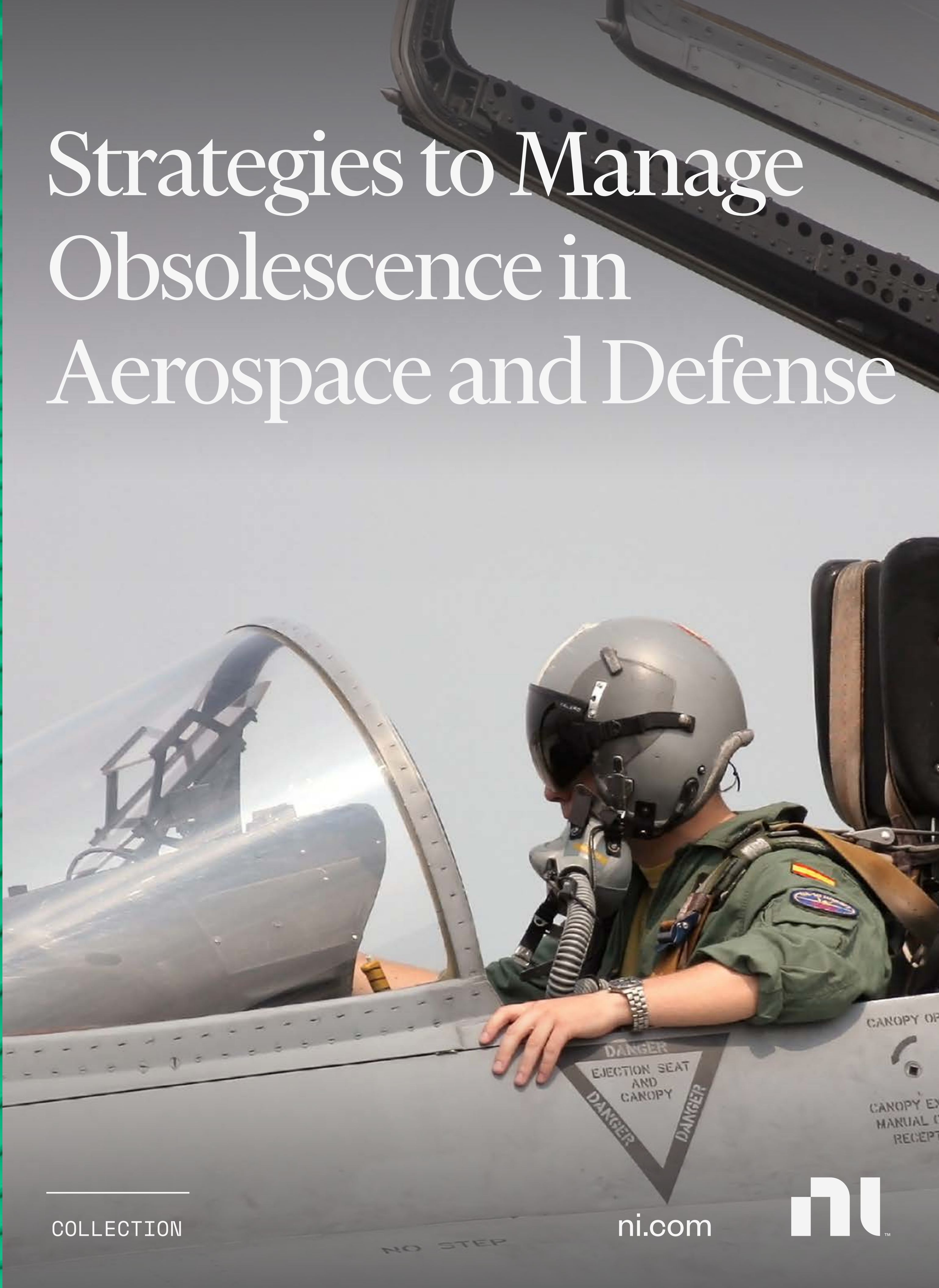
Strategies to Manage Obsolescence in Aerospace and Defense



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Test engineers spend as much as 50 percent of their time (or even more in some cases) actively dealing with obsolete hardware and software in their automated test sets (ATSs). Learn about different solutions in the marketplace to help you overcome the challenges you face today and explore best practices in operations implementation, hardware acquisition, and software design to reduce the sustainment burden of handling obsolete components in test systems long before the equipment goes end of life. NI offers several solutions to help you deal with obsolescence challenges including hardware and software tools for developing comprehensive hardware and measurement abstraction layers, code modules, and fully customizable sequencing engines and automation frameworks. Additionally NI offers technology refresh and migration services to help you quantify the ROI of updating or migrating test systems as well as offloading development freeing up engineering resources to focus on new projects while improving maintenance costs and sustainability of existing ATSs.

