

ECU Test System

End-of-Line Functional Test of Automotive Electronic Control Units

“Partnering with NI to solve our ECU functional test challenges has lowered our total cost of test while maintaining high quality standards. By standardizing on NI testers we reduced cycle and development time, increased system reuse, and made debugging, deploying, and maintenance easier.”

Sergio Mejia

I&IE Test Engineer at Vitesco Technologies

ni.com/automotive





ECU Test System

03 THE CHALLENGE

04 THE SOLUTION

ECU Functional Test Workflow

Supporting Your Business Initiatives through Test

07 ECU TEST SYSTEM SOFTWARE

Test Executive

Signal Routing

Instrument Configuration and Debugging

09 ECU TEST SYSTEM HARDWARE

PXI Instrumentation Options

Switch Load and Signal Conditioning

Mass Interconnect

DC Power Supplies

Electronic Loads

Topology Options

Simplified Hardware Maintenance

16 SERVICES AND SUPPORT

ECU Test System Service Offerings

Additional Services Available

Large-Scale Global Deployments



The Challenge

The number of electronic control units (ECUs) in modern vehicles has grown sharply because of rapidly changing consumer demands for comfort, safety, connectivity, and vehicle efficiency. ECUs increase convenience, such as the nuanced adjustment a luxury seat makes as soon as a driver's key fob enters the vehicle, or when rain-sensing windshield wipers automatically speed up during a downpour. ECUs drive efficiency through precise engine control, harnessing more performance from the same internal combustion engine. And they increase safety through automatic emergency braking and lane departure warning systems. Together, a network of more than 100 ECUs comprise the "brain" of a modern vehicle.

We know these innovations complicate production test of ECUs. Outbidding the competition and being first to market puts more pressure on production test managers to meet the delivery deadline. Because ECUs are often safety critical, especially in engine control and passive safety, thorough testing is essential and must be achieved despite time constraints and cost control measures. Failure to do so risks peoples' lives and threatens consumer trust.

NI's ECU Test System (ECUTS) helps production test teams be faster, leaner, and more agile while deploying functional testers, revolutionizing end-of-line (EOL) testing with a standardized, high-performance architecture. Greater agility is increasingly necessary to meet test requirements on time and within budget.

To help you achieve your objectives faster, we're innovating where others aren't. We don't believe that test innovation should be limited to connected car, electric vehicles, or autonomy, especially when there is so much room for improvement in the performance, intelligence, and procurement of body, chassis, and transmission ECU functional testers.

With NI's ECUTS, you can meet your timelines and quality expectations and position test as a competitive advantage, not just a cost center. Imagine what your test department could achieve if it wasn't always scrambling to meet the next deadline.

The Solution

The ECU Test System (ECUTS) is a functional tester for end-of-line (EOL) test of automotive ECUs built on NI's adaptive, open technology. Our systems R&D engineers have integrated the following core components into this system, so you can focus your energy on implementing your test plan.

- Core Rack (24U and 40U): Safety, Display, Power
- Instrumentation
- Custom Cabling
- Mass Interconnect
- Loads and High-Power Switching
- Low-Power Switching

Standardizing on this tester can reduce capital and operational expenses through efficiency—driven by asset and architecture reuse, streamlined global supply, and service programs.

The ECUTS also reduces test time and floor space through parallel test powered by a best-in-class test executive and a portfolio of high quality I/O.



FIGURE 01
NI ECU Test System (24U)

