ADAS and Autonomous Vehicle Test

Explore NI's Solutions

As advanced driver assistance systems (ADAS) and autonomous vehicles (AVs) introduce new technology into vehicles, they need adaptable, future-proof test systems. NI offers a software-connected toolchain to automotive test that covers Data Record, Data Replay, Hardware- and Software-in-the-Loop, all the way up to Sensor Fusion and Sensor characterization and manufacturing test applications to address today's and tomorrow's ADAS and Autonomous Driving (AD) technology.

MARSHA CHANG
PRINCIPAL MARKETING MANAGER,
AUTOMOTIVE, NI

Data Record For ADAS and AD

Record sensor and ground truth data during road testing to verify sensor capabilities and train 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 microsecond-level accuracy for sensor and vehicle network interfaces.

02
CHANGING & EVOLVING REQUIREMENTS— Adapt to evolving vehicle technology for current and future regulatory requirements.

03
DATA VOLUME—Manage data creation and capture in GB/s while storing hundreds of TB per day and vehicle, along with the ability to visualize data during road testing.

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

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

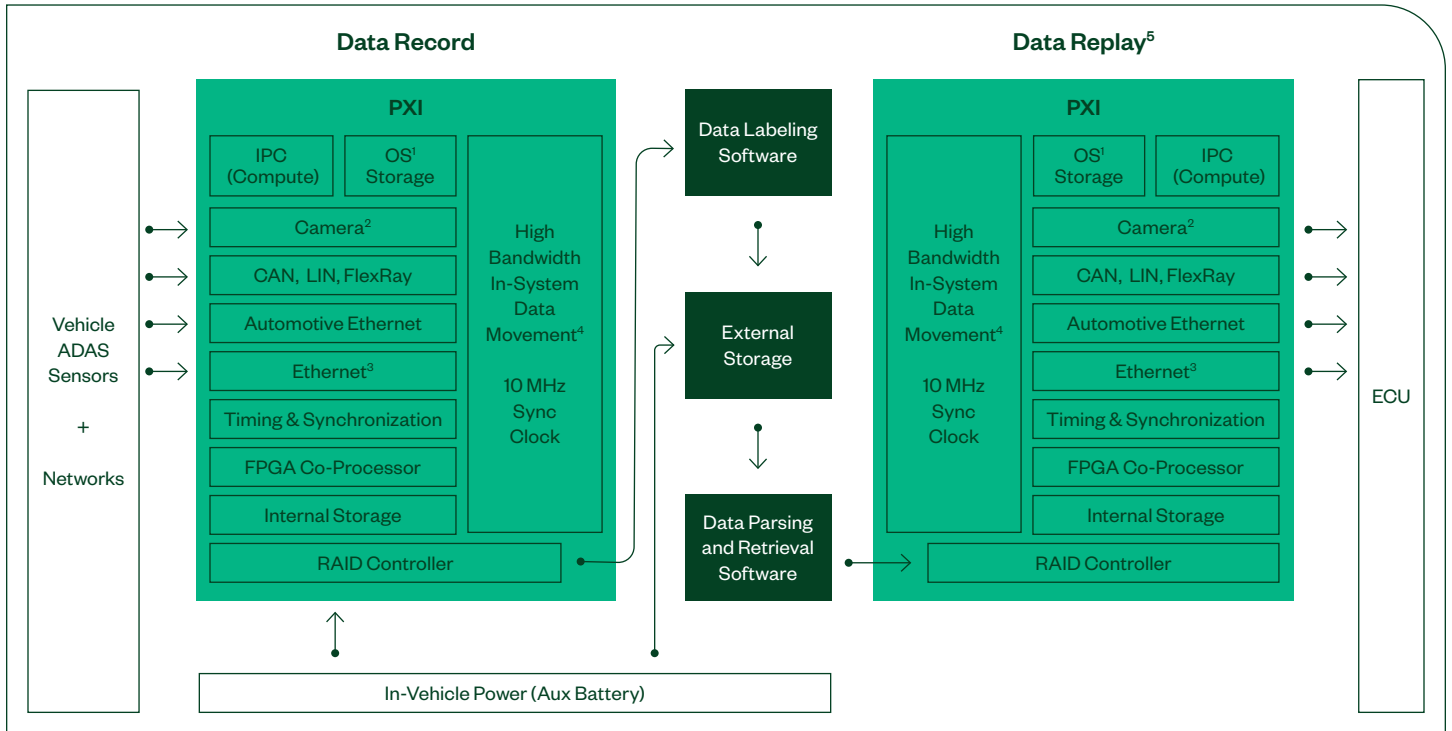## NI Solution

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

02
MAXIMUM SECURITY & 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

