AUTOMOTIVE JOURNAL

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Being a Connector Has Never Meant More

At the heart of being an expert connector is the genuine desire to put the whole above yourself. To lead through the challenges of a pandemic, an industry recession, and social injustice, being a connector takes on a whole new meaning. As people, we must connect with our community. As leaders, we must connect with our teams on a deeper, more human level. As technologists, we must connect with our peers and pool our strengths to solve the complex challenges in active safety, vehicle electrification, and V2X connectivity.

We've seen connection play out in recent industry partnerships and collaborations, and these will continue. NI has been active, too, in driving collaborations with industry leaders Amazon and ANSYS and via our acquisition of Optimal+. These collaborations are rooted in a passionate desire to help you overcome your challenges and accelerate the future of transportation by transforming test into a competitive advantage.

Let's engineer ambitiously together.

CHAD CHESNEY
VICE PRESIDENT AND GENERAL MANAGER,
TRANSPORTATION BUSINESS, NI

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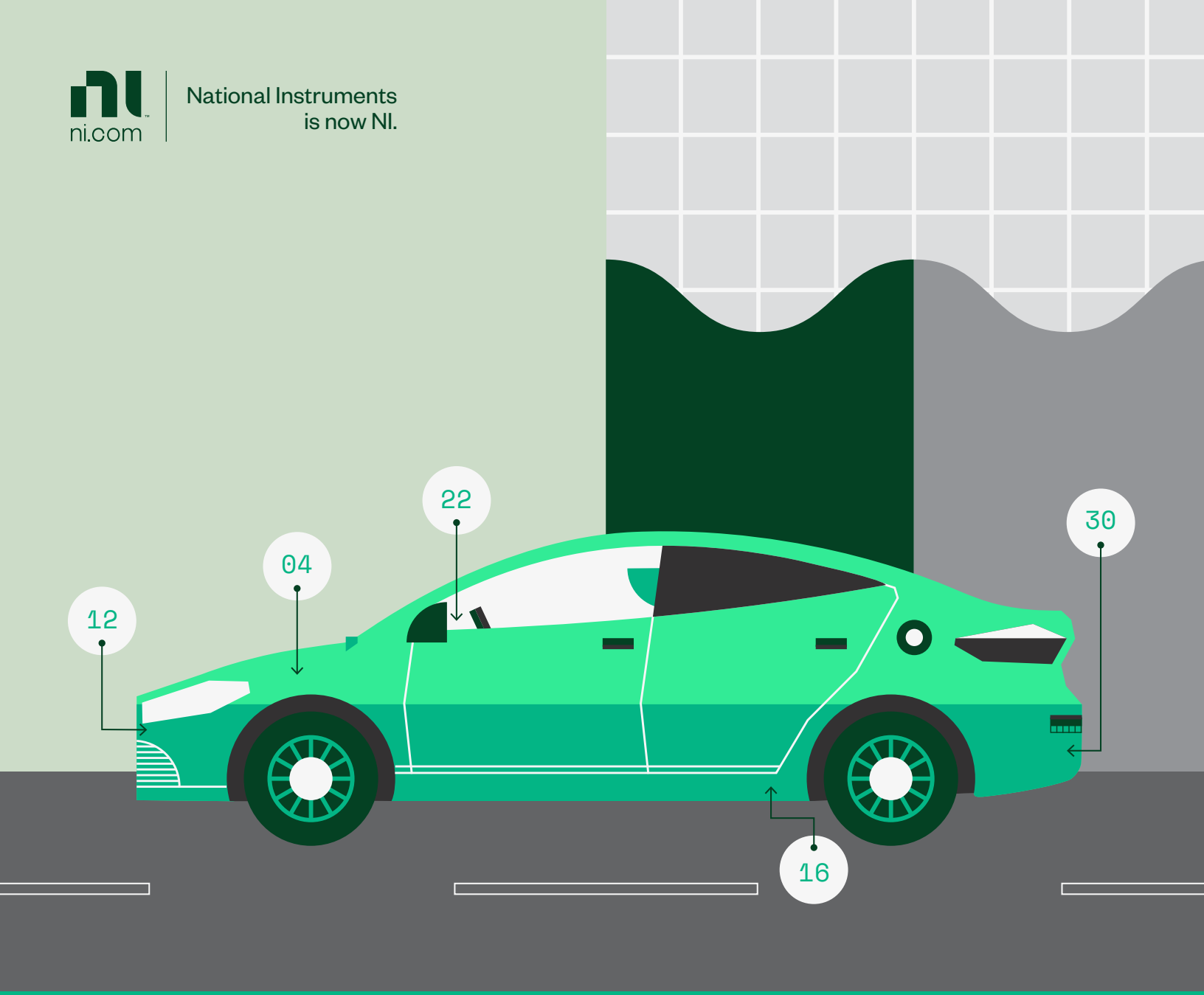
is now NI.



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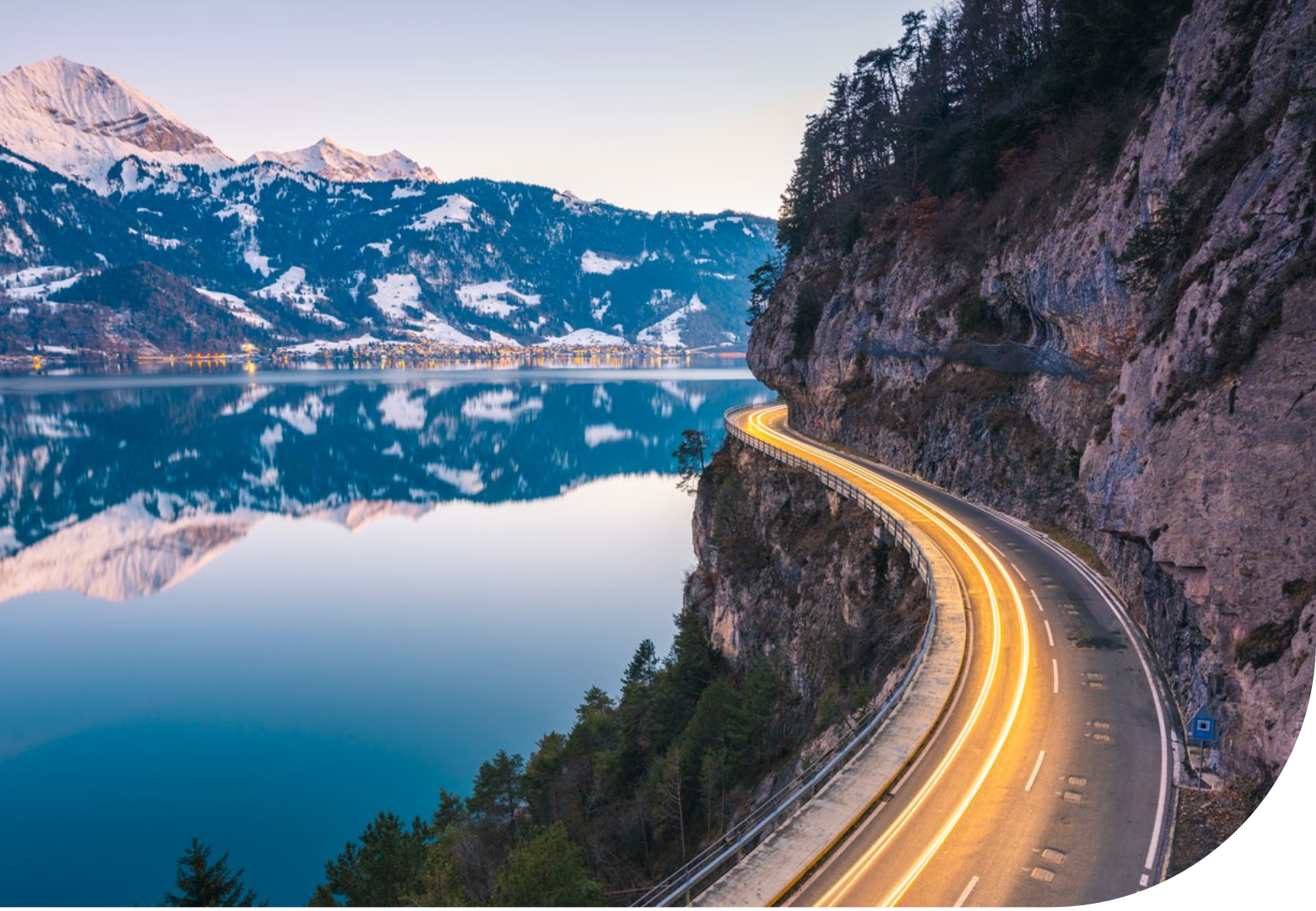


Solve the Data Challenge in ADAS and Autonomy

Autonomous vehicles, once assumed to be right around the corner, are proving to be a much bigger challenge than many predicted just a few years ago. One of the critical barriers in our journey toward autonomy is test coverage: How do we know when we have tested enough for our autonomous vehicle to be safe? Early estimates from RAND Corporation in 2016 found that we needed to drive billions of miles to prove that an autonomous vehicle was as safe as a human, but we quickly realized that the diversity of miles driven is more important than the quantity.

Miles Matter

To achieve this diversity of miles and test for the right miles, companies focus on implementing robust processes at all development phases for autonomous driving (AD) software and advanced driver-assistance systems (ADAS). For example, testing varies during development stages and can require the capability to perform thousands of parallel simulations for fast time to results. An effective test setup also must have the tools to store and analyze many petabytes of drive logs and conduct integrated and connected workflows for hundreds or thousands of developers and engineers around the world. A best-in-class collaborative development platform needs to support peak usages of thousands of graphics processing units (GPUs) for model training as well as millions of central processing units (CPUs) for processing and validation functions. As expected, the cost of these requirements must also scale up or down effectively as the needs of the project evolve and organizations seek a lower total cost of ownership (TCO).

Assessing the right miles with a comprehensive collection of tests ensures that the autonomous vehicle (AV) is ready to handle the complex scenarios that the world will put in its path. As of this writing, the industry is still trying to define those scenarios, but we know that they need to fully exercise the planning and decision-making algorithms, along with the perception algorithms that tell the vehicle what is happening around it.

These perception algorithms are typically machine learning algorithms that need to be trained and tested with real-world data to ensure that they correctly identify the world around them, regardless of the environmental conditions.

The Data Challenge for ADAS/AD

As we develop the collection of tests and gather the real-world data, a critical problem is that we don't know what we don't know. That makes the challenge of creating a comprehensive set of real-world scenarios impossible. There are methodologies using synthetic simulations, but real driving is always necessary for validation and verification. Driving vehicles around in different environments is an important method for identifying new scenarios, and recording data from these drives enables us to gather the real-world sensor data needed to train the algorithms as we encounter new scenarios. Quality data capture systems give us extremely valuable insight into exactly what the car "saw," which will enable us to thoroughly exercise our AD software to ensure that it makes the right decision in the future.

Recording data from the entire sensor suite is easier said than done. Vehicle configurations regularly include many high-definition cameras as well as multiple radars and lidars. These sensors generate vast amounts of data that must be acquired, synchronized, and stored at extremely high rates often exceeding 6 GBps. Also, test-drives are frequently implemented for several hours at a time to collect as many unique scenarios as possible in a given period. To effectively gather the volumes of synchronized, complex data from real-world test vehicles, we need data recording platforms that scale up and down very quickly and cost-efficiently for different data storage, access mechanism, and power consumption requirements.

This combination of challenges for recording in-vehicle data across a large fleet of vehicles has created a data explosion that pushes organizations to rethink their whole data strategy.

WE NEED TO BE SMARTER ABOUT HOW WE CAPTURE, STORE, MANAGE, AND USE DATA AS WE MOVE STEADILY THROUGH THE PETABYTE AGE.

This is further complicated by changing business and technical requirements for ADAS/AD development projects and a need for business agility in the solutions used for the development platforms.