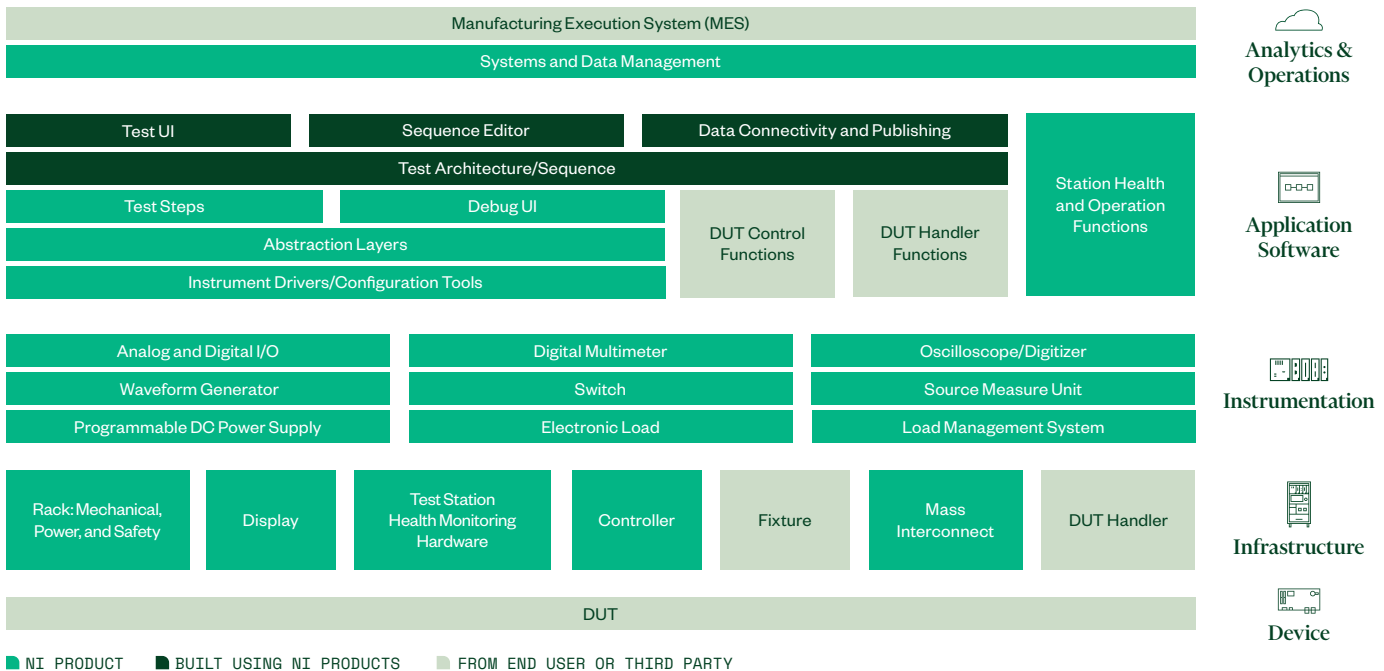
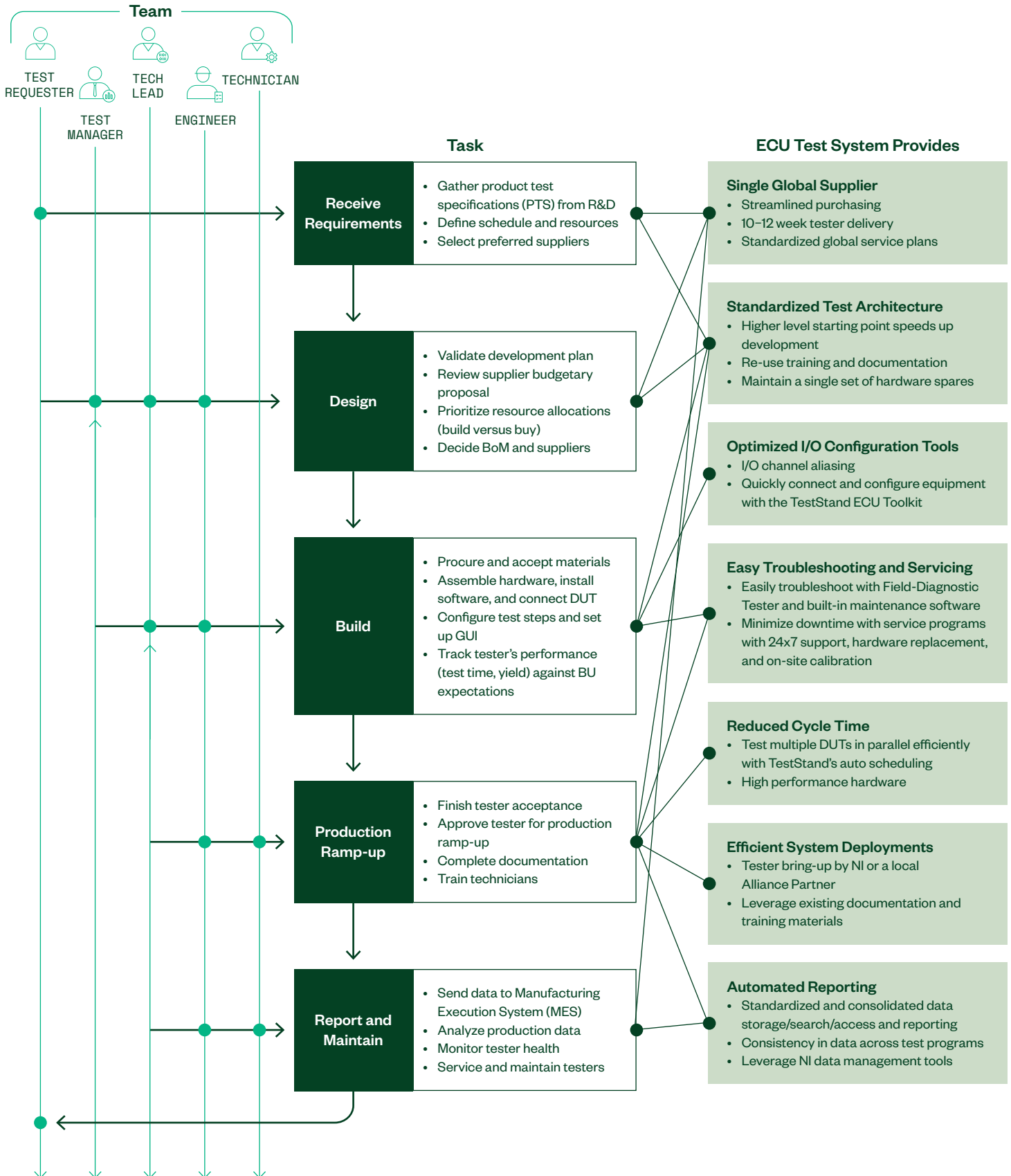


FIGURE 02
NI ECU Test System Architecture

Operation, Maintenance, and Regulatory Documentation

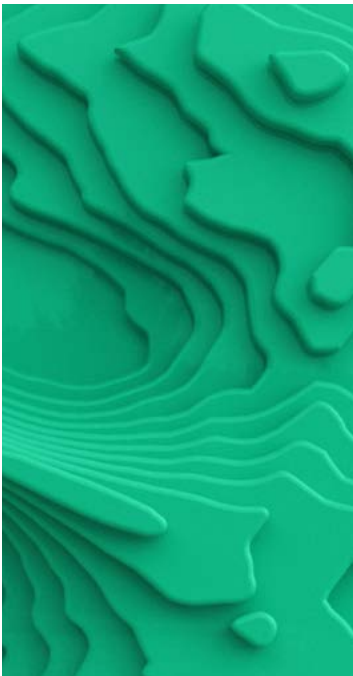
ECU Functional Test Workflow



Supporting Your Business Initiatives through Test

At NI, we go beyond a traditional vendor/client relationship by supporting you with solutions and services that are right for your specific business needs. We can partner with you to drive efficiency and differentiate through new technology or processes. Below are several areas in which we have seen production test directors realize value through partnering with NI.

- **Standardization:** NI's modular hardware and open software is ideal for standard platform development, as you can easily reuse and expand components with minimal redesign for a wide range of functionality.
- **Internal Proficiency:** On-site bring-up services ensure you are up and running swiftly and smoothly. Customer education courses are available to help operators and developers do their jobs more effectively. A single NI software toolchain that applies to multiple engineering disciplines, combined with a thriving global developer community, encourages test proficiency at the individual and team level.
- **Outsourcing ROI:** By combining consultation, support, and full integration services, you can balance in-house and outsourced work without putting deadlines or build quality at risk.
- **Operational Expense:** Industry-renowned reliability, production-optimized test and data management software, and comprehensive services and support ensure minimized downtime, real-time operational insight, and cost-effective sustaining strategies.
- **Capital Expense:** Scalable, future-proof architectures, multi-up test capability, and high-channel count instrumentation maximize return on capital investments and protect against large unexpected costs.



“Using the NI automated test platform, we achieved shorter development time and faster test speed required for functional tests of powertrain ECUs in manufacturing. We reduced development time to 1/6 of the previous system and lowered system cost to 70 percent with 15 percent faster test time.”

