AUTOMOTIVE JOURNAL

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Q4 + 2021

Change Remains Constant

Delta—the fourth letter of the Greek alphabet—has long represented the concept of change to me (and I suspect the broader engineering world). That delta, or a change, has been weighing heavily on me. The automotive industry has changed, both in the sense of the buyers' expectations and in the underlying technology. This, in turn, has changed your needs.

The delta strain of COVID continues to wreak havoc. With it, guidance from global health organizations changes. I can even see my team members fundamentally changing—as their home life has become more visible, as perspectives shift, and as our families' livelihood hangs in the balance.

Change is everywhere. But, is that really so different? Hasn't change been the singular constant throughout every aspect of our collective lives? Just in the last 100 years, we've changed more as a society than in any century before. Change will continue; it will press on.

This edition of the journal focuses on the changes we anticipate seeing in the future. We explore how NI embraces change and sees it as the driving force behind accelerating the path to Vision Zero.

NOAH REDING
SENIOR DIRECTOR OF VALIDATION, TRANSPORTATION, NI

National Instruments
is now NI.

"The road to autonomy will be paved with many things—failures included. Many of these failures warrant celebration."

Jeffrey Phillips
Director, Go-to-Market Strategy, Transportation, NI

Want to hear more?

The first video in a series of Test Talks can be found on NI Global YouTube.

What's Trending into 2022

Trends are certainly hard to predict. They're constantly developing and changing, so they're simply difficult to forecast. Picking up where Selene van der Walt left off in her feature, "What's between Us and Vision Zero" (Q2 2021 Automotive Journal), this article examines automotive trends as we look toward 2022. It focuses on the A and E of the ACES acronym—autonomous, connected, electric, and shared mobility. Vehicle autonomy and electrification are the most tangible and dominant technologies leading us into the new year.

Autonomous

The battle of the sensors almost sounds like the title of a new best-selling book, but it is increasingly the reality we are facing. At the very beginning of the march toward autonomy, we added more automated driving functionality. This made crystal clear that different sensor modalities have different advantages and disadvantages.

	CAMERA	RADAR	LiDAR	ULTRASONIC	LiDAR + RADAR + CAMERA
Object detection					
Object classification					
Distance estimation					
Object edge precision					
Lane tracking					
Range of visibility					
Functionality in bad weather					
Functionality in poor lighting					

SOURCE: WOODSIDE CAPITAL PARTNERS (WCP), "BEYOND THE HEADLIGHTS: ADAS AND AUTONOMOUS SENSING," SEPTEMBER 2016

TBL 1 | No one sensor type works well for all tasks in all conditions.

Some of the most obvious comparison criteria include object classification (color recognition), velocity detection, resilience to light (day and night) and weather conditions, range, resolution, and 3D reconstruction of the perceived real world. The natural approach to eliminate gaps was to "simply" combine sensors like cameras, radars, lidars, and others. Sensor fusion for advanced driver assistance systems (ADAS) and automated driving was born. The various sensor types and their price points were already known and tangible, but the addition of the sensor fusion challenge increased the complexity and total cost of autonomous driving. This jolted us awake from our self-driving vehicle dream.

To fight these complexity and cost challenges, the many sensor vendors in the market are working hard to develop best-in-class technology. At the same time, they are using these advancements to outperform other sensor types. With the move into 4D imaging and high-resolution radar (up to 2,000 channels by Mobileye), some vendors and OEMs claim that lidar will be necessary only for corner cases.

Interestingly enough, additional non-sensing technology, such as HD mapping, is entering this battle, too. While HD mapping has long been part of the autonomous vehicle journey, the industry is starting to ask more questions about this technology: Does it make sense to rely on a camera-based artificial intelligence (AI) algorithm to detect and classify a specific, static traffic sign? Or should this information be retrieved from a digital map? Again, our historical pattern suggests we should choose both approaches, but to make autonomy affordable and less complex, HD mapping is starting to enter the battle that previously involved only sensors.

With all these technologies in motion, a steady, solid state is still not visible on the autonomous technology horizon. Autonomous vehicles require adaptable test strategies and technology, which heavily rely on data, the insights from that data, and a software-centric approach that is flexible enough to address current and future challenges. Instead of the traditional single-vendor approach, autonomous technology requires a variety of subject matter experts to provide the best-in-class test and validation solutions as well as the research and development power to evolve with requirements.

Electrified

Over the last couple of years, new materials (solid-state batteries, different chemistries), architectures (cell to chassis, battery on roof, centralized versus distributed electronic control units), innovative business models (battery as a service, contract manufacturers from components to full vehicles), and non-automotive applications (airport ground-support equipment) have all generated productive discussions. But no single solution has become the de facto standard, and a large volume of investments is driving innovation while the existing solutions are adopted in parallel. In the area of different chemistries, CATL recently announced its move into the sodium-ion battery market. Using the much larger deposits of sodium makes manufacturing batteries way easier, so it will eventually impact pricing.

Similar to the autonomy domain, the high-voltage and high-capacity EV battery industry is revisiting its earlier days. Typically, these EV batteries were designed with innovation in mind but not necessarily the right level of safety and reliability for mass deployment.

Nowadays, all automotive companies—especially the more traditional OEMs and Tier 1 suppliers—place the safety and reliability of their batteries at the core of their design process. With higher safety and reliability standards, more thorough testing and the better use of development and test data are imperative.

Battery cost is still a big concern when considering a battery's overall product life cycle including design, development, validation, production, deployment, and residues management or the disposal of high-capacity batteries. Increasing a battery's lifetime seems obvious, but batteries eventually stop working. Therefore, the industry needs to consider the best ways to recycle the rare earth materials used in batteries and create a plan for second-life applications. In addition to CO_2 emissions while driving, the industry can address the real end-to-end life cycle of the EV by developing these second-life applications. This will truly move us toward more sustainable and environmentally friendly vehicles.

To develop a better decision-making process that maximizes return on investment, minimizes the generation of residues, and reduces the overall total cost, the industry must again extract critical information from the vast amount of data (including test data) created during the whole product life cycle, from design to disposal. Comprehensive data analytics—connecting the different data silos and providing a path to insights to drive actionable outcomes for accelerating development—can meet this need while improving overall product quality and performance.

Overall Trends

Autonomy and electrification are not the only domains that will see ongoing and overarching trends in the automotive industry in 2022. Overall vehicle production is trending upward again as the COVID impact declines and an optimistic mood dominates the market. In the second half of 2021, presentations, discussions, panels, news, and articles projected a sense that business is picking up again—with one foot slightly on the brake pedal while simultaneously accelerating.

Moreover, data and software are the major amplifiers for our new mobility evolution. Over-the-air (OTA) updates and the move toward the analogy of the smartphone on wheels will further dictate how we want to experience automobiles in the future. We will see our autonomous vehicles provide not only new convenience features but also enhanced and improved safety capabilities and less energy consumption to extend the range of the vehicle.

An evolution like this clearly requires a gigantic amount of change. Because of this, you will need partnerships to reach new heights (see "Everything Is Connected: A Look Back at 2021"). Without collaboration in this environment, competition will quickly undercut your capabilities. Let's get started now and accelerate the path toward Vision Zero (zero emissions, zero collisions, zero congestion) and define the trends of the future together.

Author

DANIEL RIEDELBAUCH
PRINCIPAL SOLUTIONS MARKETER
ADAS/AD, NI

Everything Is Connected: A Look Back at 2021

Automotive industry players need to work together to solve one of the most significant engineering challenges of our time: greater mobility safety for all of us. At NI, we believe the best way to achieve this ambitious goal is by bringing people, ideas, and technology together. No one should try to solve this challenge alone.

Over the last year, we have connected with key leaders in the transportation industry to reinforce established partnerships and build new strategic partnerships across the vehicle domains and development phases. We believe these partnerships can help guide you on the path to achieving Vision Zero. NI, along with our partners, will help you achieve your goals faster by turning test into your competitive advantage; let us show you how.

Although testing on the entire vehicle is important, most new technology and unknowns are found in the development of electric vehicle (EV) systems and advanced driver assistance systems (ADAS). The race to Vision Zero has already started, and, as in F1, you need to establish a pit crew to ensure you're ready to not just compete but win.

