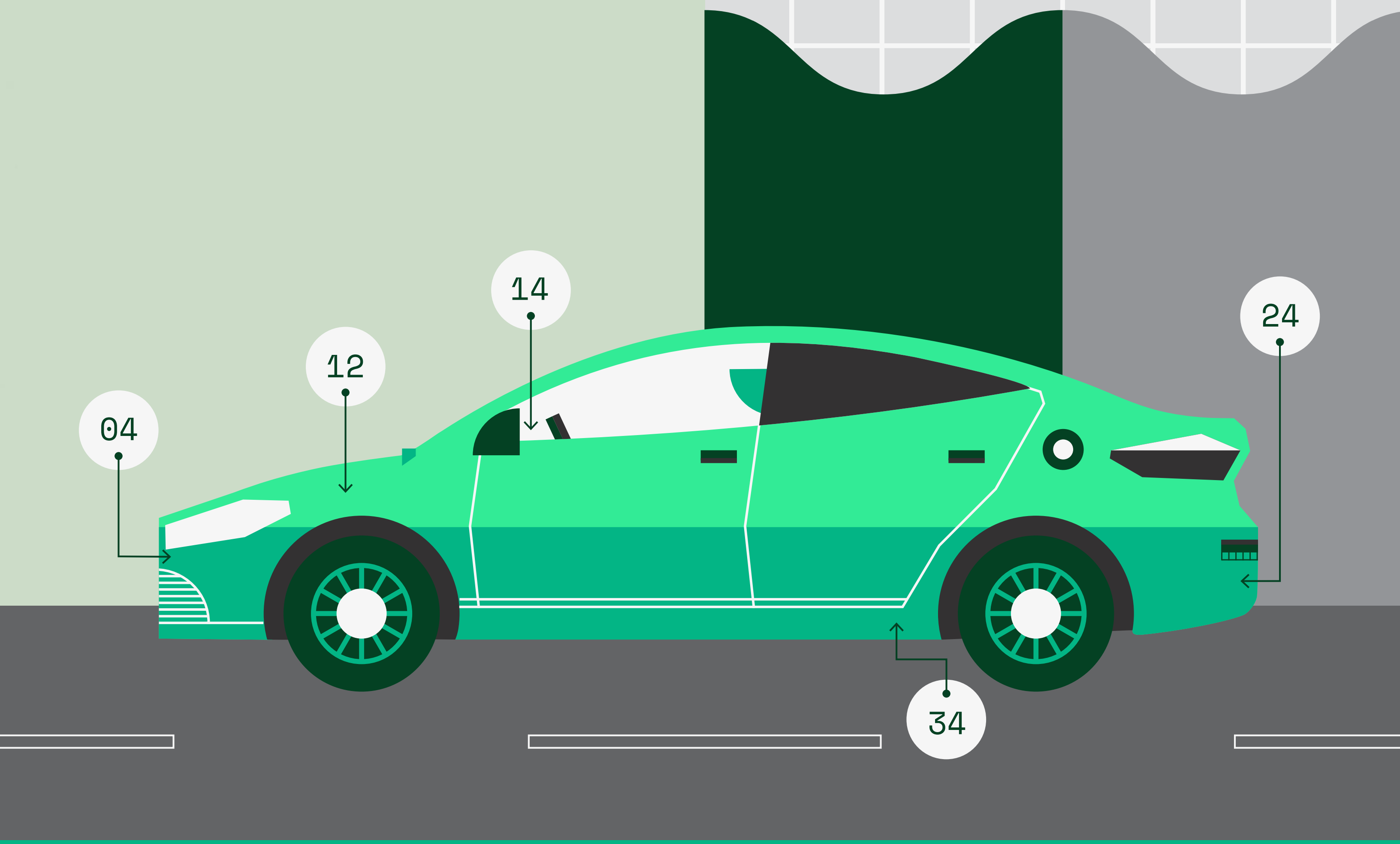
Let's get there together.

CHAD CHESNEY

VICE PRESIDENT AND GENERAL MANAGER,
TRANSPORTATION BUSINESS, NI

ni.com

National Instruments is now NI.



How Do We Win the Race to Autonomy?

If you're an automotive engineer working on autonomous vehicles, you probably saw your first self-driving car in a movie or TV show. You may remember it being powered by technology within the vehicle itself or by magic. Today, we know that when they become a reality, autonomous vehicles will be powered by technology everywhere from 5G-enabled infrastructure to cloud services, high-technology sensors and even other vehicles sharing the road.

Automotive engineers have historically focused on equipping the car with better technology to improve safety and comfort. But now the expectations are higher, and engineers need to advance every aspect of autonomy and do it in lockstep: telematics, perception, decision-making, and communications. Of course, the convergence of these aspects within the autonomous vehicle requires thorough test of individual components, such as sensors and ECUs, as well as integrated systems within the vehicle that combine these components together.

ENGINEERS CAN RELIABLY TEST THE INDIVIDUAL TECHNOLOGIES THAT MAKE A CAR AUTONOMOUS, BUT COMBINING THOSE TECHNOLOGIES IN A CAR RENDERS THE TEST PROCESS UNPREDICTABLE AS THE NUMBER OF VARIABLES AND THEIR RELATIONSHIPS INCREASES TOWARD INFINITY.

There is no shortcut to reliable autonomous vehicle technology because a system failure can lead to a person dying. It requires thorough, excruciating, comprehensive, end-to-end testing. At NI, we believe only end-to-end testing enables automotive engineers to truly understand the complexity of the testing challenge. It empowers them to turn every test step into actionable insight for the next step, extensively reuse test throughout development, and build on the knowledge that will make autonomous vehicles a reality. Understanding the complexity means not only recognizing it but also embracing it from end to end, from component- to system-level test, from design to production, from simulation to real world. Automotive engineers can accomplish that with a three-step approach.

01 Begin with the end in mind

Assume the end is clear: reliable autonomous vehicle technology, what it looks like, and its criticality to test. The goal of autonomy reveals challenges ranging from outdated organizational structures to the state of technology to the reality that autonomy is a race to be first to market that companies want to win. Each automotive company believes its decision-making will give it the advantage in the autonomy race. Joint ventures like Motional, from Hyundai and Aptiv, or spinoffs of specific business units allow for restructuring to focus on certain aspects of the race to autonomy. Each automotive company decides how it uses its new focus to win the race, and, more and more, these companies are counting on test to propel them past their competitors.

In "Model-Based Design and Test: This Is the Way," an article from the Q2 2020 issue of the *Automotive Journal*, we stated how the goal of test is to gain the knowledge engineers need to make decisions on the next steps for development, production, and deployment.

With this in mind, consider the end-to-end test process as a single chain of steps that starts with the conception of the idea itself and ends after the car is put on the road. For this approach, here's a general example:

ENGINEERS...	TO...
Test mathematical models in pure simulation environments	make data-driven decisions
Test these models in software implementations with simulated inputs	make data-driven decisions
Test this software in hardware implementations with simulated and then recorded inputs	make data-driven decisions
Test this hardware with simulated, recorded, replayed, faulty, and standardized inputs	make data-driven decisions
Complete these steps for hardware components and combine them to test at the system level	make data-driven decisions

Sounds repetitive? Well, we do it millions of times. We "drive" billions of miles (Table 1) with the devices we're testing to capture data to make decisions.

Engineers implement this "driving" using many different tools for simulation, recording, replay, hardware-in-the-loop test, functional test, integration test, analytics, machine learning training, data center management, and so on. A single tool can't cover all these types of test and data management, so the test challenge intensifies with the data correlation and tool integration inconsistencies inherent in this fragmented approach. To begin with the end in mind, the test process needs to be seen through an end-to-end lens.

02 Make the connection

End-to-end testing as described above is a challenge that not one single tool can meet. The solution lies in the company's ability to connect all stages, from establishing its test requirements and assessing the effectiveness of its statistics, models, and simulations to collecting its test data, analyzing and tracking its results, and making decisions based on those results. This connection must start with the requirements and continue all the way to analytics and decision-making.

Tools are available for each test stage, and many solutions have been developed to help reach the goal of autonomy, but engineers have fallen short on the global cooperation needed to implement the best of them. Traditionally, automotive companies have addressed this challenge by bringing these tools and collaborators closer together. Figure 2 shows this trend through changes in the supply chain. For example, Tier 0.5 suppliers are independent companies that share the space with OEMs and

STATISTICAL QUESTION	BENCHMARK FAILURE RATE		
How many miles (years*) would autonomous vehicles have to be driven...	(A) 1.09 fatalities per 100 million miles?	(B) 77 reported injuries per 100 million miles?	(C) 190 reported crashes per 100 million miles?
(1) without failure to demonstrate with 95% confidence that their failure rate is at most...	275 million miles (12.5 years)	3.9 million miles (2 months)	1.6 million miles (1 month)
(2) to demonstrate with 95% confidence their failure rate to within 20% of the true rate of...	8.8 billion miles (400 years)	125 million miles (5.7 years)	51 million miles (2.3 years)
(3) to demonstrate with 95% confidence and 80% power that their failure rate is 20% better than the human driver failure rate of...	11 billion miles (500 years)	161 million miles (7.3 years)	65 million miles (3 years)

* WE ASSESS THE TIME IT WOULD TAKE TO COMPLETE THE REQUISITE MILES WITH A FLEET OF 100 AUTONOMOUS VEHICLES (LARGER THAN ANY KNOWN EXISTING FLEET) DRIVING 24 HOURS A DAY, 365 DAYS A YEAR, AT AN AVERAGE SPEED OF 25 MILES PER HOUR.

TBL 1 These examples show how many miles and years are needed to demonstrate autonomous vehicle reliability (RAND Corporation, 2016).

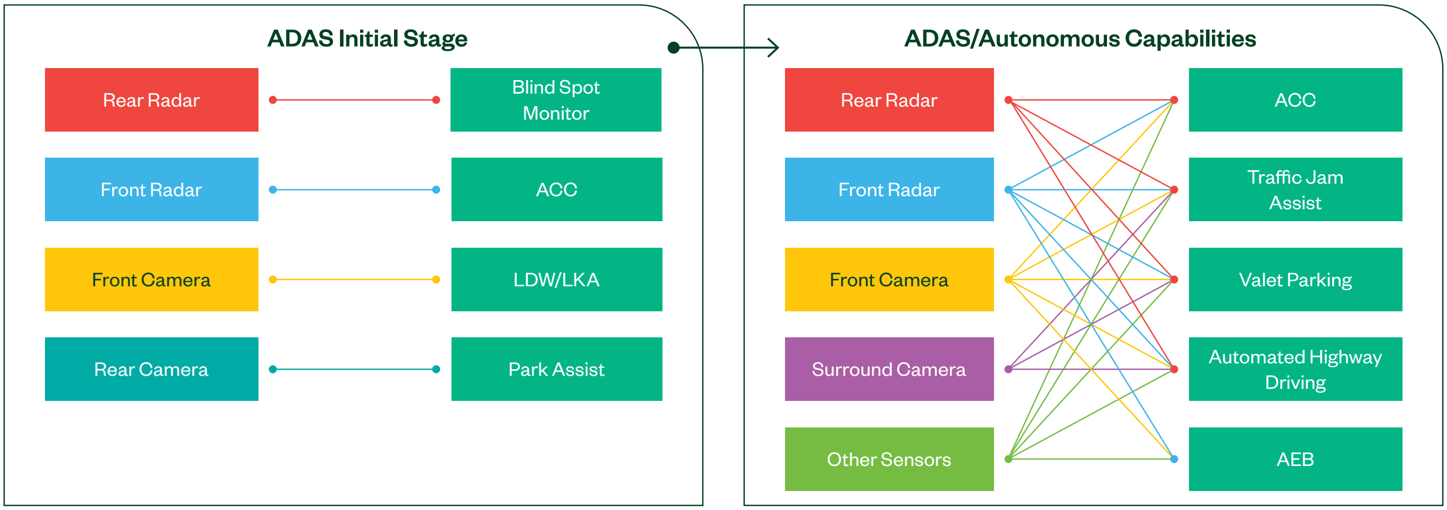


FIGURE 01

Sensors in vehicles were formerly mapped to individual functions, but now each sensor is used for a range of functions, which exponentially increases test needs.

