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Going Social with Your Test Strategy

Launching an EV Startup against All Odds

The Importance of Battery Life-Cycle Innovation in EVs

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Focus on Performance

The automotive market might appear to be in chaos. Component shortages are wreaking havoc on supply. New partnerships are redefining boundaries between suppliers and automakers. Yet, new electric vehicles seem to be introduced weekly. Somehow amidst the chaos, the industry is working together to drive innovation, increase safety, lower emissions, and increase profits. But how? In a word, focus.

More than ever, automotive innovators have a clear focus on the destination—Vision Zero—and the navigation system that will get them there: software. It's clear that automakers and their suppliers intend to add value to their customers through software. Software is adding incredible value not only to the safety and performance of the car but also to the efficiency and effectiveness of the manufacturing process.

As software continues to reshape automotive, NI is similarly focused on the opportunity presented by the infusion of software. From GPIB-based drivers to a graphical programming environment that revolutionized data acquisition, NI has been a software-centric test company for over 45 years. We have expertise in creating software that allows instrumentation to work together, customizes the capability of individual test routines, automates production test, and integrates analytics across the development process and supply chain.

No test vendor is better positioned to help you use software as a competitive advantage. There are no shortcuts on the path to Vision Zero, but there is a better way.

Let us show you how.

Going Social with Your Test Strategy

The 20th century brought us personal test and measurement. However, as systems grow bigger and more complex, we need to move to a paradigm of test and measurement as a social, cross-functional, and scalable network of people and things: test and measurement as a social network that brings together engineers, test and measurement equipment, simulations, and units under test to drive decisions that improve the quality of product design and production.

Evolving beyond Personal Test and Measurement...

The world of test and measurement has always leveraged revolutions in compute and network technology. The 20th century, for example, saw the advent of personal computing with bus technologies such as PCI and PCI express, which enabled modular and expandable hardware designs. This PC technology motivated NI to usher in the era of personal test and measurement by helping test engineers to cost-effectively create customized test and measurement devices to break free from the limitations of box instruments.

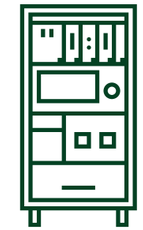

FIGURE 01

The 20th century brought us personal test and measurement technology that enabled engineers to create customized test stations in a time- and cost-effective manner.

Personal test and measurement were characterized by:

- A focus on a small team of test engineers creating personalized test and measurement stations
- Productivity gains driven by the ease of hardware assembly and expansion
- Increased ability to define a station's behavior using software
- Rapid application development environments

Into a Network of Things...

The 21st century is characterized by an explosion in the interactions between people and devices through network technology. As expected, this revolution is spilling over into test and measurement. In transportation, the driver of this revolution is a dramatic increase in both the scale and complexity of autonomous and electric vehicle testing. In battery test, for example, the challenge is not only how to handle testing a single battery cell but also how to simultaneously manage tens of thousands of cells in validation and millions in production.

To deal with the growing complexity, test and measurement systems have grown more connected. Our personal test and measurement devices get equipped with network connections and become part of a lab- or plant-wide Network of Things (NoT). On top of test results, test devices and stations publish data needed to compare the quality of results among their peers and assess their health, which reduces operational costs like service and maintenance. Processing test results and equipment health data now goes to server nodes where software is easier to scale and maintain, which further reduces the cost and complexity. As test devices and stations grow more interconnected, so do the engineering teams that design them.

In the NoT era, network technology drives innovations in system and software architectures. Network bandwidth, latency, and quality of service determine an engineer's ability to partition hardware and software in ways that help lower the cost of the overall system and improve the productivity of test engineering and operations. Time-sensitive network technologies and the XC high-speed, real-time fieldbus technology for scalable power electronics are examples of how NI took this networking trend and fit it into the test and measurement world.

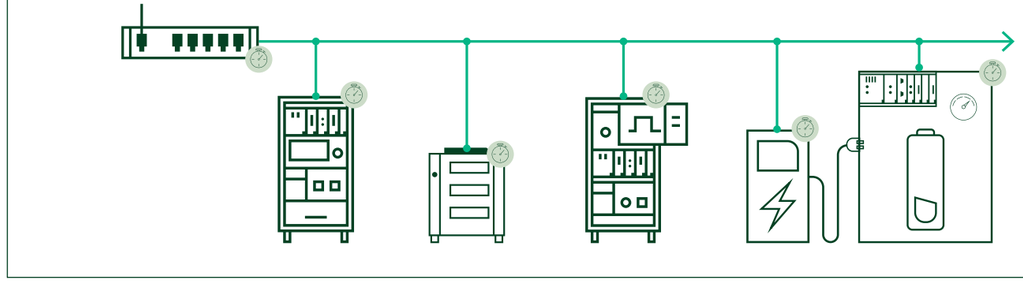

FIGURE 02

Revolutions in network technology enabled engineers to bring test equipment together in a lab- or plant-wide Network of Things. High-bandwidth network connectivity fosters modular and scalable system and software architectures, which drives down the cost of managing and expanding capacity as well as complexity.

Toward Social, Scalable Test and Measurement

The revolution does not stop with just test as a NoT because generating, capturing, pipelining, and processing test data are only one part of the story. An even bigger challenge is to make sense of all this data so it doesn't end up filling hard disks that no one has time to search. Since the purpose of collecting the data in the first place is to drive decisions and improvements, how do you decide which data and features are worth highlighting to engineers and operators?

Social network technologies are a great place to start tackling this problem, given their ability to represent people and their actions as well as automate the sifting and prioritization of the streams of data they produce. Rather than a narrow-minded focus on measurement acquisition and data transport, test and measurement infrastructure must be conceived as a social network of people and things—a social network that enables the interaction of engineers, operators, managers, measurement devices, test stations, designs, and products to drive decisions that improve the quality of product design and production.

How do we bring this social test and measurement network to life?

- **Smart digital interfaces and cloud connectivity**—Every participant in the NoT will need these. Digitization is driven deep into the sensors and actuators with smart interface behavior that is fully defined by software. For example, smart sensors and actuators offer digital interfaces, complementing raw measurement data with context, such as time or ambient conditions. Digital, software-defined interfaces are critical to making sensors and actuators intelligent and active participants in our social network of people and things.
- **Digital twins**—Software representations of both the units under test (UUTs) and test systems, digital twins are the primary means to describe expected system behavior in a way that can be understood by computers. So, if either an engineer or an automated system wants to know if a UUT or test system is behaving correctly, one way to do so is to compare measurements against predictions fielded by these digital twins. In short, digital twin technology is crucial in making sense of all the data we generate and in automating the processes to do so.

While this is not a comprehensive list, it does represent the foundational technology needed, and it's heavily driven by software. At NI, we believe that to increase product, operational, and engineering performance, test can't be stuck in the 20th century. Guided by this idea of test and measurement as a social, cross-functional, and scalable network of engineers, operators, managers, sensors, actuators, test stations, and UUTs, we invest heavily to develop our technology and platform, hone our skills, and foster our ecosystem to be a first-class leader in test engineering for the 21st century.

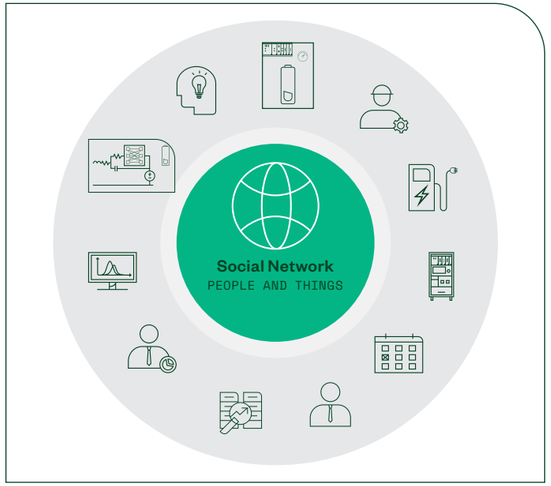

FIGURE 03

To get value out of the massive amounts of data collected in large-scale NoTs, we need to conceive test and measurement infrastructure as a social network of people and things—a social network bringing together engineers, operators, managers, measurement sensors, test stations and products under test to drive decisions that improve the quality of product design and production.