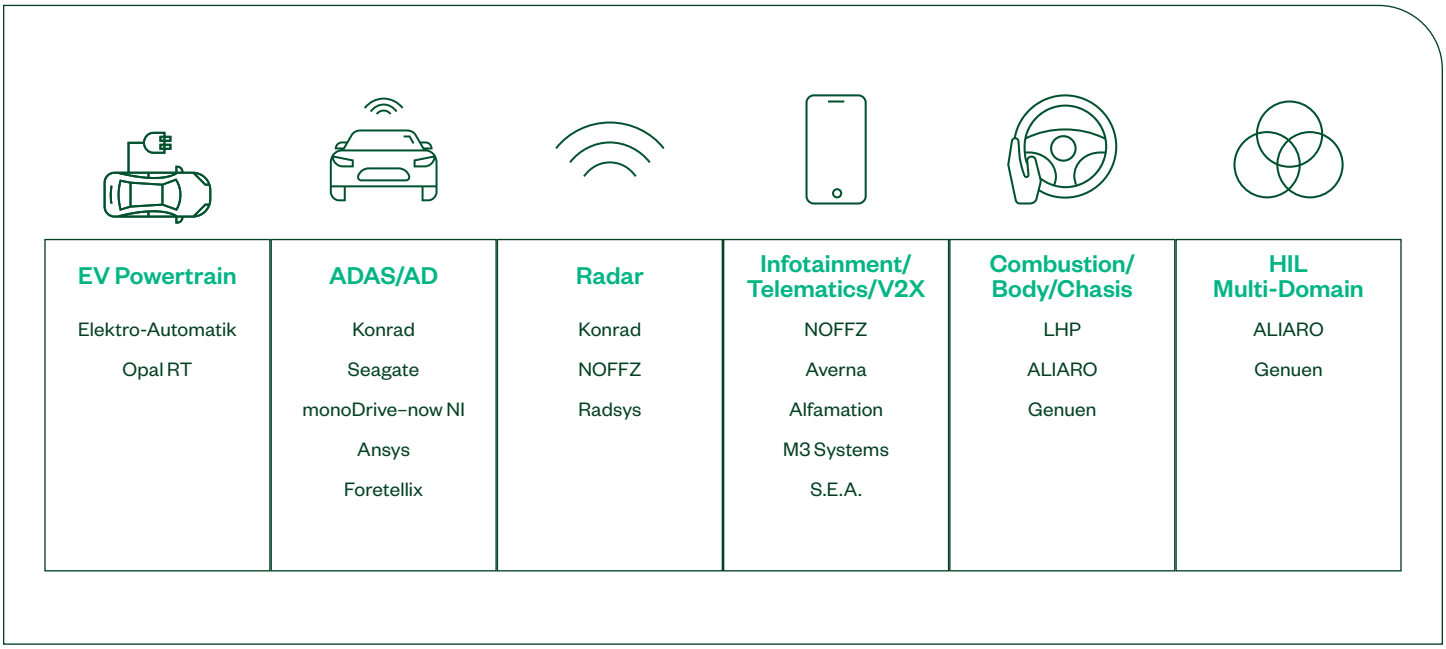

FIGURE 01

NI's strategic partnerships span across vehicle domains and development phases.

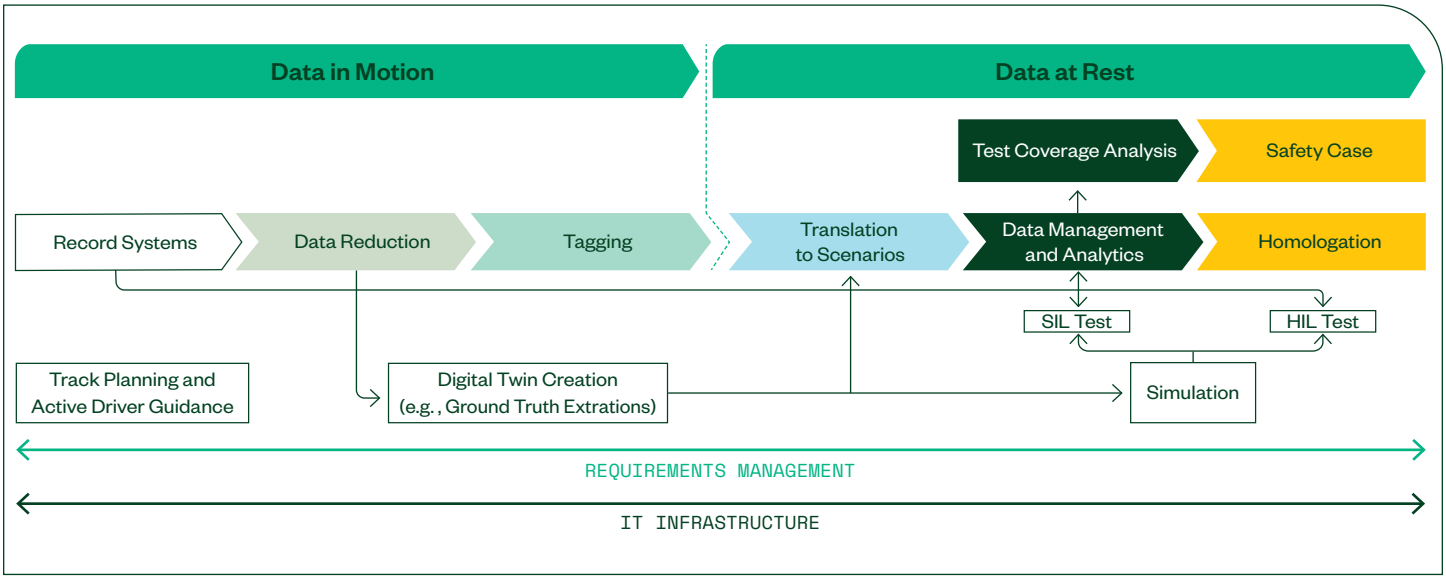

FIGURE 02

You need this combination of expertise to help achieve Vision Zero.

System Integration

Autonomous driving requires a complex mix of rapidly evolving technologies, including machine learning, lidar, and imaging radar, to come to fruition. It involves a challenging process that forces test systems to adapt in tandem to efficiently validate the complex embedded software required to operate autonomous vehicles (AVs) safely in real-world scenarios. Combining NI's software-connected test solutions with NI Partner KONRAD TECHNOLOGIES' expertise in system integration and solution delivery for ADAS creates an open, turnkey option that streamlines the validation phases, evolves with changing requirements, and accelerates the shift to self-driving cars.

Data Storage and Transfer Services

The latest AVs require more real road data than ever before, making efficient data storage even more important. NI and SEAGATE TECHNOLOGY HOLDINGS, a world leader in data storage infrastructure solutions, are collaborating to enhance data storage and transfer services. The new ADAS record offering combines NI's high-performance in-vehicle data-logging systems with Seagate's data transfer and edge storage services, enabling OEMs and suppliers to modernize their data storage strategy from self-managed to storage as a service (STaaS). This leads to reduced costs and efficient storage.

Simulation

Design cycles for ADAS are complex, so automotive OEMs and suppliers need systems that streamline the transitions between simulation and lab-based and physical test environments. These systems provide critical insights into how products will perform in the market by bridging the worlds of simulated and physical test with more precise outcomes.

With its recent acquisition of MONODRIVE, NI is leveraging monoDrive's expertise in signal processing and advanced simulation to help customers accelerate the delivery of ADAS through high-fidelity driving environments capable of modeling numerous sensors and thousands of real-time scenarios.

In addition, combining ANSYS' physics-based sensor simulation solutions with NI's driving simulation and testing infrastructure helps customers re-create real-world simulations to validate sensors and inject data into software and hardware under test in real time.

Coverage Analysis and Safety Case

In addition, automotive OEMs face a near infinite number of test scenarios to ensure the software required for today's complex vehicles is safe and reliable. As companies race to deliver autonomy, the need for a holistic view across the software validation workflow is critical to efficiently identify which test scenarios are required across each phase of product development.

The FORETELLIX platform, used for analyzing the hundreds of millions of driving scenarios needed to test ADAS and AV software, works with NI's solutions for hardware-in-the-loop (HIL) and software-in-the-loop (SIL) test as well as for ADAS data recording to provide that important holistic view. This combination accelerates the verification and validation phases of the product development life cycle and drives efficient test coverage across the entire software workflow, including HIL, SIL, and road test.

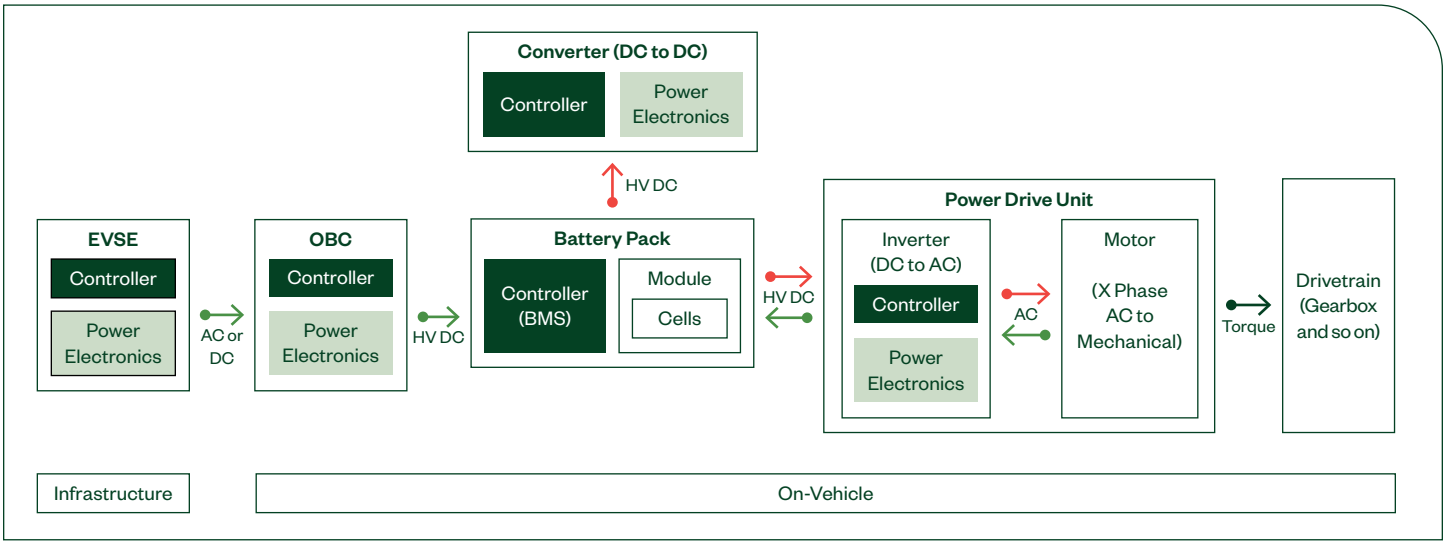

FIGURE 03

The testing needs of EV components, from power electronics to modeling for simulation, require collaboration with multiple industry leaders.