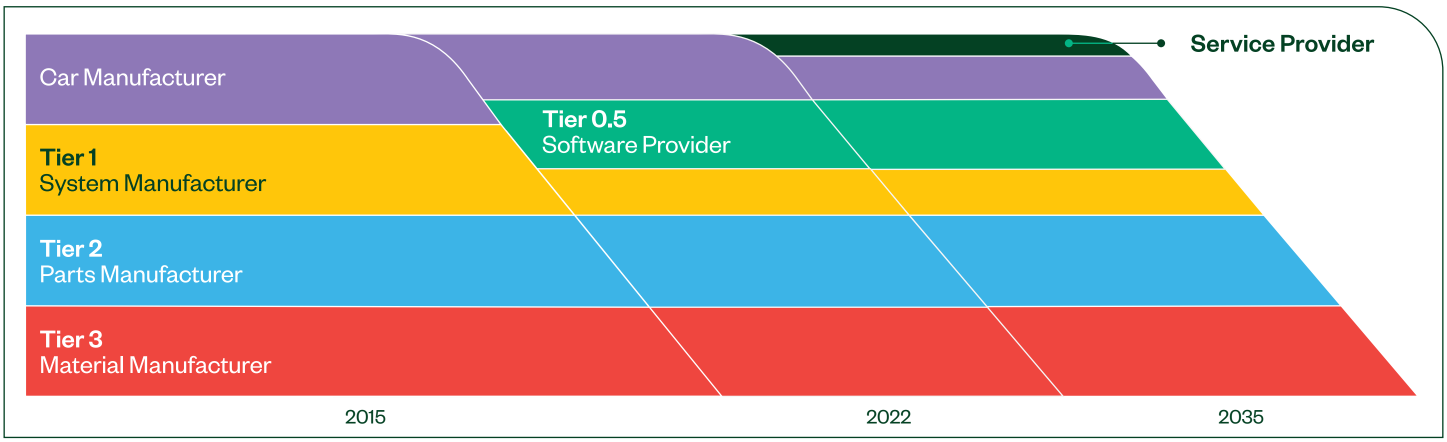


FIGURE 02

The supply chain has adapted to market needs with the concept of Tier 0.5 suppliers, who work to bring development and test closer together.

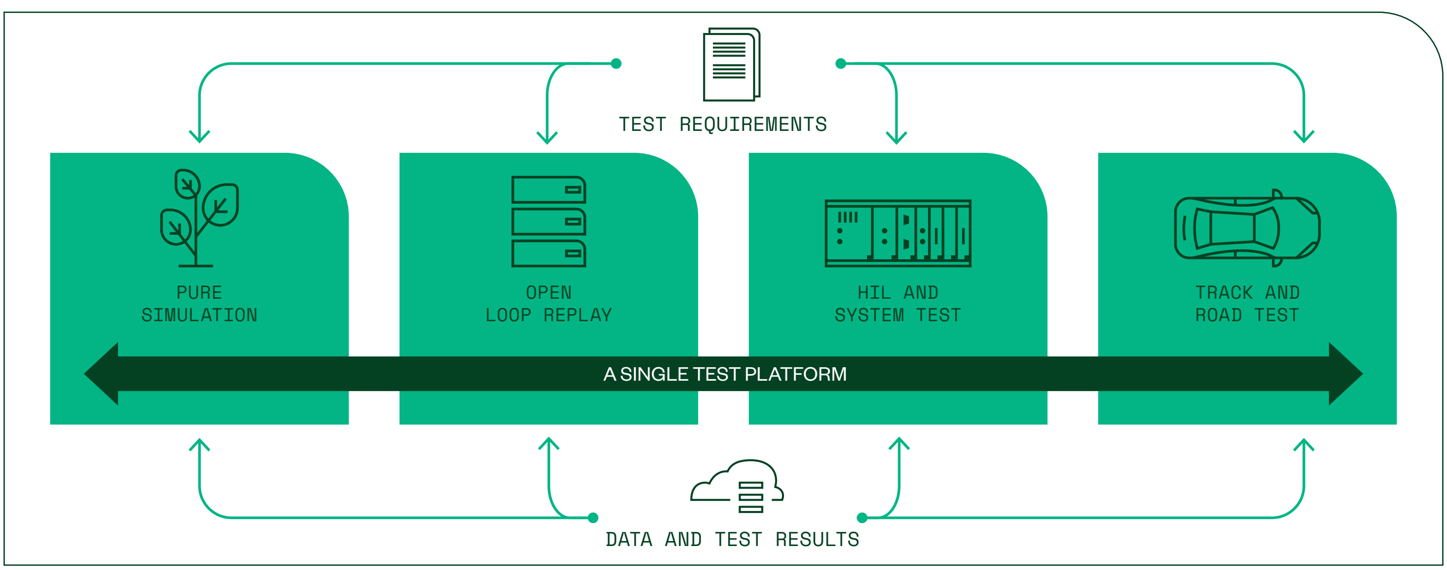


FIGURE 03

NI's end-to-end test approach involves a unified test architecture that enables engineers to think of and perform test as a single chain of steps. This approach generates the knowledge and data needed to make the best decisions for future steps.

foster the level of cooperation needed for test and development. This evolution is aimed at making the connections that resolve the end-to-end testing issue, and companies are investing in this solution to move ahead of competitors in the race.

A different approach is to see beyond the individual tools and collaborators to understand the total environment that influences the autonomy race. NI suggests heavily investing in a unified, end-to-end test architecture, like the one shown in Figure 3, to meet end-to-end testing challenges in the automotive industry and turn test into an advantage in the autonomy race.

03 Win the race

To win the autonomy race, companies generally invest in improving not only the car they're betting on but also the road infrastructure, the drivers, the rules and regulations governing the industry (which haven't been fully defined for the autonomous vehicle industry), and even the terms of what winning entails. The uncertainty created by all these options motivates automotive engineers to relentlessly work to define how the industry tests, adapts, and delivers these vehicles while leveraging the global brainpower of those committed to this cause.

NI's end-to-end approach involves:

01 FOSTERING A COMMUNITY OF ENGINEERS THAT CAN ADD TO THE AUTONOMOUS VEHICLE POOL OF KNOWLEDGE

02 CREATING END-TO-END TEST SOLUTIONS THAT OPENLY INTERFACE WITH A VARIETY OF TOOLS SO COMPANIES CAN BUILD ON THE TECHNOLOGY AND PROCESSES THEY'VE ALREADY INVESTED IN AND IMPROVE THEIR POSITIONS IN THE RACE

03 ENSURING SUSTAINABLE SOLUTIONS TO JUSTIFY THE LONG-TERM COMMITMENT NEEDED BY ALL THE STAKEHOLDERS SHAPING THE FUTURE OF TRANSPORTATION

Author

ARTURO VARGAS
ADAS TEST LEAD, NI

Using Big Data and Machine Learning to Reduce ADAS Camera Costs

Advanced driver-assistance systems (ADAS) suites have revolutionized the auto industry, but they have also generated a great deal of complexity, new technologies, and costs. One of the technologies key to ADAS is sensing cameras, which are particularly sensitive to process and material variations, especially when trying to keep costs down. Though cameras have been used in the automotive space for many years, the shift to sensing cameras (those whose video stream is seen only by computer vision algorithms) has made performance, quality, and consistency of utmost importance. So how do you make sure you're producing the best product every time? In short, you use big data and edge machine learning (ML).

The critical phase of building a camera is when the lens is aligned, focused, and married to the imager during the camera module alignment and test (CMAT) operation. This is an irreversible process during which the lens is glued into the housing, so it is critical that you do it right the first time. This is where both big data and edge ML have a large impact. Big data is really a methodology of bringing a vast amount of varied data (often terabytes) into a single system so that powerful analytics can be used to find solutions to seemingly impossible problems. An advantage to having all the data in a single source is that it's the precursor required to deploy robust ML algorithms into the edge to automate and improve complex process issues without the intervention from experienced engineers.

Lens Grading with Edge ML

One of the critical metrics for determining the performance of a lens, and subsequently a camera, is the modulation transfer function or MTF, which is a measure of how well a lens can focus across its entire field of view. Coupling this with other test and assembly data from the module/camera assembly processes, you can use big data to train an ML model that can predict which lenses will produce cameras with the highest quality. This enables you to screen out lenses that will produce bad parts before they start the assembly process. This prediction is converted into a quality index score that is integrated into the Optimal+ Advanced Analytics Platform. Using the quality index, you can tailor your supplier specs to potentially reduce the cost of the lenses and improve final yield, quality, and scrap.

Adaptive Manufacturing: Complex Decision Automation

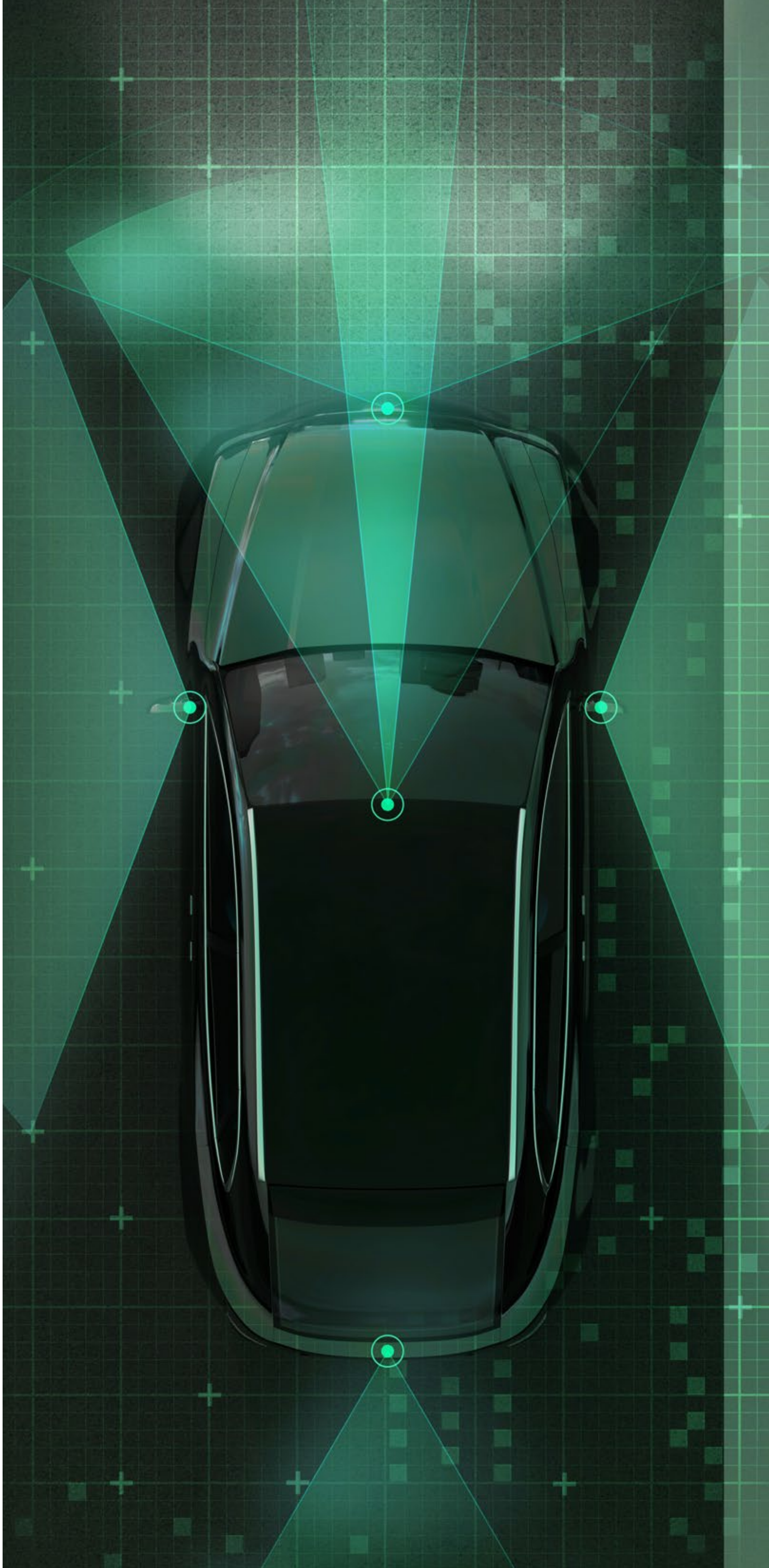
Making sure that the material you use to start the build cycle with components that have a high probability of a successful build is important, but you need to optimize the processes themselves to prevent the material from being scrapped due to process and consumable variations. An example of this is the gluing operation that's part of CMAT. Since glue shrinks when it dries, the lens needs to be offset (called pre-comp) so that it ends up in the location guaranteeing optimal focus. The pre-comp setting will likely need to change from glue batch to glue batch due to variances in the glue manufacturing process. Consequently, you need to look at both the assembly and test data from pre- and post-glue curing (drying) to determine the correct pre-comp for each epoxy batch. Currently, this is done via a manual analysis performed by a highly trained engineer, taking several hours per week. The Optimal Plus Advanced Analytics Platform Rules+ feature enables you to automate this decision process and send feedback directly into the CMAT machine. As the units progress through the process, the MTF values are evaluated against historical data, and, when needed, a new value is sent to the CMAT equipment to adjust the pre-comp value. The edge ML algorithm and Rules+ keep the scrap minimized while maintaining high camera quality without the intervention of an operator, a technician, or an engineer.