[1]Operating System   [2]GMSL, FPD-LINK, FPGA-Based   [3]1 Gbit to 50 Gbit (RDMA in-work)   [4]PCI Express Bus   [5]Data Replay Not Covered in this Solution Brief

THE 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 & EVOLUTION— NI 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

Sensor Fusion HIL with Scene Generation

Integrate scene generation tools with hardware I/O to play back simulated scenarios for validating the sensor fusion and decision-making algorithms on ADAS controllers. Scene generation increases test coverage and can be sourced through various simulation evironments (pure synthetic data) and through recorded data turned into a digital twin.

Customer Needs

01
Integrate hardware I/O with scene generation tools like IPG CarMaker, Ansys VRXPERIENCE, VIRES VTD, Simcenter Prescan by Siemens, or NI monoDrive Simulator AD.

02
Synchronously generate I/O signals to interface with the ADAS controller. With tight control over timing, you can test faults like frame delays or phase coherency.

03
Maintain flexibility for future I/O requirements as systems continue to add more cameras, radar, and I/O types like lidar.
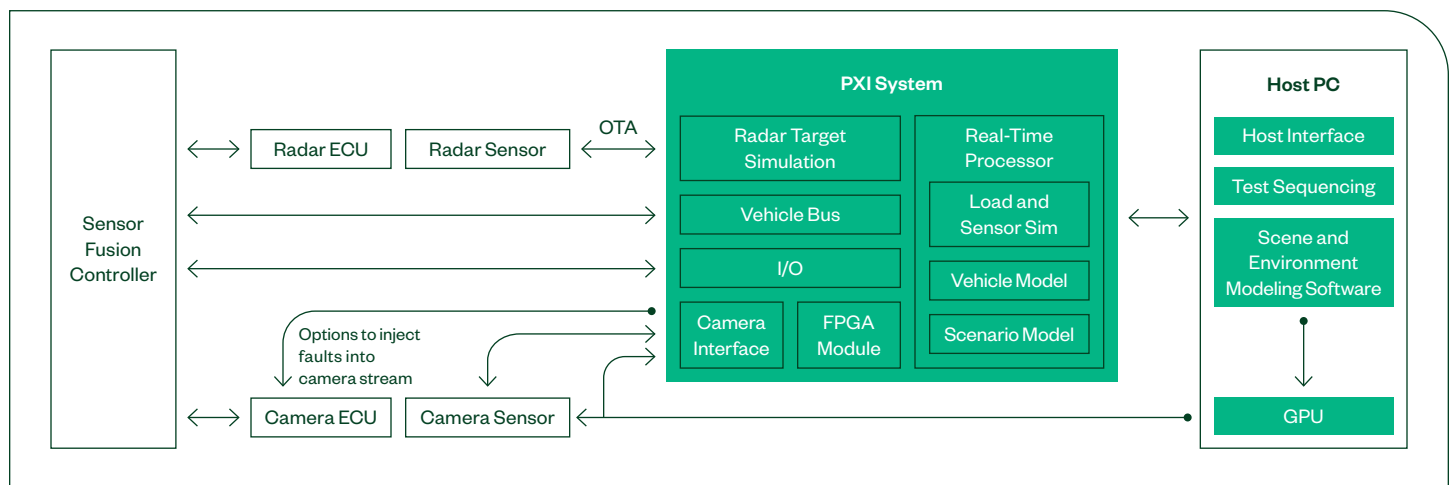
FIGURE 02

Block Diagram for Sensor Fusion HIL Applications

> The flexibility, modularity, and scalability of the NI system enable users to easily integrate it with other I/O as part of a comprehensive HIL tester for radar design and test applications—and to use the same system for both target emulation and radar device measurements, lowering the cost of device and system test.