Minsuk Ko,
Manager, Ph. D., Hyundai Kefico

ECU Test System Software

The ECU Test System (ECUTS) comes with the software you need to design, deploy, and manage test systems. It includes the following software by default and runs on the Windows 10 based PXI controller. TestStand serves as the test executive to manage and execute test sequences (plans). InstrumentStudio™ application software provides a higher abstraction to configure and debug test steps, and Switch Executive helps manage signal routing.

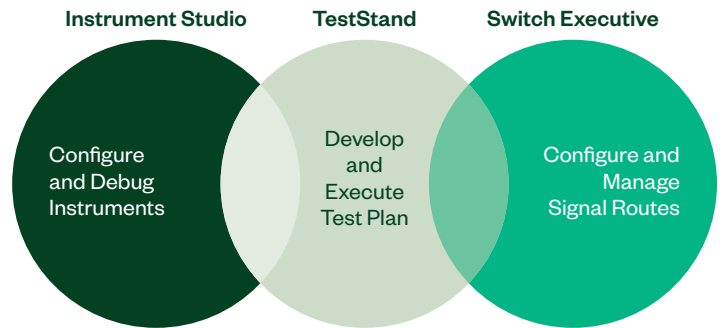


FIGURE 03
ECUTS Software Workflow

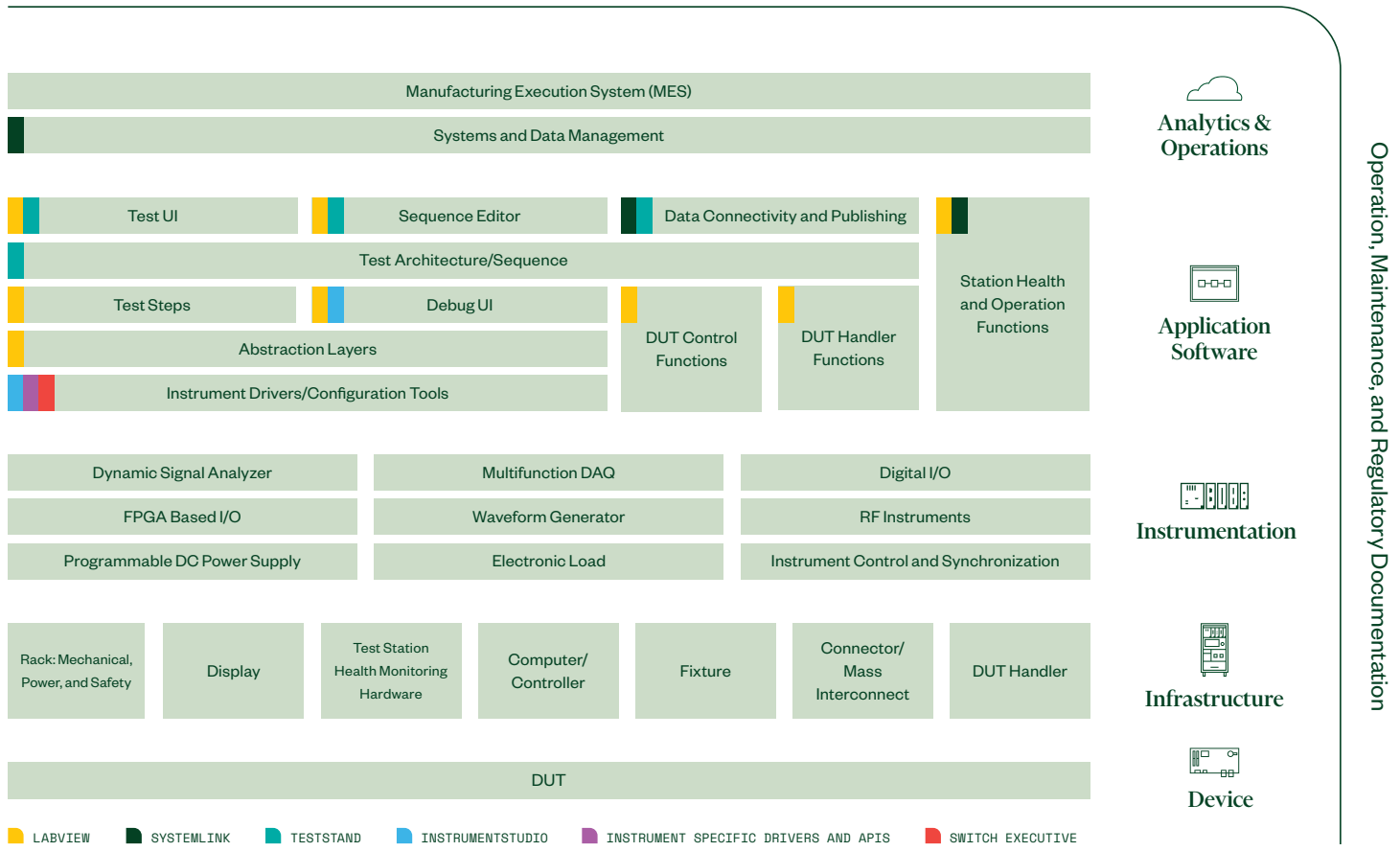


FIGURE 04
ECUTS Software Components Split by the Functions They Perform

NI PRODUCT	DESCRIPTION
TestStand	Industry-standard test management software for custom development and automated execution of test sequences.
TestStand ECU Toolkit	ECUTS specific software that integrates the workflow between TestStand and InstrumentStudio.
Switch Executive	Switch management and routing application that accelerates development and simplifies maintenance of switch systems.
InstrumentStudio	Software that provides interactive bring-up and debugging of instruments.
ECU Test System Maintenance Software	ECUTS specific software that lets you interactively visualize, diagnose, and test ECU Test System hardware components and perform continuity testing using the Field Diagnostic Tester.
LabVIEW Base	Graphical programming environment that simplifies the programming of distributed test, measurement, and control systems.
SystemLink™ Client	Client license for each test system connecting to the SystemLink Server.

Test Executive

TestStand

This industry-standard test management software functions as the test executive and is ready to run.

- Create, execute, and debug test sequences
- Reuse code developed in any programming language
- Generate reports and integrate with databases
- Develop or connect to professional operator interfaces
- Increase throughput with parallel testing and auto scheduling
- Meet custom requirements with an open and extensible framework

TestStand ECU Toolkit

This toolkit integrates the workflow between TestStand and InstrumentStudio to easily configure instruments within the ECUTS.