Author

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Launching an EV Startup against All Odds

The need to get from point A to point B has always existed, and we as humans have found creative approaches to tackle transportation challenges along the way. After the days of horse-drawn carriages were behind us, the introduction of the first vehicle powered by a gas engine helped humans travel long distances faster—albeit with access limited to privileged groups. The evolution of mass production then helped provide access to a broader audience, changing the automotive industry and paving the way for new possibilities in technological advancements beyond the engine system.

Today, we are at an inflection point regarding climate change; many experts point to 1988 as a critical turning point when watershed events placed global warming in the spotlight. Climate change and transportation go hand in hand, and the life-changing technological advances that helped revolutionize the way we move are the same technologies that have contributed to the wide-scale pollution of the planet, creating a responsibility for all of us to do better and adapt to this new era of electrification for the sake of the planet.

In this last decade, several electric vehicle (EV) startups have been established with the common goal to help preserve the planet. Still, the ones that stand out are the ones that have innovated, disrupted, and optimized the problem-solving process. Being able to adapt to ever-changing landscapes has proven crucial to surviving two of the biggest challenges in history simultaneously: a global pandemic and supply chain shortages.

A Connected Engineering Workflow

In 2020, NI had the opportunity to work alongside an EV startup. We witnessed firsthand the importance and impact of having a connected engineering workflow to perform precisely as planned and overcome technology and process challenges to get the startup's product to market faster with zero defects.

This article explores the main elements that have helped the EV startup company maintain its commitment to its customers and shareholders with the support of its employees, suppliers, and partners amidst ever-changing obstacles.

Accelerating Time to Market

One of the biggest pressures startup companies experience is delivering commitments to the market on time and before their competitors. The EV startup learned that adopting an open, connected workflow is crucial to using test as a differentiator. Moreover, having an open, flexible system built to industry standards allows scalability across suppliers and engineering teams through all stages of product development.

"I can bring in elements of any other vendor and tie them into the NI workflow. It's so open and unified that it makes my job easier." —EV Test Engineer, EV Startup

Another key factor in accelerating the time to market is shortening test timelines by shifting to the left in the validation phase. Relying on simulation test increases the development pace, expands test coverage, and identifies bugs earlier in the process.

Focusing on ways to close the loop faster with test can significantly impact business. Still, these steps are just the beginning; integrating test across functions by uniting data analytics and test data to optimize processes across the supply chain can help reduce the risk to schedule, which is crucial in the world of EV production.

Reducing Risk to Schedule

When starting our collaboration, the CEO of this EV startup defined the production schedule as his top priority. Understanding the startup's priorities from the beginning helped us build a plan that has enabled it to keep pace with its timeline:

- Comprehending its deeper needs and the challenges it faced allowed us to create a proposal that included a connected workflow, helping it **reduce delivery schedules by 50%.**
- Injecting NI engineer talent through our resident engineering program **saved 25% of its development time.**
- Being an expert connector and facilitating conversations across its teams and sites helped it save development work by leveraging code already created with remote deployment capability into its systems across the globe.

Test is essential, and it's the last step between cars leaving a factory and consumers driving their newly purchased vehicles. But before the test phases commence, other factors like supply chain issues must be considered and resolved.

Today, we face one of the most significant supply chain shortages in history. These shortages are affecting delivery lead times for components up to one year or more, which is time a startup company does not have.

Since this posed a risk to this EV startup's schedule, we worked closely with its design teams, who provided insight into features they needed to test. Based on that information and our extensive background working with other OEMs and Tier 1s in the automotive industry, we were able to request parts before they were needed to avoid schedule delays. This helped them stay on track by providing access to test equipment early to help engineers continue building and testing the vehicle in the face of uncertain global supply chain constraints.

Lastly, we engaged our automotive partner ecosystem and combined its know-how with NI's automation and measurement experience and open workflow. Our vertical expertise across vehicle domains, along with the EV startup's software and sciences expertise, helped it build its first vehicle ever in 2021. This is just the beginning as it keeps improving its manufacturing operations and developing new products and services by focusing on achieving the best possible customer experience and quality.

Improving Product Quality

Creating EVs that perform at the pace the market demands will require companies to transform the way they think and approach test for decades.

Beyond having reliable hardware and software, gaining access to data the startup feels confident it enabled its leaders to make decisions on how they can improve the quality of their next generation of vehicles and understand where they should focus their investments going forward.

The Journey Ahead

NI has transformed test with software by enabling software-connected instrumentation with a modern approach to test data and analytics to unlock the full value of test. By equipping companies with software, hardware, and connected workflows, we enable teams to improve their performance.

Implementing a connected workflow, using an open and flexible system, and positioning data analysis as its key differentiator across its organization positively impacted the way this EV startup interacted across teams and with its stakeholders. With the help of NI, it can now be more agile, define its own workflow in the entire toolchain, and react to the market and technology as it evolves during its journey to help preserve the planet.

Stay tuned for our next edition, during which we will examine how the startup's engineering teams are solving EV and advanced driver assistance systems technology challenges.

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The Importance of Battery Life-Cycle Innovation in Electric Vehicles

The automotive industry has been progressively transitioning to electric vehicles (EVs), which is likely to shake up market share and company profits. Success and performance will be based on a different set of technologies with new challenges and evolving consumer considerations. New models will have varying degrees of range, acceleration, cost, and functionality. The winners in this EV race will best adapt to customer needs and quickly deliver vehicles accordingly. However, even in this complex and hypercompetitive environment, there is a single dependency that will enable manufacturers to have a truly competitive advantage: battery innovation.

The specs of EVs will be tightly correlated to this one component: the battery. Battery design, production, and life span will play a significant role in the success of any given model. Consider the following critical dependencies:

- Recharge time
- Impact of charge/discharge cycles
- Consistency of electrical output
- Manufacturing cost
- Safety record
- Temperature extremes

Evaluation of these attributes must occur again and again, pushing manufacturers to continually innovate to create the most compelling automobile. The winner in the long run will not be the vendor who creates the best battery technology once. It will be the vendor who best implements a company culture around battery innovation, enables a platform for rapid design, and embraces data to accelerate and enhance design cycles.

This is the reason NI is taking a data-centric approach to battery innovation. Today, that starts in design and validation. R&D teams are finding new ways to manufacture batteries, and the data generated by these projects is vital. However, secure and timely access to this data across multiple sources and locations is difficult. Complexities with data formats, test procedures, storage locations, database schemas, and more make managing this valuable data a project of its own.

NI provides a comprehensive solution to address this challenge built on SystemLink software. This central platform simplifies the management of battery data by connecting to all data-generating sources to ingest and transform data into a known location with a set format and schema. The connectivity and data gateway create an extensible architecture to easily connect to existing and new validation labs. Then, a complete suite of battery awareness tools allows that data to be visualized and analyzed by the right people at the right time. With NI, manufacturers can standardize and automate their approach to battery data, which allows them to develop better battery technologies faster and at lower costs.