Giuseppe Doronzo
Advanced Architect, Altran Italia
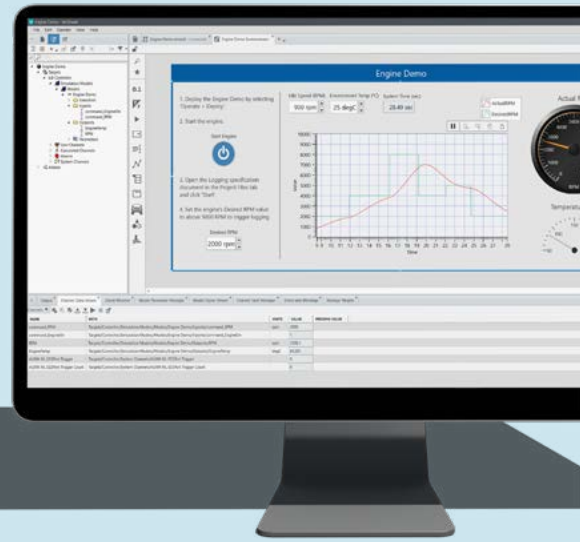
NI Solution

01

VeriStand real-time test software integrates with a wide variety of third-party scene generation tools, so you can choose the tool that works best for you, as well as utilize investments made in the past.

02

PXI modular hardware generates OTA radar signals, camera signals, vehicle bus traffic, and general-purpose I/O. It also features hardware and software faulting capabilities and nanosecond synchronization and timing control.

03

TestStand automated test software or Python scripting helps you implement test sequencing to automate test vectors and increase test coverage in shortened test schedules.

THE NI ADVANTAGE

- Achieve and maintain direct control over your test system and maximize your test coverage using the openness of the NI toolchain.

- Change camera interfaces, inject bitstream faults, and test radar sensors with real over-the-air (OTA) reflections, or add new sensor types without significant costs or hardware changes.

- Future-proof your validation test strategy with modular, software-connected systems by combining PXI with VeriStand. You can simply add an I/O module to the system as your requirements change.

KEY SPECIFICATIONS	
Synchronization	<1 µs
Scene Generation Support	Anything with an API (IPG, TASS, VIRES, Unity)
Camera Interfaces	MIPI CSI-2, FPD-Link, GMSL, HDMI, GigE, Ethernet, USB
Radar Sensor Support	77 GHz, 79 GHz
Minimum Emulated Radar Distance	2.5 m
V2X Emulation Protocols	DSRC, 4G C-V2X
Location Emulation Protocols	GNSS, GPS, GLONASS
Other I/O	General-purpose I/O, CAN, LIN, FlexRay, Automotive Ethernet, standard Ethernet, and many more

Software-in-the-Loop for Ultra-High Fidelity Perception Simulation and Test

Validation engineers in the automated driving and autonomous vehicle domain are tasked to expand their testing process further to the left, also known as front loading, to accelerate time to market as well as balance coverage needs with the cost of test. Software-in-the-Loop (SIL) is one typical method to achieve these requirements, but the infinite perception use cases, the complex workflow, and the gaps in modeling and simulation technology make it challenging to succeed.

Customer Needs

01

MAXIMUM REALISM—Increase sensor and simulator fidelity to truly implement front load testing and minimize the dependencies on expensive prototypes.