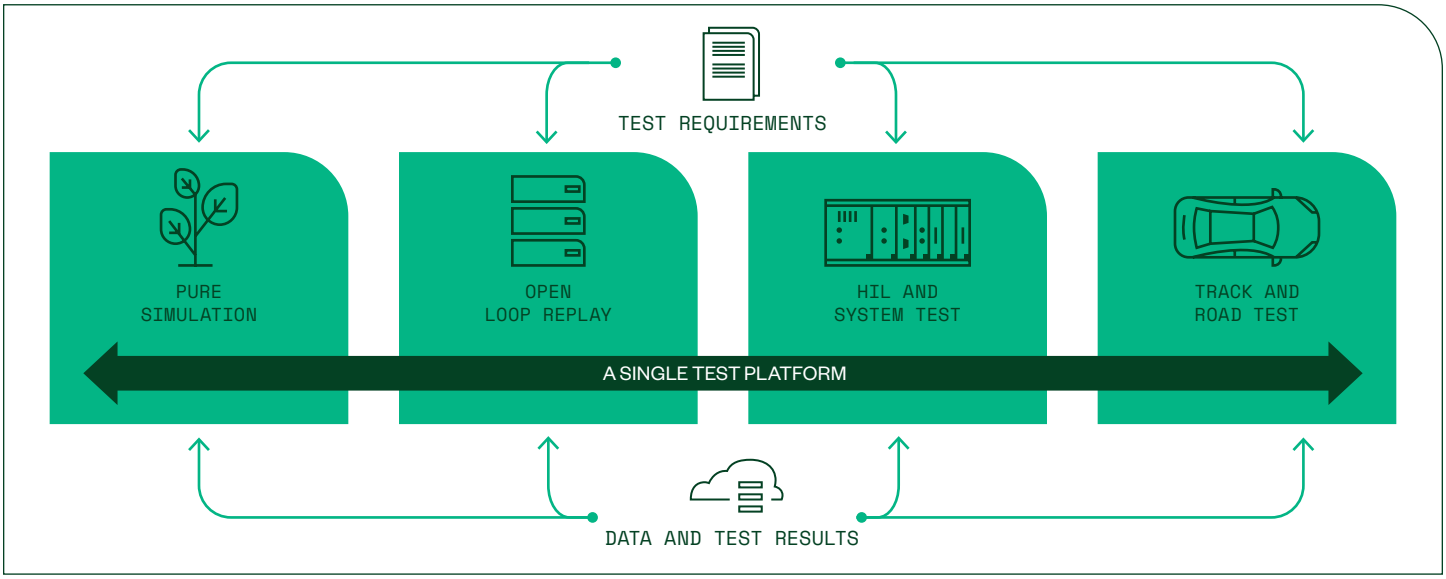


FIGURE 01

To test the right miles, we often require cloud services and edge computing to sustainably record and replay real-world data scenarios in ADAS/AD validation phases.

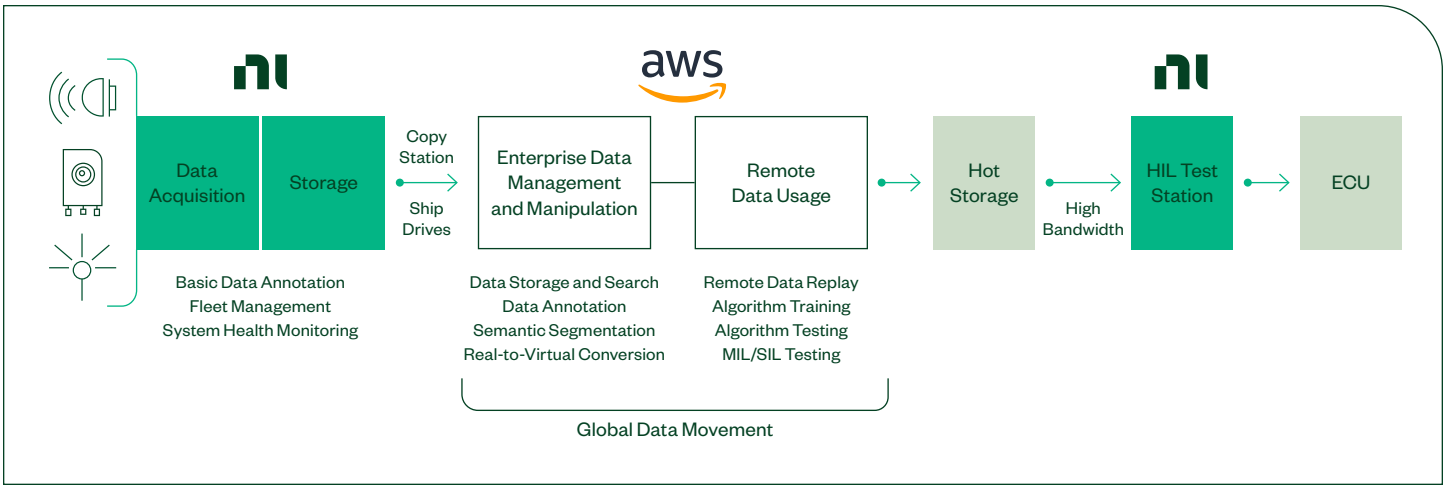


FIGURE 02

Data recording systems, edge computing, and cloud services work together to provide end-to-end solutions from the sensor to the ECU throughout the ADAS/AD validation process.

If we also consider that the data recording system must support continual deployment of improved features and enhancements to the vehicles, future needs become somewhat unpredictable. The data explosion and unpredictability are quickly leading companies developing ADAS/AD features to use a combination of edge computing and cloud services such as Amazon Web Services (AWS).

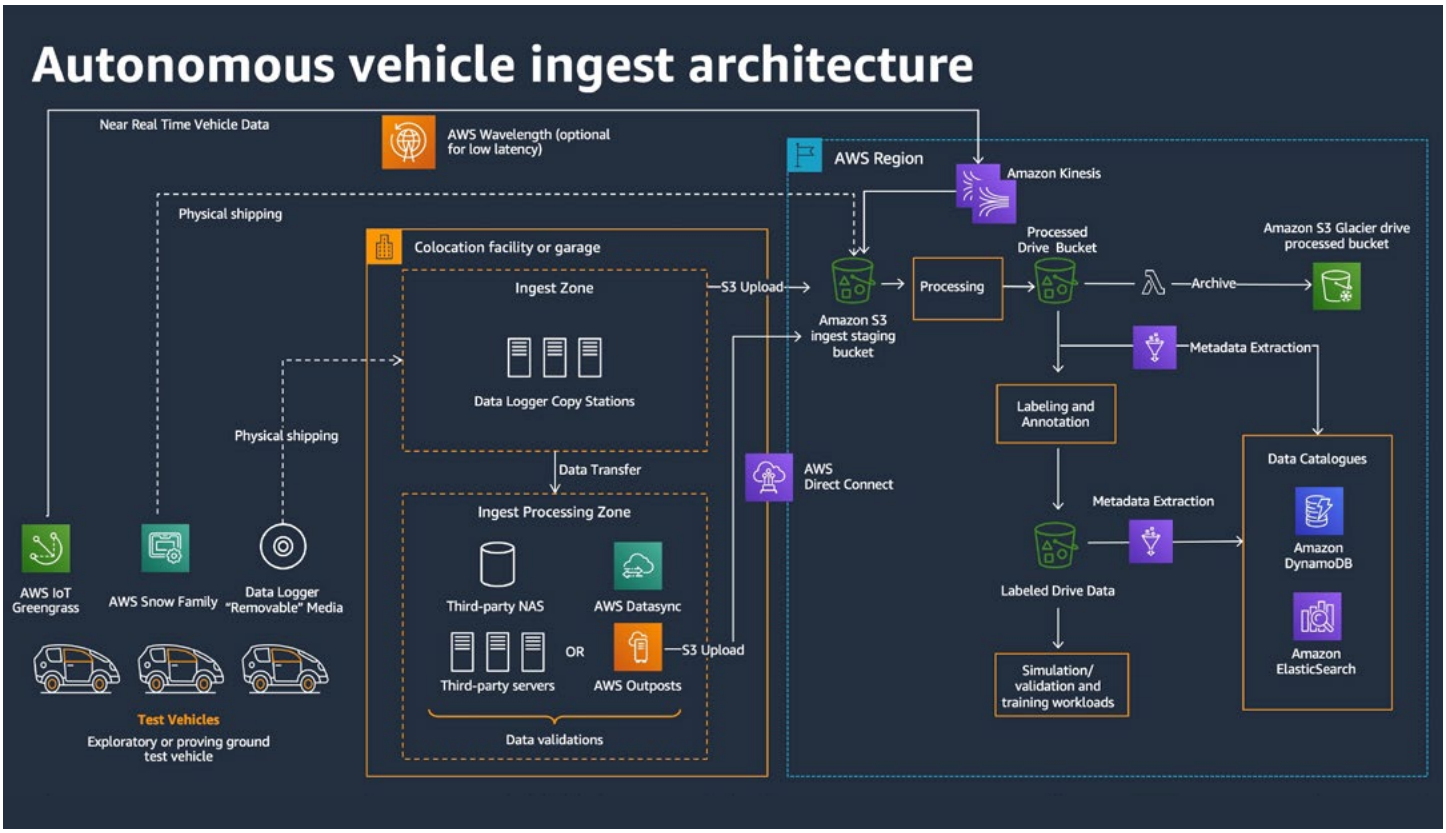
Edge Computing and Cloud Services to Solve the Data Challenge

As explained above, the ADAS and AD development workflow requires test vehicle drive-log data. This drive-log data is captured with a data recording system that formats and synchronizes the raw sensor, inertial measurement unit (IMU), and CAN bus data in the test vehicles for use in test and development. The data recording system case typically has removable media and/or can be connected to edge computing devices such as AWS Snowball Edge or AWS Snowcone. These devices are provided as an AWS offering with built-in security, compute, and storage (8 to 80 TB) functionality, and the end-to-end logistics to be shipped directly to AWS for data ingestion into Amazon Simple Storage Service (Amazon S3).

The multi-terabyte AWS Snow family of devices provides a secure, cost-efficient, and easy approach to moving data from test vehicle loggers to AWS without network usage during the road tests. In some use cases when test vehicles require high data throughputs (up to 50 Gbps) or present space and power limitations, the Snow family of devices may not be the best fit; using removable media in the data logger is better. We see customers take advantage of Amazon Direct Connect for their ingest of test vehicle data in smart garages or data center locations to achieve high-bandwidth, dedicated network connections to AWS with lower cost, lower latency, and higher security. When test vehicles are more exploratory, the data logger removable media is shipped back to these ingest sites. Some customers also leverage cellular links in the vehicles to ingest snippets of drive-log data and telemetry for these test vehicles over the air. The Illustration from AWS on page 7 shows an example of these architectural patterns.

ONCE THE DATA IS ON AWS, DEVELOPERS, RESEARCHERS, DATA SCIENTISTS, VALIDATION ENGINEERS, AND OTHER GROUPS CAN PERFORM FURTHER PROCESSING, ANALYTICS, AND VISUALIZATION TO QUICKLY AND EASILY MAP SCENES FROM DRIVE LOGS FOR THEIR SPECIFIC NEEDS.

Other simultaneous development activities that use drive-log data include massive simulations involving log replay or synthetic simulations for development and validation purposes. These use hardware-in-the-loop (HIL) validation approaches via hybrid architecture constructs. The data pipelines can incur input/output from the storage systems in terabits per second (Tbps) or petabytes per second (PBps), which points to a highly scalable storage subsystem. This is another reason why many companies are using and evolving to AWS for these workloads.



The Next Data Challenge: Data Replay

Recording, analyzing, and storing the right data are just the initial challenges in ADAS/AD development. The next one is using that data to train and test embedded software. Sensor data replay and HIL testing are necessary to validate ADAS/AD software. A common toolchain for synchronized data replay and high-fidelity environmental simulation enables us to dramatically expand test coverage without a huge increase in capital expense. Using a common framework to host large repositories of sensor data, support complete virtual environments in AWS, stream data to HIL systems such as NI's, and conduct both replay and HIL testing ensures a cost-optimized approach for maximum test coverage.