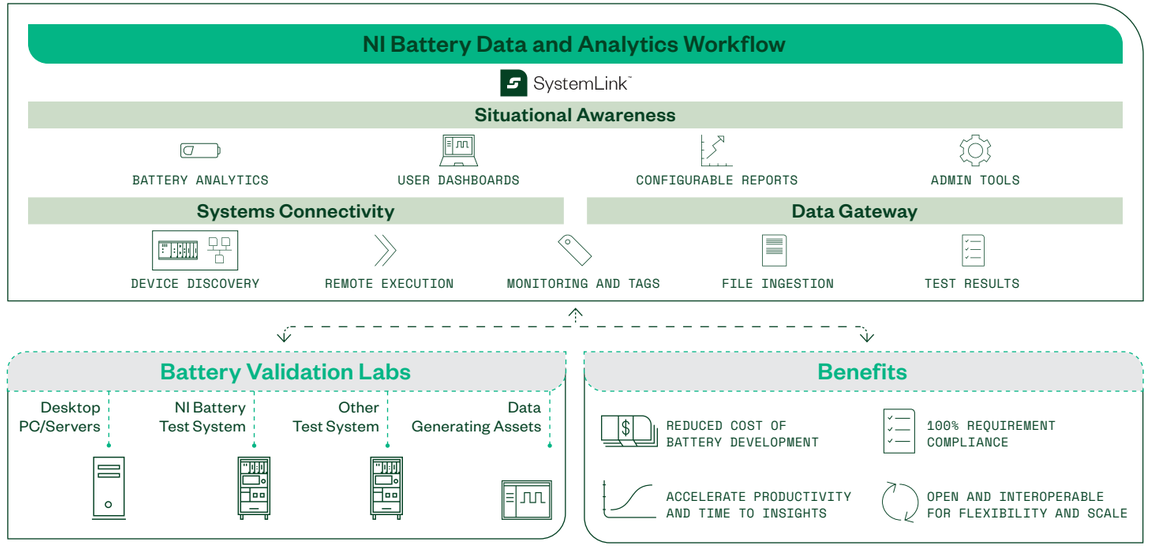

FIGURE 01
NI battery analytics applications for battery validation

Manufacturers then scale those designs into high-volume manufacturing, where focus shifts to process repeatability and accuracy. This is important to achieving profitable production at scale, and more importantly, to ensuring safe and reliable batteries are delivered to the market. With millions of units to monitor and zero margin for error, the attention once again shifts to data.

From cell to module, pack, and chassis, the batteries create a valuable stream of data. This product-centric data taken directly from the batteries is the best representation of the health and stability of the production process. To extract that value, the data needs to be collected, harmonized, and analyzed effectively. Like in the validation space, NI also has a Battery Production solution that can extract this data, combine it with other sources (like MES or ERP systems), and generate meaningful insights about the production process and the battery design itself. These insights can support an array of data-driven or even automated decisions that will improve operational and business KPIs. With advancements in video processing and machine learning, this data is not limited to just test and measurement parametric results, but can even include camera images, like those used to inspect weld quality.

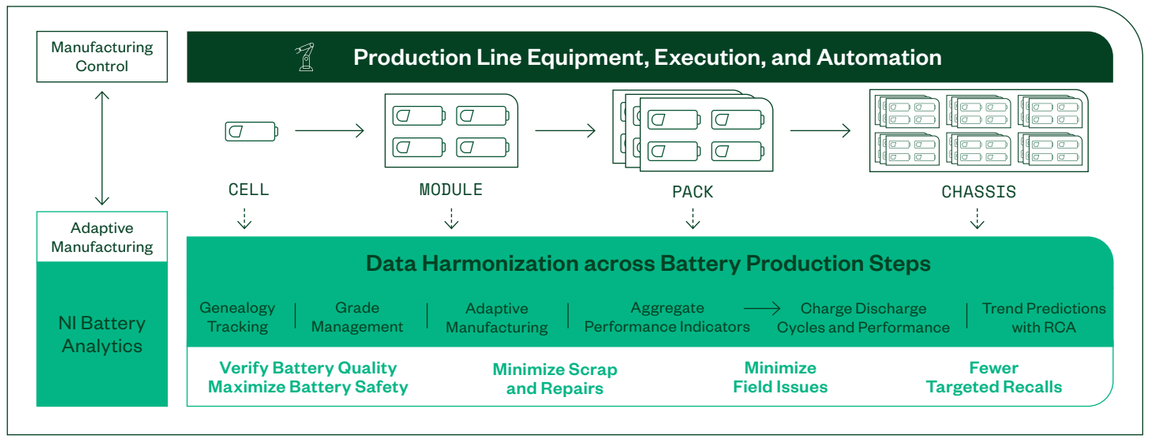

FIGURE 02
NI Battery Analytics Applications for Battery Production

Today, solutions in validation and production are available, but there is significant room to grow. Manufacturers who realize the importance of harnessing their battery life-cycle data and begin to implement infrastructure to extract that data now will have an advantage as the EV market matures. Getting ahead of the game as these technologies are developed will provide the base platform and company culture to drive battery innovation and allow manufacturers to leverage historical data to improve battery design. These companies will be positioned to deliver continual innovation on battery designs that are better than the competition.

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Watch the webinar

Customer:
Major US Truck Manufacturer

Application Area:
Digital Engineering

Challenge

The customer had siloed databases with limited contextual information about test data, such as configurations of an engine or a test vehicle. The inflexibility of the systems and sheer volume of data made analyzing all the data difficult within time constraints. These inefficiencies resulted in higher costs and longer product cycle times.

Solution

Viviota Time-to-Insight Edge

- Automates and operationalizes data ingestion and implements a flexible dynamic metadata schema
- Delivers universal access to sensor data through a single, Time-to-Insight (TTI) user interface
- Provides easy integration with existing engineering analysis tools and corporate systems
- Accelerates analysis at the edge to handle even the largest analysis workloads

NI PRODUCTS USED:

- SystemLink
- DIAdem

Automotive Digital Transformation Using SystemLink and Viviota Time-to-Insight

In a rapidly evolving marketplace, automotive manufacturers need to design, develop, and deliver their products to market as soon as possible by optimizing the iterative design process. This way, they can help lower costs, gain efficiencies, increase performance, and improve product time to market.

Challenge: Siloed Engineering Data in an Aging Infrastructure

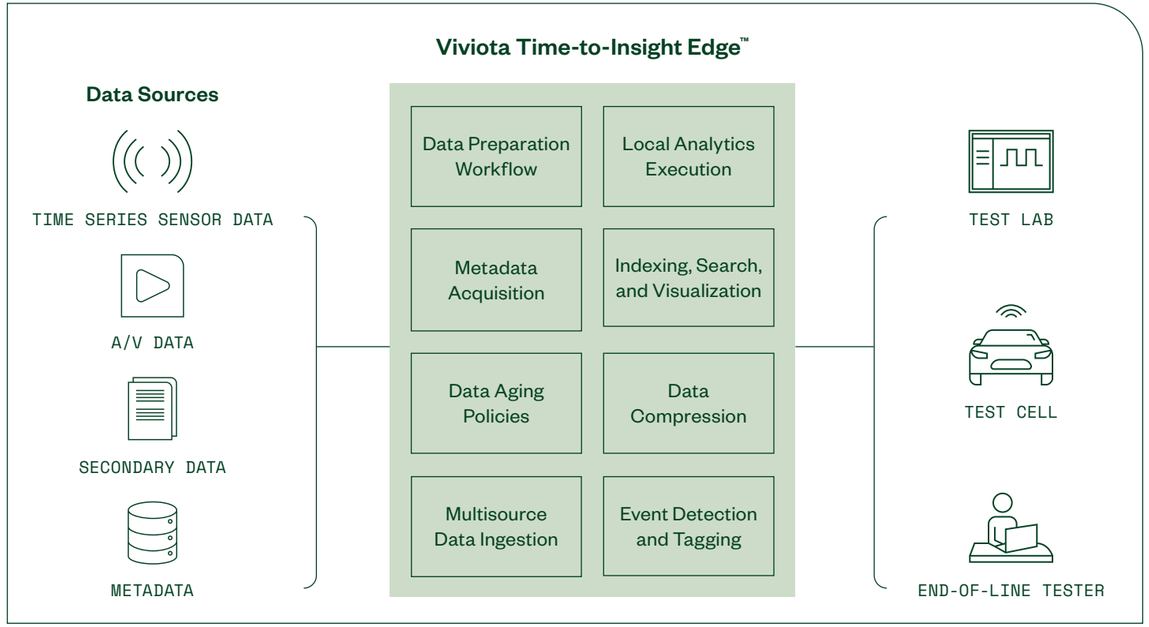
A major North American truck manufacturer selected Viviota Time-to-Insight (TTI) Edge software for enhanced engineering data management and accelerated analysis. Viviota TTI software works with SystemLink data modules and DIAdem to automate data and analytics management.