02

OPEN AND VALIDATED SENSOR MODEL— Provide white-box yet trustworthy models to reduce and ultimately avoid the additional burden of model validation.
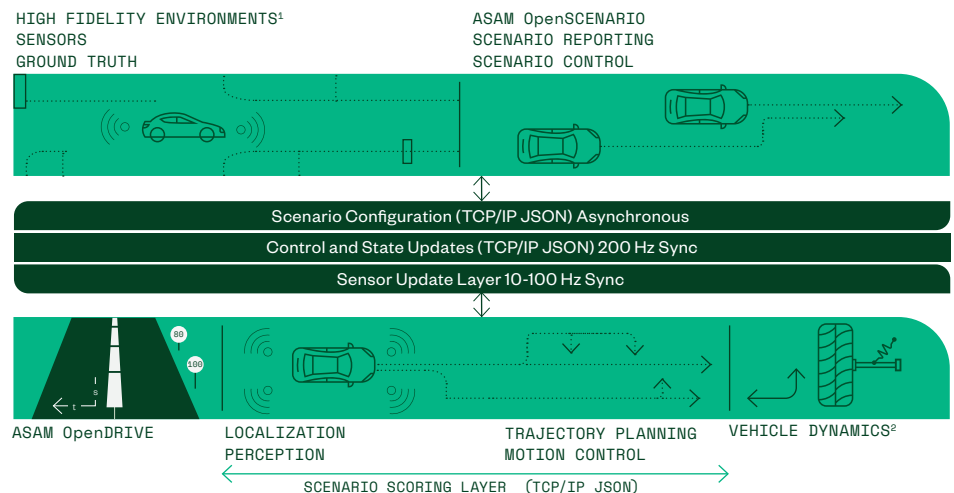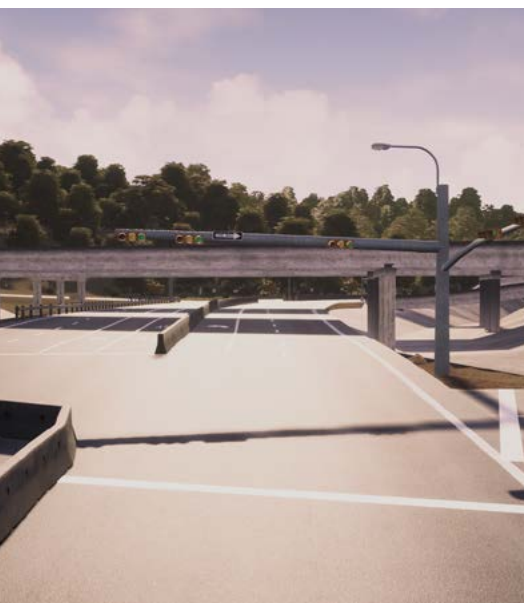
03

OPEN TO THIRD-PARTY TOOLCHAINS— Preserve existing investments in simulation tools and architectures and connect to best-in-class solutions.

04

CLOUD AND ON-PREMISE EXECUTION— Maximize and speed up validation test coverage through thousands of parallel test instances.

05

WORKFLOW SIMPLIFICATION— Streamline the setup and execution complexity of the SIL process to allow focus on testing.

HIGH FIDELITY ENVIRONMENTS[1]
SENSORS
GROUND TRUTH

ASAM OpenSCENARIO
SCENARIO REPORTING
SCENARIO CONTROL

Scenario Configuration (TCP/IP JSON) Asynchronous

Control and State Updates (TCP/IP JSON) 200 Hz Sync

Sensor Update Layer 10-100 Hz Sync

ASAM OpenDRIVE

LOCALIZATION
PERCEPTION

TRAJECTORY PLANNING
MOTION CONTROL

VEHICLE DYNAMICS[2]

SCENARIO SCORING LAYER   (TCP/IP JSON)

[1]NI monoDrive Simulator AD Including Co-simulation Options for ANSYS VRXPERIENCE, CARLA, dSPACE, IPG CarMaker, VIRES VTD, and Others.
[2]Simulink, IPG CarMaker, VIRES VTD, and others.