Real-Time HIL Simulation

The interactions between electric, electronic, and mechanical components are growing more complex and creating problems that are difficult to identify or analyze using traditional test methodologies during EV and hybrid EV development. Many of these issues can be addressed with real-time HIL simulation.

NI's flexible and open test platform and OPAL-RT's expertise in high-fidelity power electronics modeling and deployment work together to help customers increase productivity and drive rapid innovation through FPGA-based solutions. This combination offers an efficient workflow built on an open and customizable platform that reduces customers' EV test development times, resulting in shorter design cycles and time to market.

EV Battery Test

EV battery test requires power electronics that meet safety and performance standards while allowing the flexibility that rapid innovation needs. Bidirectional power supplies from ELEKTRO-AUTOMATIK (EA) work as battery cyclers with NI's battery test systems and solutions. This provides faster test development, more flexible battery cycling configurations, and quicker response times for new power-level test requirements.

Inverter Validation

Progressing from signal-level to power-level test is a critical step in ensuring comprehensive inverter validation; however, testing on the road or with a dynamometer can be expensive and dangerous when trying to test under multiple failure conditions. Power-level hardware-in-the-loop (pHIL) test can ensure safety, reduce development costs, and increase test coverage without the additional cost or risk of damaging the EV motor.

D&V ELECTRONICS enables pHIL validation of traction inverters by providing leading-edge electric motor emulators that can replicate the characteristics of induction motors or permanent magnet synchronous motors (PMSMs) at full power in all four quadrants. Combined with NI's real-time test software, FPGA-based model simulation, and optional fault injection, D&V technology provides a high-speed, deterministic solution for inverter validation with real power (see "Power-Level Inverter HIL Test").

We'll all get to the new era of mobility, but make sure to have the right team in place so that you get there first.

Author

BRENDA VARGAS
SENIOR SOLUTIONS MARKETER, ADAS/AD, NI

Power-Level Inverter HIL Test

Power-level hardware-in-the-loop (pHIL) test extends traditional signal-level HIL test to include testing the power electronics circuits on electric vehicle (EV) traction inverters in a closed-loop simulator. By emulating the power components in an EV powertrain, traction inverter validation engineers can extend their test capabilities to cover a wider range of test scenarios and faults safely in a controlled environment.

pHIL test, a lower cost alternative to dynamometer test, allows for testing before the motor is available and for replicating scenarios not easily reproduced with in-vehicle test (for example, tires slipping on an icy road). Systems need to be iterated on quickly to manage rapidly evolving devices under test and meet time-to-market requirements.

Customer Needs

01
Emulate all characteristics of a permanent magnet synchronous motor (PMSM) or an induction motor at full power in all four quadrants

02
Run motor and electrical models at 80 kHz or faster loop rates to achieve sufficient model accuracy for testing the inverter in simulation

03
Deploy quickly using existing models, tools, and workflows; test systems need to be up and running quickly with fast delivery schedules

04
Offer fault insertion in hardware for opens and shorts and software for network messages

05
Scale with future test requirements

NI + D&V Solution

01
NI PXI high-speed serial modules can link the FPGA directly to the D&V emulators with fiber-optic cable, ensuring full power can be delivered and manipulated at the necessary loop rates

02
Models are readily deployed from a variety of electrical modeling environments directly to NI PXI FPGA modules to reuse existing models and accelerate development

03
Open, short, and ground hardware faults are implemented with NI SLSC or on D&V's emulators while software faults are implemented directly in the FPGA

NI + D&V ADVANTAGE:

- Lower operating costs, reduce facility requirements, and enable compact design for maximum flexibility through novel power circulation
- Future-proof test systems through scalable I/O and power electronics
- Reduce time to first test with D&V integration expertise

D&V ELECTRIC MOTOR EMULATOR

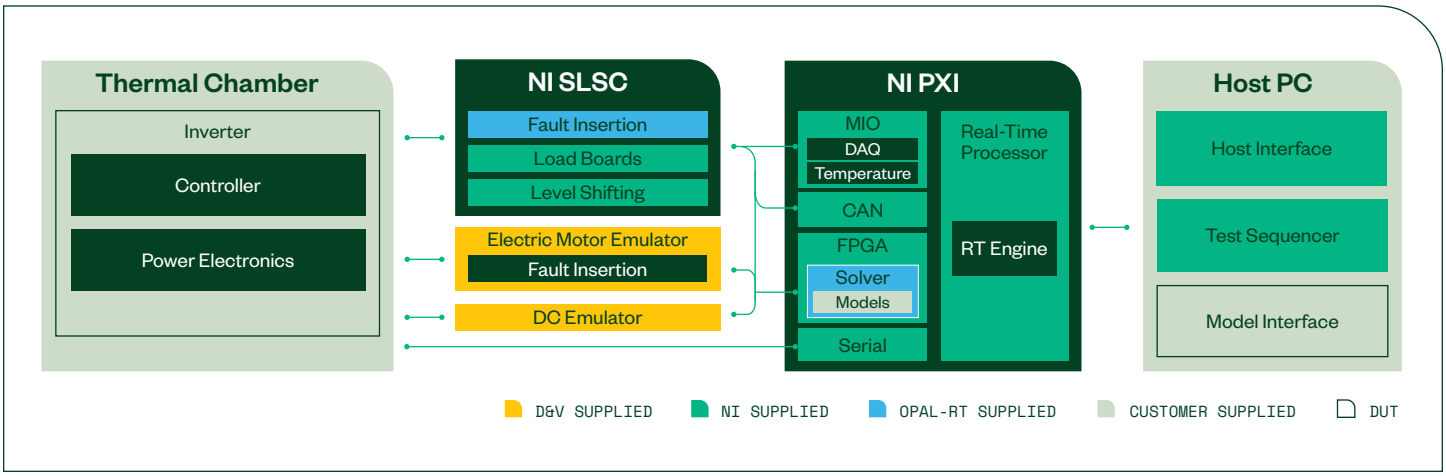

FIGURE 01

D&V pHIL Inverter Test Block Diagram

SPECIFICATIONS				
Emulator Model	150500-1	250500-2	275960-1	550960-2
Emulated Motor Quantity	1	2	1	2
Cabinet Quantity	1	1	1	2 or 3
Motor Type	Synchronous PM or induction, 3-phase/emulator (6-phase in parallel)			
Max Continuous Power (kW)	150 kW/emulator; 250 kW parallel		275 kW/emulator; 550 kW parallel	
AC Continuous Current	350 Arms/emulator; 700 Arms in parallel connection			
Fundamental Frequency	DC to 2250 Hz			
Motor Voltage	0 to 365 VAC RMS L-L		0 to 700 VAC RMS L-L	
Scalability	Parallel up to 4 emulators—1400 Arms, 1200 ADC, up to 1.1 MW			
DC Emulator Voltage	Up to 500 VDC		Up to 960 VDC	
DC Emulator Bandwidth	3 Hz up to 20kHz (with choice of DC power supply)			

JEFFREY PHILLIPS
DIRECTOR, GO-TO-MARKET STRATEGY, TRANSPORTATION, NI

Standardizing Battery Test to Reach Vision Zero Faster

Electric vehicles (EVs) have disrupted the automotive market and the way that cars are tested. EV batteries demand more than just iterative optimization; they require innovation across multiple dimensions for which there is no playbook or established best practices. Today, we're talking about how the industry can meet aggressive EV goals with Ben Wrightsman, president and CEO of the Battery Innovation Center (BIC) in Newberry, Indiana, USA, and his team members, Danny Marshall, test and evaluation team leader; Bill Walter, operations manager; and Rodney Kidd, junior lab technician.

JEFFREY PHILLIPS: THE BIC PLAYS A UNIQUE ROLE IN ALL THINGS BATTERY RELATED, FROM MANUFACTURING TO CONSULTATION. CAN YOU TELL US MORE ABOUT THE BIC'S POSITION?

BEN WRIGHTSMAN: The BIC fills a unique, multifaceted role in the energy storage ecosystem. As a nonprofit, it was created to facilitate the rapid development, testing, and commercialization of safe and reliable systems in the energy storage industry. Our advanced cell fabrication, test, and evaluation; R&D; accredited training; short courses; and technical advising teams provide a wide range of capabilities with expert feedback to help the industry move forward.

We do this by connecting commercial, academic, and government agencies to share facilities, equipment, and technical advice to catalyze advanced battery innovation while reducing cost and shortening the development and commercialization cycle. The BIC has become a trusted partner for those embracing new or experimental energy storage challenges, whether they're a new startup or an industry stalwart.

JP: WHILE THE IMPACT ON EMISSIONS IS CLEAR, THE TRADE-OFFS BETWEEN SAFETY, RELIABILITY, AND PERFORMANCE ARE TOP OF MIND FOR ENGINEERS TESTING EV BATTERIES. WHAT IS UNIQUE ABOUT THE BIC'S APPROACH THAT CAN HELP?

DANNY MARSHALL: We can perform standard testing as a service (TaaS), but our mission is to evaluate why something might have "failed" or to what degree it "passed" and transfer those learnings as targeted design feedback. This process allows our partner companies to self-sustain in the long term instead of continuing to rely on third parties. We have a unique and capable array of infrastructure on-site such as large dry rooms, bi-directional power supplies, and an explosive-rated bunker that we affectionately call the "boom room."

Our expertise and network are critical to facilitating this dynamic. Small business and startups aren't the only ones who need training and education in safety standards for high-voltage propagation, mitigation, and overall best practices. Established OEM leaders need it, too.