The truck manufacturer's typical engineering workflow was supported by the analysis of engine test data acquired in several environments, including multiple test cells and in-vehicle test facilities. This arrangement had siloed test data and limited contextual information (metadata), such as configurations of an engine or a test vehicle, or the setup of the test cell and the type of test performed. Finding test data and related contextual data involved looking up information in disparate databases and directories to understand details about the test and the acquired test data. Consequently, the ability to gather all the required information to perform an analysis resulted in hours of preparation time.

The inflexibility of the systems and sheer volume of data made analyzing the data difficult within time constraints. The inability to find data easily led to expensive retesting, which slowed down the development process.

Objective: A Single, Open, and Scalable System for Engineering Data Management

The customer's team members wanted a software platform capable of automating all aspects of their sensor data consumption and sharing. The team required well-documented and validated data for reliable and faster analytics and reporting. Removing manual processes and providing universal access to better quality data would give engineers the freedom to focus on higher value-add activities for product design, prototyping, and testing. This would lead to shorter product time to market.



Viviota Time-to-Insight Edge Software

Solution: Viviota Time-to-Insight Edge Software with SystemLink Data Modules and DIAdem

Viviota provided a complete, end-to-end data management and analytics solution. TTI Edge was implemented in multiple edge computing environments including test cell, lab, and test track. The solution united data from these edge environments along with centrally available data so the user has a single window for all sources. The solution platform also included an HPE Moonshot server, a powerful server-class system that can effectively scale for data management, analysis, and reporting. TTI offered a better user experience by providing a single point of access to engineering data from any data source. The flexible, dynamic metadata schema provided by TTI gave engineers the rich data context they needed to access all relevant data and reach reliable conclusions more quickly. It also provided a single interface and the ability to run analytics using their current set of engineering tools.

The fundamental processing components of TTI Edge were able to distribute storage and processing across all available server cartridges, helping to optimize data management, searching, and analysis. Viviota's TTI software also used the HPE Moonshot platform to increase I/O scalability.

These data management improvements shortened product time to market. The digital transformation team estimates a system payback period of one year and expects continued savings.

Author

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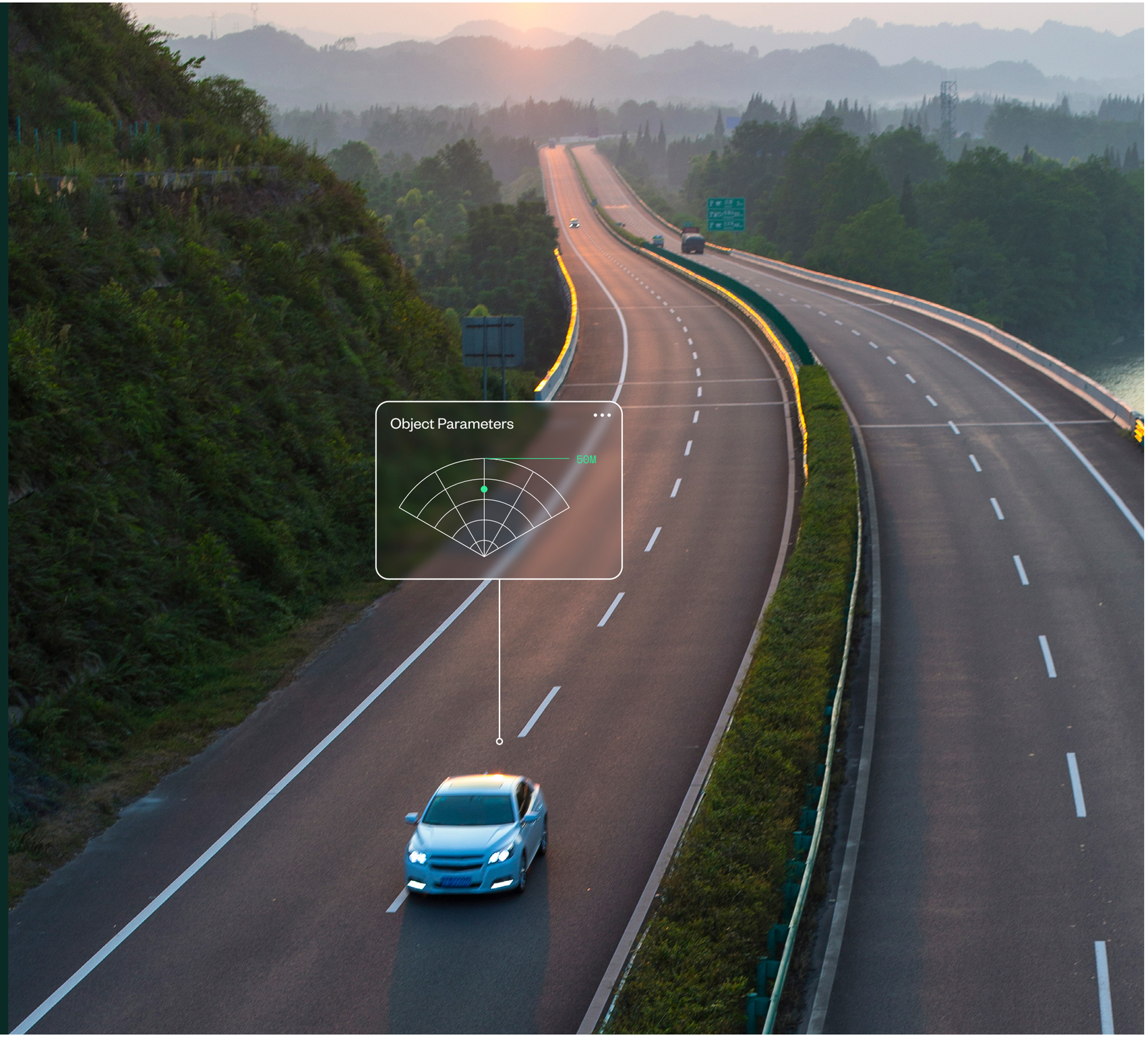
A Better Path to Vision Zero

No test vendor is better positioned to help you use software as a competitive advantage. There are no shortcuts on the path to Vision Zero, but there is a better way.

Let us show you



EVs Are Changing Lifestyles and Manufacturing Forever

When the time came to replace my 10-year-old sedan in 2015, I knew I wouldn't be purchasing another internal combustion engine vehicle. The idea of buying a gasoline car felt akin to using a typewriter for work: old-fashioned. This was not a widely held opinion then, or even now. Yet, it's remarkable to observe the shifting sentiment since that time and consider the implications for consumers and the automotive industry.

After purchasing my first EV, I was met with concerns from even my tech-savviest friends and colleagues: "How will you charge it? Can you take road trips? How long will the battery last?" While these concerns were not entirely unfounded, they demonstrated how far EVs had to go before becoming mainstream.

My family and I quickly fell in love with the EV lifestyle. We woke up every morning to a fully charged car - no more trying to squeeze in a stop at the gas station. Cross—country road trips were actually less stressful in our EV—they became easier to plan since we mapped out charging stops beforehand and knew exactly where we'd be stopping.

Most of all, it felt good to be a part of a movement we believed in, but the instant torque of an electric motor and the handling of a car with such a low center-of-gravity didn't hurt either. Our first EV was joined by a second after only a year, making our transition to a fully electric family complete.

Fast forward to 2022: this year's Super Bowl had no fewer than four ads for new all-electric vehicles, marking a major milestone in the ongoing transition. We are at the beginning of a massive S-curve, the likes of which the industry hasn't seen in decades as EVs become more commonplace and sought after. Conservative estimates are forecasting that the industry will manufacture as many as 12M new battery electric vehicles (BEVs) in 2025, requiring a global capacity of well over 1,300 GWh.