FIGURE 03

Block Diagram for NI monoDrive Simulator AD based Software-in-the-Loop (SIL) Applications

> The Assisted and Automated Driving Verification and Validation (V&V) department at JLR works closely together with NI to develop synergies between V&V methods and tools. The possibility of using the same data as well as common hardware and software platforms for ADAS data logging, SIL, HIL, and VIL increases our V&V testing to be more robust and efficient, and delivers better quality. We adjust tools to our process, not the opposite!

Marek Krezalek
Senior Technical Specialist, Assisted and Automated Driving V&V, Jaguar Land Rover

NI Solution

01
Leverage NI monoDrive Simulator AD for ultra-high fidelity scenario generation and resulting sensor information for perception and planning system validation.

02
Integrate and execute physics-based, high-fidelity sensor models (lidar, radar, camera, RPM, GPS, IMU) of your choice to maximize realism and increase product quality.

03
Create perception cases for virtual testing in minutes to accelerate the validation development process and focus on getting tests done.

04
Utilize Unreal Engine—the world's most advanced real-time 3D creation tool—as the foundation of NI monoDrive Simulator AD to stay at the forefront of technology.

05
Connect and combine third-party environmental simulation and modeling tools like Ansys VRXPERIENCE, CARLA, IPG CarMaker, VIRES VTD, Simcenter Prescan, SCANeR, and more.

THE NI ADVANTAGE

- **BEST-IN-CLASS SUPPORT**—Getting started, bring-up, and ongoing maintenance to set you up for a successful SIL installation and implementation

- **VALIDATED SENSOR MODELS**—Proven and properly characterized physics-based models that reduce the additional burden to also validate the models

- **INTEGRATION WITH EXISTING SIMULATION INFRASTRUCTURE**—Leverage existing toolchains and augment available capabilities with trusted third-party technology

- **NI ADAS AND AD ECOSYSTEM**—Connect the smartest subject matter experts, the brightest ideas, and best-in-class technology to increase fidelity and realism

- **MORE THAN JUST SIL**—Single, unified toolchain for data record, replay, SIL, HIL, XIL, and other V&V applications to maximize test reuse and data correlation

4 GHz Automotive Radar Test

Safety and ADAS features like autonomous emergency braking (AEB) or rear cross traffic alert (RCTA) rely on radars to function properly. As automotive radars evolve to have 4 GHz of bandwidth, testing becomes more challenging since more test coverage is needed for both parametric and simulation test. Additionally, the reliability needed calls for higher levels of accuracy and repeatability in the test system. At the same time, organizations cannot lose sight of future requirements like higher bandwidth sensors or different antennae designs.

Customer Needs

01

Take parametric measurements and simulate radar obstacles for 77 GHz and 79 GHz with 1 GHz and 4 GHz bandwidths.

02

Perform repeatable, accurate, and reliable testing to comply with OEM requirements for validation and production test.