- Controls instruments in TestStand based on configurations defined in InstrumentStudio
- Debugs instruments using InstrumentStudio while running a test sequence in TestStand
- Works for measurement instruments supported only in the ECUTS

Signal Routing

Switch Executive

This intelligent switch management and routing application accelerates development and simplifies maintenance of switch systems.

- Graphical and automatic routing options
- Intuitive channel aliases (“DMM_HI” versus “r129”)
- Custom naming for individual routes and route groups
- Tight integration with TestStand
- API for LabVIEW and LabWindows™/CVI software

NI Switch Health Center

To simplify relay maintenance and reliability in high-channel-count systems, all NI SwitchBlock modules and PXI Matrix modules are shipped with the NI Switch Health Center, which includes an integrated relay test and provides access to the relay-count tracking data stored on the NI switch hardware.

Instrument Configuration and Debugging

InstrumentStudio

This application software helps you unify your display, export instrument configurations for a higher-level starting point, and monitor and debug your automated test system.

- Configure hardware using familiar instrument front panels
- Easily navigate web browser-like user interface
- Export data and screenshots
- Export instrument configurations to automation code
- Enjoy a simplified debug experience for automated test

ECU Test System Hardware

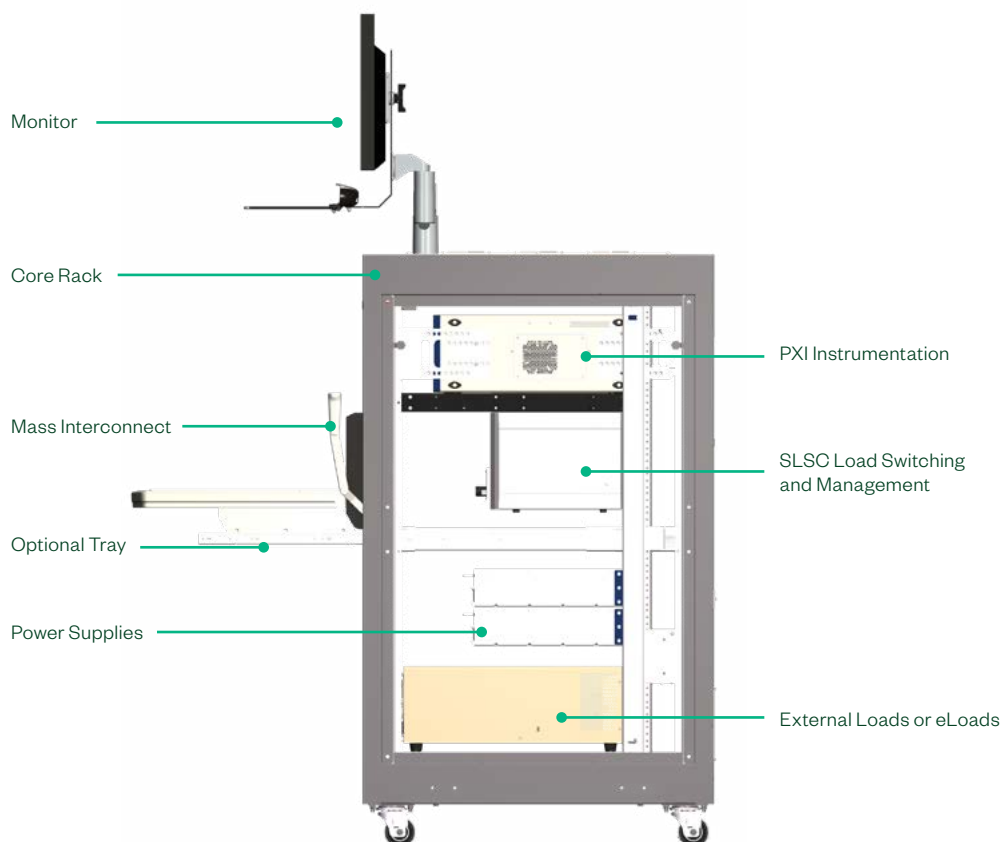


FIGURE 05
Side View of the 24U ECU Test System (ECUTS-16000)

HARDWARE SPECIFICATIONS

Core Rack	ESD (IEC 61340-5-1), RAL 7035 paint. 24U (ECUTS-16000) and 40U (ECUTS-16001) form factors available. Power Input: 200-240 V (1-Phase, 50/60Hz) PDU DC Output: + 12 V, + 24 V
Power Supply	200 W (20/36/60 V), 400 W (20/36/60 V), and 800W (20/36/60 V)
PXI Instrumentation	High performance PXI chassis and quad-core controller. Configure up to 16 additional PXI instruments and I/O modules such as DMM, SMU, PSU, SCOPE, FGEN, Isolated AI/AO, and DIO.
Automotive Communications	CAN, LIN, RS232, GPIB, Automotive Ethernet
PXI Pin Switch	2-wire, support up to four each 4x64, 8x32, or 16x16 matrix modules, to create matrices of 4x256, 8x128, or 16x64 respectively. EMR, 60 V/2 A (60 W). 1-wire (64x1), 2-wire (32x1), or 4-wire (16x1). Multiplexer also available.
Load Switching and Management	8 A, up to 96-ch with current measurement. 30 A, up to 24-ch with current measurement. 5A, up to 192-ch with current measurement.
Loads	Space for either external load or electronic load (eLoad) 100 W (60 V/20 A) 8-ch or 350 W (60 V/40 A) 4-ch
Mass Interconnect	Virginia Panel Corporation (VPC) 9025, 25 slots Optional tray