DANNY MARSHALL
TEST AND EVALUATION
TEAM LEADER, BIC

JP: LOOKING TOWARD THE NI AND BIC COLLABORATION, HOW WILL THE DEMO CENTER HELP ACCELERATE THE TIMELINES FOR THE INDUSTRY?

BW: Synchronizing and integrating enterprise data is key, and will provide an intuitive data interpretation and visualization framework. Fast and consistent data streams are instrumental to understanding the "why" of a test, and this information trickles down to the design of a pack. Because the underlying technology is evolving so quickly, this data may need to be interpreted in unplanned ways based on the results. This time-intensive step can compromise the time-to-market requirements.

DM: The integrated hardware and software systems being evaluated by those in the battery space will enable reliability, flexibility, and extensibility from a testing perspective. Reliability is one of the elements missing from other systems. NI has a great mechanism for developing not only tests but also test stands. Having a demo center for this capability at the BIC allows the evaluation of validation to occur at a low cost, which facilitates wider access to the industry.

BILL WALTER: The lack of a consistent data collection paradigm is a common problem with other systems. The applications used are usually a one-off piece of hardware/software combined to create a one-time high cost per test, and then they're not applicable for any other test setup. NI has introduced a better standard that is cost-effective for several applications with data collection streams as a main focus.

RODNEY KIDD: NI equipment drivers enable plug-and-play interoperability with several different makes and models of standard testing equipment. These system improvements are on a "try it before you buy it" demo basis and are highly cost-effective. Time to market is reduced for future developments with more cost-effective equipment, consistent data points, and a centralized collection area to harness the value of data. Finally, enterprise data integration enables fast and accurate communication among all instrumentation across the laboratory today and throughout multiple laboratories around the world in the near future.

JP: THE EV REVOLUTION IS PERVASIVE, SPANNING NOT JUST AUTOMOTIVE BUT ALSO MANY ADJACENT MARKETS. GOVERNMENT COMMITTEES, STANDARDS BODIES, INDUSTRY CONSORTIA, ACADEMIC RESEARCH ORGANIZATIONS, AND EVEN NONPROFITS DESIGNED TO ACCELERATE THE PATH FORWARD ARE ALL WORKING TOGETHER TO REACH VISION ZERO FASTER. THERE IS A BETTER PATH; LET NI AND THE BIC SHOW YOU HOW.

RODNEY KIDD
JUNIOR LAB TECHNICIAN, BIC

BEN WRIGHTSMAN
PRESIDENT AND CEO, BIC

Data Record for ADAS and AD

Recording sensor and ground truth data during road testing verifies sensor capabilities and trains advanced driver assistance systems (ADAS) and autonomous vehicle (AV) algorithms. Autonomous driving (AD) software demands multiple high-bandwidth sensors, driving exponential data volume and movement growth. To cost-effectively keep up with technology, today's data-recording solutions must be simultaneously high-performance, forward-thinking, and adaptable.

Customer Needs

01
SYNCHRONIZATION—Provide µs accuracy for sensor and vehicle network interfaces

02
CHANGING REQUIREMENTS—Adapt to evolving technology and regulatory requirements

03
DATA VOLUME—Manage data creation in GB/s and store hundreds of TB per day while visualizing it during road testing

04
DATA QUALITY AND COST—Precisely measure I/O, lossless data handling, and reduction at the start of the data life cycle

05
INTEGRATED SYSTEM—Eliminate multiple disparate solutions to avoid installation complexity and decrease risk of failure

NI Solution

01
INCREASED DATA QUALITY—Instrument-grade I/O, throughput, timing and synchronization, and edge computing capabilities for smart data reduction

02
MAXIMUM DATA SECURITY AND REDUCED COST OF DATA—Fully encrypted enterprise-grade storage solution and cost-efficient storage as a service (STaaS) subscription model

03
MINIMUM SYSTEM COMPLEXITY—One system for a reduced footprint, power consumption, and error-proneness

"We typically deploy a PXI chassis in a vehicle and interface it to live camera, ultrasonic, vehicle bus, and environmental sensor data from typical driving situations. We use this live data to train and validate our computer vision deep learning algorithms at the bench later."

Derek O'Dea
Measurement Equipment and Tools Development Manager, Valeo

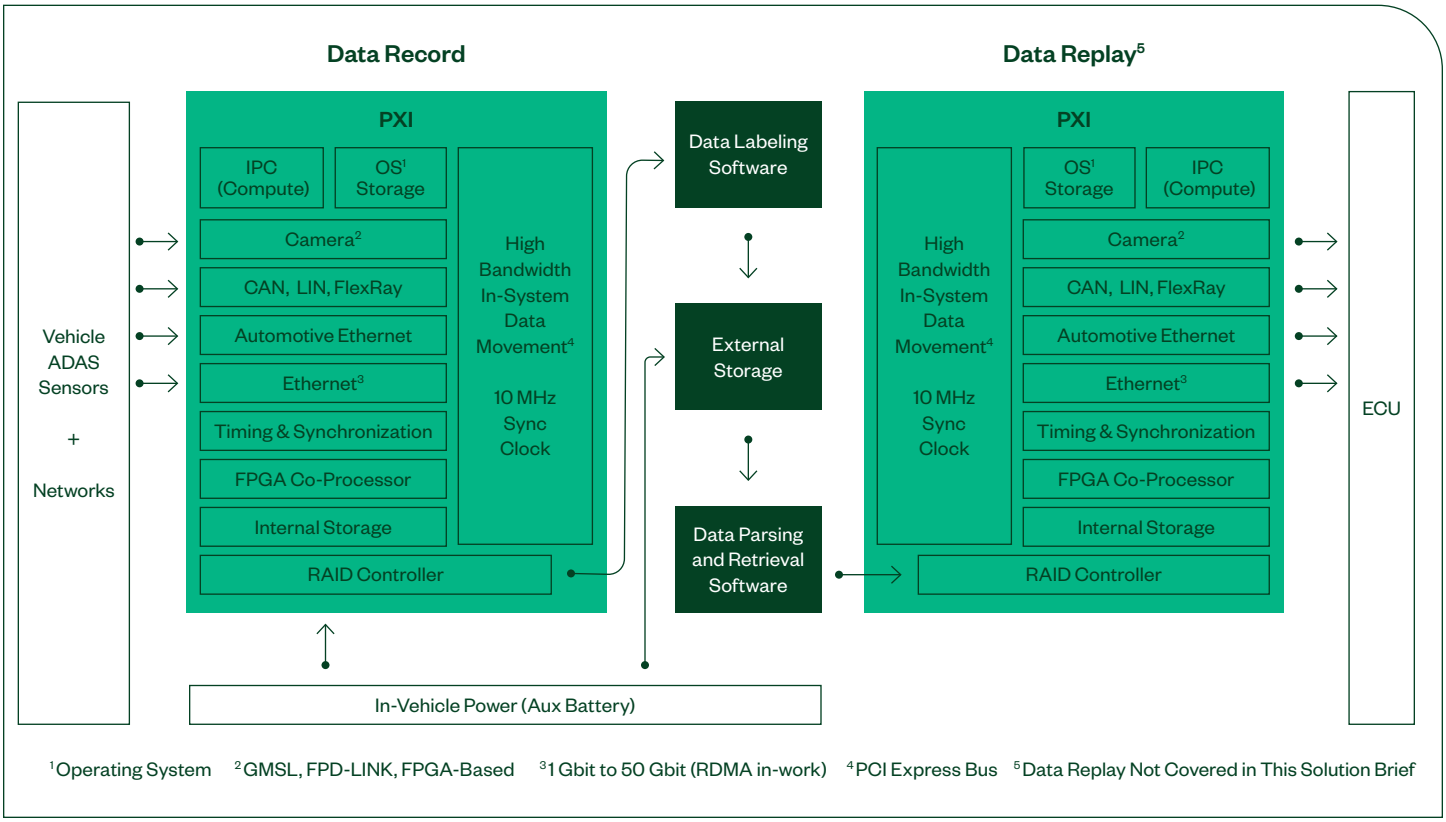

FIGURE 01
Block Diagram for Data Record Applications

NI ADVANTAGE:

- FUTURE-PROOF SYSTEMS—Hardware and software customization, flexibility, and third-party openness
- MORE THAN JUST A LOGGER—A single unified toolchain for data record, digital twin creation, data replay, software-in-the-loop (SIL), and hardware-in-the-loop (HIL)
- SYSTEM INTEGRATION AND EVOLUTION—NI Certified Solution Partner Konrad Technologies and a vast ADAS ecosystem of IT and cloud subject matter expert support

KEY SPECIFICATIONS	
Maximum Data Rate	6 GB/s (up to 15 GB/s using multiple storage devices)
Storage Capacity	Up to 200+ TB (through Seagate Lyve Mobile and third-party storage options)
Synchronization	<1 µs
Camera Interfaces	FPD-LINK, GMSL, GigE, Ethernet, USB
Vehicle Networks Support	Automotive Ethernet, FlexRay, CAN FD, LIN
Radar, Lidar, Ultrasonics Support	Through vehicle networks and Ethernet
Ethernet Devices	Up to 40 Gbit Ethernet
Operating Voltage Range	9 VDC to 30 VDC
Application Software	Data Record AD—High-performance data movement and data synchronization Software
Supported File Formats	MDF4, TDMS, KITTI, Parquet, and others via file conversion and plug-ins
Data Labeling	Pre-labeling tool by Konrad Technologies interfacing with Data Record AD via gRPC API
Digital Twin Creation	Convert recorded data into simulated scenarios through Real-to-Virtual technology

Solving the ADAS and AD Puzzle Together

I am a lover of puzzles. I am fascinated by stitching something together—something bigger from many small fragments. It is literally about that bigger picture, which can be achieved only by bringing together all the puzzle pieces to become one.