03

Integrate handling, actuation, and an anechoic chamber with the simulation and measurement instrumentation.
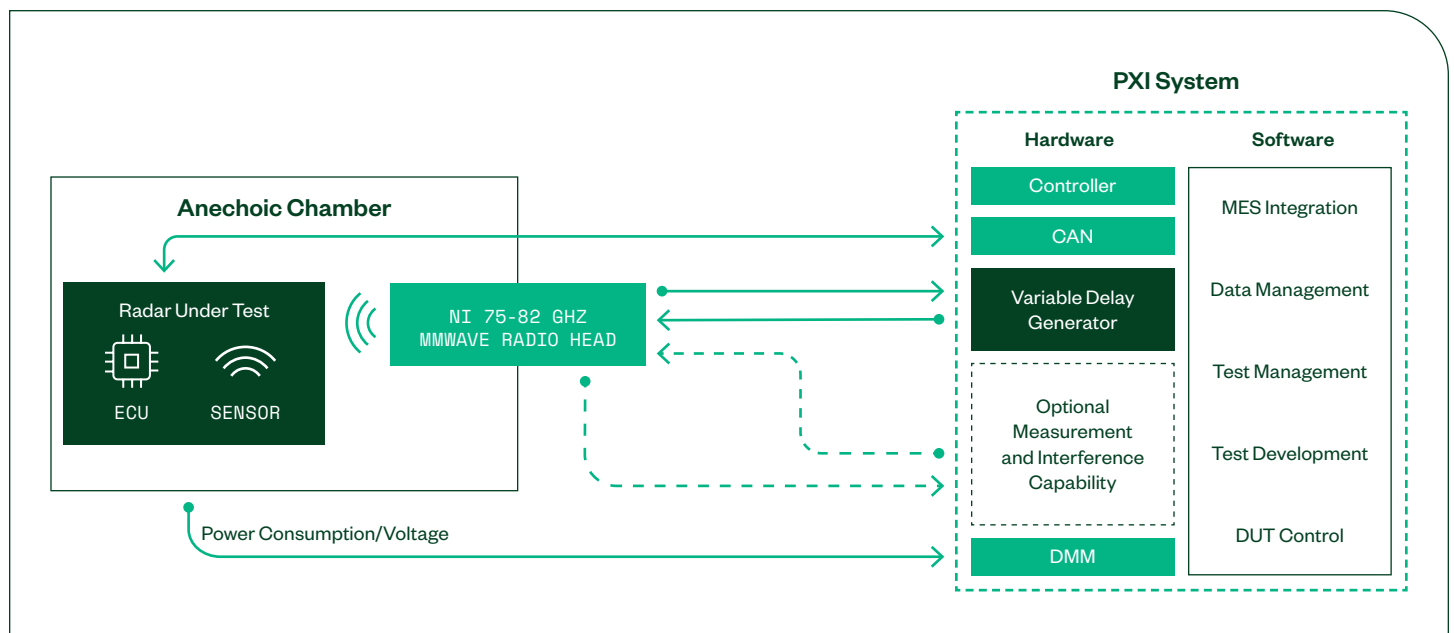

FIGURE 04

Block Diagram for Radar Test Applications

> NI's mmWave radar technology provides the industry's widest bandwidth and low-latency software, which helps us develop automotive radar technology research in great depth. Through NI's flexible platform-based approach, we could finish both radar performance test and radar simulation, helping us accelerate the process of autonomous driving.

Geely Automotive

NI Solution

01

The 4 GHz Vehicle Radar Test System (VRTS) performs highly repeatable and accurate radar obstacle simulation and parametric measurements in parallel to reduce test time.

02

Affordable and easy to upgrade, NI-based radar test solutions are modular, flexible, and capable of addressing all validation and production test and measurement needs.

03

VRTS integration partners provide solutions leveraging NI RF test systems, including anechoic chambers, mechatronics, actuation, and software development.

THE NI ADVANTAGE

- Reduce takt time, capital expenses, and footprint by performing parametric and simulation test in parallel for 77 GHz and 79 GHz automotive radars.

- Future-proof your investment with a modular solution that can be upgraded to add measurements, angles, and objects.

- Leverage work across design, validation, and production to speed up implementation by using a single toolchain and API.

KEY SPECIFICATIONS	
Frequency Range	76 GHz to 82 GHz with up to 4 GHz instantaneous bandwidth
Object Distance	2.5 m to 300 m excluding setup distance, 5 cm resolution
Object Velocity	0 km/h to +/-500 km/h with +/-0.5 km/h accuracy
Radar Cross Section (RCS)	50 dB dynamic range, with 0.25 dB resolution
Measurements	EIRP, phase noise, occupied bandwidth, radiation pattern, beam width, and chirp analysis

HPC Validation Test

Autonomous vehicles (AVs) are among the most complex systems being tested today. At the heart of the AV sits a powerful High Performance Compute (HPC), or a Multi Domain Compute platform, that covers perception, planning, and control of the vehicle to determine the appropriate action to ensure safety of the car and its surroundings. The HPC platform must be able to take in synchronized data from multiple sensors; detect objects, their distances, lanes, and the environment; and plan the route and trajectory of the vehicle. As companies design and build their own AV supercomputers that combine automotive-specific networks and sensors with consumer electronic components, a critical balance must be struck between high-computing power and adequate efficiency. Testing this balance is crucial to building safe and reliable AVs.