Making a Difference with Your Data

Terms like big data, I4.0, and ML have been used for many years and are seen as long on promise but short on delivery. However, by connecting incoming material, assembly, and test data together in a single platform with an integrated feedback engine like Rules+, you can start to see some of those promised benefits. The Optimal+ Advanced Analytics Platform has been proven and deployed in automotive factories to deliver on the promise with a concrete and definitive impact on assembly processes.

Author

PETER HODGINS
ENTERPRISE SOFTWARE
MARKETING LEAD, NI



Improving LV124/ LV148 ADAS Testing with a Modular, Generic Approach

The automotive industry faces a dynamic innovation pace and mounting pressure to meet strict safety requirements for ECUs, especially for advanced driver-assistance systems (ADAS).

ADAS ECU Testing Challenges

ADAS ECUs are increasing in complexity and require more in-depth testing to ensure their functionality and safety. Manual test methods are too expensive and slow, and the risks of relying on insufficient testing data or the short attention span of a person are too great.

LV124/LV148 standards and their specific OEM derivatives are under constant review, and each release has new demands, so test departments and labs need to be equipped with a flexible setup to modify tests along requirements. ECUs that need to support more than one automotive network call for a test system that can be scaled up to meet power and electrical requirements according to standards such as LV123 or derivatives such as VW 80300.

RTStand LV124: A Scalable, Upgradable System

WKS Informatik, an NI Partner, focuses on automated test systems that can remove human error from validation and reduce test times and costs for ECU manufacturers.

RTStand LV124 is a fully automated system that tests compliance with LV124/LV148 standards and their specific OEM derivatives. The scalable hardware platform goes up to 96 pins and can include buses such as CAN, LIN, and Automotive Ethernet.

The LV124/LV148 standards describe different electrical tests that simulate the types of disturbances that happen in a car, from undervoltage (during cold winters) to very short interruptions (due to cable breakage) to overload dumps to short circuits.

Usually, various test setups are needed to cover these tests, but because of the following four core components built on NI technology, you can run all electrical tests with the RTStand LV124. Additionally, by adding other components, such as ECU loads, you can customize the system for a variety of ECU types.

Challenge

Confidently comply with evolving LV124/LV148 standards without constantly changing test technology to adapt to new requirements.

Solution

Utilize a scalable, automated solution designed to test LV124/ LV148 compliance and OEM derivatives that adapts to any ECU.

Core Components

01 Tube Analyzer ensures that all ECU pins and currents are monitored and logged in parallel with precise time synchronization.

02 Ultra-fast interrupter needed for short interruption requirements can also interrupt fieldbuses such as Automotive Ethernet.

03 RTStand SignalGeneration enables the automated generation of norm pulses and the definition of additional custom pulses.

04 RTStand enables the test automation and integration of third-party tools, such as CANoe/CANape for restbus simulations or existing customer software modules.

Benefits

Flexibility: The RTStand LV124 system meets LV124, LV148, and OEM-specific derivatives with flexible test sequence creation through TestStand and LabVIEW. By integrating additional ECU-specific loads or simulation units, you can scale and upgrade the system to meet a variety of customer needs and new ADAS ECU requirements.

Insight: Unlike usual test setups, RTStand LV124 displays the ECU behavior in the voltage and current waveforms for all pins, completely time synchronized. This gives you unprecedented insights into the software and hardware performance of the ECU during tests.

Cost Reduction: With fully automated testing, you can significantly reduce the time you usually invest in test preparation, execution, analysis, and documentation. Moreover, the generic aspect of the system enables fast reconfiguration for testing new releases and generations of ECUs. With the RTStand LV124, customers reduced their test execution and analysis times by more than 50%.

Company:
WKS INFORMATIK GMBH
ULMER STRASSE 8
88212 RAVENSBURG GERMANY

Industry:
AUTOMOTIVE/ELECTRONICS

Application Area:
COMPLIANCE TEST

Authors:
ANDREEA SOLOMON
BUSINESS DEVELOPMENT
WKS INFORMATIK GMBH

RONALD KAEMPF
CEO
WKS INFORMATIK GMBH

NI PRODUCTS USED:

- PXI
- LabVIEW
- TestStand

ADAS In-Vehicle Data Logger

Raw ADAS sensor data is crucial to accurately identify and train autonomous vehicle ECU software. In order to collect this data, automotive companies record sensor data with numerous ADAS sensors during field testing. These sensors occupy an astronomically high bandwidth, which requires high computing power, large data storage space, and quick data copy before the vehicle goes back out on the road.

Customer Needs

01
Record all sensor data within <1 µs synchronously and play back to properly simulate test-drives.

02
Interface with many different I/O types, including camera, radar, lidar, IMU, and vehicle networks.

03
Record all raw sensor data at high bandwidth in the most complex ADAS.

NI + HPE Solution

01
Synchronize interfaces to the microsecond for various ADAS sensors (camera, radar, lidar, IMU, and ultrasonic).

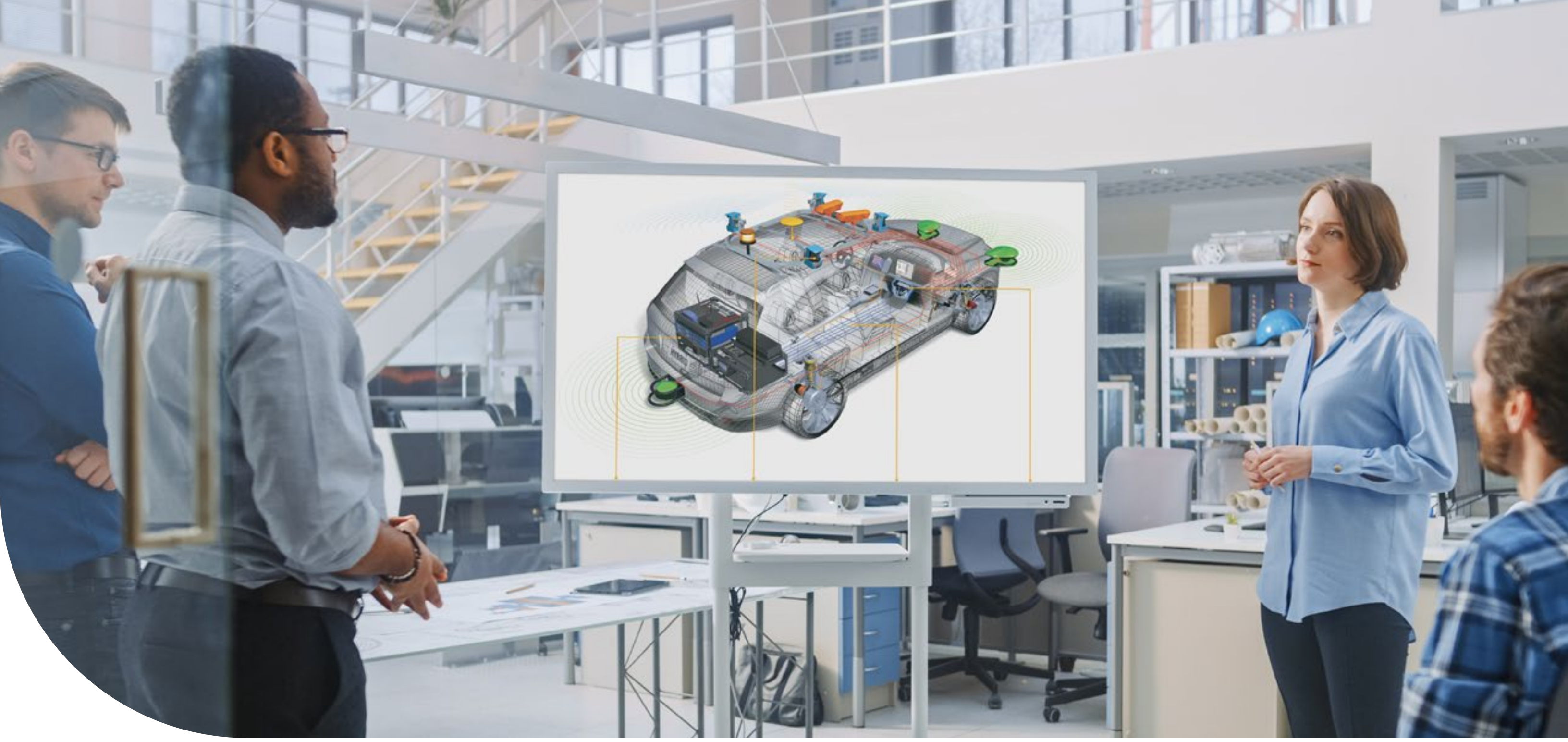
02
Stream terabytes of data at up to 6 GB/s with NI or third-party storage options that seamlessly interface with the PXI system.

03
Collect data with a flexible number and type of sensors with modular hardware.

04
Store data with scalable storage space and high computing power with the HPE Edgeline EL8000.

“HPE’s Edgeline EL8000 is Size Weight and Power (SWaP) optimized making it the perfect platform for parallel processing of UHD Video, LiDAR, Radar, vehicle bus, and sensor data for ADAS test and development. The PXI platform is the ideal choice for HPE because of its sub-microsecond synchronization capabilities, breadth of I/O support, 6GB/s data rates and inline signal processing using FPGAs”

Jason Nassar
Senior Product Manager, HPE



NI ADVANTAGE

- Collect massive sensor data with high bandwidth using flexible PXI hardware.
- Future-proof the system against changing requirements with a modular, software-connected approach.
- Reduce implementation time, capital costs, and sparing costs by using the same hardware for recording and playback.