Until we close this loop between data recording and replaying, we cannot reach our test coverage goals. We also need to monitor key performance indicators including cost, development time, and scalability. NI firmly believes that partnerships between industry leaders are the best path to develop AVs.

WE ARE PROUD OF OUR PARTNERSHIPS WITH INDUSTRY LEADERS LIKE AWS THAT PROVIDE A COMPREHENSIVE, END-TO-END SOLUTION FOR SUCCESSFULLY TESTING AVS.

NI is working with AWS to validate using Snow devices with NI loggers, copy stations, HIL rigs, and other tools needed downstream for further analysis. This gives NI customers the flexibility they need to determine their ideal solutions.

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Connecting Design and Test Workflows through Model-Based Engineering

The interlock between design and test teams remains a friction point and an area of inefficiency in the product development process. NI and MathWorks recognize this and are collaborating to improve the design-test connection using model-based engineering. We aim to connect design and test teams with a digital thread to speed the development process, increase design and test iteration opportunities, and move test earlier in the development process.

Roadblocks to an effective interlock include:

- Adapting the algorithm for real-time execution—A model often must be compiled from the design software running on a development machine before being imported and used on a real-time controller running test software.
- Determining the best way to interact with design models.
- Instrumenting the code to get meaningful results.
- Accessing the hardware or the lab.

Consider the work of Dan, the design engineer, and Tessa, the test engineer. Dan writes algorithms for hybrid electric vehicle (HEV) system control. He spends his day in MathWorks MATLAB® and Simulink® software and doesn't know that much about real-time implementation. He's currently working to update controller code to incorporate a new sensor input.

Dan gives his design to Tessa without much collaboration ("throws it over the wall"). Tessa tests ECU control software and I/O using hardware-in-the-loop (HIL) testing methodology and tools. She spends her day with NI hardware and software test systems. She doesn't know that much about control algorithm implementation. She's currently tasked with testing the new system for HEV control that Dan's been working on. Lacking integrated tools, Tessa can't easily get Dan's new update to run in the test system.

Does Dan and Tessa's interaction sound familiar? It's an illustration of all-too-common barriers to effective collaboration between design and test teams.

Many of our customers face similar problems arising from these friction points between design and test teams:

- Exchanges between teams without collaboration ("Throwing things over the wall")
- Version compatibility
- Poorly documented or undocumented workflows
- Platform issues between design tools and test tools (Windows/Linux, desktop/real-time, 32-bit/64-bit, compiler differences)

These challenges prevent organizations from achieving the goal of full-coverage testing with best-in-class methods.

Most engineers want to test as much as possible because of the hidden costs and risks associated with less testing: the cost of rework, issues found in the field leading to liability concerns, recalls, and brand image and market share impacts. But resources such as time (schedule), costs (budget), and people (expertise) are limited, so more testing is usually not possible past a certain point by throwing more resources at the problem. Instead, that movement is achieved by fundamentally changing test methodologies and processes to become more efficient within existing constraints. The ability to make this shift is a significant competitive advantage because it involves doing more with less, minimizing risk, and maximizing quality and performance during a program.

Connecting design and test through model-based engineering is one fundamental way to improve design and test efficiency that leads to second-order effects. It provides the ability to move test earlier in the development process (from the track to the lab and from the lab to the desktop), so engineers can find errors earlier, debug algorithms faster, and iterate through the design/test cycle more quickly.

Establishing this digital thread, this common language teams use to communicate, starts with making toolchains interoperable.

Teams need a translation layer to enable bidirectional communication of information, which reduces rework, troubleshooting, and

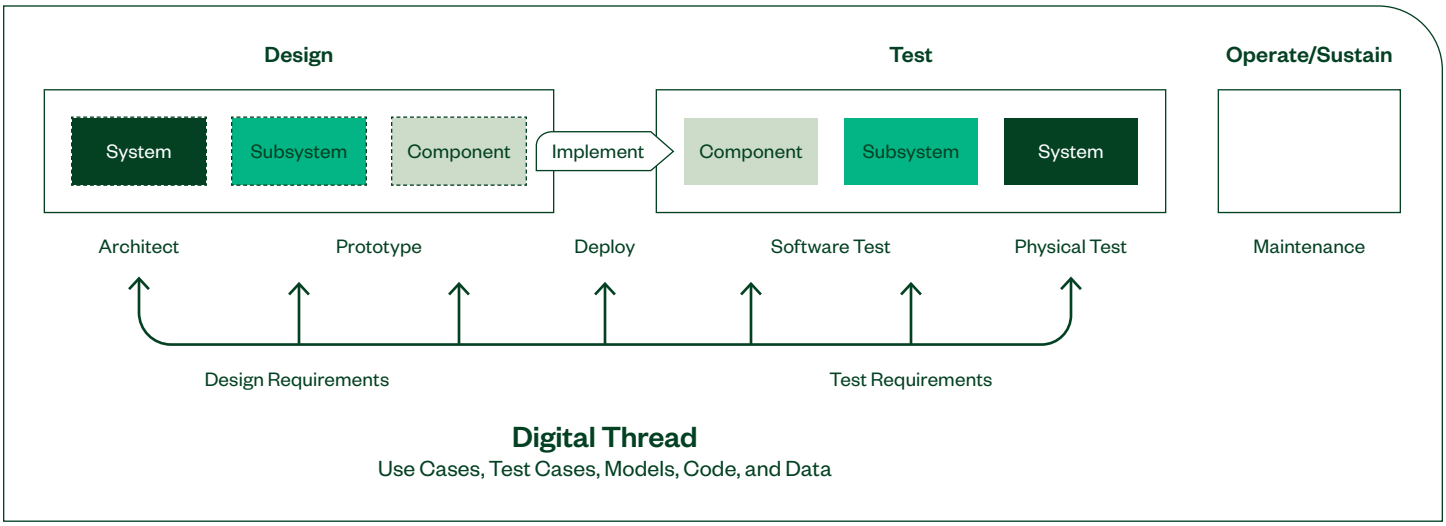

FIGURE 01

Connecting design and test teams with a common digital thread improves development efficiency.

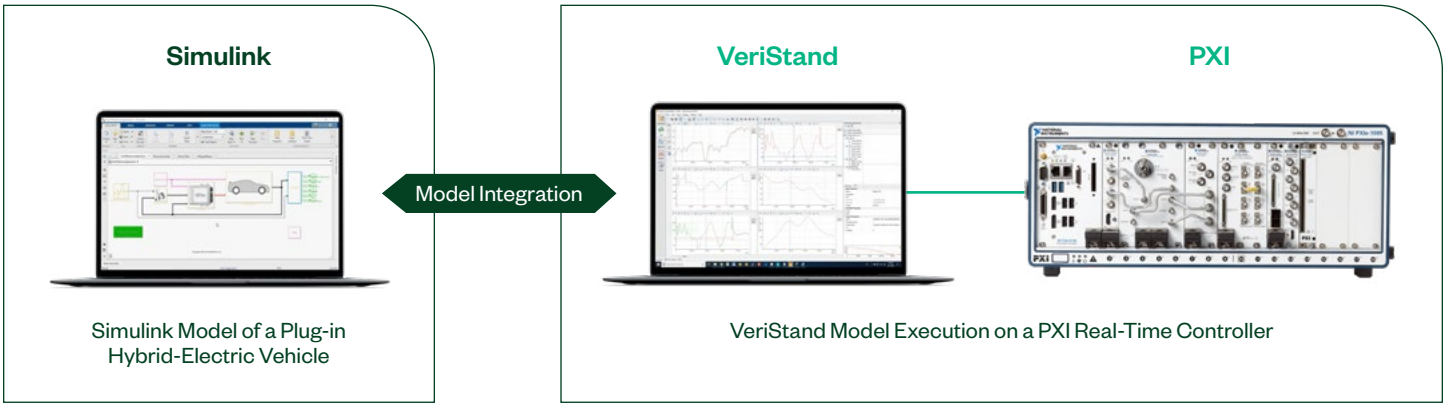

FIGURE 02

Model integration between MathWorks Simulink and NI VeriStand is the key to connecting design and test workflows.

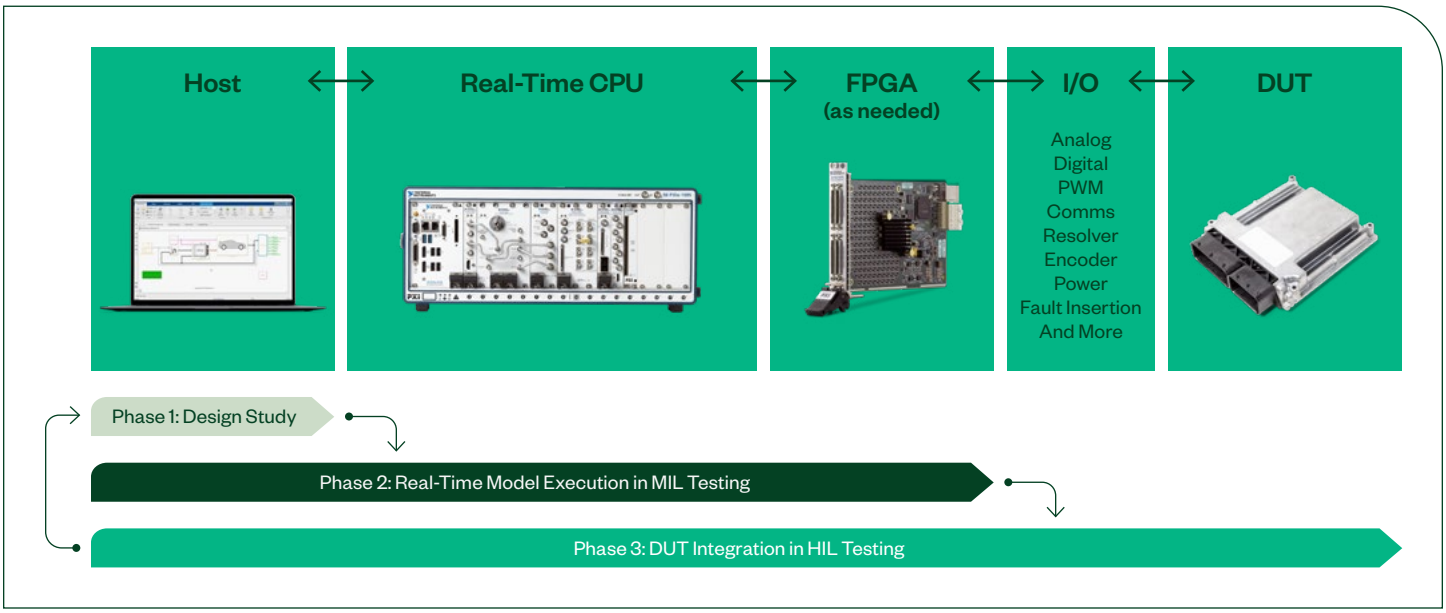

FIGURE 03

This example of a joint workflow incorporates models from design to test with interoperable tools to allow for quick iterations through the development process to fix bugs or optimize performance.

reimplementation. MathWorks and NI are working on this because we recognize that models are a primary method of communication between the design and test worlds.

Models are rich in information. They describe the behavior of the system and provide the basis for building test cases and quantifying test requirements. Integrating the same models used for design into test allows for a common platform to evaluate performance and simulate/emulate the world around the devices and components under test. This frees test teams from tool-imposed requirements and enables them to speak the same language as the designers.

Establishing a digital thread between teams using models as a primary means of communication improves development efficiency. It connects design and test workflows with interoperable tools developed to work together. This solution helps Dan and Tessa work together more closely, test more often, and give their organization a competitive advantage.

MathWorks and NI have improved compatibility between Simulink and VeriStand. We now have lock-step releases (for example, MATLAB R2020a release compatibility with VeriStand R2020). And we are collaborating on further improvements like automating more of the joint workflow that is manual today and providing deeper access to signals and parameters in the model hierarchy.