Strategies to Manage Obsolescence in Aerospace and Defense

In the aerospace and defense industry, the terms “sustainment” and “obsolescence management” are common, and it’s easy to understand why. Unlike conventional consumer products such as cellular phones, which have a lifespan of only a few years, “products” in aerospace and defense are produced and supported for decades. For example, the Boeing B-52 Stratofortress was first introduced in 1954 and is expected to remain in service until the 2040s after nearly a century in service. This poses unique challenges to test engineers who must maintain a fleet of test stations based on legacy and, in many cases, obsolete equipment. Test engineers spend as much as 50 percent of their time (or even more in some cases) actively dealing with obsolescence in their automated test sets (ATSs). To make matters worse, the test program sets (TPSs) written for these testers were often written in ancient software languages, with little to no documentation, by someone who is likely long retired.

In this paper, learn about reactive obsolescence management strategies to help you overcome the challenges you face today while reducing the risk of a complete technology refresh. Additionally, discover how you can reduce your sustainment burden over the life of your ATS by proactively integrating operations implementation, hardware acquisition, and software design into your obsolescence planning.

Reactive Obsolescence Management Strategies

The four main strategies to reactively address obsolescence are:

- Last-time buy
- Drop-in replacement
- Redesigning around a similar component
- Integrating a new component or migrating to a new platform

In this paper, we won’t focus on last-time buy or drop-in replacement because the pros and cons are obvious. They require little to no engineering or revalidation cost; however, they may lead to large upfront capital expenditures and increased risk. With a last-time buy, you own 100 percent of the supply risk, and the support for that component likely is close to expiring or has completely expired. With a drop-in replacement, you often have a light validation effort, but you may face yet another obsolescence challenge in the near future. This is especially true for instruments based on the legacy VXI platform.

Let’s examine the latter two approaches and review some options in the marketplace today that will help you overcome your immediate obsolescence challenges.

Least Impact

Last-Time Buy
Stockpile and maintain a store of end-of-life hardware

Drop-In Replacement
Plan to replace the legacy component with a compatible, new component

Redesigning Around a Similar Component
Plan to integrate a new hardware component that requires small changes and some revalidation

Integrating a New Component
Use a new component that may require significant changes in the system and a revalidation effort

Most Extensible

FIG 1 The four approaches to meeting obsolescence challenges range greatly in cost and extensibility.

A New Way Forward

When dealing with obsolescence in an ideal world, you would have infinite resources to plan a completely new tester from the ground up. However, you have limited time and budget to deal with an obsolete component in your test system. Though they are concerned with capital budgets, test leaders also must consider the operational expenses when upgrading technology in their testers.

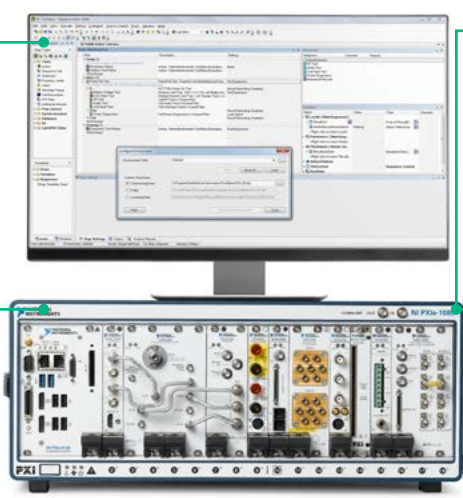
Dr. David R. Carey, an associate professor of electrical engineering at Wilkes University, conducted an in-depth study and found that the cost to rewrite a TPS due to the replacement of legacy or obsolete instrumentation is approximately $150,000 USD per TPS. Multiply that figure across dozens of TPSs running on a single ATS, and again across multiple programs, and the costs can be staggering. Therefore, engineers should consider modern test platforms whenever possible to streamline the validation effort. One such platform is PXI.

Software

Test Management and Code Development
Code sequencing, database reporting, user management, operator interface, parallel execution, signal processing: LabVIEW, C/C++, BET, Python

Computer

PXI Embedded Controller
Windows and real-time OS options, Intel Xeon processing, peripheral ports, display output, integrated hard drive



Timing and Synchronization

PXI Chassis
PCI Express Gen 3 throughput up to 24 GB/s subnanosecond latency, P2P streaming, integrated triggering

Instrumentation

PXI Modules
DC to mmWave, oscilloscope, programmable power supply, switch/MUX, DMM, VSA, VSG, VST, AWG, SMU DAQ

FIG 2 PXI is a rugged PC-based platform for measurement and automation systems.

Powered by software, PXI is a rugged PC-based platform for measurement and automation systems. It combines PCI electrical-bus features with the modular Eurocard packaging of CompactPCI and then adds specialized synchronization buses and key software features. PXI is both a high-performance and low-cost deployment platform for applications such as manufacturing test, military and aerospace, machine monitoring, automotive, and industrial test. Developed in 1997 and launched in 1998, PXI is an open industry standard governed by the PXI Systems Alliance (PXISA), a group of more than 70 companies chartered to promote the PXI standard, ensure interoperability, and maintain the PXI specification.

NI offers more than 600 different PXI modules ranging from DC to mmWave. Because PXI is an open industry standard, nearly 1,500 products are available from more than 70 different instrument vendors. With standard processing and control functions designated to a controller, PXI instruments need to contain only the actual instrumentation circuitry, which provides effective performance in a small footprint. 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.