HPE ADVANTAGE

- Quickly and easily transport data from the logger to the upload station with the extractable drive bay.
- Achieve server performance at the edge in unprecedented logging rates and simultaneous data analysis.
- Stay secure with data-center security featuring hardware root-of-trust, TPM 2.0, and HPE-developed BIOS ROM and the integrated Lights Out (iLO) platform management code.
- Enjoy server data integrity, ECC memory, RAID for storage, and iLO platform management that constantly monitors system health.

		NI PXIE-8880 + HPE EDGELINE EL8000 446 X 192 X 495 MM + 432 X 213 X 221 MM
COMPUTING POWER	Processor and RAM	HPE: Intel Xeon SP 24-core 6212U (2.4 GHz base, 3.9 GHz turbo) Intel Xeon 8-core (2.3 GHz base, 3.4 GHz single-core turbo)
	DDR4 RAM	HPE: 1 TB; NI: 8 GB standard, max 24 GB
	Storage capacity	HPE: 20 TB on 2U blade/motherboard, 122 TB hot-swappable in storage bay
	USB ports	2 x USB 3.0, 4 x USB 2.0; HPE: 2 x USB 3.0
ADAS I/O	Maximum Data Rate	6 GB/s
	Synchronization	<1 µs
	100/1000BASE-T1	4 ports per module
	Other vehicle bus support	CAN LS/FT, CAN HS/FD, LIN, FlexRay, Automotive Ethernet
	Camera interfaces	FPD-Link, GMSL, USB, MIPI-CSI 2
	Radar support	Via vehicle bus
	Lidar support	Via vehicle bus
	Ultrasonic support	Via vehicle bus

Engineer Perception and Planning into ADAS

Estimates say advanced driver-assistance systems (ADAS) have the potential to prevent more than a third of all passenger-vehicle crashes. According to a AAA Foundation for Traffic Safety report, this reduction would prevent 37% of injuries and 29% of deaths in crashes that involve passenger vehicles. To fulfill the potential of ADAS and ensure their corresponding safety, simulation is needed to show that vehicles can perceive the world around them, predict what might happen next, and plan accordingly.

A lot of literal and figurative miles exist between the current state of ADAS and Level 5 fully autonomous vehicles. An oft-cited report from RAND Corporation (see Table 1 on Page 5) makes the case that autonomous vehicles would need to be driven hundreds of millions of miles and sometimes hundreds of billions of miles to demonstrate their reliability in terms of fatalities and injuries.

Currently, most ADAS functions fall in the Level 1 or 2 range. Even achieving Level 3 autonomy, in which a vehicle can take full control when certain operating conditions are met, is a challenging technological leap. It requires a combination of physical testing and simulation that includes hardware, software, and humans in the loop. Each aspect of the autonomous vehicle technology stack is critical and requires the involvement of people with different skills and knowledge.

Solve the Perception and Planning Problems with Sensors and AI

Sensors are the eyes and ears of ADAS. Weather and complicated driving conditions can confuse and overwhelm them. Suppliers are challenged to develop sensors and sensing systems that function at a higher level so they perform well not only on sunny days in light freeway traffic but also in blizzards, on busy city streets, and under a multitude of "edge cases." Edge cases encompass those unusual scenarios that don't happen often but commonly lead to accidents.

ANSYS SCADE Vision powered by Hologram helps identify the edge cases to pinpoint the weakness of AI. Armed with edge case information, SCADE Vision can trigger more AI training actions and new testing scenario conditions.

Software developers are interested in generating synthetic data from simulation to more quickly train AI in various operation design domains (ODDs), the term used to describe subsets of driving conditions with particular environmental, geographical, time of day, traffic, and/or roadway characteristics. Defining and identifying ODDs is challenging because they affect testing, compliance, and real-world Level 3 autonomous driving. For a car to enter autonomous mode, the sensors must perceive those conditions and the software must interpret those perceptions to determine whether ODD requirements have been met. Simulation helps developers explore those ODD edge cases.

OEMs rely on their suppliers to provide sensor sets. However, OEMs are ultimately responsible for the safety of the cars they produce, so they must be sure suppliers have fully vetted those technologies. Suppliers are using simulation at the component and packaging levels to better understand the strengths and weaknesses of various sensing technologies, such as ANSYS SPEOS for lidar and cameras and ANSYS HFSS for radar. The goals are to improve individual sensing technologies and ensure the various technologies can be used together to help create a robust sensor array that can handle whatever edge cases arise.

The ANSYS VRXPERIENCE Driving Simulator powered by SCANeR forms the basis of an ADAS development cycle. It provides ADAS development teams with the capability to re-create driving scenarios and enables testing against a variety of objectives and performance requirements. By replicating roads generated from high-definition maps and libraries, traffic situations, weather conditions, vehicle dynamics, and more, ADAS development teams can validate sensor and AI modules, sensor systems, vehicle models, and human-machine interfaces (HMIs).

Simulate ADAS Functions

ADAS functions are driven by software development. Custom vehicle models can be connected to VRXPERIENCE through FMI, C/C++, ANSYS Twin Builder, or MathWorks Simulink® software. Engineers can put vehicles in an environment with certain conditions—for example, on a highway arriving at a traffic jam at a certain speed—and quickly modify them for the scenarios and validation they'd like to perform. Based on that, they can simulate the scenario with different levels and types of sensors to assess sensor perception, sensor fusion, and systems operations.

VRXPERIENCE can speed edge case exploration and sensor simulation. Take, for example, headlamp development. There are a lot of missed detection edge cases at night, so VRXPERIENCE has specific modules to simulate the physics of light. Intelligent lighting to automate when high beams should turn on and off or automatically adjust to minimize glare may seem like a simple convenience, but lighting is an important piece of ADAS because the car's camera sensors react to it. Cameras that identify signs, road lanes, and oncoming vehicles are sensitive to headlamp design changes, for example. VRXPERIENCE reduces the time and cost of development by enabling a repeatable process for modified sensor inputs, such as lighting changes.

Another example is an emergency braking function that is part of ADAS. To develop it, the function is first described as a model, often in MathWorks Simulink or ANSYS SCADE. It is tested to meet objectives and then designed as a more detailed model. The coding of the emergency braking function can then be evaluated versus scenarios with software-in-the-loop and hardware-in-the-loop test.

With the ANSYS VRXPERIENCE Driving Simulator powered by SCANeR, customers have a seamless process to test the model, connect it with SCANeR, and then keep the same vehicle test environment to connect software and/or hardware as they simulate different ODD edge cases. The streamlined workflow saves time and makes it easier for geographically dispersed teams and experts from different disciplines to collaborate.

Planning for Humans in the Loop

ADAS also need to account for how people will behave inside their cars. And, according to University of Iowa research, people's behavior can change based on ADAS features. About 25% of the drivers surveyed who used blind spot monitoring or rear cross traffic alert systems reported feeling comfortable relying solely on the systems and not performing visual checks or looking over their shoulders for oncoming traffic or pedestrians. About 25% of vehicle owners using forward collision warning or lane departure warning systems also reported feeling comfortable engaging in other tasks while driving.

The ANSYS VRXPERIENCE Driving Simulator powered by SCANeR integrates with driver hardware simulator interfaces to create an immersive driving experience with virtual reality. The VRXPERIENCE HMI module can be used to test and validate the full cockpit design for HMIs. The virtual test driver can interact directly with the virtual interfaces, from touchscreens to switches, thanks to a fine finger tracking system. As the system records the behavior of the driver and displays driving and infotainment information, it identifies and interprets the actions of the pilot and triggers the adapted HMI reaction automatically.

ADAS developers can easily evaluate the relevance of the displayed information, in real time, for a safer drive. VRXPERIENCE reduces the time and cost of design because the evaluation of the design is mostly performed on virtual prototypes.

Create a Distinct Experience

Safety is paramount, but HMIs are also a way for OEMs to differentiate themselves in the market. Much like the sound of an engine or the feel of a car door closing, the way people and automation interact has become a means to build a brand.

VRXPERIENCE allows OEMs and suppliers to evaluate different driver and passenger experiences as part of the same overall development process. Beyond ADAS, VRXPERIENCE allows users to visualize the impact of assembly and shape deviations on the perceived quality of a product, considering manufacturing variations. Engineers can see and present the influence of perceived quality based on design and manufacturing data such as materials, fasteners, and tolerances. They can simulate complex deformation effects such as arching, bending, and distorting to identify the root cause of problem areas.

The ANSYS VRXPERIENCE SOUND module provides an intuitive graphic display of sounds and a one-click magnification control feature to help create a sound signature. Users can also set up psychoacoustic tests based on a listener panel to obtain statistics about the real perception of sounds. Sound perception can be evaluated using tools based on time-frequency representations.

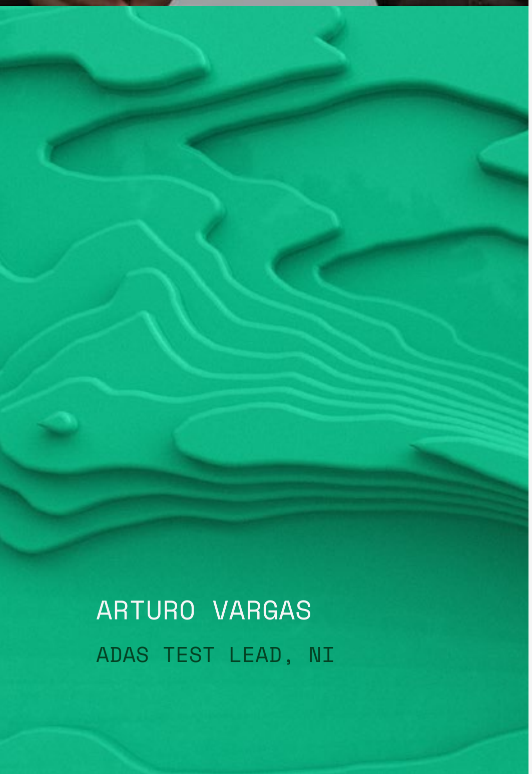
Collaborate to Combine Technological and Cultural Shifts

The development of autonomous vehicles is one of the greatest engineering challenges of our day because it has a global impact on the life dynamics of everyone who uses transportation—shared, private, or public—and, perhaps most importantly, because it absolutely requires global cooperation to make it a reality. To meet the challenge, startups and established players are using simulation to get from here to there safely and efficiently, and are counting on test technology to ensure both safety and efficiency conditions are met. NI and ANSYS work together to bring state-of-the-art simulation technology into test to get from lab to road while connecting data, requirements, and test results along the way. One example is the seamless integration of ANSYS VRXPERIENCE with NI VeriStand and NI hardware for ADAS HIL Test. Only with cooperation like this can we expect to meet the challenge that autonomous driving presents and enable test engineers to overcome it.

Authors

GILLES GALLEE
TECH EVANGELIST,
AUTONOMOUS VEHICLE SIMULATION SOLUTIONS, ANSYS

ASHISH NAIK
SENIOR BUSINESS DEVELOPMENT MANAGER,
ADAS/AD, NI



ARTURO VARGAS

ADAS TEST LEAD, NI

Radar Test Keeps Changing. Are You Testing the Same Way?

> We interviewed Kitt Farrar and Vitali Anselm from NI's Transportation Group to discuss their experience with radar test, what we've learned so far, and what we still need to do to increase vehicle safety.