Maybe this is why I am also drawn to areas that feel like puzzles in the business world, such as the complex advanced driver assistance systems (ADAS) and autonomous driving (AD) validation workflow. We must bring together different applications, testing methodologies, and technology for this workflow. The difference is that the puzzle pieces haven't been cut into their shapes for us already. This is the work that we still must do; we need to make sure that all technology puzzle pieces fit together to establish a connected workflow. To achieve this, we need to look at some other components, including data, software, and collaboration, because no single company can master the complexity of the ADAS and AD validation workflow on its own. We need to work together to see the big picture: the software and data connected workflow through collaboration.

Collaboration: No Single Entity Can Do It Alone

At the recent 2020 Summer Olympics in Tokyo, Canada's Damian Warner broke the Olympic record in the decathlon.[1] The decathlon involves competing in 10 different disciplines (see TABLE 01). Decathlon athletes are often referred to as the kings and queens of athletics because of the variety of disciplines they must master. The disciplines cross multiple domains and require speed, duration, and strength from one individual throughout two days. TABLE 01 shows the current world record held by Kevin Mayer (France),[2] which is slightly better than Warner's achievement in Tokyo. The table also compares the current single-discipline world records with Mayer's scores. The best-case specialist scenario is an almost 40% increase in performance. Wouldn't we like to achieve this in our ADAS and AD validation workflow, too?

Consider three of the subject matter experts with whom NI is collaborating—ANSYS, SEAGATE, and KONRAD TECHNOLOGIES (KT)—and focus on their equivalent to world records in terms of technology and engineering power (people and expertise).

Ansys is well known in the automotive industry as the key player in the modeling and simulation space, especially for its physics-based ADAS sensor models. Ansys covers the design, development, and validation cycle for ADAS and AD systems, which makes it the leading powerhouse for simulation capabilities and the domain expert.

Seagate is widely known for its storage devices used in PCs and laptops but even more so for its storage devices used in servers, which ultimately are the foundation of the cloud we all love to use. With its Lyve Mobile portfolio, Seagate provides massive data throughput in-vehicle storage solutions with the highest security (encryption) standards on the market. It also provides the logistics for data (data transfer as a service or DTaaS) and a business model focused on operating expenses, which can drastically reduce the total cost of data or simply the total cost of ownership (TCO) as a whole.

KT offers deep expertise in system integration and solution delivery for ADAS and AD test applications, ranging from data record to data replay all the way up to hardware-in-the-loop (HIL) and sophisticated sensor fusion and driver-in-the-loop (DIL) test systems.

Just these three specialized companies combine to create a very diverse skill set. Imagine that you want to reach the same levels as these three on your own. Seems unlikely because you are focused not only on achieving status quo but also keeping up with the three companies in terms of ongoing technology and expertise development. Companies like Ansys and Seagate have immense R&D budgets (Seagate fiscal year 2021: $903M;[4] Ansys fiscal year 2020: $355M[5]) and workforces (Ansys fiscal year 2020: ~1,800 R&D employees[5]), which allow them to outperform other companies that would like to compete with them, especially single companies battling both of them at different technology and expertise fronts.

KT certainly does not play on the same levels as Ansys and Seagate as far as investment budgets and employee numbers; nevertheless, it rules its niche and is far more agile than some of the larger competitors on the market. This allows the

	KEVIN MAYER WR HOLDER DECATHLON		WRs BY SPECIALISTS		PERFORMANCE INCREASE	
100 meters	10.55 s	963	9.58 s	1202	239	24.8%
Long jump	7.80 m	1010	8.95 m	1312	302	29.9%
Shot put	16.00 m	851	23.37 m	1311	460	54.1%
High jump	2.05 m	850	2.45 m	1244	394	46.4%
400 meters	48.42 s	889	43.03 s	1164	275	30.9%
110 meter hurdles	13.75 s	1007	12.80 s	1135	128	12.7%
Discus throw	50.54 m	882	74.08 m	1383	501	56.8%
Pole vault	5.45 m	1051	6.18 m	1291	240	22.8%
Javelin throw	71.90 m	918	98.48 m	1331	413	45.0%
1500 meters	4:36.11	705	3:26.00	1218	513	72.8%
TOTAL POINTS		**9126**		**12591**	**3465**	**38.0%**

TBL 1 | Comparing Performance of Decathlon World Record Holder Kevin Mayer with Individual World Records by Specialists[3]

company to adapt to change and trends much quicker. It is this balance that only an ecosystem of collaboration partners can provide. A single company trying to master the ADAS and AD validation workflow decathlon will gravitate toward mediocrity as it gets lost in the shadow of an ecosystem.

Software and Data: The Internet Age's Oil and Gold

We have seen it before: the rush for gold or oil in mankind's history when we were still striving heavily for Mother Nature's resources. Not much has changed between the age of colonization and the age of the internet. We no longer call something a rush; instead, it's a major trend. Still, the demand for rare earth metals has not changed. Just look at the need for minerals to develop and build silicon for smartphones, tablets, and vehicles—in particular, electric vehicles including huge batteries. But a couple of other resources are gaining attention.

Obviously, the term "human resources" includes the word "resources." Human resources has become a major focus area for organizations in our globalized business setup. Talent acquisition, onboarding, and continuous learning are trendy words for harvesting, seeding, and growing (human) resources.

The age of the internet presents two more resources: software and data. If you think of data as the equivalent of oil, software can be the equivalent of an oil refinery, which significantly refines the value of data. You could call a refinery an asset or a resource to be utilized.

In the automotive world, we are witnessing this gravitation toward software and data, too. Tesla is the prime example of how to truly turn a vehicle into a smartphone on wheels. Over-the-air (OTA) updates still seem scary to many, but they enable our vehicles to evolve in the field, without the need for lengthy five- to seven-year release cycles.

Software and data are the keys to this new mobility evolution, and the automotive industry is shifting toward them. Consider Volkswagen outsourcing its software capabilities to the newly formed CARIAD organization striving to develop the VW.OS,[6] an OS designed to be used across the many different brands and vehicle programs within the VW Group. Or Bosch pooling 17,000 employees together to create a further step function in software development and data science.[7]

For NI, this has been and continues to be a focus area. LabVIEW is definitely the poster child for combining data and software; we started on that journey back in 1986. Nevertheless, the journey is not complete, so bringing data analytics capabilities in house, through the technology and expertise of Optimal+, is a critical element.

It is and will be software and data that provide the link, and therefore the connection, between our initially mentioned puzzle pieces. Application programming interfaces (APIs) and plug-in architectures are just a few examples that demonstrate the power of software to ultimately exchange, convert, and format data from one step to the next and back within the workflow. This is possible only if the underlying foundation is both software and data centric in nature as well as open to adapt to changes and connect with third-party tools and technology.

NI systems are built with software and data centricity in mind. Software and data have been the DNA of every NI system since the early beginnings of LabVIEW. Therefore, they lay the perfect foundation to create solutions that accelerate the ADAS and AD product development cycle. NI systems act as bridges between the necessary validation workflow components or stages, and their openness allows users to connect them with third-party technology to further maximize the coverage of the verification and validation (V&V) process. This leads to higher product quality that ultimately will save lives.

Expert Connector: Connecting People, Ideas, and Technologies

Establishing connections seems to be so easy today. We pick up our phones, dial a number or select a contact, and we are connected. We open our browser and enter the URL or click a shortcut link to our favorite website, and we are connected. We plug a USB device into a laptop or PC, a dialog pops up or, even better, the appropriate app launches directly, and we are connected. But this is just superficial because the technology discussed in the following paragraphs has evolved over decades to provide us with this ease of use. In fact, this is really the hard part. Just think how many different devices are out there, and still they work mostly seamlessly with each other. The days of 10BASE2 networks using coaxial cables and BNC connectors are long gone.

Getting to this connected world we are living in took some time. It's based on defense research projects like the Advanced Research Projects Agency Network (ARPANET), which led us to the Transmission Control Protocol/Internet Protocol (TCP/IP) and the birth of the World Wide Web (WWW) sparked by Tim Berners-Lee through his science work at CERN in 1989.

Here we are again trying to master another grand challenge: automated driving. This includes the slightly smaller yet still complex challenge of mastering the connected validation workflow. When computer scientists first tried to connect computers to form a network, they couldn't skip to the levels of the Internet of Things (IoT) seen in 2021. It is hard work, but considering the advantages that the internet provides today and