PXI Instrumentation Options

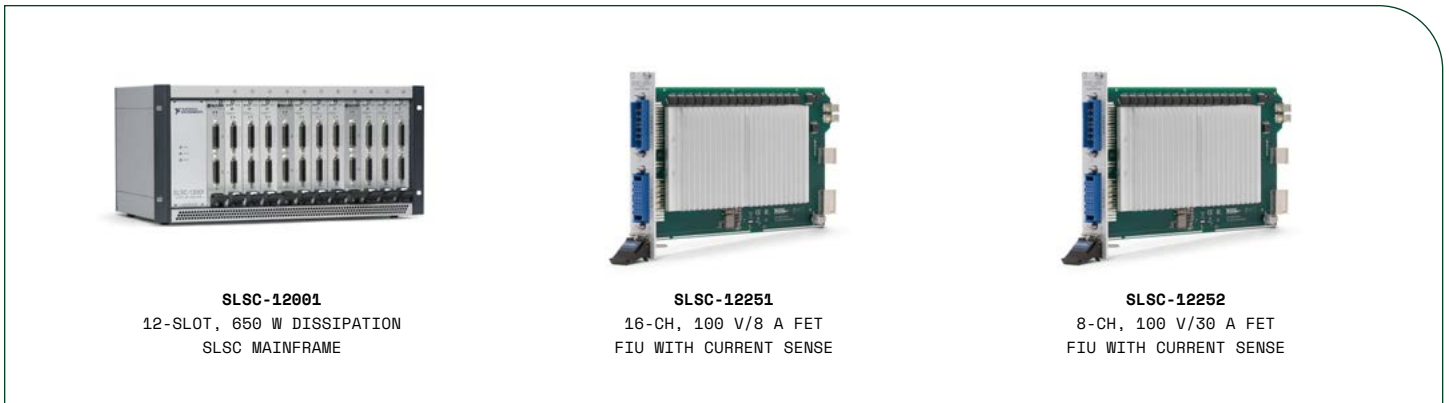
Combined with a chassis and controller, PXI systems feature high-throughput data movement using PCI Express bus interfaces and subnanosecond synchronization with integrated timing and triggering. Select up to 16 PXI modules from the standard options listed below to create the ideal I/O set to meet your ECU test requirements.

			
PXIe-4081 7 1/2-DIGIT, 1000 V/3 A DIGITAL MULTIMETER	PXIe-2737 100 V/2 A EMR, 4X64 2-WIRE MATRIX SWITCH	PXIe-8510 6-PORT CAN/LIN INTERFACE	PXIe-84030/8 8-PORT RS232 SERIAL INTERFACE
			
PXIe-4130 8-CH ± 60 VDC 400 KHZ CH-CH ISOLATED, ANALOG INPUTS	PXIe-5105 8-CH 30 V _{pp} 60 MHZ 12-BIT OSCILLOSCOPE	PXIe-4322 8-CH ± 16 VDC 250 KHZ CH-CH ISOLATED, ANALOG OUTPUTS	PXIe-5413 2-CH 24 V _{pp} 20 MHZ FUNCTION GENERATOR
			
PXIe-4139 1-CH, 60 V/3 A/20 W SOURCE MEASUREMENT UNIT	PXIe-4112 2-CH, 60 V/1 A/60 W PROGRAMMABLE POWER SUPPLY	PXI-2564 16-CHANNEL, 5 A SPST RELAY	PXI-6515 ± 30 VDC 32 SINK/SOURCE INPUTS, 32 SINK OUTPUTS

INSTRUMENT	MAX. PER SYSTEM	DESCRIPTION
Digital Multimeter (DMM)	4	PXIe-4081 DMM (DC current, DC voltage, resistance)
Source Measurement Unit (SMU)	4	PXIe-4139 1-ch, 60 V, 3 A
Programmable Power Supply (PSU)	4	PXIe-4112 2-ch, 60 V, 1 A
Scope	2	PXIe-5105 8-ch, 60 MHz, 12-bit, ± 15 V
Analog Input (AI)	4	PXIe-4310 8-ch isolated, 400 kS/s/ch, ± 60 V
Function Generator	2	PXIe-5413 2-ch, 20 MHz, 16-bit, 24 V _{pp}
Analog Output (AO)	8	PXIe-4322 8-ch isolated, 250 kS/s/ch, ± 16 V
Digital Input (DI)	1	PXI-6515 32-ch sink/source, ± 30 VDC, bank-isolated
Digital Output (DO)	1	PXI-6515 32-ch sink, ± 30 VDC, bank-isolated
Relay	1	PXI-2564 16-ch, 5 A and PXI-2520 80-ch, 2 A SPST relay

Switch Load and Signal Conditioning

NI Switch Load and Signal Conditioning (SLSC) hardware extends the PXI platform with front-end modules for load switching and management. With standardized connectivity and form factor, it eliminates the fault-prone process of point-to-point wiring, simplifying the overall system by handling small to medium loads on a simple circuit card. The ECUTS leverages the SLSC hardware below, which enables larger switches for fault insertion, adds custom signal conditioning, and reduces signal routing complexity.



INSTRUMENT	DESCRIPTION
Chassis for SLSC SLSC-12001	12-slot chassis provides power, active cooling, triggering, and a communication interface to SLSC modules
8 A Fault Insertion Unit (FIU) SLSC-12251	Provides 16 channels for 8 A continuous RMS maximum current for load switch routes with current measurement
30 A Fault Insertion Unit (FIU) SLSC-12252	Provides 8 channels for 30 A continuous RMS maximum current for load switch routes with current measurement

The SLSC-12251/2 can present the DUT with the following errors: open circuit, pin shorted to two different potentials (for example, V_{batt} or GND), and short to another pin. These modules provide current sensing on each channel when coupled with a measurement module in a data acquisition system. This functionality can be used to measure current profiles; for example, measuring the profile of a solenoid injector.

Mass Interconnect

NI partnered with the Virginia Panel Corporation (VPC) to provide a mass interconnect that enables rapid system changeover through a standardized approach that minimizes downtime and reduces maintenance with reliable long-term operation.

This mass interconnect receiver arrangement is standardized across all ECU Test Systems, which allows for easy pin testing with the Field Diagnostic Tester (FDT). The layout was designed to avoid cable crossovers with symmetry, keep cables as straight as possible, and leave blank spaces for future expansion or customization.

Both the VPC 9025 position modular mass interconnect and VPC 9025TR (tray option) are available with the ECUTS.