ARTURO VARGAS: THERE'S ABOUT HALF A CENTURY OF EXPERIENCE IN THIS GROUP. KITT, YOU KNOW RADAR TEST FROM AEROSPACE TO AUTOMOTIVE. VITALI, YOU'VE BEEN ON THE DESIGN SIDE OF ADVANCED DRIVER-ASSISTANCE SYSTEMS (ADAS) AND RADAR TEST SYSTEMS. WHAT IS THE BIGGEST CHALLENGE RADAR TEST ENGINEERS FACE?

Vitali Anselm: Having a clear picture of what and how to test, especially as companies enter the radar marketplace and learn about the technology and the requirements they need to meet for the radar to be successful in the market.

Kitt Farrar: The complexity and power of radars continue to increase, and the time to calibrate and test radars naturally increases, so we get creative to test that complexity that naturally takes longer, without adding to the test time.

AV: WHAT ARE THE MAIN RADAR TEST LIMITATIONS YOU'VE SEEN IN THE INDUSTRY?

KF: Historically, radars have been tested using corner reflectors and delay lines. With those two, testing is very limited. For example, with corner reflectors you have no ability to change your radar cross section (RCS). You can move it and change object distance, but you cannot implement parametric test effectively. With delay lines, you can control the RCS with amplifiers and attenuators, but you can't change your distance, so again you're limited. Additionally, being able to complete the RF measurements on top of the object simulation test without adding test time is something engineers find challenging. We used to talk about ±1 m errors, then 30 cm. Now we're talking subcentimeter resolution, so how do we simulate that precision but also test the RF performance with such big trade-offs in traditional reflector and delay-line approaches?

AV: AND WE NEED TO HIT THOSE ± RANGES CONSISTENTLY AND WITH REPEATABILITY TO COMPLY WITH PROGRAMS AND STANDARDS SUCH AS NEW CAR ASSESSMENT PROGRAM (NCAP) AND ISO 26262. WHAT CAN YOU TELL US ABOUT THAT?

VA: We have to decipher regulations and standards to understand what the test requires and implies. Many times, you need to use different tools that work together to provide an end-to-end test solution. For example, with NCAP test, you need to define the test scenarios based on a traffic simulation. With different tools, you vary the parameters, execute the tests, and manage the test results. Connecting those tools to get to the end-to-end solution and confidently meet the test standard is what we're striving for at NI.

KF: Regarding repeatability, this is the story I hear. Test developers start in the lab designing antennas and chips with high-end vector network analyzers and vector signal generators. Then they get to a prototype sensor and, from there, move to the parking lot or the rooftop to test the radar prototype. That test is not repeatable at all for regression-type testing, so radar simulators save time and cost by providing a repeatable, controllable test environment. After characterizing the sensor, you insert it into more realistic use cases like "driving" through those NCAP scenarios.

AV: YOU'VE GIVEN US A GREAT OVERVIEW OF HOW RADAR TESTING HAS UNIQUE CHALLENGES TO MEET SAFETY STANDARDS. WHAT LIES AHEAD FOR RADAR IN THE ROAD TO AUTONOMY?

KF: Radar will always be there. Every ADAS sensor will play its part given the different advantages of each. Regarding radar, it is unclear whether we'll use the huge bandwidths available to achieve high precision or divide them up to avoid radar interference. We may just use more, smaller subgigahertz radar sensors and create a sort of cocoon around the car. There are a lot of ways it can be done. I believe we'll absolutely use the larger bandwidths, but it's just a matter of how.

VA: I completely agree. Radar will be part of the autonomous vehicle and will be combined with the other sensors through sensor fusion and, of course, that's a different testing conversation around the algorithm. For example, for adaptive cruise control (ACC), test is easier because the object simulation doesn't require a very fine resolution and accuracy. As long as the simulated targets roughly perform the trajectory movement, the ACC algorithm can be tested. However, if your test focus is on low-level components of the radar to characterize specific parameters like the separability of two different objects, you will certainly have much higher expectations regarding the resolution and repeatability of the object emulation.

Challenge

Perform representative, real-world, repeatable driving testing in a safe environment that can bridge the gap from simulation to road test for autonomous vehicles.

Solution

Build a test environment to perform model-, software-, hardware-, vehicle-, and driver-in-the-loop testing that's configurable and scalable to meet research and commercial test cases for safe autonomous driving.

Enabling Safe, Repeatable, Immersive CAV Testing with a Software-Connected Approach

> At WMG, our vision is to test or evaluate any new connected and autonomous vehicle (CAV) technologies in representative, real-world conditions with a "driver" in the loop. This requires a scalable, flexible, software-connected core that allows us to support all our stakeholders and their research.

The Impact of CAVs

CAVs are expected to impact society in five fundamental ways:

01 Increased safety

Human error is a factor in over 90% of collisions. CAVs provide the opportunity to reduce accidents in the long term.

02 Reduced congestion

CAVs have the potential to make better use of existing road space, which benefits the environment.

03 Increased productivity

The average driver drives 235 hours every year. CAVs provide the opportunity for drivers to make more productive use of their time.

04 Increased mobility

Young, disabled, and elderly people will have greater access to mobility services through CAVs.

05 Reduced cost

About 40% of bus operator costs impact driving staff. If these are passed directly to passengers, the costs of traveling will significantly decrease.

These fundamental impacts are widely assumed to result in a significant increase in user demand for CAVs. Current forecasts predict that by 2030, 30% of newly made vehicles for UK roads will be SAE Level 3 or higher.

Ensuring Safe and Dependable CAVs

An April 2016 RAND Corporation report stated that it would be necessary to drive 5 billion miles to provide 95% confidence that a CAV was 20% safer than human drivers. This makes modeling and simulation an attractive option for validating these systems.

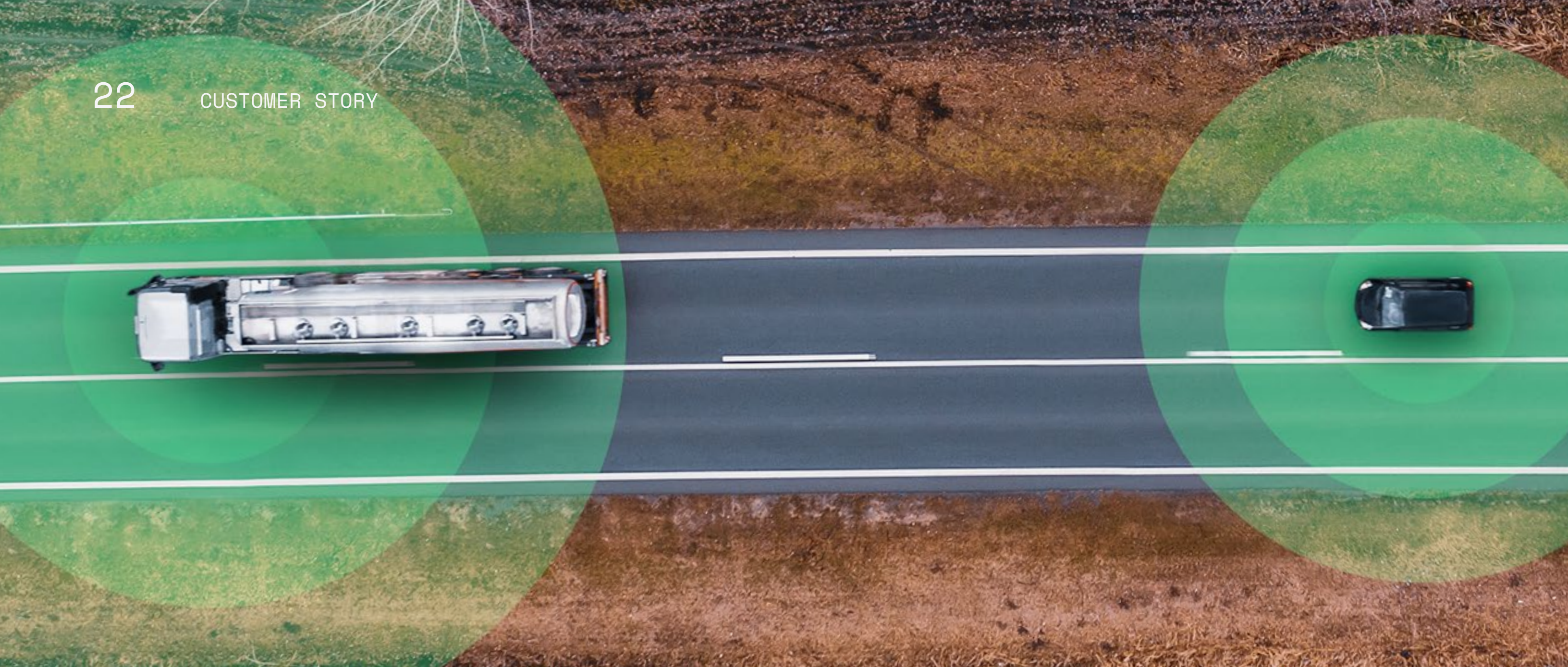
To make future vehicles, technologies, and services dependable, desirable, and viable, we need to ensure that our test programs, simulations, and trials are bolstered by the best facilities and equipment available. The employees at these facilities must not only address the complexities of cutting-edge technology and the multiple stakeholders who need to use it but also deal with unknown requirements as the industry and market evolve.

This means that at their core, these facilities must be state of the art and easily configurable and upgradable to implement mechanisms that increase realism, fidelity, and therefore test coverage. The finely tuned set of tools in the integrated toolchain at WMG enables safer, repeatable tests for autonomous vehicle technologies.

3xD Simulator for Intelligent Vehicles

WMG's 3xD Simulator for Intelligent Vehicles provides an innovative platform to bridge the gaps among traditional simulation, hardware-in-the-loop (HIL) tests, and road-based field tests.

The simulator offers a drive-in, driver-in-the-loop (DIL), and driving experience, hence the "3xD" in its name. The agile setup allows for model-in-the-loop (MIL), software-in-the-loop (SIL), and vehicle-in-the-loop (VIL) tests as well as DIL and HIL tests.



The 3xD simulator delivers a real-time, safe, controlled, and repeatable physical environment, which allows for not only the sensor and communications, including 5G mmWave, but also the driver to be in the loop.

Used for pure research, collaborative research, and commercial use cases, the simulator attracts multiple autonomous vehicle stakeholders, from vehicle manufacturers and suppliers to transport and logistics experts, startups, infrastructure providers, legislators, regulators, and insurance companies.

Since 2015, WMG has been working on an immersive simulator including implementing several upgrades. With its software-connected approach, NI has been crucial in enabling WMG and its customers to choose the technology and setup they need for each test case and make upgrades as new requirements are introduced.

Collaborating to Improve Simulation

For the latest system upgrade, WMG sought out market-leading providers to help enhance the realism the driver felt within the simulator. The three goals were to improve the visualization ability of the driver, increase the realism of the vehicle model, and continually consider new emulation techniques for sensors and signals while offering an open approach to minimize the time and effort to integrate these tools.

This brought together rFpro to focus on world environment visualization, IPG Automotive to specialize in vehicle model and scenario simulation, and NI to work on emulation techniques for sensors and signals, real-time HIL, and the software-connected approach to integrate them.

We collaborated to demonstrate this to our key stakeholders using limited resources with a timeline of one to two months. We achieved this with the open collaboration of the organizations, technology APIs, and the support of NI as part of the proof of concept.

We demonstrated state-of-the-art immersive visualization; realistic vehicle dynamics models; over-the-air sensor emulation techniques for radar, 5G, and GNSS; and the ability to control electromechanical steering plates.

This capability allows for earlier testing within the product development cycle, and, in the future, we hope we can play a role in the certification process for safe and highly automated vehicles.