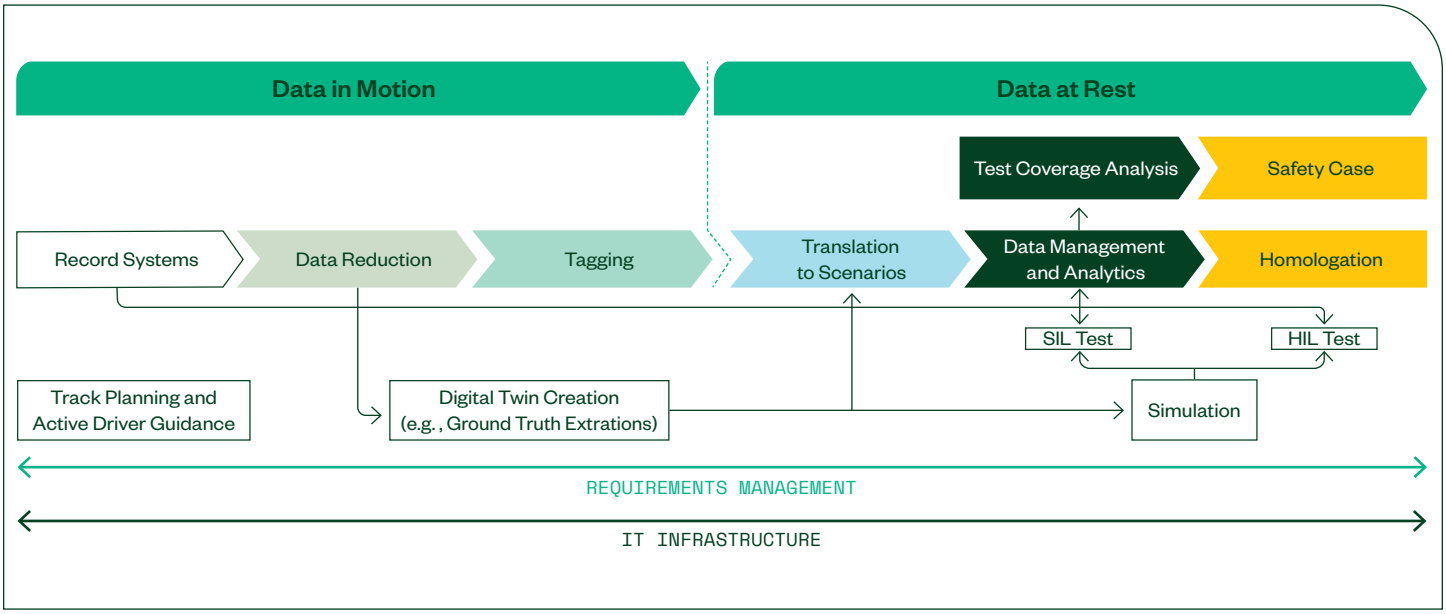

FIGURE 01

You need this combination of expertise to help achieve Vision Zero.

what it will do for us tomorrow, we all can agree that connecting people, ideas, and technology is a game changer.

At NI, we embrace this philosophy. It is our goal to bring together the smartest brains and the best hardware and software to generate innovative thinking with you and ultimately build your software and data connected validation workflow. To avoid leaving you with just theory, we are highlighting an example that demonstrates what you can achieve with a software and data connected workflow (see FIGURE 01) through collaboration. This example turns recorded ADAS road test data into a digital twin to fuel and accelerate HIL and software-in-the-loop (SIL) testing as part of your overall validation strategy.

It starts with logging your high-bandwidth ADAS data within a test vehicle using the NI Data Record System AD and the NI Ground Truth Sensor Kit. These two products already combine multiple partner technologies like Seagate's Lyve Mobile Array in-vehicle storage solutions. Furthermore, NI's strategic partner for ADAS and AD applications, KT, provides additional software capabilities like data pre-labeling during the test-drive and integration services for your logger setup. With the help of Seagate, the data is then offloaded from the vehicle and ingested into IT and cloud infrastructure to further enhance it using, for example, the capabilities of Amazon Web Services (AWS) and MICROSOFT AZURE.

With NI's recent acquisition of MONODRIVE, we have gained access to its Real-to-Virtual (R2V) technology, which enables you to turn recorded data into a digital twin through an R2V pipeline that generates synthetic data for use in a high-fidelity AD simulator. Through this setup, you can greatly reduce the number of scenarios recorded on the road, create permutations within simulation easily (different weather, lighting, traffic conditions), and conduct ground truth extraction way faster than ever before. Moreover, you can use the physics-based sensor models in Ansys VRXPERIENCE to add more best-in-class simulation capabilities to your validation process and establish sophisticated AD SIL and HIL testing applications. You might want to further augment this with IPG CarMaker simulation technology for vehicle dynamics or any MATHWORKS Simulink® models developed on the MathWorks toolchain.

Making the puzzle pieces fit together properly is not an easy task. Neither is asking the best technology athletes to work together seamlessly and pass the data baton like in a relay race. Nevertheless, the example of turning recorded ADAS road test data into a digital twin to fuel and accelerate SIL and HIL testing is a starting point for us as we travel on the journey to Vision Zero together.

Author

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ADAS/AD, NI

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EV Battery Cell Production Test Solutions

The manufacturing of safe, reliable, and top-performing electric vehicle (EV) batteries requires rigorous testing, from formation to aging and assembly. The growing consumer demand for EVs and their promise of zero emissions are forcing battery manufacturers and OEMs to accelerate production without sacrificing precision, repeatability, and traceability.

Modern battery packs and modules contain hundreds and even thousands of battery cells, exponentially multiplying the risk of failure. As the industry strives toward zero defects, manufacturing test and the insights that come from the test data make the difference between effective battery performance and recalls.

Customer Needs

01
Perform different tests like weld integrity, open-circuit voltage (OCV), and AC internal resistance (AC-IR) during assembly and finishing of battery cells and modules

02
Shorten test times to meet production volume with zero compromises on test precision and quality

03
Precisely control test probes at high speed to make measurements on test cells and modules

04
Make extremely precise measurements at high speed for high channel counts and long test runs

05
Use test data to drive insights that help continuously improve the test process

NI Solution

01
NI PXI provides the most compact and high-performance form factor to pack more test and scale up production volumes

02
The source measure unit (SMU) provides repeatable and precise measurement and current sourcing for AC-IR and weld integrity test

03
The digital multimeter (DMM) performs fast and precise voltage measurements for OCV and weld integrity test

04
NI software helps you execute tests and gather insights to improve uptime, monitor test assets, and perform preemptive maintenance to your test stations

NI ADVANTAGE:

- Cost-effective, compact, precise, and high-throughput PXI configurations composed of source measure units, high-speed multiplexers, and voltage measurement modules
- Scalability from 32 to 64 channels per system in a small footprint
- Simple integration with production test tools such as TestStand test executive and SystemLink™ software for enterprise data and systems management
- Service programs for maximum equipment availability and uptime
- Connection to data analytics solutions for preemptive problem solving