To learn more, you can read about our collaboration on both mathworks.com and ni.com. We'd love to hear about your experiences and needs in connecting MathWorks design tools and NI test tools to continue improving the workflow and tailoring our roadmaps to your specific projects.

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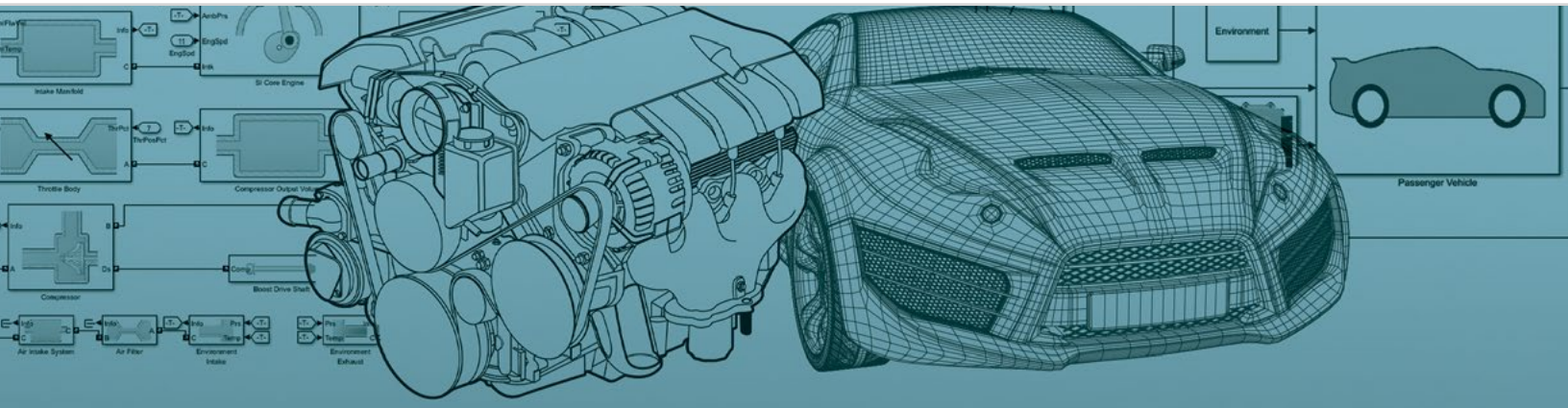

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“What’s remarkable about our collaboration with YEA and NI is the short time to market we achieved, such that other Russian companies are looking into also including HIL testing in their processes.”

Nikolay Mezentsev
Head of the Department of Intelligent Vehicles, NAMI

Challenge

Establish a first-of-its kind advanced driver-assistance systems (ADAS) test laboratory to test ADAS ECUs, radars, cameras, and ADAS features both separately and together using hardware-in-the-loop (HIL) test methodologies and enable autonomous vehicle testing from lab to road in Russia.

Solution

Connect NI Partner YEA Engineering’s expertise with NI’s toolchain to design, build, and deploy Russia’s first ADAS closed-loop HIL system that allows the Central Scientific Research Automobile and Automotive Engines Institute (NAMI) and its suppliers and customers to test their ADAS features in a controlled lab environment, minimizing the time and resources they spend on real-world drive tests.

Building an ADAS Test Lab with an HIL Solution

Established 100 years ago, NAMI is the leading automotive R&D center in Russia. Its services have expanded from design and test of electronic and mechanical components to the development of software and full vehicles. One recent example of NAMI's automotive development capability is AURUS, a new fleet of luxury vehicles originally created for the government that will eventually become available to the public.

As we've learned from the experience of all global automakers, designing and manufacturing a vehicle require many engineering resources and much expertise. From electronic design to scenario creation for testing algorithms in simulation, the process of bringing ADAS functions to market is complex and demanding. This type of expertise is not always available in-house, which makes collaborations critical to the success of such projects. Starting in 2014, NAMI began exploring integrating ADAS and autonomous vehicle functions in AURUS, and so far the institute has successfully developed safety functions like adaptive cruise control (ACC) and autonomous emergency braking (AEB). NAMI is now working toward the next set of autonomous functions, which involves connecting with the right partners to deliver on all ADAS safety expectations.

In 2020, NAMI collaborated with YEA Engineering, an NI Partner, to create Russia's first ADAS closed-loop HIL system for testing:

- NAMI's ADAS ECUs with an HIL approach
- Automotive radar with active object simulation
- Camera functionality with optical projection
- ADAS sensor fusion

Additionally, the system installed at NAMI is scalable to add an automotive lidar environment simulation system and a GLONASS/GPS signal simulator, making it ideal to serve current needs and prepare NAMI for future autonomy test requirements.

For NAMI, the reduction in the time to market was remarkable because it involved the whole process from the creation, programming, and validation of NAMI's ADAS ECU to the development of a test plan that covered standard and corner scenarios not possible to create with road testing. This increased NAMI's confidence in the reliability of the ADAS features in AURUS.

YEA Engineering's ADAS Closed-Loop HIL Test System combines NI's commercial off-the-shelf components with the flexibility to customize the solution to NAMI's needs so the institute can test autonomous vehicles from lab to road in the future.

In addition to automotive development, NAMI performs automotive industry activities including standardization and certification, the operation of the Centre for Automotive Vehicle Testing and Refinement, and the fostering of automotive development by cooperating closely with all main Russian OEMs and Tier 1 suppliers. For those activities, having the right connections between industry players, technology, expertise, and research is increasingly important and can mean the difference between meeting time-to-market goals and becoming a leader or trailing behind in the industry.

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FSUE «NAMI»
MOSCOW

Industry:
AUTOMOTIVE, RESEARCH

Application Area:
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NI PRODUCTS USED:

- Automotive Communications
- NI Vehicle Radar Test System
- NI RF Instrumentation

ADAS-HIL Platform

YEA ENGINEERING

1 Hardware-in-the-loop system for ADAS ECUs

2 Automotive RADAR Target Simulation System

3 Camera Optical Projection System

4 Automotive LiDAR Environment Simulation System

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AUTOMOTIVE SOLUTIONS

Accelerating Digital Transformation with Test Innovation and Advanced Product Analytics

We sat down with Uzi Baruch, former general manager of the Electronics Business Unit at OptimalPlus (O+) and current vice president of Enterprise Software Solutions at NI.

KEVIN LAPHAM, SENIOR DIRECTOR, TRANSPORTATION PRODUCTION TEST, NI: HI, UZI. THANKS FOR BEING HERE AND WELCOME TO THE NI FAMILY! WE'RE REALLY EXCITED TO HAVE OPTIMALPLUS BECOME A PART OF THE EVOLUTION OF NI BY BRINGING PRODUCT LIFE-CYCLE ANALYTICS TO OUR PLATFORMS. COULD YOU EXPLAIN A LITTLE ABOUT THE HISTORY OF O+?

Uzi Baruch: O+ was born out of the idea of integrating big data and machine learning in manufacturing because there is a huge need for this across most industries. Though we started out in the semiconductor space, as our founders had spent many years in that industry, we realized that there was a need for this type of product in other verticals like automotive and electronics. This brought about new challenges because auto and electronics are much more diverse than semi, but it gave us the opportunity to create a new set of technologies based on our foundation to bring a truly unique product to market. From the beginning, our guiding star has been to give customers the ability to improve their product quality while reducing product costs. Now, with NI, we'll be able to scale our offerings and extend into new markets as well as integrate NI's expertise in design and test with our high-volume manufacturing solutions to provide a complete product life-cycle solution.

KL: THAT'S VERY INTERESTING THAT YOU WERE ABLE TO MOVE FROM SEMI INTO OTHER MARKETS SUCH AS ELECTRONICS AND AUTOMOTIVE. WHAT ARE SOME OF THE O+ PLATFORM ADVANTAGES THAT ENABLED THIS TRANSITION?

UB: It comes down to our major differentiation—that we perform analytics on not just test data but the full product life cycle, from the design and validation data to the components and consumables to the in-use data and everything in between. This gives our customers a truly complete picture of their manufacturing and design processes. We have a few key technologies, like our Unified Data Model and Rules+, that enable customers to get what they need from a platform like this. Both technologies allow us to deploy some truly unique capabilities to our customers, like adaptive manufacturing, which reduces the time to action in the factory. Rules+ allows us to deploy edge machine learning algorithms directly into the factory so they can be incorporated into the manufacturing process. In the end, this allows our customers to reduce the cost of producing their products by reducing scrap and increasing efficiency while improving quality at scale.

KL: SO THE ADVANTAGES ARE IN BEING ABLE TO NOT ONLY COLLECT THE DATA AND ANALYZE IT BUT ALSO DRIVE AUTOMATED ACTIONS BACK TO THE EDGE. DO YOU HAVE ANY EXAMPLES WHERE YOU'VE BEEN ABLE TO DEMONSTRATE THIS WITH CUSTOMERS?

UB: We've had a number of successful deployments over the years since we started moving into automotive and electronics. Working closely with these customers, we were able to combine our domain expertise in automotive and electronics manufacturing data with their expertise in their processes to give them actionable insights. For instance, we've been able to deploy an adaptive manufacturing solution for automotive camera, specifically for lens alignment. Essentially, we've been able to automate a complex analysis and decision-making process that required an experienced engineer to spend many hours weekly and had a long feedback loop. By deploying this solution into the edge, we've shortened the feedback time from days to hours while reducing scrap and improving efficiency and quality.

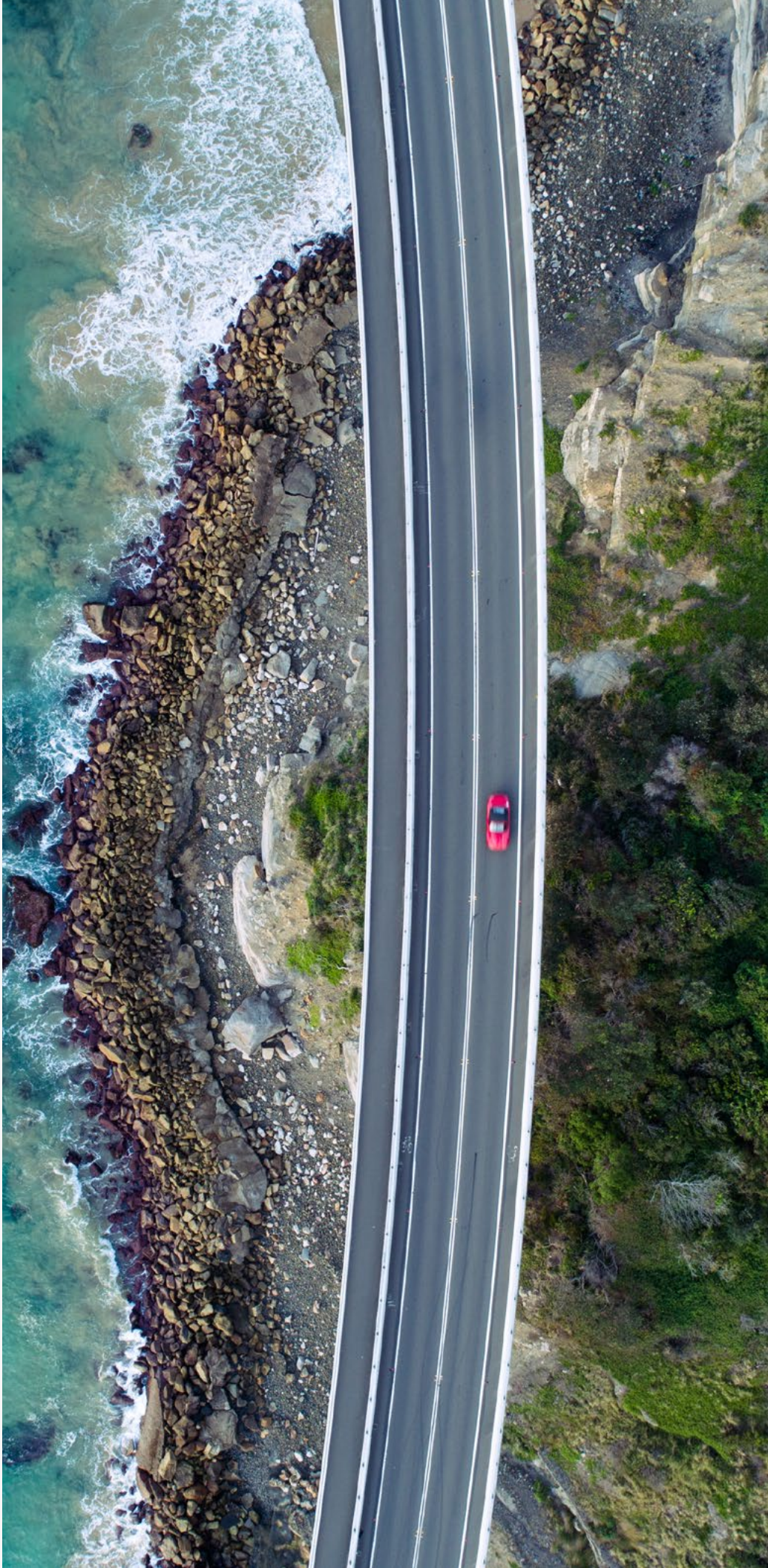
Having insight from data isn't enough; you must take action on that insight in meaningful and rapid ways. The partnerships that we've developed to support specific features and use cases for each of these customers improve our product and drive more value for our partners.