FIGURE 06
Mass Interconnect Example Pinout



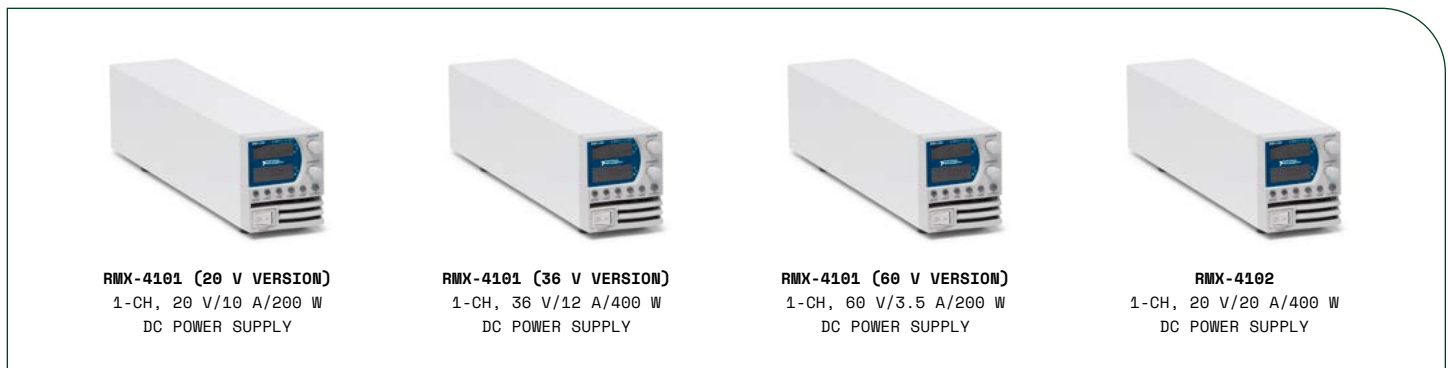
FIGURE 07
VPC 9025 TR with Fixture and DUTs

DC Power Supplies

The ECUTS includes options to include 2U, 1/6 rack-width, single-channel, and rack mount DC programmable power supplies. Based on your requirements, you can choose options such as:

RMX-4101 comes in four versions and offers up to 216 W of power with options that support up to 100 VDC or 10 A.

RMX-4102 offers up to 432 W of power with options that support up to 100 VDC or 20 A.



Electronic Loads

Built for automated test and measurement, electronic load devices can sink power at various current and voltage levels for power supply design, quality inspection, and functional tests. Their modular design and multiple operating modes help them simulate the real load that a power source handles in its actual application. They also feature buttons and knobs for interactive

use, as well as USB or RS232 interface options for automation. You can connect multiple loads in parallel to increase your system's overall power capacity.

Instead of the RMX electronic loads, you can also choose to use an external load box with dimensions 5U (200 mm) height, 530 mm depth, and 480 mm width.



LOAD MODULE MODEL	CHANNELS	MAX. POWER	MAX. VOLTAGE	MAX. CURRENT
RMX-4003	2	100 W/100 W	80 V/80 V	20 A/20 A
RMX-4005	1	350 W	80 V	70 A

Topology Options

There are several topology options you can select for testing DUTs in parallel based on your desired throughput, DUT complexity, and budget requirements.

A NEST refers to the place a DUT connects to a test fixture; each NEST has dedicated instrumentation and test pins for parallel test execution. One NEST can hold several DUTs, and those DUTs will share instrumentation. Parallel testing can result in a 10–40 percent reduction in test time compared to previous testers.

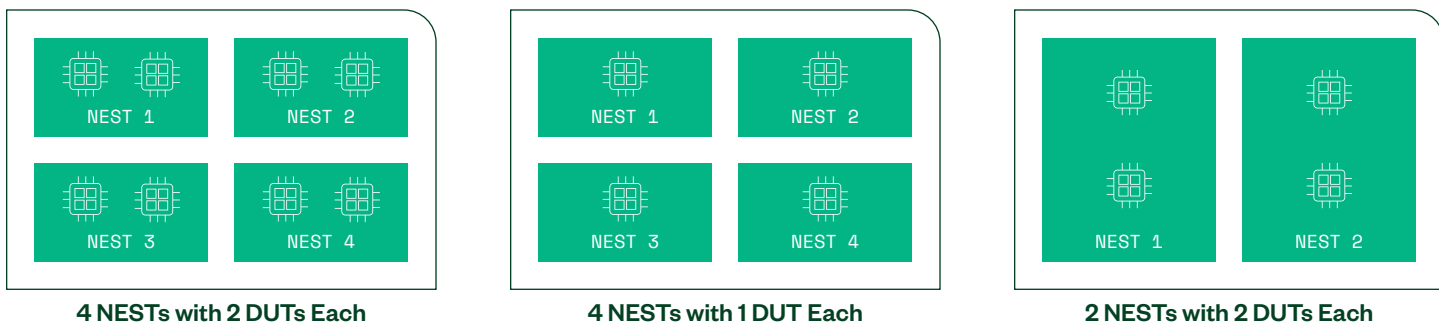


FIGURE 08 Selection of ECUTS Topology Options

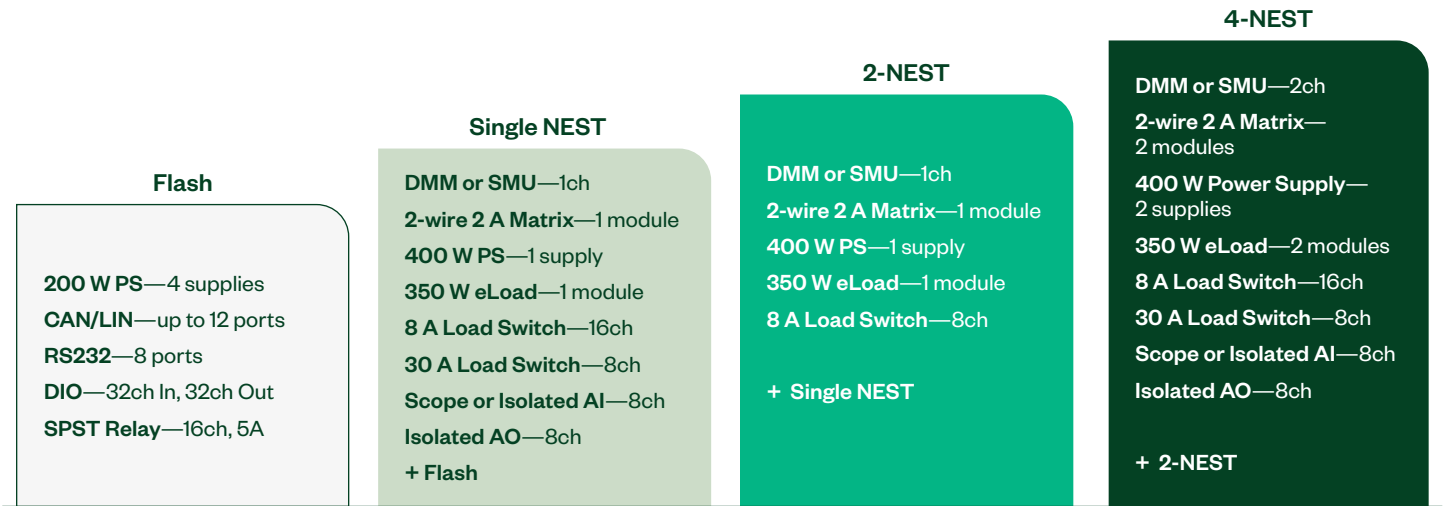


FIGURE 09
Example Hardware Configurations for Different Topologies

Simplified Hardware Maintenance

Because system uptime and reliability are essential in a production test environment, the ECUTS includes options to simplify servicing and maintenance: the ECU Test System Maintenance Software (included in the ECUTS Software Suite) and the Field Diagnostics Tester (optional hardware add-on) for automated pin continuity checking. With these tools, if just one pin breaks in this complex system, it can be identified in minutes rather than hours.