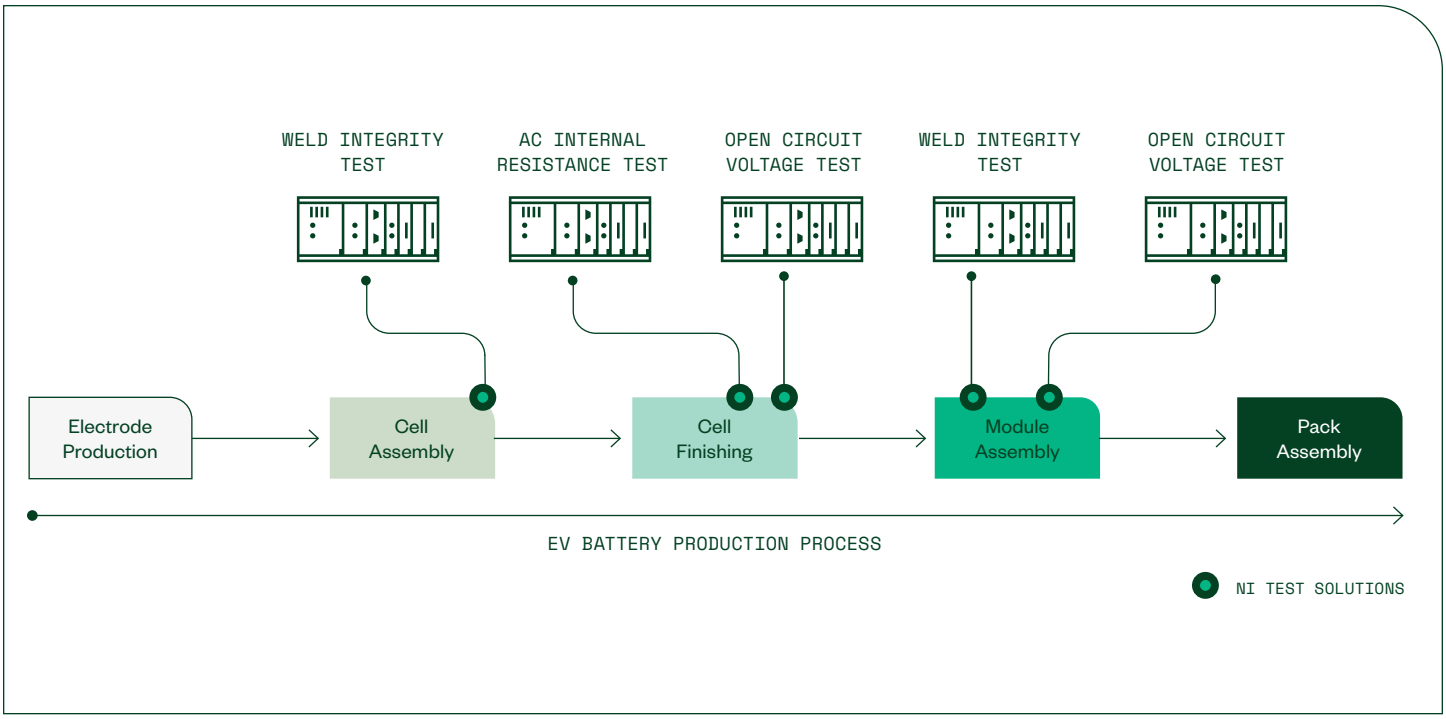


FIGURE 01

Battery Cell Production Test throughout the Manufacturing Process

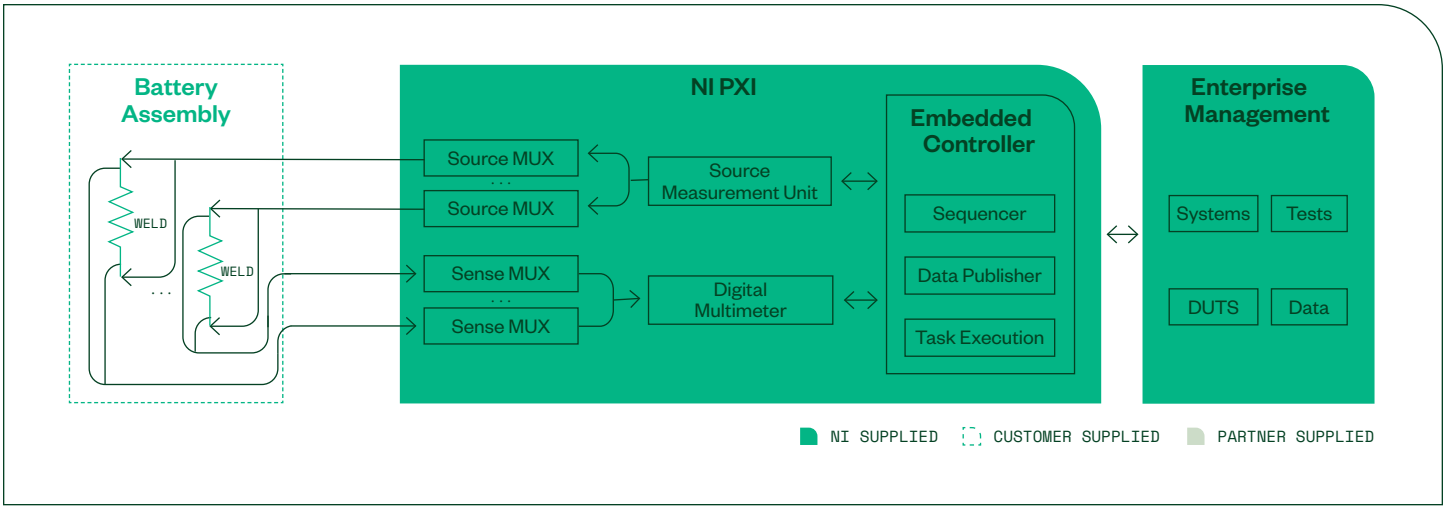


FIGURE 01

Weld Integrity Test Solution

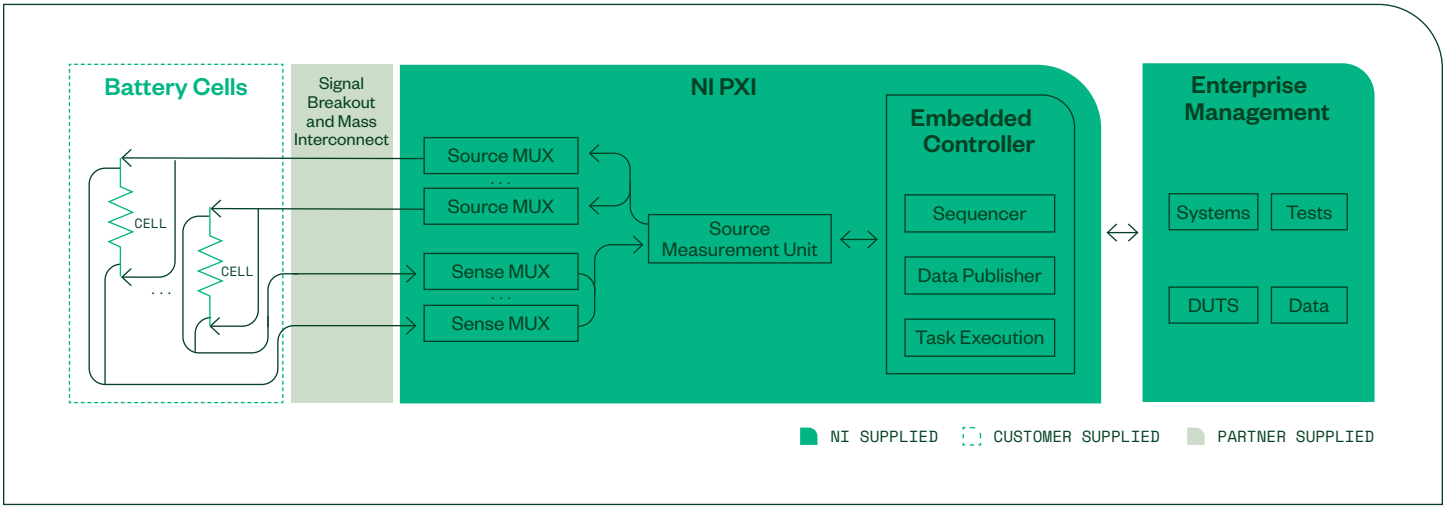


FIGURE 02

AC Internal Resistance (AC-IR) Test Solution

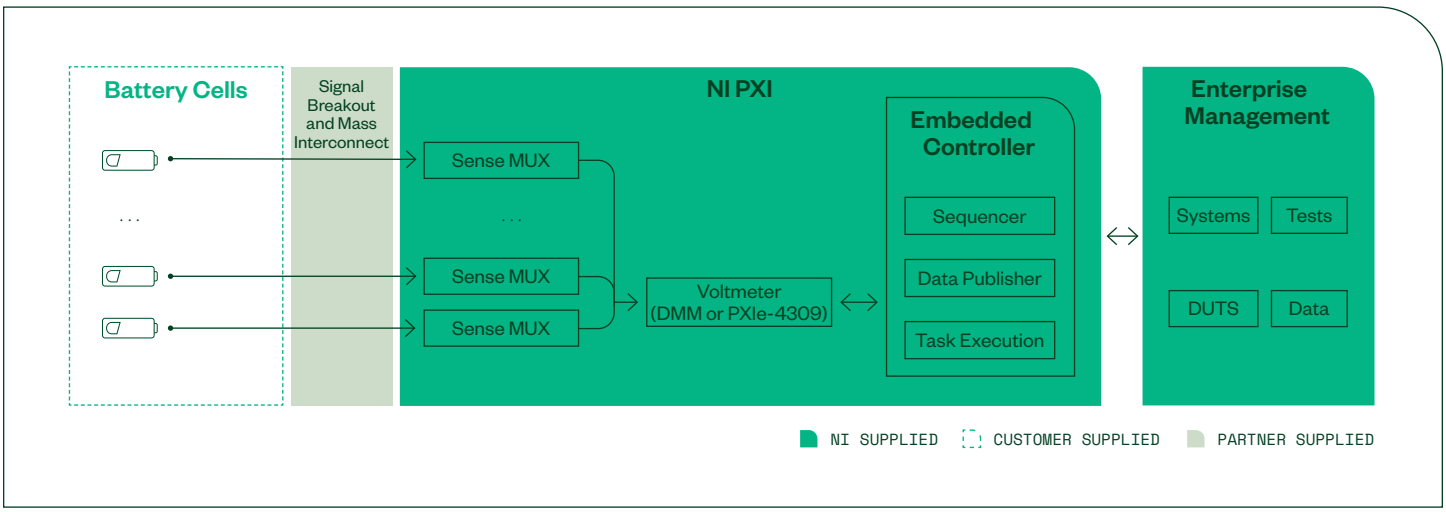


FIGURE 03

Open Circuit Voltage (OCV) Test Solution

Vehicle Systems Integration HIL Test

As vehicles grow more complicated, systems integration testing ("full vehicle" or "network" hardware in-the-loop [HIL]) is more important than ever. Rigorous systems integration HIL testing ensures that engine control units (ECUs) across the vehicle—in different systems, developed by different teams—all function correctly and safely together.

Customer Needs

01
Scale to high channel counts (thousands of signal paths) across multiple ECUs

02
Support real and simulated loads and sensors with fault insertion on all signal paths to simultaneously simulate all used ECU physical interfaces

03
Use multi-ECU bus communication and fault insertion to generate all bus traffic normally flowing in a vehicle

04
Execute dynamic models simulating the behavior of all connected ECUs and simulated models

NI + Aliaro Solution

01
Reconfigure more than 2,000 channels in minutes and store multiple test system configurations with the Aliaro Configurator for SLSC and NI VeriStand

02
Shorten system configuration and test development time so that you can expand test coverage using an NI platform-based approach combined with Aliaro SLSC cards and system configuration tools

03
Accommodate testing different system configurations and decouple requirements on other teams using model integration and real-time model-based control and provisions for real/simulated switching

"The major advantages that made us pick NI and Aliaro were third-party integration of smaller suppliers, time to delivery, price advantage, agile development, and VeriStand. We found VeriStand to be very intuitive and easy to work with. The car project for which the HIL is intended evolved as we created the specs for the HIL, which meant that we could not deliver a full spec order. NI and Aliaro were flexible and preferred communicative delivery."