As a consumer, I'm thrilled by my experience and the feeling of contributing to a more sustainable future. As someone who has spent their entire career in test and measurement, I'm fascinated by the technical challenges that OEMs and the supply chain face.

The battery is the core element of a BEV: it defines the range, performance, and cost and profitability. Batteries also have direct implications on safety: most BEVs are heavy and have a very low center of gravity, making them very safe thanks to their unwillingness to roll over. The absence of a massive engine and transmission in front of the passenger makes the deadliest of collisions, high-speed front-end collisions, far more survivable. However, batteries pose their own set of concerns regarding thermal events that could lead to expensive recalls or even fires.

It's for these reasons that few components so acutely illustrate the balancing act of manufacturing throughput and testing coverage. The average cost of a battery pack was $137/kWh in 2021, and it's said that the $100/kWh milestone will mark the key price point at which a BEV is less expensive than a comparable gasoline car. Though for some vehicle categories, ownership costs are already tilted in favor of BEVs.

Trending headlines continue to reinforce the ongoing investments into standing up new facilities by both OEMs and cell suppliers. The formation and aging of a cell takes about two weeks, making it one of the costliest and resource-intensive aspects of battery production. Assembly of the modules and packs is more straightforward, but the implications and cost associated with reworking failed products or servicing field failures can be massive.

Successfully scaling battery operations will require novel approaches to test and manufacturing that focus on the following:

- **Prioritize scale**—The capacity required to profitably deliver the aspirational goals of the industry will require novel approaches that maximize the utility of expensive cycling and testing equipment across massive volumes of devices.
- **Screen for defects early and often**—The expense, complexity, and danger of a battery make it expensive and time-consuming to rework defects after final assembly. Comprehensive test strategies need to be combined with analytics to detect defects as early as possible, especially at the cell level.
- **Connect process and test data**—Data from the fleet needs to be combined with test and process data from across the supply chain and even R&D to rapidly determine the root cause, identify any other products that could be impacted, and quickly make process and testing improvements.
- **Ensure testing accuracy and repeatability**—It may seem obvious, but taking this for granted is especially problematic when working with low impedance devices like batteries and only becomes more important when combined with complex fixturing.
- **Integrate testing into the product**—The electronics that control and monitor the battery components should be leveraged throughout the manufacturing process to provide additional testing coverage and data to ensure the quality of the final product.
- **Use an adaptive manufacturing process**—The manufacturing process must be nimble given the rapid pace of change as cell chemistries, form factors, and testing methodologies continue to evolve and improve. This requires flexible and module approaches to instrumentation and power electronics that maximize existing investments.

Finally, part of what makes this time so exciting is that, in many ways, scaling EV manufacturing is still a new frontier of innovation and technology. I'm excited by the role NI and our solutions are playing in such a pivotal moment—we're making these novel solutions more available and accessible for high volume manufacturing, and we're genuinely excited for the role our products are playing in accelerating the advent of more sustainable transportation.

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Driving Innovation through Inclusion

Whether you attribute it to the epiphanies of #COVIDlife or just those darn millennials, it's nearly impossible to deny the fundamental change that our society is undergoing regarding greater awareness of our individualities and learning how to embrace them for the better. This quarter, I talked with Kazique Prince, director of Diversity, Equity, and Inclusion (DEI) at NI.

Jeff Phillips: Thanks for joining me, Kazique! Can you share a bit about yourself, your background, and your role at NI?

Kazique Prince: I've lived in Austin for 20 years, and this is where I and my family, including two kids—both now adults, call home. One of the things that I love about Austin is that it professes to be a place that is diverse and inclusive, which is certainly true to a point. However, a short drive reveals you're still in the middle of Texas. All my life, that realization combined with the stories and experiences of bias I've witnessed left me little choice. I've spent the better part of 25 years in a career centered on DEI.

JP: Many often look at DEI as a new industry or new area, but like you mention, you've been focused on this for 25 years. Beyond your encounters with bias you mentioned, how has your experience shaped you?

KP: I'm a psychologist by degree and have worked in a variety of industries. In many ways, it was those experiences that did prepare me. There are 2 million people in the greater Austin area, which includes hundreds of languages and dozens of cultures. Before joining NI, I was a policy adviser for the mayor of Austin consulting on issues ranging from race relations and police interactions to economic development and education reform.

JP: That's an impressive resume, Kazique! I'm curious—why the shift to "big business"?

KP: In most of my roles previously, there was an end date from the beginning. I would stand up a program and then move on. I'm eager to have the opportunity to look at DEI from a global perspective. The shift to business is quite simple. In my eyes, DEI is the business. The more our company culture naturally engrains the ideals of DEI, the better we'll do. We'll realize more revenue, be more innovative, and be able to lead our industry.

JP: It's difficult to directly tie these things to KPIs like revenue and innovation, so how do you quantify the impact of your efforts?

KP: Luckily, there's a world full of academics doing research on this topic. Research and literature have been clear—organizations that do well in these areas versus those that don't make more money. In fact, they make on average $500 million more than those organizations that don't. Ultimately, one key question has helped us gain insights into this: How comfortable do you feel talking about cultural differences?

This directly leads to skills like being a good manager, team member, problem solver, and conflict resolver.

JP: Let's move beyond the metrics and talk about the implementation. NI has a goal that by 2030, we want our workforce to be 50% female. How do we move beyond the altruistic need to "do better" and see these ideals show up in the fabric of our management community?

KP: Ultimately, I believe it comes down to how you cascade ideals and align intentions. I honestly believe that most organizations' leadership has wonderful ideas about how to make a measurable impact, but they aren't truly thinking about how to develop a workforce that leads through inclusion and is interculturally competent. It's clearly more than just being a good manager. Often called power skills, these traits are necessary for collaborative problem-solving and high-innovation companies.

JP: Let's bring it back to NI. Can you talk about your journey here and the opportunity you see ahead?

KP: Great segue, Jeff. It was ultimately the passion and intent of NI's leadership to build this type of culture that brought me here. NI is an organization that has a reputation of being responsive to big challenges, finding ways to solve problems, and being committed to leading through innovation. Why would this company not be attractive to women or people of color? I want to celebrate that, include others, and discover what can happen when we tap into our collective strength and live up to our greatest potential. It's here where our quality of life improves, where our individuals can make a difference in the world, and where we can each live out dreams and aspirations in a meaningful way.

COVID has produced a new set of challenges for individuals and businesses the world over. Change is neither good, nor bad—just constant. I'm proud of the changes that I've seen NI make to embrace these ideals and build a company that's dedicated to developing a high-performance organization that comprises a highly diverse, capable, and motivated workforce.

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

Modern EV Battery Lab

Electric vehicle (EV) battery quality and performance directly impact brand, marketability, and margins for EV automakers. Rapidly changing battery technology hinders the acceleration of validation activities and requires expensive capital investments and resources to meet time-to-market commitments and cost expectations.

To determine battery performance, durability, and safety, engineers test for hundreds of variables over multiple environmental conditions, charge/discharge profiles, failure modes, and long periods of time. Additionally, compliance testing to meet standards such as IEC 62660 or SAE J2464 adds complexity to the already highly demanding job of testing EV batteries.