KL: ARE CUSTOMERS REQUIRED TO USE ONLY O+ TOOLS OR DO YOU INTEGRATE WITH OTHER STANDARD TOOLS AND PLATFORMS?

UB: We have an open platform concept that allows us to integrate with any tools, systems, or platforms that a customer is currently using. What this means is that our customers don't have to replace their existing tools and infrastructure. They can easily integrate with our platform via APIs and other partner integrations, whether it's a BI tool, MES, cloud platform, ERP, ML platform, etc. So, if the customer has an existing BI tool like PowerBI or Tableau, they can keep using it while still gaining the benefits from having the O+ platform, like Rules+, and all the data in one place. If anything, it actually makes the existing tools more powerful because O+ automates and simplifies the data collection and preparation required to do the powerful analytics needed in today's market, and still allows for actions to be taken at the edge based on those analyses. We focus on making it easy for our customers to adopt our platform.

KL: LET'S DIVE INTO THE NEED FOR LIFE-CYCLE ANALYTICS. WHY IS IT IMPORTANT FOR ADAS/AD DEVELOPMENT AND VALIDATION CUSTOMERS?

UB: The thousands of sophisticated parts in ADAS/AD electronics are produced and assembled into vehicles by a wide variety of suppliers with



disparate factories resulting in heavily siloed critical information that is difficult to analyze. In order to combat this and make sure that the complexity is being managed, the data needs to be housed under a single roof, cleansed, and prepared to be able to draw the powerful insights that big data is known for.

Life-cycle analytics is a comprehensive solution for detecting manufacturing issues in real time while parts are being developed or in use, improving the safety and reliability, which ultimately lead to the quality, of the vehicles. Quality can be expensive, and using the life-cycle analytics solution can help reduce the costs of these critical systems by reducing scrap and improving overall equipment effectiveness (OEE). Additionally, safety is a significant concern for our customers as they push further into autonomy. Specifically, our customers need to have predictable and repeatable processes, connected to the in-use data, to ensure that every vehicle's systems are working at peak performance, so that the end customer has absolute confidence in these products.

UB: Actually, I have a couple of questions, if you don't mind changing places. With the drive for digital transformation in the industry, how do you view the integration of the O+ and NI platforms?

KL: TEST DATA ONLY TELLS YOU WHETHER SOMETHING WENT WRONG IN PRODUCTION; HOWEVER, TO UNDERSTAND WHY IT HAPPENED, YOU NEED TO LOOK AT THE ASSEMBLY, THE PRODUCT, AND SUPPLY CHAIN INFORMATION. NI HAS A GREAT TOOL FOR MANAGING TEST DATA AND EXECUTION, WHICH GET TO THE WHAT PART. AND WITH O+, WE CAN ADDRESS THE WHY OR HOW PARTS OF THE EQUATION. THE COMBINATION OF A TOOL THAT GIVES NI'S CUSTOMERS ACCESS TO A SUITE OF TEST MANAGEMENT RESOURCES THROUGH NI'S LEGACY PRODUCTS WITH THE ADVANCED ANALYTICS AND ACTIONS OF THE O+ PLATFORM CREATES A ONE-STOP SHOP FOR ANYTHING RELATED TO TEST AND MANUFACTURING DATA ANALYTICS.

UB: So it's the idea of the whole being greater than the sum of the parts. Based on that, what are the next steps at NI toward realizing those outcomes?

KL: THROUGH THE ACQUISITION OF O+, NI IS UNIQUELY POSITIONED TO HELP CUSTOMERS ACCELERATE THEIR DIGITAL TRANSFORMATION INITIATIVES BY COUPLING OUR LEADERSHIP IN TEST OPERATIONS WITH NEW ADVANCED PRODUCT ANALYTICS FOR ENTERPRISES. THIS, IN TURN, WILL ENABLE ORGANIZATIONS TO CONNECT DESIGN, TEST, ASSEMBLY, MEASUREMENT, AND IN-USE DATA FROM REAL-WORLD DEVICES TO HELP GET TECHNOLOGIES TO MARKET FASTER AND LOWER THE COST OF TEST. ADDITIONALLY, NI'S GLOBAL FOOTPRINT AND DIVERSE CUSTOMER BASE WILL HELP O+ SCALE MORE QUICKLY AND DELIVER THE POWER OF BIG DATA AND MACHINE LEARNING TO IMPROVE METRICS LIKE OEE, WARRANTY CLAIMS, AND SCRAP TO OUR CUSTOMERS FASTER.

To help drive this forward, O+'s capabilities are being integrated with NI's products, delivering additional value to NI's production test and validation test customers. For example, we already have a tight integration between NI's Technical Data Management Streaming (TDMS) data format and the O+ unified data management (UDM), simplifying the data pipeline and allowing us to deploy faster.

The idea is that we want to connect everything from design and validation test to in-use production data and make the process of producing automotive products simpler and more efficient while improving quality and safety. That's where O+ with NI can really make a significant impact in the market!

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INNOVATION IN TEST

ZHENG KAI
CEO, RADSYS

Connecting Industry, Government, and Research for Increased Safety in China

Our team talked to Zheng Kai, CEO of NI Partner Radsys in China, to discuss its role in creating a test standard for millimeter wave (mmWave) radar that was recently published for the Chinese automotive industry.

XIAOCHENG TANG, FIELD MARKETING MANAGER, TRANSPORTATION, NI: WHAT'S THE STATUS OF MMWAVE RADAR IN THE CHINESE AUTOMOTIVE INDUSTRY RIGHT NOW?

Zheng Kai: mmWave radars are booming in the Chinese market, specifically the 77 GHz radar, which has gradually become mainstream in the industry. With the continual improvement of automotive safety standards, mmWave radar will increase its market share and, with it, the demand for more efficient, scalable test.

XT: HOW IS RADSYS CONTRIBUTING TO THE EFFICIENCY AND SCALABILITY OF RADAR TEST IN CHINA?

ZK: We are actively involved with the industry, and, most recently, we contributed to the creation of the T/CAAMTB 15-2020, a test standard issued by the China Association of Automobile Manufacturers that stipulates the test condition, performance, transmitter, and electrical characteristics to test mmWave radar.

XT: HOW EXACTLY IS THIS STANDARD IMPACTING RADAR TEST?

ZK: Before the standard was published, it was necessary to collect the common requirements and product specs from ADAS R&D teams, component manufacturers, module design teams, etc., and then define a test plan for it that was effective and repeatable. This fragmented process was simply not scalable and was limiting our capacity to test mmWave radar in the volumes the industry demands. With the release of this standard, we promote the consolidation of testing and certification mechanisms and establish an effective, scalable test method that encourages the rapid development of autonomous driving technology.

XT: WHAT WAS RADSYS' ROLE FOR THIS PROCESS?

ZK: Radsys took a leadership role and worked with the Tsinghua University Suzhou Automotive Research Institute to bring together the team that developed the T/CAAMTB 15-2020 standard. As part of the team, Radsys was the main definer

and writer of the entire standard, and we ensured it was professionally reviewed and verified exhaustively by industry peers before it was released by the China Association of Automobile Manufacturers.

XT: AND NI'S ROLE WAS ON THE TEST TECHNOLOGY?

ZK: That's correct. Radsys adopted NI's Vehicle Radar Test System (VRTS) and software to perform and document the tests, validate results, and guarantee the scalability of the test method from laboratory to production. We found that traditional test equipment is difficult to implement for different products, and equipment reuse at different development stages requires multiple investments, which increases the cost pressure. Also, different instruments have different requirements for users, which increases the complexity of the system. Using NI VRTS, we were able to overcome those obstacles and scale so that the standard is useful for multiple users at multiple test stages.

XT: BEYOND THE RIGHT TECHNOLOGY, I IMAGINE THAT USING THE RIGHT APPROACH TO CONNECT ALL THESE PARTIES AND ACHIEVE A COMMON RESULT POSED ITS PARTICULAR CHALLENGES. WHAT DID YOU AND RADSYS LEARN FROM THE EXPERIENCE TO MAKE THIS SUCCESSFUL?

ZK: Radsys is deeply aware of the importance of testing for the future of automotive. Standardization of test methods is a common demand of the industry and an urgent problem to be solved. When the formulation of the mmWave radar test standard was proposed, it generated widespread interest, and now many vehicle manufacturers, component suppliers, and industry associations have endorsed the importance of the standard and unanimously recognized its significance for solving the current industry challenges. One key factor was connecting all of them through our reputation in the industry. Over the years, Radsys has established a good, cooperative relationship with domestic automobile manufacturers and newly emerging local automobile companies. At present, we're helping many companies such as FAW, Asia-Pacific Mechanical and Electrical, Chengtai Technology, Nova Electronics, etc., test their radars. This created confidence in Radsys and enabled us to effectively lead this joint effort, meet the needs of the participants, and ultimately provide value for the development of the automotive industry in China.

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So You Want to Test Multiple Domains?

Just as the whole is greater than the sum of the parts, so, too, are modern vehicles greater than the sum of their components. The promise of self-driving, zero-emissions vehicles in the near future is exciting but fraught with significant test challenges. All those parts must be tested together, successfully, in their various combinations to realize this synergy. Enter the increasingly relevant hero: system integration testing using multidomain hardware-in-the-loop (HIL) solutions.

HIL is a test methodology well-established in vehicle validation. By using simulation and models, engineers can rapidly iterate on designs. HIL testing is required at a wide range of component levels to completely validate a full vehicle design. For example, as seen in FIGURE 01, when examining a seat, subcomponent HIL testing would be used to verify the function of the ECU while interacting with different loads, be they real or simulated. System-level HIL testing might bring several motors together to test the seat as a whole, and then multidomain HIL might test the function of the seat in combination with the infotainment system, which also can be used to control some of its function. Then the coordinated functions of adjustment, haptic feedback, heating, cooling, and infotainment input and display of the seat must be tested to ensure safe and reliable operation. This is the purpose of the multidomain HIL solution.

Performing system integration test using multidomain HIL solutions is more important than ever as vehicle systems are increasingly using complex electronic, intelligent, and interconnected systems to provide advanced safety and comfort features to vehicle occupants. Many unexpected behaviors can occur when systems come together that may be impossible to identify when testing in isolation either at the component or subsystem level. For example, multidomain testing can reveal how the unexpected draw on a vehicle battery can compromise the performance of other electronics or how networking bottlenecks that arise when multiple data-heavy systems like ADAS and powertrain are combined result in a system slowdown. Even physical challenges can be revealed, such as grounding problems between ECUs that lead to unexpected values. Finding such problems early in the design process with a multidomain HIL solution, before even having a prototype vehicle for testing, can help engineers save valuable time, reduce the costs associated with addressing the identified issues, and avoid potential costly recalls for bugs that are otherwise not found by conventional testing. Realizing the significant competitive advantage multidomain HIL solutions offer, organizations have begun deploying them, as seen in FIGURE 02.