Company:
WMG, UNIVERSITY OF WARWICK
COVENTRY, CV4 7AL, UNITED KINGDOM

Industry:
AUTOMOTIVE, ADAS AND AUTONOMY SYSTEMS

Application Area:
VALIDATION

Authors:
JAKES GROENEWALD
LEAD ENGINEER, WMG
UNIVERSITY OF WARWICK

ASHISH NAIK
SENIOR BUSINESS DEVELOPMENT
ADAS/AD, NI

NI PRODUCTS USED:

- NI VeriStand
- PXI RF Instrumentation
- Automotive Networks
- USRP

ADAS Test Solutions

From Lab to Production Line

One stop ADAS test solutions for customers

- Based on NI VRTS & software/hardware system, provide 24GHz or 77GHz Radar lab test solutions.
- Provide production line test equipment and services for both 24GHz and 77GHz Radar.
- Provide forward camera injection and surround camera injection products and solutions.
- Ultrasonic echo simulation system.
- Combine real drive scenario, set up sensor fusion hardware–in–the–loop simulation system. Realize APA, AEB, ACC and other low or high speed scene–in–the–loop simulation and testing.

KT ADAS/AD Sensor Fusion HIL Test Workbench

A configurable, PXI-based system to reliably and safely test ADAS/AD functionality in a lab environment is presented here. Combinations of sensors and ECUs with ADAS/AD algorithms together in a hardware in the loop (HIL) can be tested and configured for multiple radar, camera, lidar, and ultrasonic sensors with connectivity to most third-party modeling and simulation software and hardware platforms. Test scenarios for regulatory standards (NCAP) can also be implemented.

Customer Needs

01
Reliably verify functional ECU hardware, ADAS/AD software, and sensor package effectiveness performance in a controlled environment.

02
Scale for different sensor packages consisting of multiple radar, lidar, camera, and/or ultrasonic sensors with connectivity to NI and/or other third-party HIL hardware platforms.

03
Safely implement ADAS/AD subsystem regression and repeatability tests before drive tests.

KT Solution

01
Combine sensor measurements with object identification for reliable ADAS/AD functional tests in the lab.

02
Use a modular architecture to scale for different sensors and sensor combinations with connectivity to third-party software and hardware simulation platforms for open- and closed-loop HIL tests.

03
Connect ADAS/AD sensors, subsystems, ECUs, and body and chassis components for component tests and total vehicle safety feature performance evaluation in a lab for HIL, DIL, and VIL testing before drive tests.

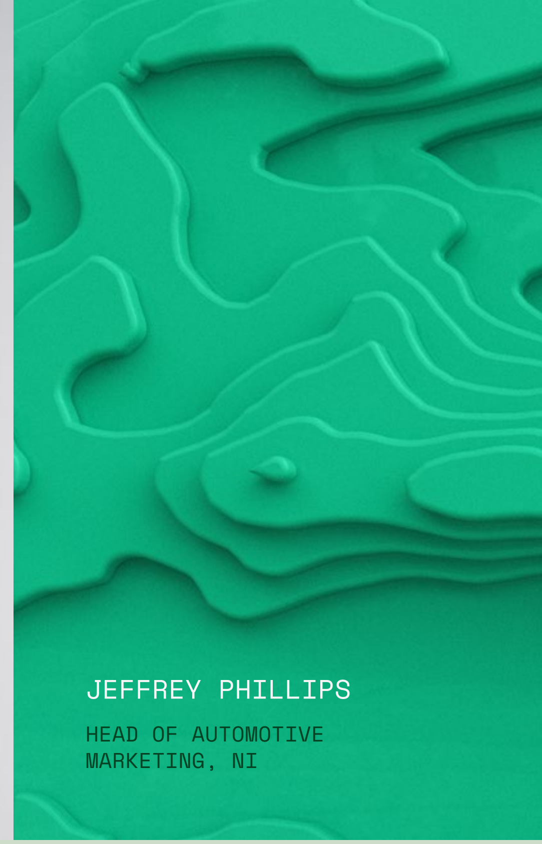
“As CAERI leads the ADAS test and certification efforts in China, this modular and scalable Konrad system is an industry-leading sensor fusion test bench that is anticipated to reduce our overall test development and implementation by up to 20% of total project time. The Konrad ADAS HIL Test Workbench allows us to quickly and efficiently implement a variety of test protocols for sensor- and module-level test for ADAS functions for certification and product development purposes.”

Zhou Zhou
Vice General Manager, CAERI

THE KT ADVANTAGE

- Future-proof your test plans with a modular and scalable validation test workbench.
- Reduce development time and costs with in-lab regression and repeatability tests.
- Optimize ADAS/AD function by validating component, subsystem, and system-level ADAS/AD performance with a single workbench before drive tests.
- Test ADAS/AD functions for corner cases in a safe, controlled environment.

KEY SPECIFICATIONS	
Number of Sensors	Configurable for radar, lidar, camera, and ultrasonic sensors
HIL System	NI HIL or third-party system
Bus Communication	Over-the-air, data injection, parametric measurements, and object identification
Connectivity to Third-Party Simulation Tools	IPG CarMaker, VI-CarRealTime, VIRES Virtual Test Drive, monoDrive
Vehicle Component Simulators	Steering, brake, custom
Wireless Test	V2X, GPS, Bluetooth



JEFFREY PHILLIPS

HEAD OF AUTOMOTIVE
MARKETING, NI

Evaluating the Impact of ADAS Partnerships in Automotive

> I sat down with Ashish Naik, a resident expert monitoring advanced driver-assistance systems and autonomous driving, to discuss how the recent influx of industry partnerships across the automotive supply chain will impact the journey to mobility.

JEFF PHILLIPS: DESPITE YEARS OF PROMISE TO THE CONTRARY, 2020 IS NOT THE YEAR THAT AUTONOMOUS VEHICLES WILL HIT THE MARKET EN MASSE. WHY DO YOU THINK THAT PROGRESS HAS BEEN SLOWER THAN ANTICIPATED, EVEN JUST A FEW SHORT YEARS AGO?

Ashish Naik: We're at a unique point in the history of the industry. Technology fundamentally shifting how a car is designed, customer needs changing at a historic rate, and automakers having less money and fewer resources during an industrial recession are all slowing down progress. Over the last few years, there has been a lot of talk about high levels of active safety and autonomy being around the corner in 2020 after news of experimental prototypes was shared. These announcements—new mobility concepts such as robo-taxis, autonomous freight, and so on—came from large OEMs and Tier 1s. These have not materialized, and organizations are making significant changes to adapt. The COVID-19 pandemic has undoubtedly influenced the automotive supply chain in a meaningful way; however, I think it has exacerbated existing cracks in the industry rather than creating new ones.

JP: RECENT ANNOUNCEMENTS DESCRIBE MARKET LEADERS, SOME OF WHICH ARE NOT TRADITIONAL AUTOMOTIVE COMPANIES, PAIRING UP. EXAMPLES INCLUDE THE DAIMLER AND NVIDIA PARTNERSHIP, AMAZON'S ACQUISITION OF ZOOX, AND VOLVO WORKING WITH WAYMO. WHAT'S YOUR TAKEAWAY FROM THESE ANNOUNCEMENTS?

AN: The paths to mobility are multiple. There are many types of solutions that can leverage this, such as robo-taxis, autonomous freight, last-mile solutions, shared mobility, traditional consumer owned, and so on. Additionally, there are multiple minds from all walks of life that can profit from this, such as financial organizations, big data analysts, capital-reach tech companies, and cloud and server companies. This creates a hotbed for collaboration, encourages organizations to test multiple theories in parallel, and tests the water in multiple areas to find the right future approach. We are already witnessing different approaches forming and unraveling continually that have produced mixed results.

JP: THIS ALL SOUNDS VERY COMPLEX—LOTS OF MOVING PIECES: N-TO-N DEPENDENCIES, CHALLENGING MARKET DYNAMICS. HOW IS THE INDUSTRY HANDLING THIS LEVEL OF COMPLEXITY AND AMBIGUITY?

AN: Author John Maxwell once captured my sentiments beautifully: “Change is inevitable. Growth is optional.”

They’re growing. Instead of cowering under the shadow of uncertainty, they’re boldly embracing the ambiguity. Change in requirements and consumer expectations has always been inevitable, but the timetable has shifted. Traditionally, automotive hasn’t been heavily dependent on robust software, and this massive shift has upended the development procedure. Automotive companies are changing their organizations in all aspects to handle this. In Europe, Bosch and VW Group have announced the creation of software-centric centers of excellence and delivered platform-based capabilities. This builds flexibility and modularity to enable efficiency and agility; that’s something we’ve been advocating across test. I’m excited to see how this continues to drive synergy in a unified approach with our customers.

JP: FOLLOWING THE JOURNEY TO SAFER VEHICLES IS A STEADY DICHOTOMY OF NEW AND INTERESTING TECHNOLOGICAL DEVELOPMENT PAIRED WITH VERY PUBLIC FAILURES. ONE THING THAT’S CLEAR IS THAT IT WILL TAKE MORE THAN JUST THE CAR COMPANIES. WE WILL ALL PLAY A ROLE AS CONSUMERS, AND LEGISLATION (AT MULTIPLE LEVELS) IS STILL A QUESTION MARK. WHAT DO YOU THINK CONSUMERS AND LEGISLATORS SHOULD BE DOING RIGHT NOW?

AN: This is a great question. It is critical that we view this as an overall topic and not in isolation. As we saw from the multiple manufacturers promising autonomy, the legislation, regulation, insurance, and model cycles can be a potential barrier to delivering this technology to market if they’re not embraced by all bodies properly. We need to work together. I’m encouraged by the proactive intentions of governments, insurance organizations, and so on in this space. For example, in my home country, the UK government announced a public consultation around automated lane-keep assist to ensure regulation is ready where necessary to introduce this technology by spring 2021.

JP: THE AUTOMOTIVE INDUSTRY IS EMBRACING A BIT OF THE LATE BASKETBALL PLAYER KOBE BRYANT’S “BLACK MAMBA” MINDSET: “EVERYTHING NEGATIVE—PRESSURE, CHALLENGES—IS ALL AN OPPORTUNITY FOR ME TO RISE.” LET’S EMBRACE THE CHALLENGE TOGETHER.

ASHISH NAIK

SENIOR BUSINESS DEVELOPMENT MANAGER, ADAS/AD, NI

NI + monoDrive HIL: Augmenting Test Fidelity

> Conducting real-world road testing for every autonomous vehicle is prohibitive in terms of scale, cost, quality, and coverage. The task of identifying and characterizing test cases, pass/fail criteria, and test-case producibility and repeatability with current tools is difficult. Also, pure simulation approaches do not provide the realism needed for many test scenarios and may not operate in real time (see Figure 1). Hardware-in-the-loop (HIL) solutions can bridge the gap between simulation and road testing to deliver improved test fidelity.

NI and monoDrive, an NI Partner, have developed a new HIL-based solution that augments simulation quality and alleviates the reliance on road testing for test coverage. Test engineers can now validate vehicle perception, planning, and control with superior simulation coverage in a completely virtual environment.

MonoDrive is a market leader in the real-time high-fidelity emulation of lidar, radar, camera, RPM, GPS, and inertial measurement unit sensors. Using the monoDrive platform, you can generate test scenarios with intelligent driving models, the CUDA Toolkit, and C++ for real-time sensor emulation performance. NI's partnership with monoDrive enables best-in-class simulation of sensors and this composite HIL solution, which has gained traction with major OEMs and Tier 1 suppliers and offers Python, LabVIEW, and robot operating system clients.