NI Solution

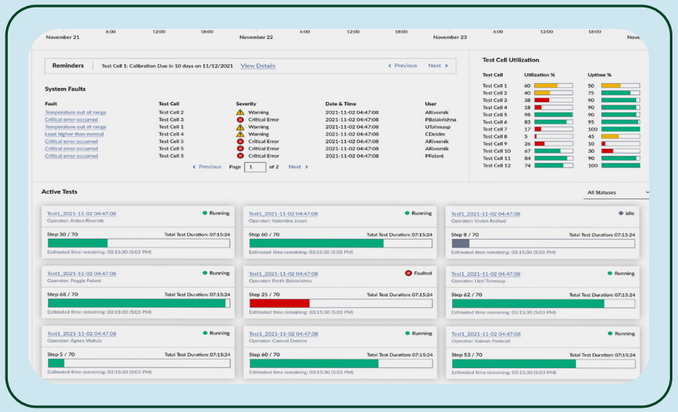
01
Focus on Test, Not Distractions
Get to test faster with the Battery Test System (BTS) Software Suite out-of-the-box functionality or customize your test plan to meet any test need, from configuration to automation

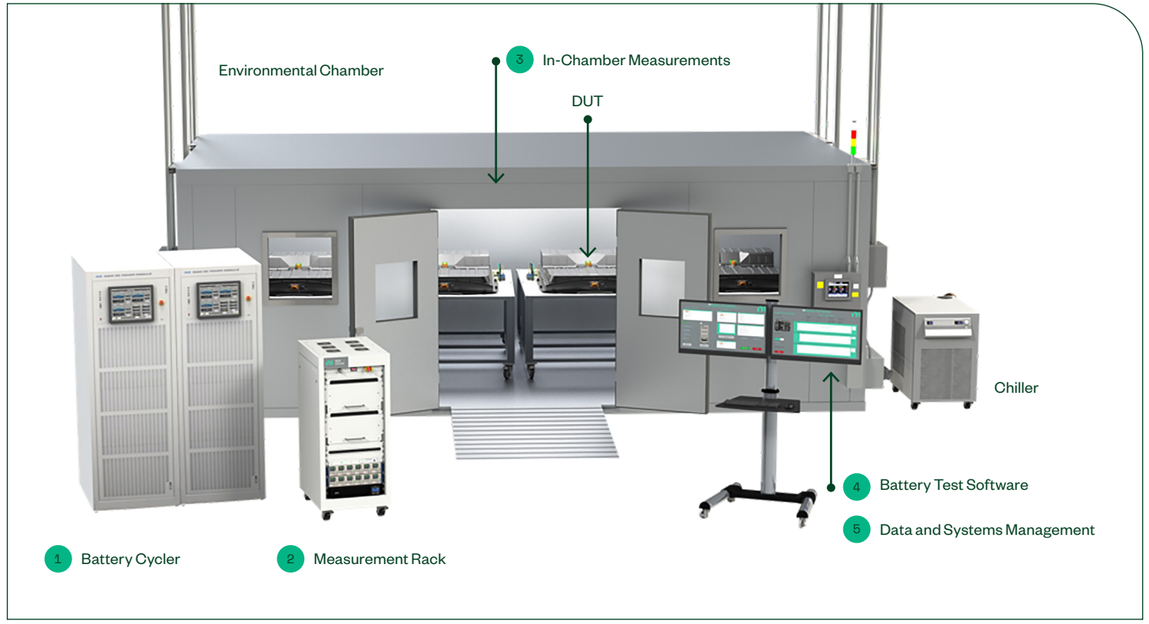
02
Disencumber Test Engineering
Reduce development overhead with a unified software toolchain for requesting, implementing, executing, and reporting on test results with customizable UIs for different roles and users

03
Keep Up with Scale and Budget
Lower total cost of test by seamlessly connecting to existing equipment, adding new equipment, and scaling to large tester fleet deployments while preserving the ability to make fast, data-driven decisions from test results

NI ADVANTAGE

- Respond to time-to-market pressures with a system architecture that scales and adapts from single test cells to large-scale, distributed battery test labs
- Optimize OpEx and reduce the overall CO_2 footprint of your battery test facility by leveraging powerful data and system management software to improve test cell utilization and efficiency
- Deliver higher performance batteries faster and in budget with agile test plan development, improved workflow management from design to test engineering, and powerful data management and analytics software





Battery Test System components

1. Connection to power electronics for battery cycling from NI or third party, such as NH Research, Heinzinger Automotive, and EA Elektro-Automatik, through an instrument abstraction layer that allows the integration without the need to modify the rest of the test system
2. Measurement rack with real-time controller that is expandable to thousands of channels for direct, synchronized device under test (DUT) measurement, battery management system (BMS) communication, and other variables from the chamber or other test and control equipment, with minimum incremental cost per channel
3. Rugged, IP-rated, in-chamber measurement modules and thermal chamber control for temperature and humidity profile test execution and other DUT measurements like strain, voltage, current, or vibration
4. Battery test software with out-of-the-box experience and flexibility to customize implementation, including plug-ins, drivers, and analysis/test IP; features lossless data logging for best traceability and repeatability of test, all on a unified software toolchain
5. NI's data and system management software for creation of customized data dashboards to maximize utilization and uptime, as well as perform facility management to optimize energy usage and reduce CO_2 footprint

System Integration on Your Terms

NI offers a variety of solution integration options customized to your application-specific requirements. You can use your own internal integration teams for full system control or leverage the expertise of our worldwide network of NI Partners to obtain a turnkey system.

To learn how you can increase product quality and shorten test timelines, contact your account manager or NI at (888) 280-7645 or **info@ni.com**.

S.E.A. 3610 V2X Sniffer

To improve road safety and reduce congestion, the vehicle to everything (V2X) communication system needs to interface and be interoperable with other vehicles, traffic infrastructure such as traffic lights, roadside units, and pedestrian devices.

Government agencies, automotive OEMs, and suppliers must validate and monitor the V2X signals in the V2X lab and field applications. Monitoring RF situations and packet-based V2X communication in a compact device is required for this task.

Customer Needs

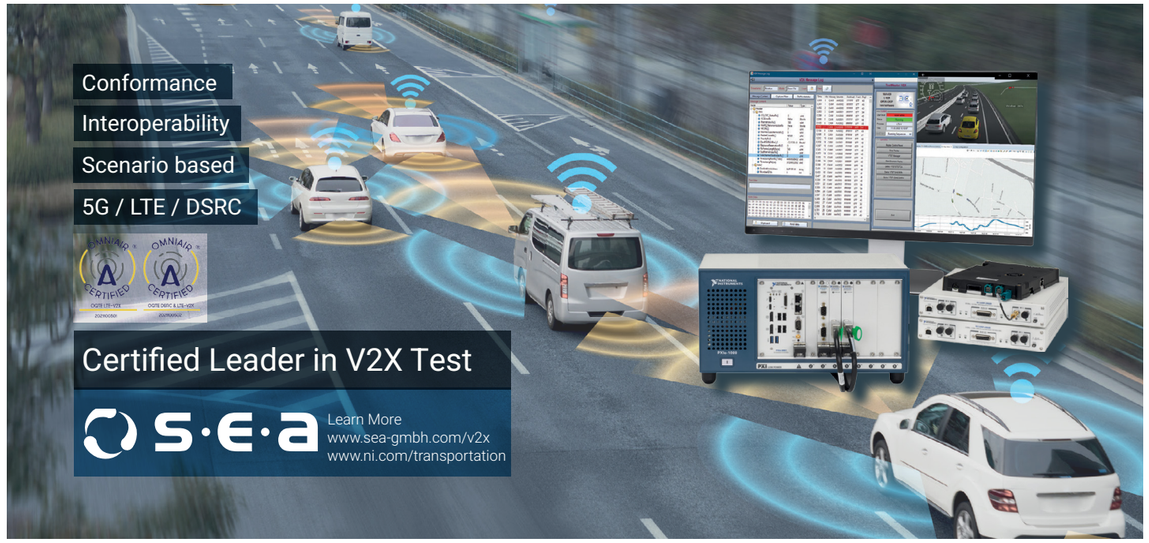
01
Validate the V2X interfaces in all types of vehicles, traffic infrastructure, roadside units, and pedestrian devices