Unfortunately, merely being convinced of the value of multidomain HIL testing does not mean successful implementation. Configuring and setting up these systems properly can be a daunting task because of their scale and complexity. Fortunately, several unique characteristics of tools from NI and its partners, like those from NI Partner Aliaro, shown in FIGURE 03, help organizations successfully integrate multidomain HIL testing in their validation process.

Open and Flexible Approach

Most successful manufacturers and suppliers recognize the importance of testing and have made significant investments in various validation tools and HIL solutions. Success in this area therefore relies on the ability to seamlessly integrate these toolchains, test cases, and models into one system. For example, applications can include test execution in Python along with a test system that comprises dSPACE and NI hardware, CANoe software, and ASAM XIL-related components integrated together into a multidomain HIL solution. NI's modular hardware and open software make this integration possible. PXI allows customers to extend current test capabilities with a wide range of modules to meet different system integration testing needs as new ECUs are added to the system. VeriStand supports the inclusion of new and existing models in an HIL test system. Compliance with standards such as ASAM, AUTOSAR, and FMI ensures that customers can incorporate additional suppliers' offerings in the future as requirements change.

Test Reuse

Selecting a modular, open platform allows hardware and software to be reused as testing scales from component level to system level to full vehicle system testing. Aliaro specifically has enabled this by developing self-contained subsystem units that can be used in isolation to confirm the functioning of one ECU. These can also be incorporated into a system-level or multidomain rack. Transitioning

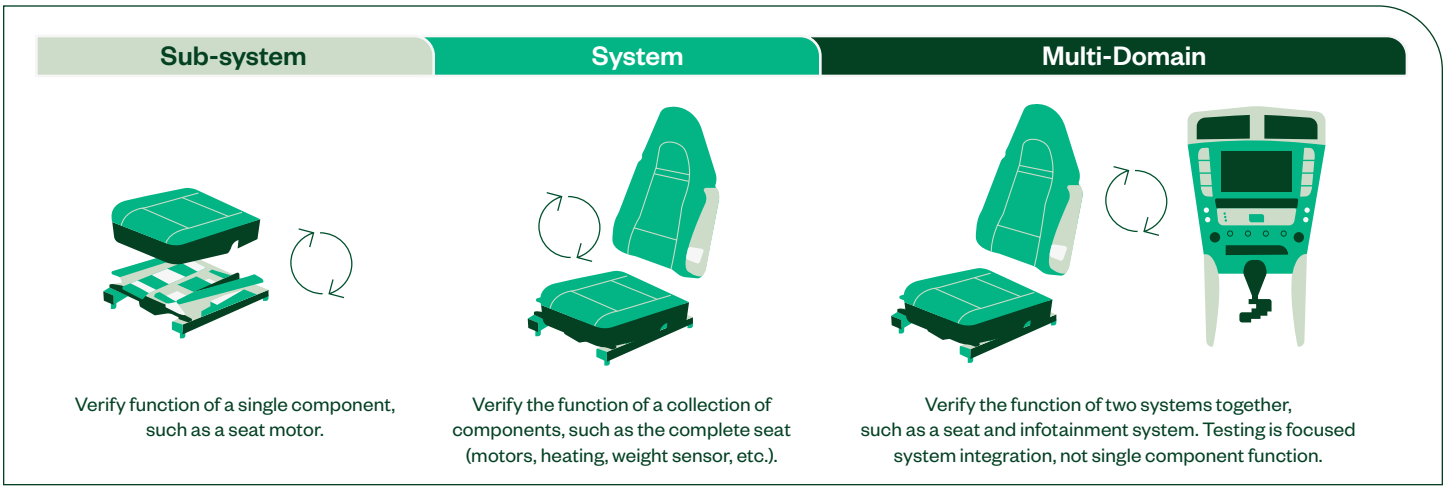

FIGURE 01

This illustration shows scaling from subsystem to multidomain testing.

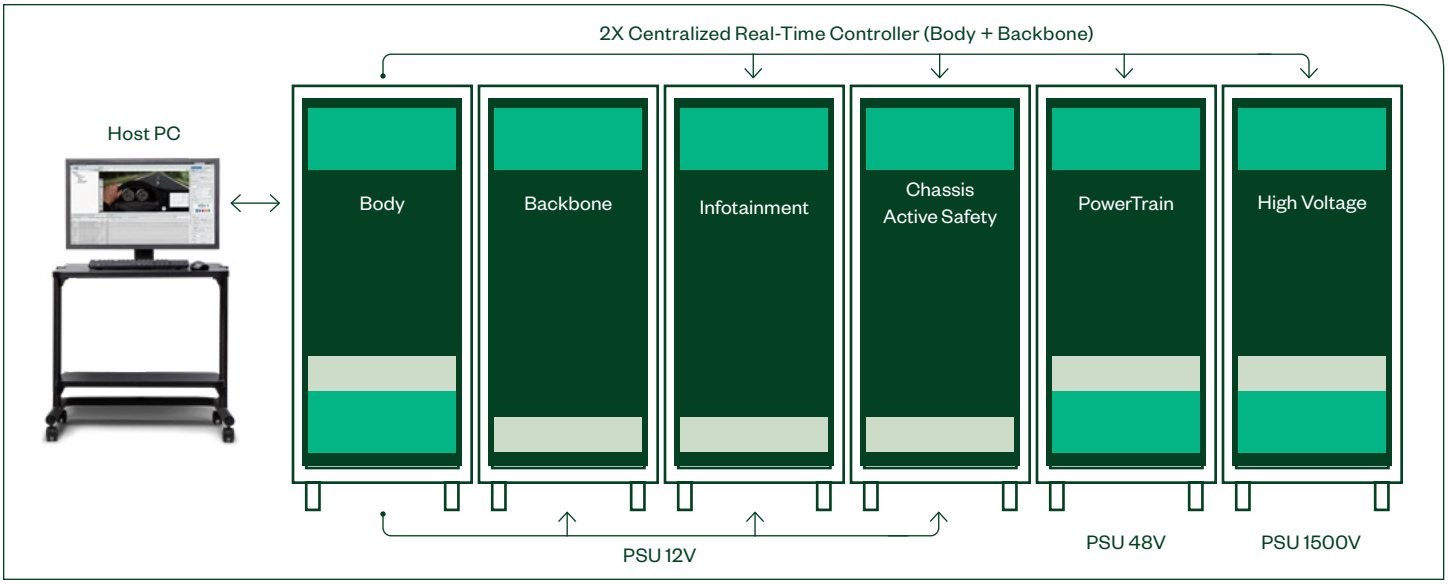

FIGURE 02

In this full vehicle simulator system by NI Partner Aliaro, each rack represents one vehicle system driven by two real-time controllers.

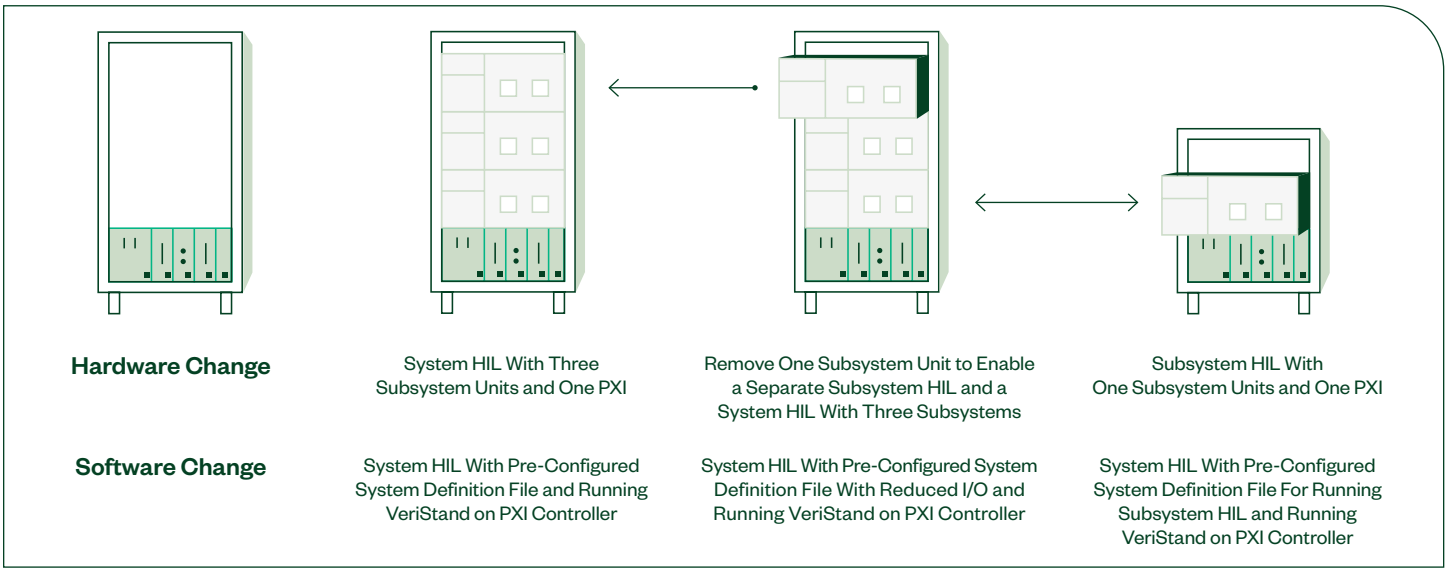

FIGURE 03

A modular approach to hardware and software enables easy scaling across levels with self-contained subsystem units for each ECU and with preconfigured system-definition files.

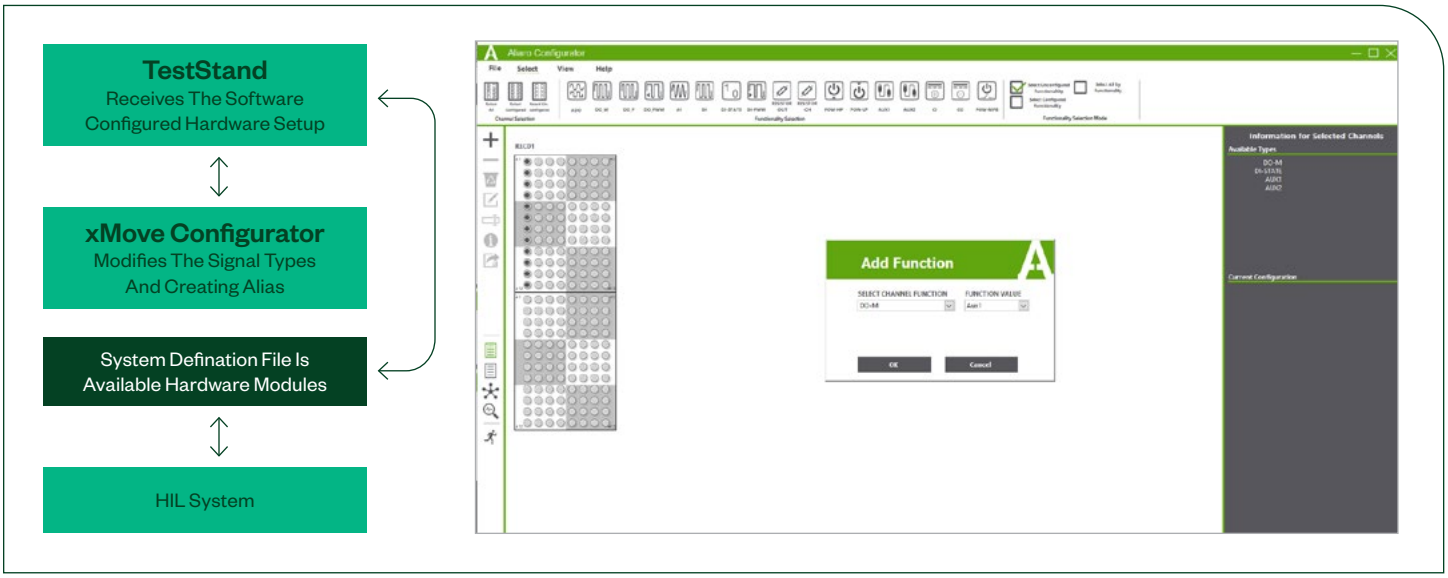

FIGURE 04

Aliaro Configurator software decreases downtime during system reconfiguration and allows rapid updating of many channels, which is often required when maintaining multidomain HIL systems.

from system-level to multidomain simulation is achieved by adding a master rack with a controller to integrate across multiple domains. Similarly, system definition files can be merged as new vehicle domains and racks are introduced into the system, providing excellent flexibility and extensibility of the system for many years to come.