FIGURE 08
Exterior View of a Field Diagnostics Tester

Field Diagnostic Tester

You have the option of including a Field Diagnostics Tester (FDT) with the ECUTS for higher maintenance and serviceability of the system. This tool performs continuity testing to the mass termination and is housed in the 15-inch deep ITA enclosure compatible with the VPC 9025 rack-mount receiver. Diagnostics tests are performed using the ECU Test System Maintenance Software. Because the mass interconnect layout is standard on all ECU Test Systems, one FDT can service multiple test systems.

Note: The FDT works only for pre-defined slots and pins. It does not cover open slots (J3, J11, J13, J15, J17, and J25).

When paired with an FDT, the ECU Test System Maintenance Software provides a report of components expected in the system and performs a continuity check on all pre-defined slots and pins.

ECU Test System Maintenance Software Report

GENERAL INFORMATION	
Report start date and time (YYYY-MM-DD, hh:mm)	2020-04-20, 04:28
Report end date and time (YYYY-MM-DD, hh:mm)	2020-04-20, 04:32
Model Name	ECUTS-16000
Configuration Name	Hard name
Part Number	Hard number
Serial Number	1EC91E9

System Configuration Verification Summary Components Expected and Found

MODEL NAME	RESOURCE NAME, ALIAS, OR OTHER UNIQUE ID	PART NUMBER	LOCATION WITHIN SYSTEM
NI PXIe-8861		200519A-01	PXICHassis1, Slot 1
TRC-8543	CAN1	200429A-01	PXICHassis1, Slot 18, Port 1
NI PXIe-8510	CAN1, CAN2, CAN3, CAN4, LIN5, LIN6	200414A-01	PXICHassis1, Slot 18
TRC-8543	CAN2	200429A-01	PXICHassis1, Slot 18, Port 2
TRC-8543	CAN3	200429A-01	PXICHassis1, Slot 18, Port 3
TRC-8543	CAN4	200429A-01	PXICHassis1, Slot 18, Port 4
TRC-8543	CAN7	200429A-01	PXICHassis1, Slot 17, Port 1
NI PXIe-8510	CAN7, CAN8, CAN9, CAN10, LIN11, LIN12	200414A-01	PXICHassis1, Slot 17
TRC-8543	CAN8	200429A-01	PXICHassis1, Slot 17, Port 2
TRC-8543	CAN9	200429A-01	PXICHassis1, Slot 17, Port 3
TRC-8543	CAN10	200429A-01	PXICHassis1, Slot 17, Port 4
NI PXIe-6375	FIU_MIO_1	200427A-01	PXICHassis1, Slot 13
NI PXIe-6363 (Mass Termination)	FIU_MIO_2	200513A-01	N/A

FIGURE 11

Example First Page of an ECUTS Maintenance Report

Services and Support

You expect NI systems to help you solve some of the most challenging engineering problems; expect the same level of capability in our services. With every ECU Test System (ECUTS) deployment, we partner with you to determine the level of service that best meets your application needs and ensures long-term success.



Receive Basic Support: Obtain peace of mind through support from ECUTS experts to accompany your in-house maintenance operations. One year of our Basic Service Program is included with every ECUTS.



Maximize Production Uptime: Maximize uptime of your ECUTS with faster turnaround times from NI when hardware fails or expert support is needed. NI has the global infrastructure and resources to help you manage a tiered sparing model across your ECUTS installed base. We provide flexible service options from a regional inventory of spares that can be delivered in less than 24 hours to an on-site spares inventory.



Optimize Tester Performance: With more than 10 years' experience calibrating PXI instruments and more than 20 years working with calibrating precision instrumentation, we're well equipped to provide on-site and laboratory calibration options that meet your needs.



Maximize Efficiency: To help you quickly develop and deploy testers, NI offers a variety of options for engineering services, such as test program development, custom operator interface (OI) development, test cell integration, and tester migration. We also deliver a spectrum of services to help integrate ECUTS into your factory and train your engineers, technicians, and operators.



Achieve Longevity: NI knows every application has different requirements for support and longevity, so we're committed to providing the life-cycle support you need for your applications. We offer consultative engagements on the life-cycle status of products, recommended updates, and planning related to sustaining engineering.

ECU Test System Service Offerings

Availability of service programs varies by region. Contact your account manager for more information.

	BASIC	FULL	CUSTOM
Software Support Access updates and bug fixes	Access to SW Updates	Access to SW Updates	Scope to be defined tailored to your specific needs and deployment goals
Repair and Replacement Minimize downtime	3-5 Days Replacement	<24 Hour Replacement	
Technical Support Resolve issues quickly	Technical Support 8x5	Technical Support 8x5	
Field and Remote Services Fixed maintenance cost		Troubleshooting and Support	
Life-Cycle Management Mitigate obsolescence risk	Standard Product Notifications	Standard Product Notifications	
Training Increase productivity	Online Operator and Maintenance Training	Online Operator and Maintenance Training	

Additional Services Available

Calibration Quality measurements and traceability	Laboratory Calibration On-site Calibration Calibration Replacement
Bring-Up Assistance Hassle-free commissioning	On-site or Remote Tester Bring-Up
Training Reduce development time	Instructor-Led, On-Site and/or Customized Training Operator and/or Maintenance Training Test Engineer Training
Professional Services	Integration Engineering Services Methodology Consulting Services Resident Engineering Services