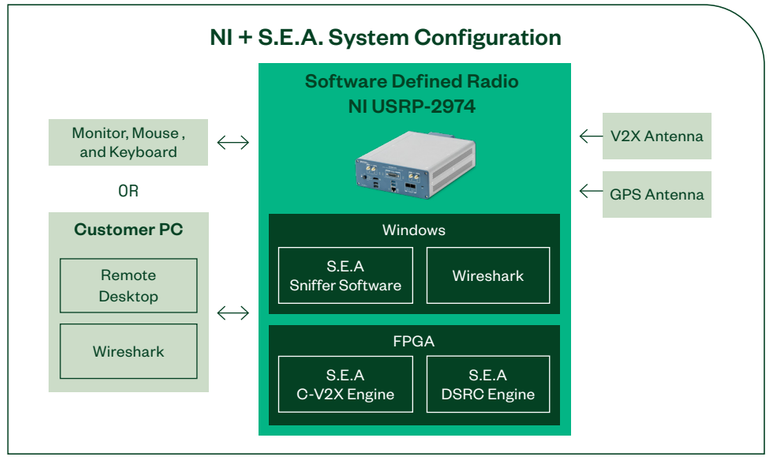
02
Monitor the V2X transmissions to confirm the devices continue to function properly

03
Decode V2X signals including basic messages, advanced protocols, and raw wireless signals for C-V2X (cellular) and DSRC (802.11p) concurrently with GPS/GNSS position signals

04
Record V2X messages captured from these interfaces

05
Monitor and provide overview about RF-signal quality in real time





V2X Sniffer system

NI + S.E.A. Solution

01
The NI USRP-2974 software defined radio stand-alone device provides a high-performance Windows PC, FPGA, and the farthest RF signal support of known V2X sniffers.

02
S.E.A. 3610 V2X Sniffer software monitors C-V2X and DSRC RF signals, logs C-V2X and DSRC events, and records data in an industry-standard format.

03
An enhanced extension to Wireshark monitors and records packets with the V2X messages, supports advanced protocols such as TZSP, and uniquely provides MAC LTE information.

NI + S.E.A. ADVANTAGE

- Only V2X sniffer that is OmniAir certified for C-V2X (cellular) and DSRC (802.11p)
- Future-safe design with software defined radio technology and integration into the comprehensive NI/S.E.A. V2X test and measurement ecosystem
- Concurrent monitoring of C-V2X and DSRC communication and online monitoring of RF signal quality and messages
- Support of high-load (congestion) situations with hundreds of vehicles at a time
- Ability to extend for logging and IQ data recording

KEY SPECIFICATIONS	
S.E.A. 3610 V2X Sniffer Software S.E.A. C-V2X Engine and DSRC Engine on the FPGA	Monitors wireless V2X RF signals in addition to V2X messages Supports C-V2X and DSRC simultaneously Acquires GNSS information Includes the following RF signal views: spectrum, baseband, and constellation for C-V2X and DSRC (C-V2X added subframe timing) Saves packets in the PCAP file format Extends V2X message information with additional PHY/MAC information (SCI-1) for each packet Includes profiles for common parameter settings for US, European, and Chinese V2X applications
Enhanced version of Wireshark	Wireshark Packet Analyzer, extensions with advanced protocol decoding
NI USRP-2974 Software Defined Radio Stand-Alone Device	Includes an Intel i7 2 GHz quad-core processor, Windows OS, and Kintex-7 XC7K410T FPGA
Accessories Including Antennas	Connectors for antennas and other accessories

ADAS Test Coverage Analysis

To ensure safe and reliable vehicles reach the market, the industry needs to account for the almost infinite number of drive scenarios the vehicle may encounter. Whether for advanced driver assistance systems (ADAS) or fully autonomous vehicles (AVs), extensive testing throughout each phase of the product development cycle needs to occur. That requires tools and methodologies that are equipped to meet a variety of customer needs.

Customer Needs

01
Evaluate the safety of an ADAS/AV system based on a large-scale testing plan and coverage methodology and tools

02
Use industry-standard Open Scenario 2.0 to specify abstract scenarios with KPIs to ensure high coverage

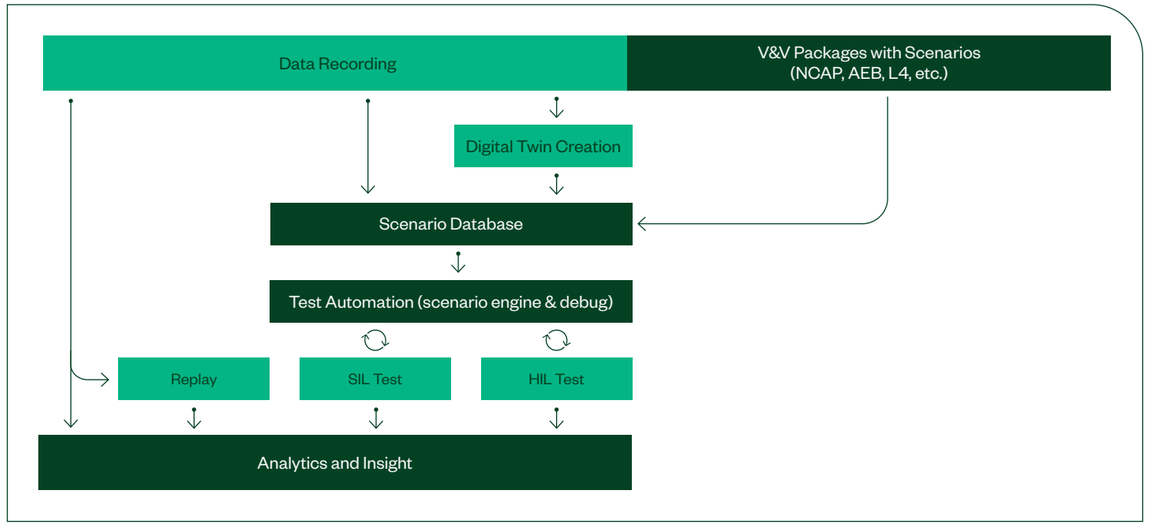
03
Use solver technology to create a massive number of relevant tests for the OSC2 scenarios

04
Analyze results and determine when the vehicle has reached its specific safety goal

05
Quickly test against standard scenario packages like EURO-NCAP

NI + FORETELLIX ADVANTAGE

- Efficient time- and money-saving solution that provides automotive companies a way to objectively build and prove ADAS
- Holistic ADAS solution that improves scenario-based testing, coverage, and ultimately confidence for customers
- Adaptable and dynamic V&V packages with specific ADAS/AV scenarios to test from day 1
- Ability to perform abstract scenarios/cutting scenarios, creating the infinite instances that need to be tested
- Global adaptation feature to allow the reuse of predefined scenarios across regions and consideration of the different regulations, saving development work and time for automotive companies



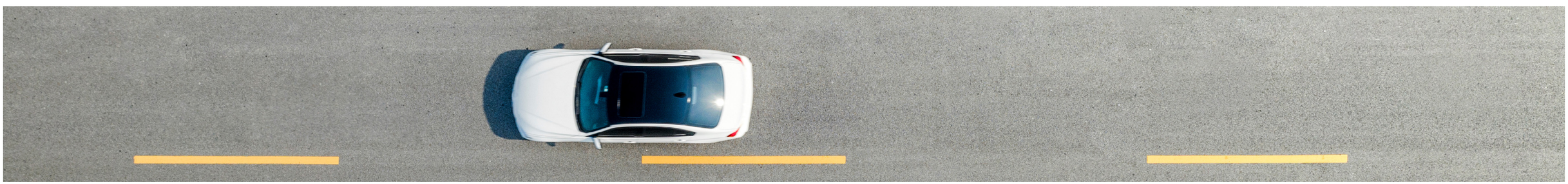
The NI + Foretellix solution provides differentiated test coverage and insight across the ADAS software validation workflow.

NI + Foretellix Solution

01
Use Foretify, Foretellix's test management platform, to generate scenarios, identify safety gaps, and optimize the development process

02
Execute predefined scenarios from the validation and verification (V&V) package created with the global industry standard, Open Scenario 2.0

03
Leverage NI monoDrive Simulator AD for ultra-high fidelity scenario generation and execution, resulting in vehicle information for planning system validation



No Battery? Let's Test Anyway. The Role of a Battery Emulator in EV Testing

Aside from being hazardous, electric vehicle (EV) batteries are expensive, and no one wants to render one useless. However, they are the heart of the EV, and just like a real heart, all functions depend on it functioning properly for the vehicle to perform at its best.