Test Coordinator
Major OEM

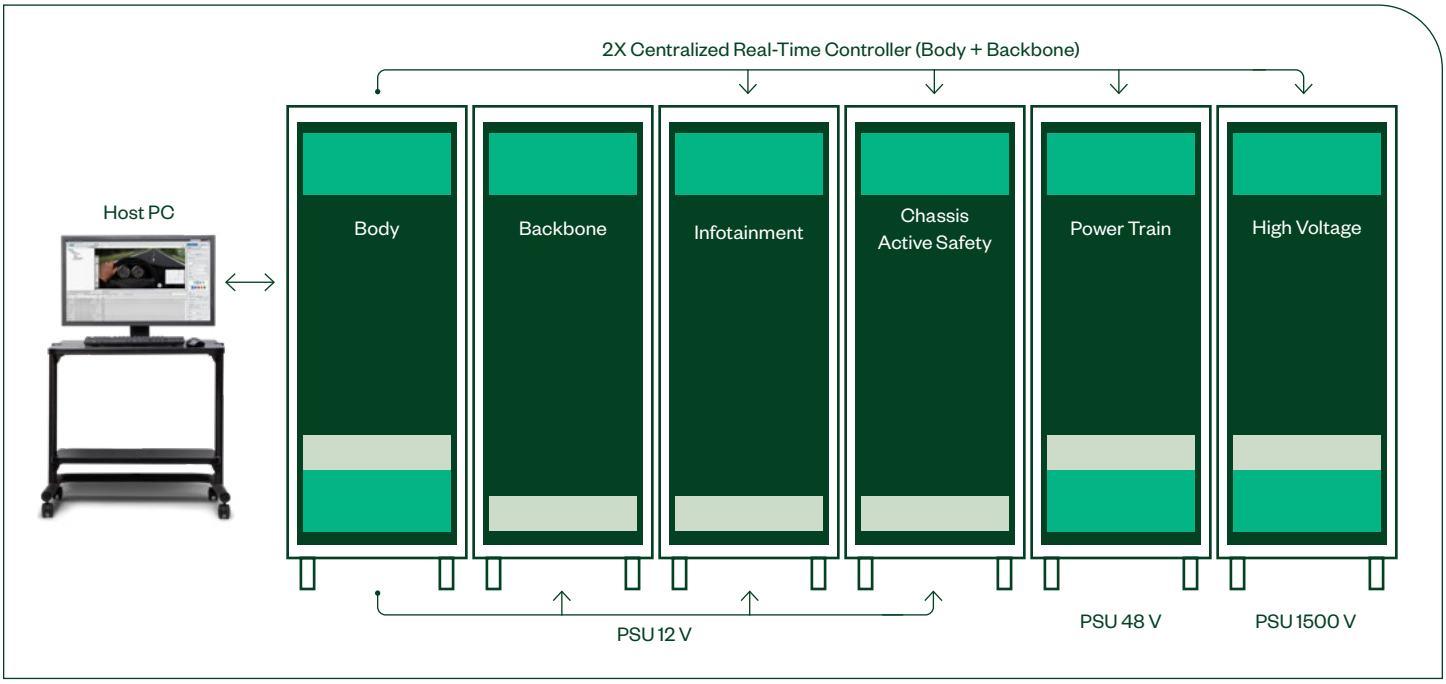


FIGURE 01

Aliaro Full Vehicle HIL Simulator

NI + ALIARO ADVANTAGE:

- Scalable system design (can be distributed)
- Efficient system reconfiguration: Rapidly adapt to changing test requirements and system configurations/models
- Multivendor test environment with ASAM XIL/Python support
- High-power and mixed-signal I/O capabilities

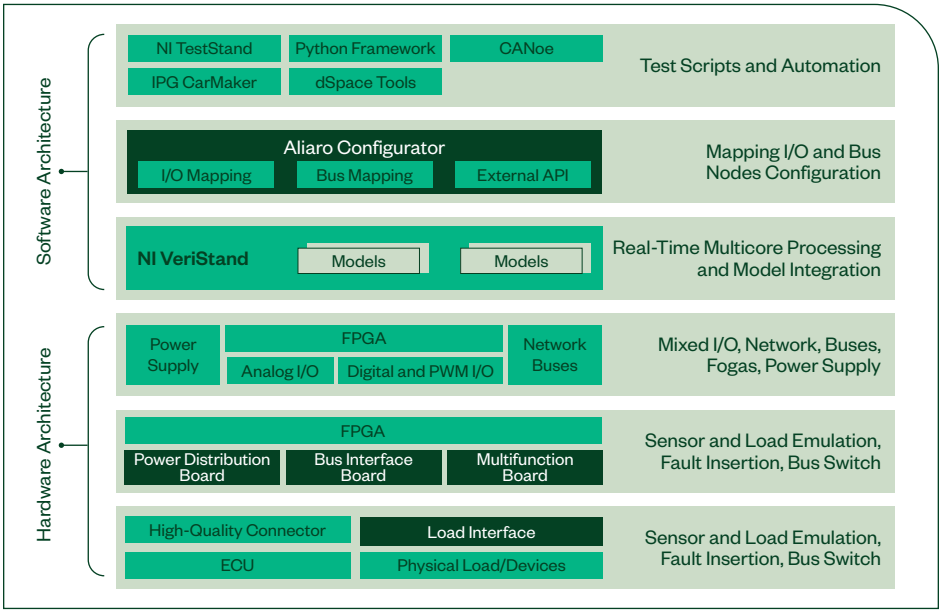
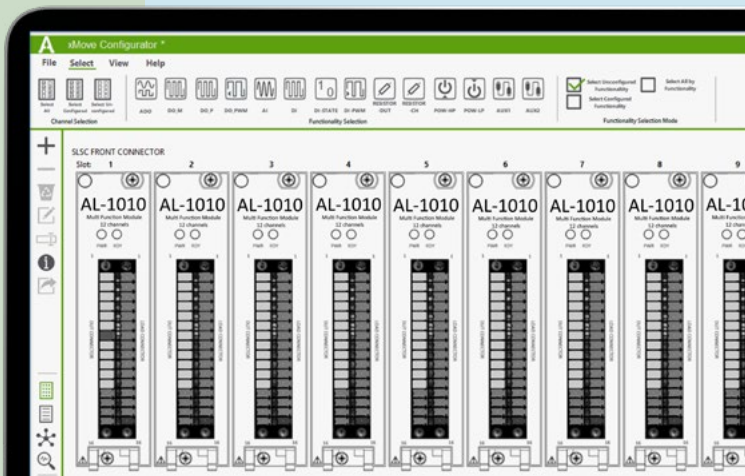


FIGURE 02

Open Platform HIL Architecture

Aliaro xMove Configurator Software

- Decrease downtime during system reconfiguration
- Change and update a large number of channels
- Save channel and system configurations
- Use included API for external access



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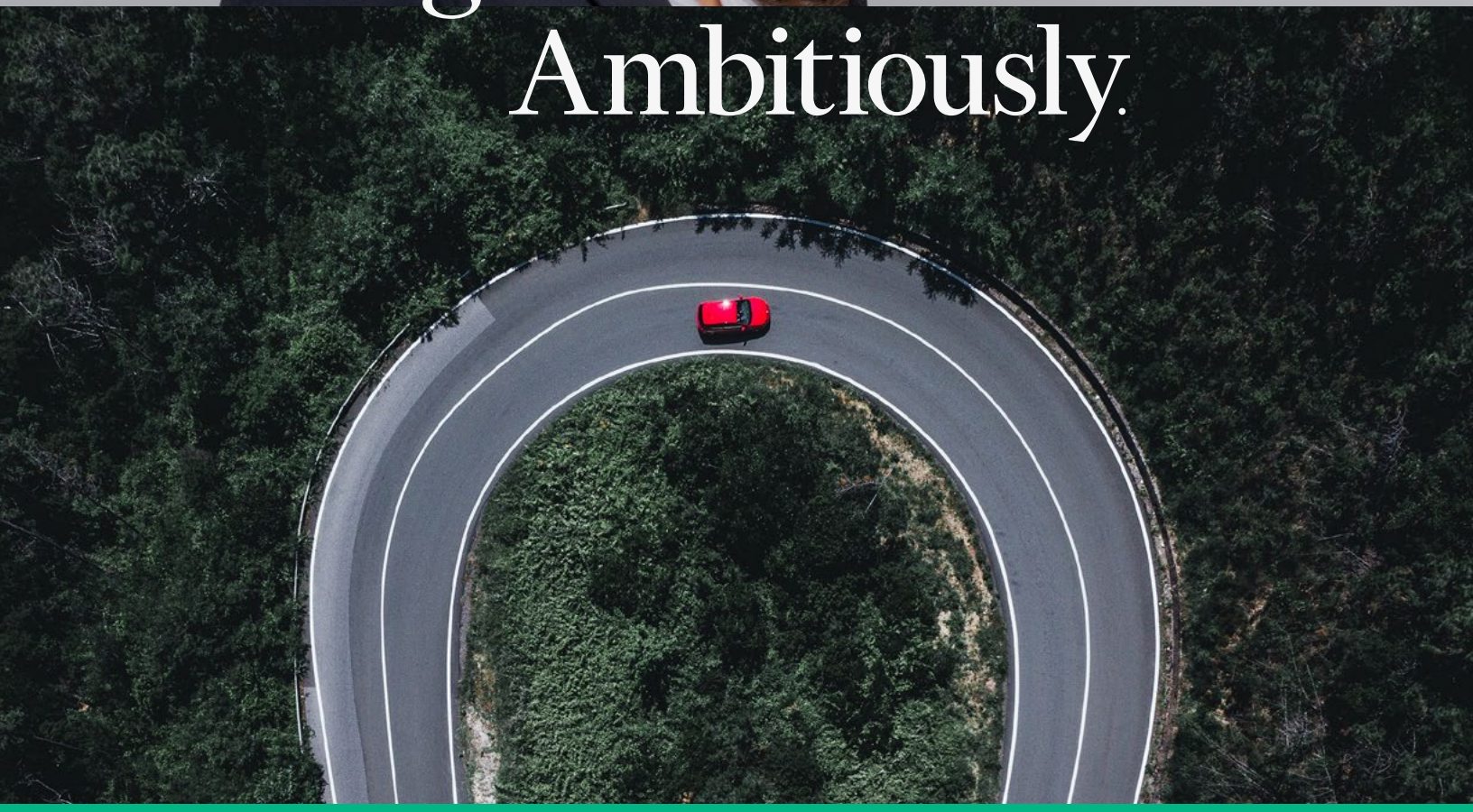

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