NI + monoDrive Solution

The NI and monoDrive solution comprises the monoDrive simulator; scenario creation tools; high-performance PC clusters with NVIDIA RTX GPUs to run the clients; the NI PXIe-8880 embedded controller; CAN, Gigabit Multimedia Serial Link 2 (GMSL 2), or FPD-Link III Automotive Ethernet cards; and an ECU.

As shown in Figure 2, the monoDrive master runs a vehicle-plant model in hard real time on NI Linux Real-Time. Sensor simulators, running on Windows 10 with NI Linux Real-Time, are clock-synchronized to a monoDrive master. The vehicle's ECU in the loop is synchronized with NI Linux Real-Time for translating throttle, brake, and steering commands to the vehicle's pose state.

An initial vehicle (aka ego) pose state is recorded into the PXI Express system to inform the ECU about the starting coordinates and parameters of the vehicle. An installed camera can take vehicle image inputs either directly from the HD monitor or via the direct injection path from the scenario database. The PXI Express system converts those scenarios into appropriate electric signals to the ECU for processing. The ECU returns throttle/steering/brake information to be fed back into the monoDrive simulator.

NI + MONODRIVE ADVANTAGE

- Improve ADAS/AV feature safety in a production vehicle.
- Improve time to market for new, innovative, perception-heavy features such as pedestrian detection, collision avoidance, lane keeping, and traffic jam assist.
- Significantly reduce validation cost with more simulation and less "mule vehicle" over-the-road testing.

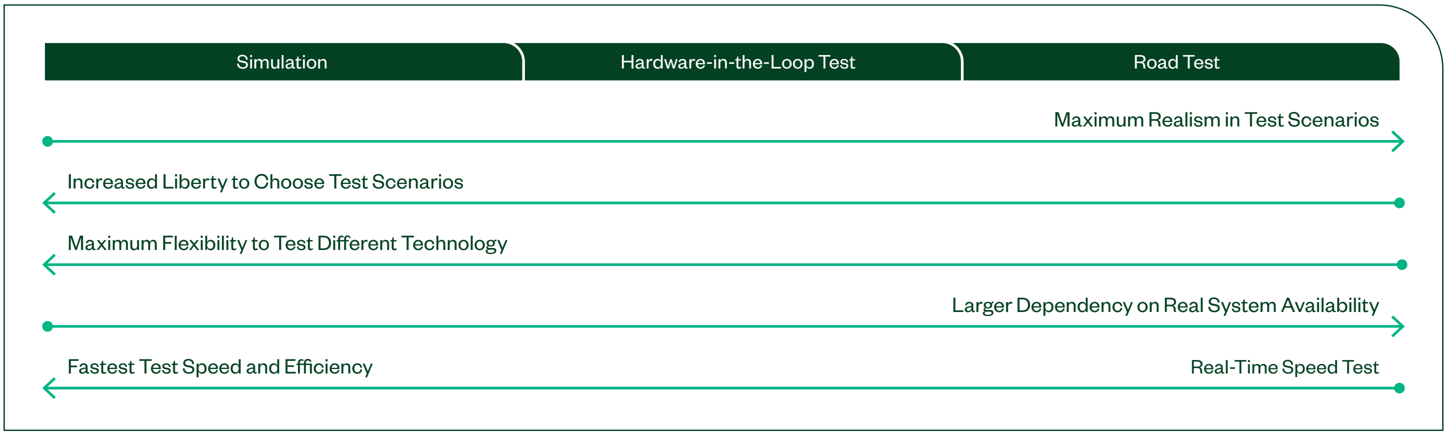


FIGURE 01

Advanced Driver-Assistance Systems Test Spectrum (©WMG, The University of Warwick, 2018)

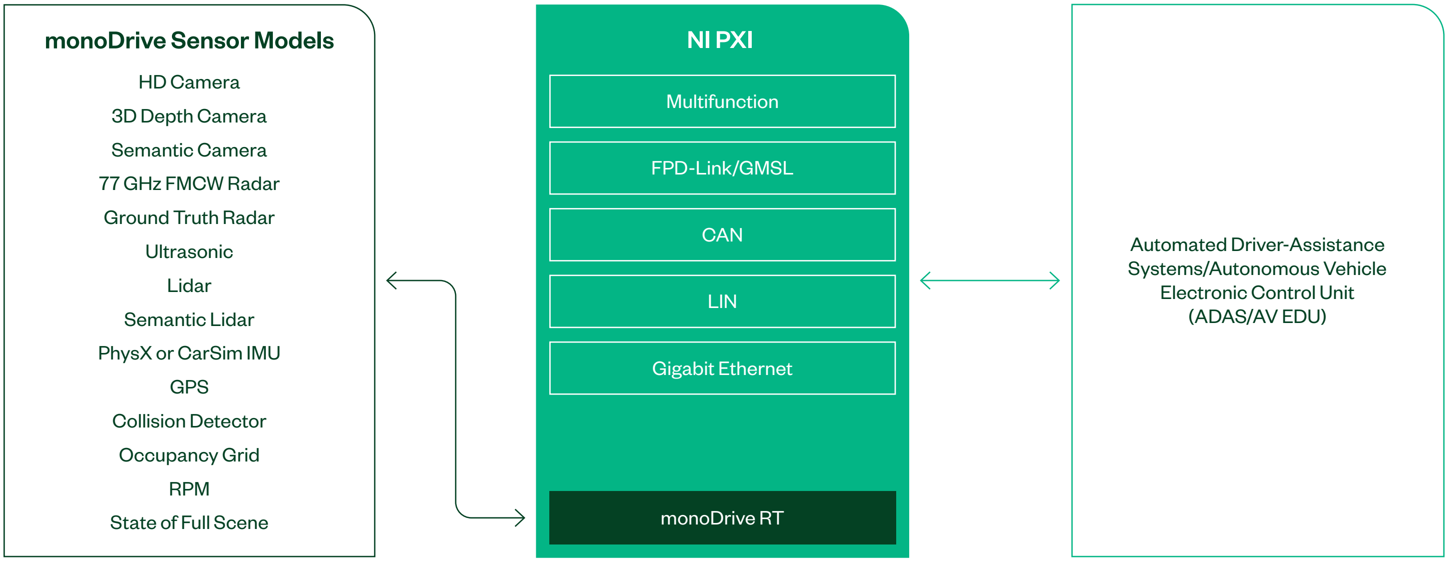


FIGURE 02

System Overview

Radar Sensor Production Test

Radar sensors are a significant ADAS and autonomous driving component that need innovative test for both radar object emulation and RF performance. In addition to accuracy, repeatability, and scalable integration, radar production test volumes require cost- and space-efficient integration into production environments.

Customer Needs

01
High-volume production and automation capability with short cycle time and a design that saves floor space.

02
Highly accurate measurement and calibration offering azimuth and elevation DUT motion in the same test system.

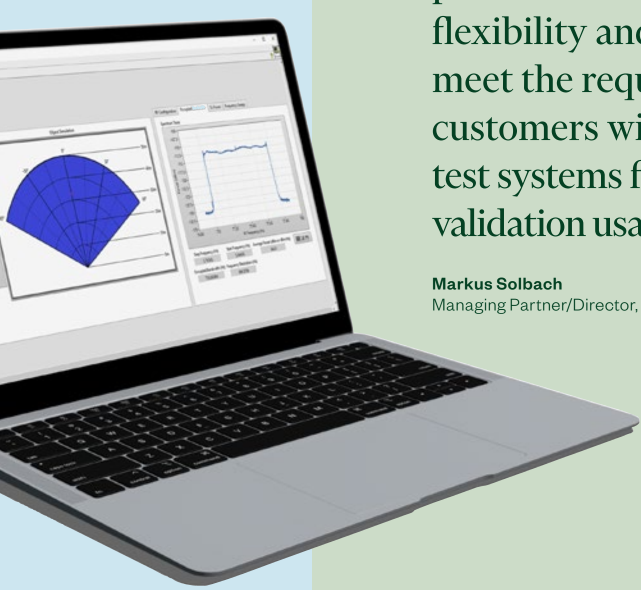
03
Clean anechoic environment and small DUT motion unit for stable and reproduceable measurement quality.

Noffz + NI Solution

01
Vertical design saves up to 70% on the footprint and is compatible with manual and automated DUT test system input.

02
Best reflection suppression and analysis are achieved through a clean anechoic environment and small DUT motion.

03
Two-axis DUT motion for object detection and recognition is designed specifically for a vertical compact antenna test range (CATR) solution.



"With the NI VRTS we have the power in software and hardware flexibility and scalability to meet the requirements from our customers within the latest radar test systems for production and validation usage."

Markus Solbach
Managing Partner/Director, Sales & Marketing, Noffz

THE NOFFZ ADVANTAGE

- Integration of NI Vehicle Radar Test System (VRTS) radar object simulation ranging from 76 GHz to 81 GHz and 4 GHz bandwidth for single- or multi-angular deviating objects.
- State-of-the-art test system that offers best conditions in environmental quality, functionality, modularity, flexibility, accuracy, and cost-efficiency.
- Flexible and modular end-of-line test solutions, including run-in/ screening solution integration for environmental tests.

KEY FEATURES	DUT/RTS Setup	Direct-beam or CATR design
	Internal DUT handling	Automated
	External DUT handling	Manual handling or fully automated with robot or pick-and-place technology
	Frequency ranges	76-81 GHz/24 GHz (other frequencies upon request)
	Radar objects	Single object or multiple angular deviating objects
	Radar object definition	Variable distance, power level (RCS), and object velocity
	Object simulator bandwidth	Up to 5 GHz
	Measurement axis	Azimuth and elevation
	Axis motion	Both axis up to ±90 deg
	Motion accuracy	<0.001 deg position repeatability
RF MEASUREMENT	Frequency domain analysis	EIRP, occupied bandwidth, chirp linearity
	Time domain analysis	Chirp power, power over time
	Chirp analysis	Chirp's rate, length, and rate deviation
	Further measurements	Radiation pattern, noise, spectrum occupancy, beam width
MECHANICS/ POWER	Housing dimensions	800 x 1500 x 2700 mm (WxDxH)
	Setup	Vertical/distance between radar sensor and object simulator 1.0-2.5 m (CATR) available for far-field distances >2.5 m

JAMIE SMITH

DIRECTOR OF RESEARCH, DESIGN, AND PROTOTYPING, TRANSPORTATION, NI

Investments in Vehicle to Everything (V2X) Are Accelerating

We sat down with Dr. Gerd Schmitz, CEO/co-founder of S.E.A., to understand why, after nearly 20 years of exploration, V2X is happening now.

JAMIE SMITH: 5G IS A CURRENT MEGATREND THAT REPRESENTS THE NEXT GENERATION OF MOBILE COMMUNICATIONS. HOW WILL 5G IMPACT AUTOMOTIVE?

Dr. Gerd Schmitz: 5G will close the gap between mobile communication and direct communication, especially in urban areas, where we have good 5G coverage. This will improve local information distribution between the vehicles, traffic signals, and pedestrians as well as infrastructure information over longer ranges such as traffic information and high-definition maps to help guide better traffic flow.

Advanced direct bidirectional communication between vehicles (cooperative V2X) will become possible because of the available bandwidth.

JS: S.E.A., AN NI PARTNER NETWORK GOLD MEMBER, HAS BEEN AN ENGINEERING SERVICES COMPANY FOR 30 YEARS, AND TODAY S.E.A. IS A LEADER IN V2X TESTING SOLUTIONS. CAN YOU SHARE THE PATH S.E.A. TOOK TO BECOME A LEADER IN SUCH A FAST-MOVING AND INNOVATIVE MARKET?

GS: For 25 years, S.E.A. has built test systems mostly for the automotive industry to test electronics like electronic control units (ECUs) and other mechatronic systems. We have also designed communications systems and developed communications IP for satellite, automotive key fobs, and wireless communication silicon.