As FIGURE 03 shows, these flexible, modular subsystem units from Aliaro interface with different ECUs (real, simulated, or via restbus) and their related software components to enable easy transition and reuse of components across subsystem- and system-level HIL testing. This greatly simplifies test setup to help companies save time and money.

Scalable and Reconfigurable Solution

Not surprisingly, full-vehicle testing means these HIL systems need to scale to high channel counts with thousands of signal paths across multiple ECUs. In addition, designs are always evolving, so the ability to swiftly reconfigure these complex, multichannel systems can be the difference between efficient validation and endless frustration. Aliaro Configurator software, shown in FIGURE 04, provides a drag-and-drop interface to swiftly configure systems. It makes it simple to rapidly adjust to new requirements and add new ECUs by remapping your signals with a few clicks of a button.

It is also likely that based on design/prototype availability, customers will be constantly switching between real and simulated ECUs and loads. Because of this, the ability to activate and deactivate nodes or restbus simulations with streamlined ECU switching is another essential system capability.

Fully Automated Functional Test of the Complete Vehicle

Testing vehicle domains in combination with each other is increasingly important to validate a full vehicle and avoid unexpected behaviors as systems work together. Leveraging HIL testing to perform this validation moves test earlier in the design cycle, so adjustments can be made before requiring a full prototype vehicle. NI and Aliaro solutions make transitioning to multidomain test easier by enabling reuse, scale, and flexibility.

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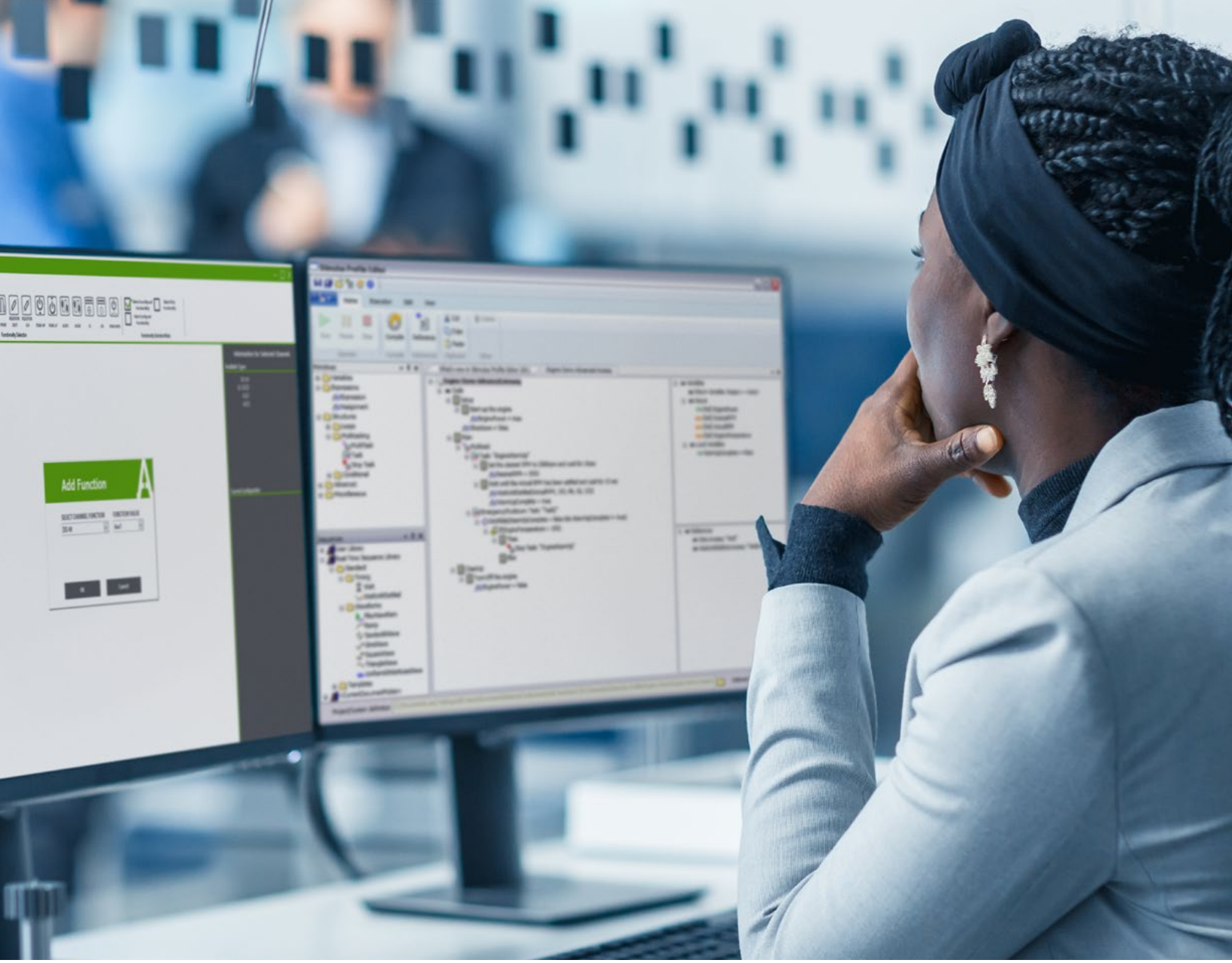

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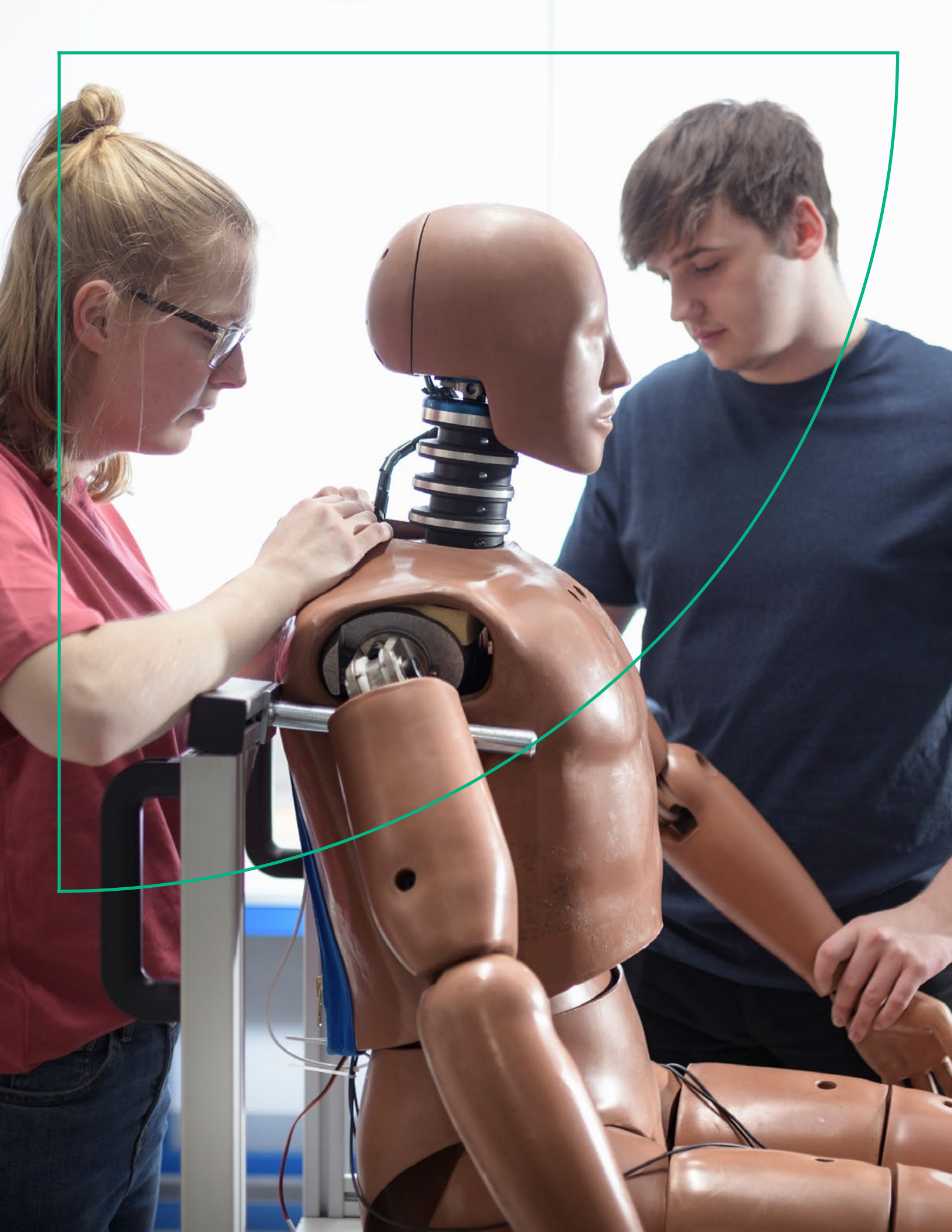


Flexible Test and Analysis for Digital Transformation

Integrated solutions by measX and NI help reduce waste, mitigate risk, and optimize value by digitally connecting people, processes, and technology.

The automotive industry is undergoing a renaissance to support a greener, safer world. Established OEMs and startups alike are investing heavily to bring disruptive technologies to market. They're taking advantage of new developments in electric vehicles (EVs), advanced driver-assistance systems (ADAS), connectivity, and shared-mobility models. As a result, the engineering quest for leaner, more automated R&D operations is imperative for companies that want to stay competitive in this market. With the huge investments required to bring these disruptive technologies to market and the entrance of new players, industry leaders recognize that they need to work together instead of competing alone, and industry players are adopting increased collaboration at the macro level through joint ventures and other strategies. At the micro level, organizations are striving to build better products faster, and analysts report similar amounts of collaboration across engineering departments. Methodologies like design thinking and agile development also promote collaboration and have been proven to increase the success rate for innovation substantially.

The critical importance of collaborative efforts that connect people, processes, and technology has been underscored by the COVID-19 global health and economic crisis. Industry analysts report that automotive companies are accelerating their digital transformation initiatives on multiple levels by looking for fresh, new ways to add flexibility to their organizational structures and operational models. In many cases, executives are empowering department leads to take control and ownership of their budgets in order to reduce unnecessary costs and rationalize activities throughout the value chain. Some companies are adopting zero-based budgeting—justifying expenses for each new period—and discovering other ways to build flexibility into their processes and eliminate waste.

Lower Costs, Better Results with Virtual Testing

The most important corporate goal for engineering test solutions is to develop an increasingly dynamic, knowledge-driven, and customer-focused process. In particular, the aim is to continually reduce waste and create value by eliminating activities that don't contribute to the bottom line and by automating wherever possible. Improvements can also include new cost models that better reflect actual needs while lowering test costs. For example, in crash testing, 50 to 60 physical tests are not uncommon. Early physical tests that use hand-built prototypes can easily cost $1 million to $5 million;

later physical tests, though less expensive, can still run upwards of $200,000 each. ADAS and EVs involve new testing complexity that further increases costs. All budgets should be justified based on need, but, whenever possible, a physical test should be replaced with a more cost-efficient simulated test in a virtual environment.