Customer Needs

01

Validate features of the HPC platform, such as:

- Thermal performance
- Power consumption
- Automotive networks functionality
- AV sensor interface functionality
- PCB electrical measurements
- GNSS functionality

02

Quickly adapt the system following design changes of the HPC platform

03

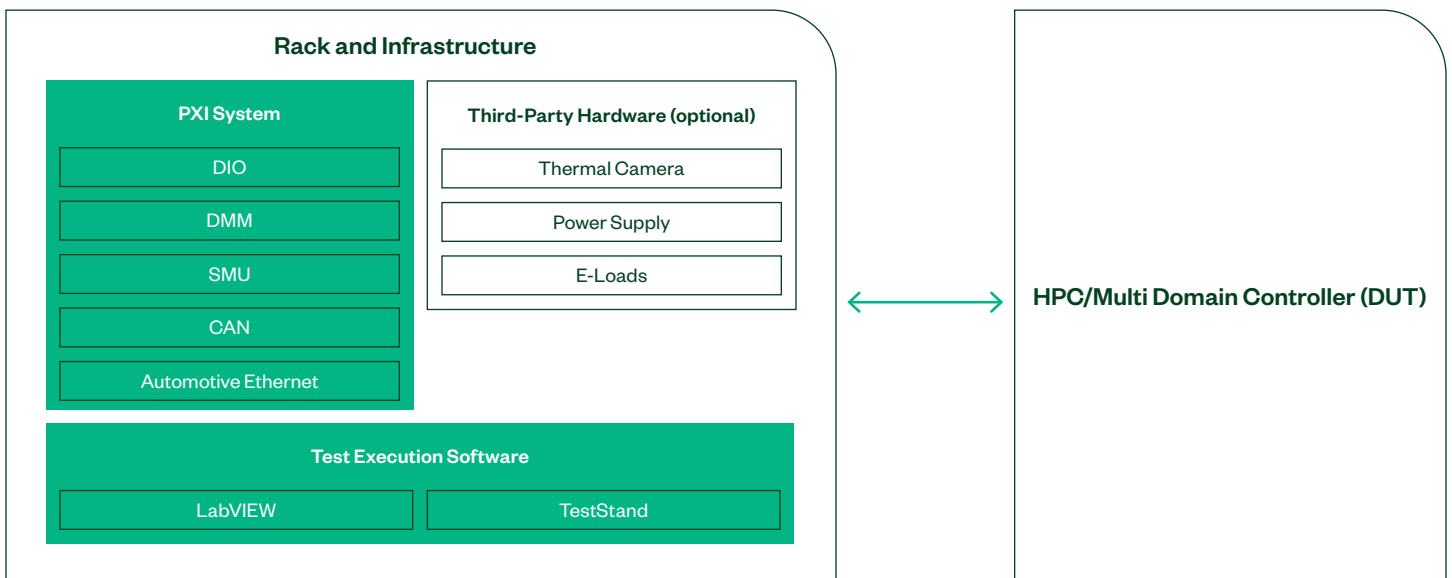Meet the time-to-market deadline for building AVs