Calibration Levels Offered

CALIBRATION STANDARDS	NI CALIBRATION LEVEL	INDUSTRY REQUIREMENTS	TYPICAL INDUSTRIES
No Industry Standard (ISO 9001 umbrella may be used)	Traceable	Verification and adjustment of measurement performance using calibration procedures and measurement standards traceable to SI units (NIST traceable). Includes "As Found" and "As Left" data.	All
ISO/IEC 17025	Accredited	Traceable calibration level plus detailed measurement uncertainty for each test point. Includes the official logo of the accreditation body Performed at an ISO 17025-accredited laboratory.	Transportation (Automotive IATF 16949), Medical
ANSI/NCSLI Z540.1-1994	Compliant	Traceable calibration level plus a measurement uncertainty evaluation; identify test points where ratio is less than specified (NI uses 4:1 ratio).	Defense, Aerospace

NI Traceable and Compliant calibrations are performed in an ISO 17025 Lab even though it's not required. NI Calibration Labs are accredited by A2LA. (NI China Calibration Lab accreditation in progress.) NI-manufactured products that do not have accredited service availability can be covered under IATF 16949 for a specific customer in some cases.

Methodology Consulting Services

With more than 40 years' test experience, NI is an expert in test-related processes and strategies. We provide a framework to help you evaluate your people, processes, and technology to recommend a test strategy appropriately customized to your business. Let's work together to solidify a business case that articulates your future state and expected program ROI to secure the funding you need.

Planning and project management consulting helps build a project execution plan that keeps teams on track to achieve major development milestones. Together, we can help you establish priorities, identify the right resources, and make trade-offs to optimize cost without putting projects at risk.

Integration Engineering Services

With global solution centers and engineers in more than 40 countries supported by more than 900 NI Partner companies, NI offers design and development assistance in every region and industry. Our engineers help you mitigate risk, develop faster, and reduce costs through project management, architecture development, and system documentation to deliver an integrated solution.

Education Services

NI Education Services helps ensure test customers realize the full potential of NI systems and end users achieve personal success. Our training curriculum is available in a variety of formats—including virtual classrooms and private on-site events—and is designed by role and by task so users can quickly obtain the knowledge and skills they need.

System Completion

Interested in a turnkey solution? Contact your NI sales manager to learn about various options for second-level integration provided by our Integration Engineering Services or an NI Partner. Options include test program development, custom operator interface development, test fixture development, production line integration, tester migration, and more.



FIGURE 12
Services Offered by NI Partners Help Ensure Your Success

Large-Scale Global Deployments

Our footprint of service centers and manufacturing sites around the world ensure the success of your large-scale global deployments.

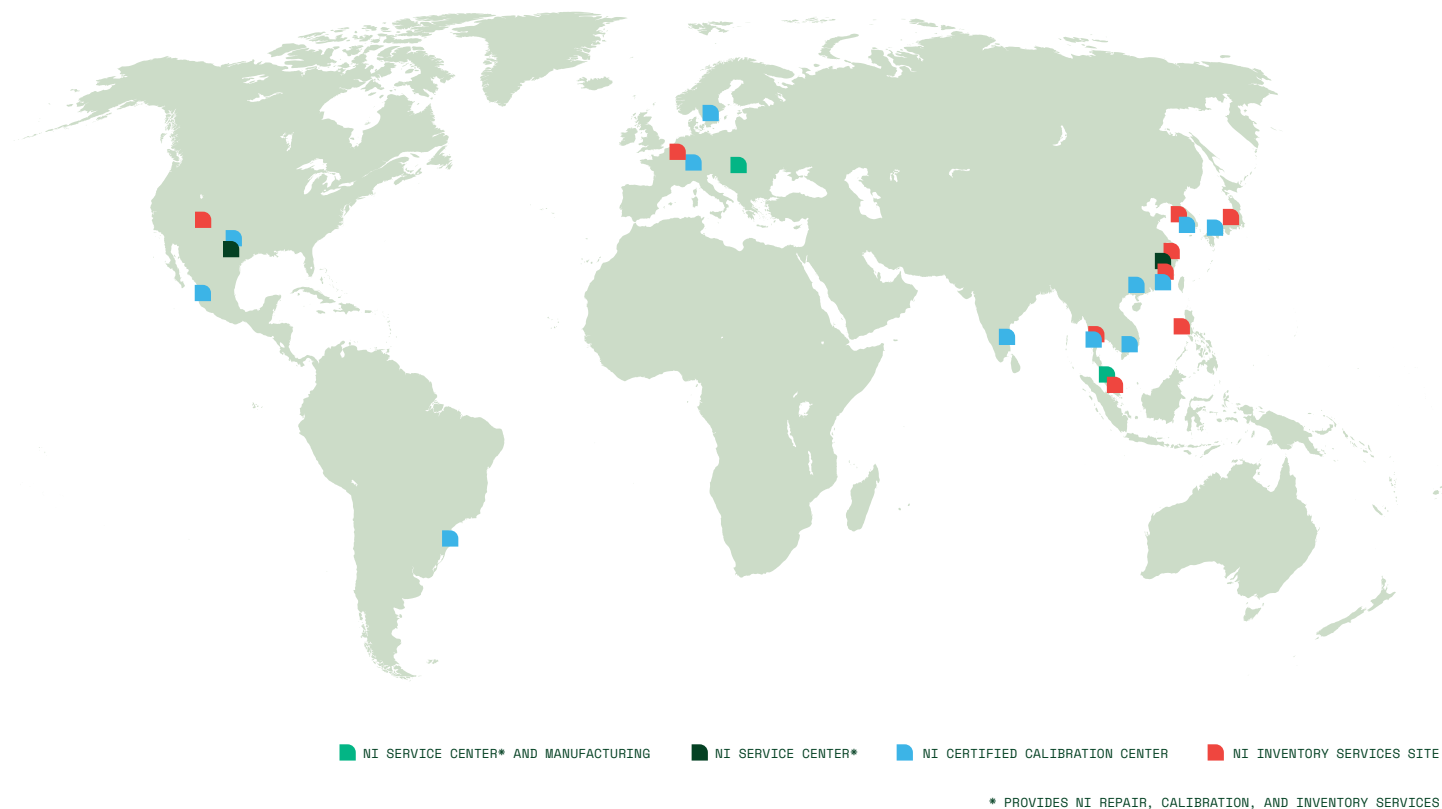


FIGURE 13
NI's Global Footprint of Service and Calibration Centers

Next Steps

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.



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