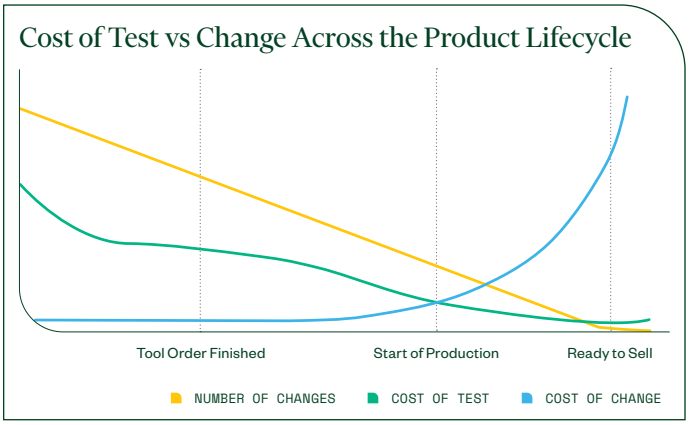


FIGURE 01

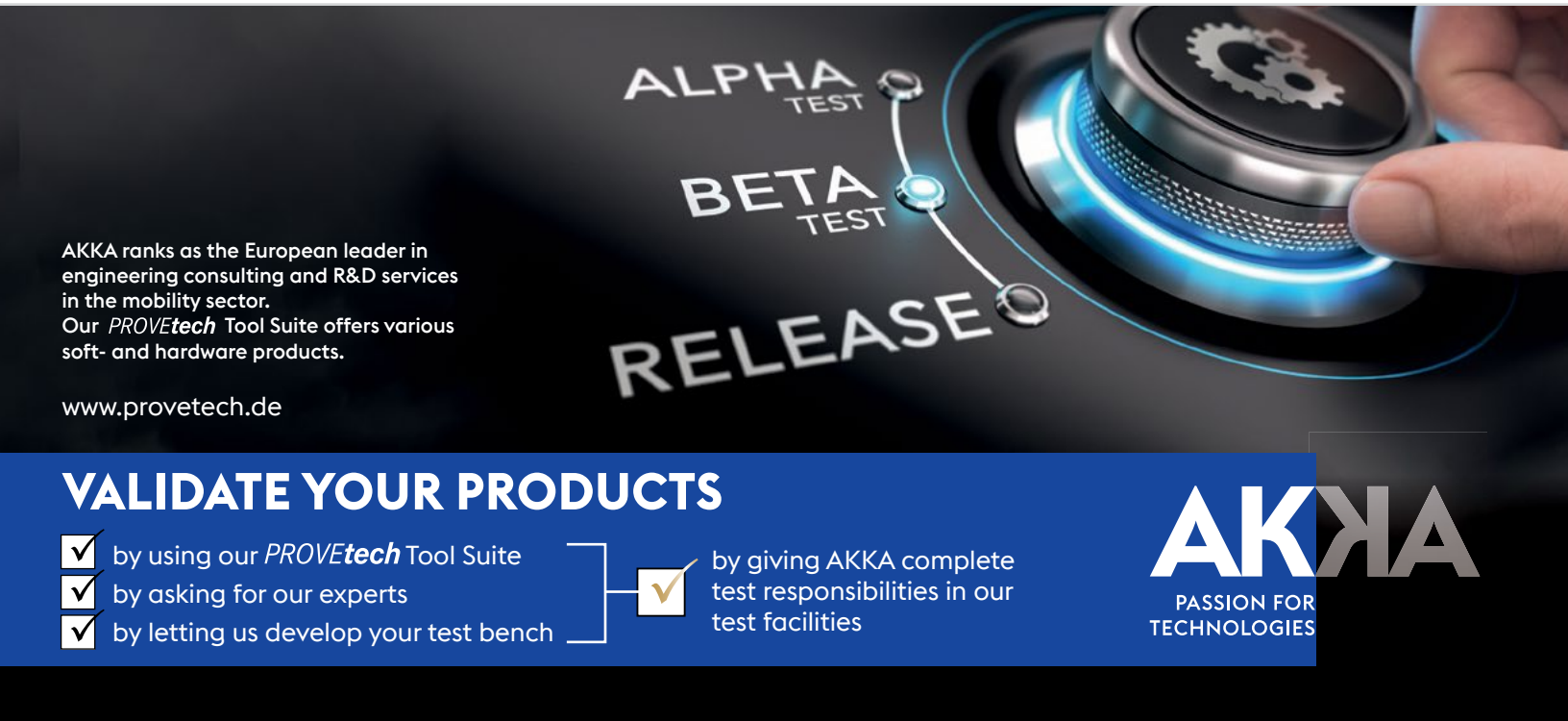
The later a fault is revealed in the testing process, the more costly the change. Virtual crash test analysis and visualization lead to earlier fault detection and less costly change.

To increase virtual testing, engineers need software-connected systems and access to an engineering data pipe, the core of digital transformation. NI and measX, an NI SystemLink™ Platinum Partner, provide the software platform and analysis framework to connect test systems and manage the engineering data pipe from concept to manufacturing. NI SystemLink software is a server-based intelligent systems and data management platform. Its focused applications and data services allow engineers to easily integrate current tools and workflows to leverage data across multiple applications.

On the client side, measX provides X-Frame, an analysis framework that offers a scalable and unified way to work with data across the test organization. X-Frame on the desktop interfaces with SystemLink and uses data management module features in its analysis and visualization process. With the ability to seamlessly switch from X-Frame to X-Frame Server, which is built on SystemLink, all X-Frame users can easily take advantage of server-based workflow/analysis to help remove operational inefficiencies and improve overall performance across test workflows. For example, a major automotive manufacturer uses X-Frame and X-Frame Server to analyze engine tests and has built other component test systems using X-Frame both for R&D and end-of-line activities. This provides a consistent structured analysis and visualization framework and reduces the number of tools engineers need to learn.

Added Flexibility

In addition to providing server-based solutions that work with SystemLink, measX is meeting zero-based budgeting requirements, which helps organizations try new capabilities. A pay-per-use model has been designed for X-Crash, an application that uses X-Frame



for virtual crash test analysis and visualization. This payment model can help meet the budgetary goals of crash laboratories that want to evaluate a small number of tests per month.

Deeper Insights with Digital Connections

Gaining deeper insights from virtual testing depends on a company's ability to connect and manage all stages of a new product introduction. It requires platforms with open data formats and interfaces across different data threads that engineers can use to read and work with any data in a fully transparent way, from initial concepts to manufactured products.

X-Frame and SystemLink work together to help companies achieve this level of data transparency among systems and departments. Ultimately, engineers will need physical tests only to prove what has already been validated through virtual tests. And as more testing is shifted to the virtual world, the cost of testing will be dramatically reduced without compromising testing quality. For companies, this can mean a stronger and more sustainable position in an increasingly competitive marketplace.

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MEASX IS AN NI SYSTEMLINK PLATINUM PARTNER THAT HAS DELIVERED EXPERT SOFTWARE SYSTEMS AND PROFESSIONAL SERVICES FOR TEST CELLS AND TEST DATA MANAGEMENT TO THE AUTOMOTIVE INDUSTRY FOR OVER 35 YEARS. MEASX IS THE MAKER OF MOSES, X-FRAME, AND X-CRASH, WHICH IS WORLD-RENOWN ANALYSIS, VISUALIZATION, AND RATING SOFTWARE FOR CONDUCTING VEHICLE SAFETY TESTS AND MEETING THE EURO NCAP STANDARD. MEASX.COM

JEFFREY PHILLIPS
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Building the Future: A Look Inside the Systems R&D Organization

To explore the unique challenges 2020 presented a global team, I talked with Cesar Gamez. He's the senior director of our Systems R&D team in the Transportation Business Unit, and he manages a globally distributed team that had to scale through the pandemic.

JEFF PHILLIPS: YOUR TEAM IS THE LARGEST WITHIN THE TRANSPORTATION BU. WHAT DOES THE SYSTEMS R&D TEAM DO?

Cesar Gamez: Ultimately, my team strives to provide our customers with systems that solve their test challenges effectively and efficiently. We do that by actually designing and creating the holistic systems on top of our rich product portfolio. Having a dedicated function enables us to quickly respond to market trends and demands by working closely with our customers to understand their needs, so we can design systems that add the most possible value. This need for being dynamic is what drove the foundation of Systems R&D. With how much we've been able to accomplish, it's easy to forget that our function as a whole is less than two years old at NI.

This was the case with our ECU Test System and our Battery Test System. We worked closely with customers on early versions as we designed and improved on these systems. We also know firsthand how important it is to have high-performing systems that are reliable. We thoroughly test our systems like our customers test their products. This way, our customers can have full confidence when using our systems.

JP: THE AUTOMOTIVE INDUSTRY IS GOING THROUGH A MAJOR TRANSFORMATION WHERE TECHNOLOGY IS EVOLVING AT AN ACCELERATED PACE AND CUSTOMERS' NEEDS ARE CHANGING RAPIDLY. HOW DO YOU WORK WITH CUSTOMERS TO UNDERSTAND THEIR NEEDS?

CG: These rapid changes require us to stay on top of market trends and work closely with our customers to ensure we are creating systems that solve our customers' challenges in the most effective and efficient ways. We have decades of experience on our team integrating these types of systems, but we also work closely with a handful of customers to use initial prototypes for collaboration throughout the process. It's critical that our customers maximize efficiency even during the early stages, so we also use the prototypes to help them make progress on production goals, even while we're iterating. At the end, we release much better and more flexible systems that can very effectively solve our customers' challenges.

JP: YOU'VE BEEN GROWING YOUR TEAM THROUGH THE PANDEMIC WHILE NO DOUBT DEALING WITH YOUR OWN SET OF CHALLENGES. WHAT HAVE BEEN THE BIGGEST CHALLENGES AND WINS FOR YOU IN RUNNING A GLOBAL TEAM DURING THE PANDEMIC?

CG: This pandemic has been hard for everybody; we've been no exception. At the same time, we're fortunate enough to have the

ability to work remotely in many of our functions, and I am very proud to work with an outstanding group of engineers who have consistently gone the extra mile to adapt to these times.

Building high-performing systems requires teams with different backgrounds, and, in our case, close collaboration globally across different regions. In March, we decided to start working remotely as much as possible, which we had not done before at this scale. We experienced what I believe to be a pretty normal set of challenges: untimely crashes and virtual meeting errors, rapidly evolving best practices for virtual engagement, communication breakdowns, the pain of losing the "water cooler" conversations, and back-to-back meetings without breaks.

One area that is particularly unique and is forcing us to think differently is recruiting and ramping up new employees. Now we have new employees who start with our group without ever having an in-person conversation. We are having to pay extra attention to the onboarding process to be effective and maintain our strong team culture.

We also continue to see great examples of people within our teams stepping up to adapt and help in these times. For example, as we started to work remotely, engineer Albert Block took it upon himself to set up a lab in his garage so people could continue to push through the rigorous validation process. He also worked with IT to provide secure access to our groups globally, which resulted in round-the-clock, global validation to keep our ECUTS project on time. Another great example, our own engineer Brian MacCleery, who, in collaboration with a local doctor, designed and built intubation tents that are being used by healthcare workers on the front lines treating patients with COVID-19.

JP: THOSE ARE INCREDIBLE EXAMPLES! BRIAN EVEN RECEIVED COVERAGE IN OUR LOCAL NEWS FOR HIS LEADERSHIP. WHAT ARE YOUR PRIORITIES AS WE TURN THE PAGE ON 2020 AND HEAD INTO 2021?

CG: The accelerated pace of transformation of the automotive industry is going to continue, and we must stay on top of the latest trends and test strategies. To achieve this, we must strive to stay nimble, understand the market trends, and even anticipate our customers' needs.

From a roadmap perspective, our plan is to continue to make great progress in our focus areas, which include electric vehicle component testing, electronics production test, and ADAS validation test. At NI, we are increasing our investment in Systems R&D in 2021, and we plan to grow our global team by over 30% the first half of the year. As we continue to increase our investment in our focus areas, we must also continue to maximize our development efficiency and release the right systems to the market at the right time. Going into 2021, we have high confidence in our team's ability to advance our customers' top objectives with the state-of-the-art test systems we are building. We look forward to future collaborations that will help us transform test into a competitive advantage.

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