Vehicle to everything (V2X) communication represented an opportunity to bring these two areas of expertise together. We used our background in automotive and communications as a foundation. We then studied the V2X standards and actively participated in the V2X community. Our experience in automotive and communications technologies enabled us to develop a solution in a short amount of time.

JS: V2X COMMUNICATION IS ONE OF THE SIGNIFICANT TECHNOLOGY TRENDS IN AUTOMOTIVE. CAN YOU DESCRIBE V2X AND WHAT IT WILL ENABLE?

GS: V2X is an obvious idea of collecting information from everything participating in traffic and distributing that information everywhere. V2X uses wireless standards to send information between vehicles and other objects. Unlike sensing technology, which looks at one type of physical characteristic, V2X takes the information at one node and distributes it to all the other nodes. It's a very different approach to improving safety on the road.

V2X can let drivers know about objects hidden by "blind corners" or vehicles rapidly braking that are obscured by weather or other vehicles. It also makes smaller participants' locations known, including motorcycles or pedestrians, ultimately to avoid collisions.

JS: WILL AUTONOMOUS VEHICLES (AVS) USE V2X?

GS: Yes, V2X is critical to provide another layer of information and redundancy to augment and confirm what sensors (radar, lidar, cameras) provide.

V2X will allow AVs to negotiate or communicate intent. The classic example is the four-way intersection where two or more cars arrive at the same time. Today, we make eye contact and wave at someone to go first. AVs will replace gestures with V2X communications.

JS: WHAT ARE THE LATEST DEVELOPMENTS IN V2X?

GS: Regions, specifically China, recently decided to implement V2X broadly. China's Ministry of Industry and Information Technology promoted a V2X standard developed by an automotive working group.

While China has selected one standard, US industry leaders are still debating between two standards: cellular V2X (C-V2X) and Dedicated Short Range Communications (DSRC). An IEEE standard, DSRC is based on Wi-Fi technology. Advancements in DSRC are still in progress and will be included in 802.11bd. C-V2X is a 3GPP standard, which governs mobile communications and 5G. Released in August, 3GPP version 16 uses 5G New Radio and adds capabilities for vehicle platooning and improved error checking.

JS: WHAT ARE THE CHALLENGES IN DEVELOPING AND DEPLOYING V2X?

GS: V2X is complex and, in its core requirements, similar to mobile communications. Each node needs to adhere to the same standard for vehicles to communicate or it will not work. And the systems need to interact in real time in a communication environment that is constantly changing as nodes move in and out of range.

We also need to provide interoperability as vehicles move between regions that use different messages and facility layers. China's V2X messages are different than those in Europe or the United States. We also need a plan for backward compatibility as the standard evolves. Newer cars must communicate with older cars using a prior version of the standard.

JS: HOW IS THE TEST AND MEASUREMENT INDUSTRY ENABLING V2X, AND HOW ARE YOU WORKING WITH NI?

GS: S.E.A. has built systems based on NI hardware and software for 30 years. We applied our experience in NI tools to V2X. We built systems quickly because of the capabilities of NI hardware and software, our knowledge of V2X, and our mastery of NI tools.

Our systems are used by V2X chip providers, automotive suppliers, vehicle manufacturers, and infrastructure providers. We are working together to test the entire V2X chain, from RF measurements to test compliance on components to the evaluation of complete V2X systems. The complete systems need to coordinate and synchronize V2X, GNSS, and vehicle communication. They can simulate hundreds or thousands of vehicles communicating to a single node and scale to meet different requirements. Because we chose a software defined radio (SDR) architecture, we can modify the behavior of systems to meet changing standards or specific end-customer requirements.

By working together, S.E.A. and NI have inspired each other to provide unique V2X testing capabilities faster than either organization thought possible.

DR. GERD SCHMITZ

CEO/CO-FOUNDER
S.E.A.

ISO 26262 Toolchain for ADAS Testing

The autonomous vehicle (AV) industry generally views safety as its primary mission, including the safety of advanced driver-assistance systems (ADAS). Because of this, many industry participants have converged on functional safety and the ISO 26262 standard.

Central to ISO 26262 implementation is an assessment of potential injury to people. It includes a hazard analysis and risk assessment (HARA) that answers the following questions:

- What are the possible hazard events?
- How severe is the possible resulting damage or injury?
- What is the exposure (probability of the event occurring)?
- In the case of occurrence, how controllable is the situation?

ISO 26262 covers electronic/electric (E/E) safety-critical malfunctions associated with a system (learn more at lhpes.com). Additionally, ISO 26262 is only the beginning of a safer AV. The standard satisfies testing autonomous driver levels L0–L2 and partially L3 (conditional automation). Sensors and controls could function perfectly as designed, yet the AV under their guidance could still act in unsafe ways if, for instance, the sensors misinterpret environmental conditions or a human operator intervenes and misdirects the vehicle in some manner.

Examples like these led to the need for the Safety of the Intended Functionality (SOTIF) standard. Originally envisioned to be part of ISO 26262, SOTIF grew into its own standard, ISO/PAS 21448. For levels L3–L5 (full automation), ISO 26262 and SOTIF help to identify and promote low-risk approaches.

ISO 26262 and SOTIF compliance is attained through the entire design-to-test workflow, sometimes referred to as the V diagram.

Design

Automotive designs should follow a safety-by-design approach through which any hazard-causing shortcomings can be evaluated during the early design phase.

During design, the functional requirements to be delivered are clearly defined, and the necessary resulting components are fully characterized. ISO 26262 is full of recommendations and guidelines so that systems embedded in road vehicles will be designed with an appropriate level of rigor for their intended application.

LHP Engineering Solutions provides a gap analysis and recommended action plan with ISO 26262-certified professionals. For example, a company felt it had gaps in its software development. LHP showed the company how to implement a modular software architecture, unit testing, and change management per ISO 26262.

Other best practices include showing customers how to use Model-Based Design (MBD) for modeling their software, enable scale and simulation testing, and use AUTOSAR to standardize the software architecture for an automotive ECU.

Verification and Validation

Verification and validation can be accomplished by simulating various scenarios, laboratory tests like hardware-in-the-loop (HIL) tests, and road tests. Verification proves that the design works and can handle all possible known/unsafe scenarios. Validation then follows to show that the systems are robust enough to handle unknown/unsafe conditions to a point where the residual risk of unintended behaviors is low enough to be considered acceptable.

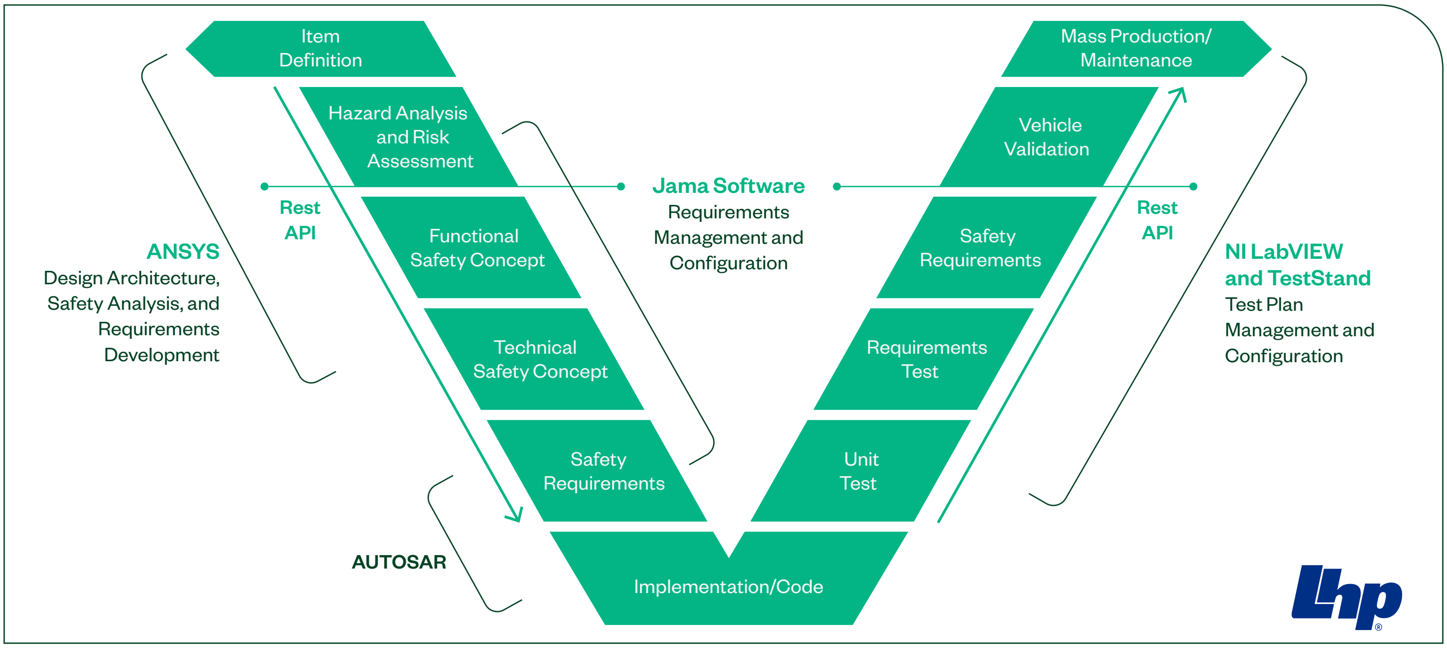


FIGURE 01

LHP functional safety toolchain includes Jama for requirements, ANSYS for simulation, and NI for test.

In general, validation plans declare a certain level of risk as acceptable or reasonable (say, a one in 1 billion chance that harm could occur). The system and its components, such as the sensors, decision-making algorithms, and actuators, are validated against numerous real-life cases to confirm that the defined level of risk will be met.

Consider the validation of a lane-departure warning system. Driving scenarios can be simulated in a controlled environment with various parameters such as road features (for example, turns, crossing, surface condition), environmental conditions, and speed.

The susceptibility of the system to react inappropriately to real-life triggers is identified by analyzing the algorithm and its decision paths. If the lane departure system is found to be sensitive to false artifacts (for instance, changes in paving type), it is probably suitable to include more of these scenario types and/or include more hours of testing to increase confidence in the system and reduce the risk of unintended behavior. With millions of lines of code in AVs, the establishment of automated testing systems and processes is crucial when considering the safety-critical environment.

To physically test the system and include regression and potential dependent failures, test systems create a continuous reduction in “unknown scenarios/risk” before a vehicle gets on the road.

Workflow

To ensure control of the software and managed release to the client, LHP implements an application life-cycle management process. It ensures a robust design-to-test workflow for functional safety.

LHP has further identified a toolchain for working across this workflow. It is a plug-in architecture featuring best-in-class tools such as Jama products for requirements, ANSYS products for simulation, and NI products for test as shown in Figure 01.

NI’s approach is ideal for developing a standardized testing system to perform functional safety tests. LabVIEW, TestStand, and PXI are used extensively in physical laboratory testing including HIL. LHP is also working with members of the NI Partner Network to further enhance its offering for ADAS test and simulation.

To see the tools in action, view the webinar at lhpes.com/webinar/iso-26262-tool-integration.

Authors

STEVE NEEMEH
PRESIDENT, LHP SOFTWARE SOLUTIONS

TONY VENTO
LHP CONSULTANT

US CORPORATE HEADQUARTERS
11500 N MOPAC EXPWY, AUSTIN, TX 78759-3504

T: 512 683 0100
F: 512 683 9300

INFO@NI.COM

ni.com/global – International Branch Offices
ni.com/automotive