To reduce the risks, cost, and time associated with using real batteries, test engineers rely on using a battery emulator to test EV components like the powertrain, fast charger, supply equipment (EVSE), DC/DC converters, and others. By pretending an actual battery is connected to such components, engineers can test in a faster, safer, highly repeatable environment while gaining flexibility and reducing the effect of variables like temperature dependency or human errors in the early stages of test.

Perhaps most importantly, though, engineers gain the scarcest resource there is: time.

Reduce Test Time

Using real batteries requires time-consuming processes like charging, discharging, and letting the battery rest to bring it to a test-appropriate state of charge (SOC). When using battery emulation, all this preparation is significantly reduced because the battery emulator immediately provides the realistic battery characteristics needed, which helps engineers focus on test instead of battery behavior nuances.

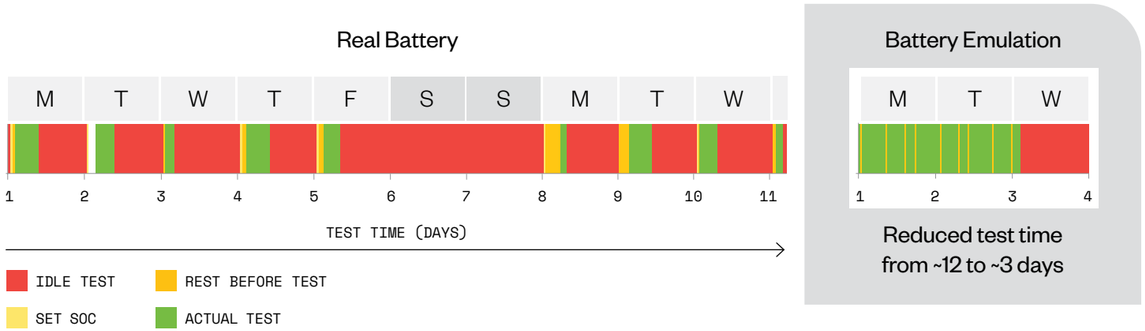


FIGURE 01

Customer results showed a 70% reduction in total test time by replacing real batteries with an NHR battery emulator.

To demonstrate this point, NH Research (NHR) compiled data from a real-world scenario running nine tests with an actual battery and compared it with the results of the same tests using NHR's battery emulator. The battery emulator showed a **70% reduction in test time** (see Figure 1), coming primarily from the idle and rest times.

Improve Safety

Batteries are high-voltage, high-energy devices that pose high risks upon failure, so all related testing is about ensuring not only proper functioning but also safe failing. Risks like exposure to dangerous gases, corrosives, fires, or explosions have led EV companies to create safety policies that state how and when testing with real batteries can be conducted, usually restricting the test time to work hours. Since using a battery emulator does not pose these risks, it provides a way to get ahead of testing without these concerns and limitations.

Increase Repeatability and Accuracy

As a battery wears out, its behavior inevitably changes due to charge/discharge cycles or simply because of aging. Additionally, batteries require significant environmental management, such as coolant systems and temperature changes, to operate properly. Because of this, the power output of real batteries lacks the repeatability needed to perform thorough testing of other components.

To meet these conditions of being realistic but repeatable, battery emulators model real batteries as a bidirectional voltage source along with a series resistance (see Figure 2). In this way, any battery at any SOC can be simulated, providing repeatable and accurate results.

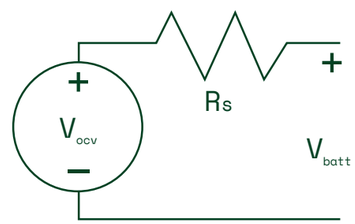


FIGURE 02

Equivalent Model of a Battery

Battery emulators must be designed to generate an output that truly represents any SOC of a battery by following that equivalent model. With this "battery emulation mode," the emulator automatically adjusts the terminal voltage (V_{batt}) by measuring the current flowing to and from it and using it to calculate the voltage needed (V_{ocv}) to consistently maintain, like a battery would, the desired output at the terminal, regardless of current flow.

Choosing a Battery Emulator

You need to consider the following when choosing a battery emulator.

Adaptability

To model any battery and adapt to test needs, the voltage and the resistance values and behaviors of the equivalent battery model need to be programmable. For example, aside from setting the desired voltage, the ability to slew it at slow rates can emulate the change in voltage expected as a battery charges or discharges. Figure 3 shows this effect of programmable series resistance as it is subjected to multiple discharge pulses. Since the change in voltage is proportional to the current with a programmable series resistance model, engineers are able to test a device as if it were connected to a new (low resistance) or an old (higher resistance) battery. This approach allows for faster, consistent, and safe testing.

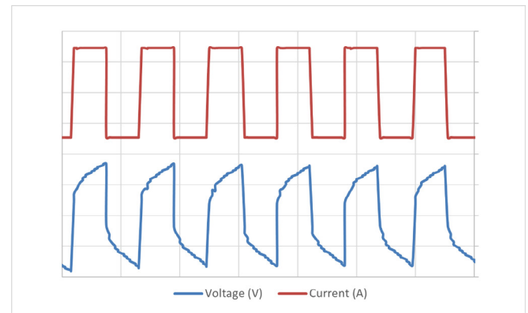


FIGURE 03

EV Battery Simulation Using Series Resistance Model

Low Capacitance

Aside from the programmability of the resistance, a battery emulator must have low output capacitance to accurately emulate the effects of the resistance when the current changes. This is a key differentiation with bidirectional power supplies that usually have high-output capacitance to reduce noise.

Figure 4 shows a comparison of a real battery and an emulated one. The characteristics of the emulated battery precisely match the characteristics of the real battery, in part due to the low-output capacitance.

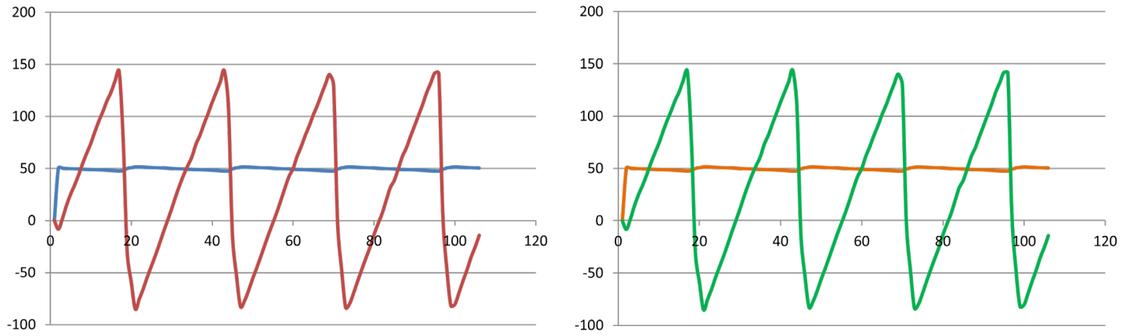


FIGURE 04
Real Battery (left) versus NHR's Battery Emulator (right)

Scalability through Software

In addition to the low capacitance and programmability of the battery emulator, EV test engineers expect battery emulators to have the following characteristics:

- Bidirectional, isolated terminals that handle back EMF effects safely
- Modularity to add up power and meet test needs as they evolve
- Fast response times to emulate real-world conditions and reduce test time

Holistically testing EV powertrains requires open connectivity and flexible test software to manage multiple test stations, add measurement and communication channels, or integrate with other test equipment. As part of NI's portfolio, NHR's battery emulators seamlessly integrate with NI's test software including VeriStand and TestStand as well as data/asset management tools like SystemLink software. EV test engineers benefit from NI's lossless data logging, automated reporting, integrated workflows, and life-cycle analytics capabilities, which result in lower total cost of tests, shorter time to market, and increased product performance.

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