FIGURE 05
Block Diagram for High Performance Compute (HPC) and Multi Domain Controller Validation Test Applications
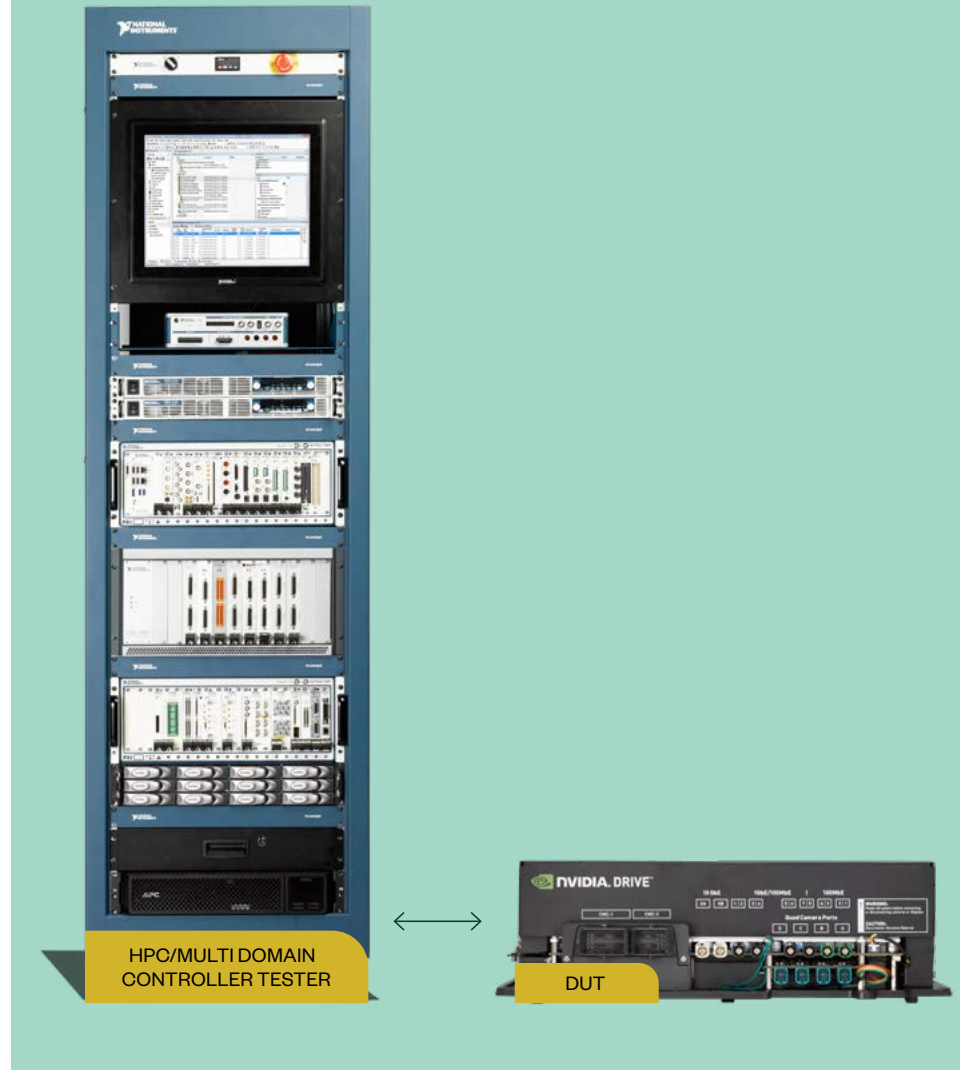
NI Solution

01

Modular hardware for CAN, Automotive Ethernet, current and voltage measurement, current and voltage generation, and more to customize a system that fits your exact I/O needs.

02

Flexible and interoperable with third-party hardware to complete the system with your existing hardware and/or with hardware that meets your requirements. Stream terabytes of data at up to 15 GB/s with NI or third-party RAID storage options that easily interface with a PXI system.

HPC/MULTI DOMAIN CONTROLLER TESTER

DUT

THE NI ADVANTAGE

- NI provides flexible software-connected systems with modular hardware and a configurable set of I/O.

- NI's solution is equipped to test multiple functionalities of the computing platform with one system, including the automotive network, network interfaces, thermal performance, power measurements, electrical measurements, and more.

- NI's modular and software-connected system can adapt quickly to new requirements or design changes.

With more than 40 years working with teams automating V&V test systems, NI is a trusted advisor for helping test engineering groups maximize test effectiveness, enabling them to release quality products efficiently and confidently.

Chad Chesney
General Manager and Vice President, Transportation, NI

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 solution.

Contact your account manager or call or email us to learn more about how NI can help you increase product quality and accelerate test timelines at (888) 280-7645 or info@ni.com.

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