Frost & Sullivan, a market research leader, has maintained a study since 2007 that shows the historical and projected future deployments of industrial technology platforms. In 2019, Frost & Sullivan updated the numbers, which show a continuing, drastic decline in deployed VXI systems.

FIG 3 PXI deployments continue to grow at a steady rate and will continue to dominate test and measurement platform deployments.

This decline in VXI deployments will make it difficult for vendors to maintain the economy of offering VXI products for sale. In contrast, PXI deployments continue to grow at a steady rate and will continue to dominate test and measurement platform deployments. For that reason, you should use caution when considering drop-in replacements instead of migrating to a new platform like PXI, especially when they require revalidation.

Taking an Incremental Approach to a Modern Platform

Making the switch to a new platform is risky because it can introduce a lot of technical debt. For example, making a minor change from a VXI-based instrument to a PXI-based instrument could introduce significant technical challenges in the TPS including driver, OS, and IDE compatibility. Therefore, to make a platform change and use the new technology, test engineers are seemingly forced to “go all in” at significant risk. But you can choose from several products available on the market to help you ease into a new platform like PXI.

Astronics Test Systems: Bridging Technology Using PXI-VXI Adapters/Carriers

With a bridge method, you can use your existing VXI infrastructure by replacing a single VXI instrument with a new PXI instrument in the same VXI slot. This means you can upgrade your aging VXI instrument suite with PXI instruments one by one without the need for infrastructure changes. Note that you can host one or two PXI/PXI Express modules in a single VXI slot (with mechanical provisions provided). Also, you can add a signal conditioning board using a PMC slot in the rear of the unit to help replace any legacy instrument functionality that is not already addressed by the PXI modules. Once you have replaced all the VXI modules, then you can easily replace the chassis and controller. This incremental obsolescence migration plan fits well with programs that have tight funding requirements or need to minimize station downtime.

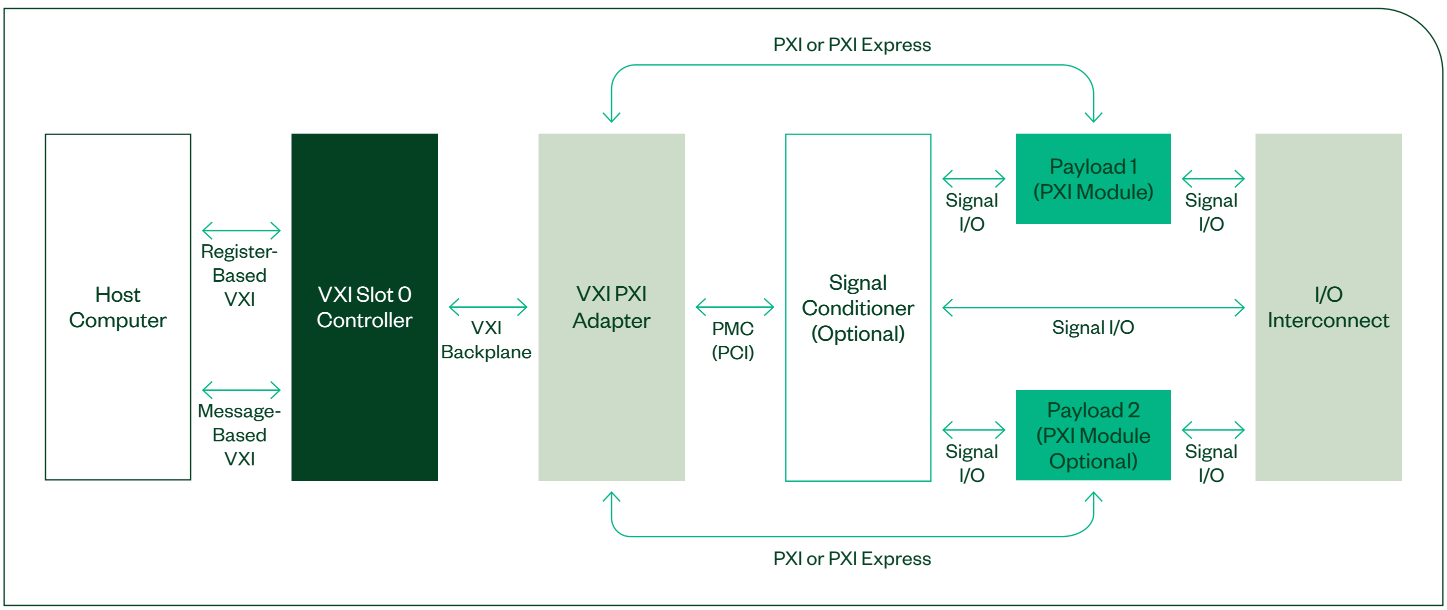


FIG 4 Generic Block Diagram for Connecting PXI Modules to a VXI System via a Bridge/Carrier.
(Image courtesy of Astronics Test Systems.)

One of these bridges, the Astronics VX407C PXI-VXI adapter, is typically used to bridge PXI register I/O to VXI for quasi-register-based operation. Another Astronics PXI-VXI adapter, the 6084H, is used to embed PXI or PXI Express modules in the VXI bus for message-based operation through the use of SCPI or other commands.

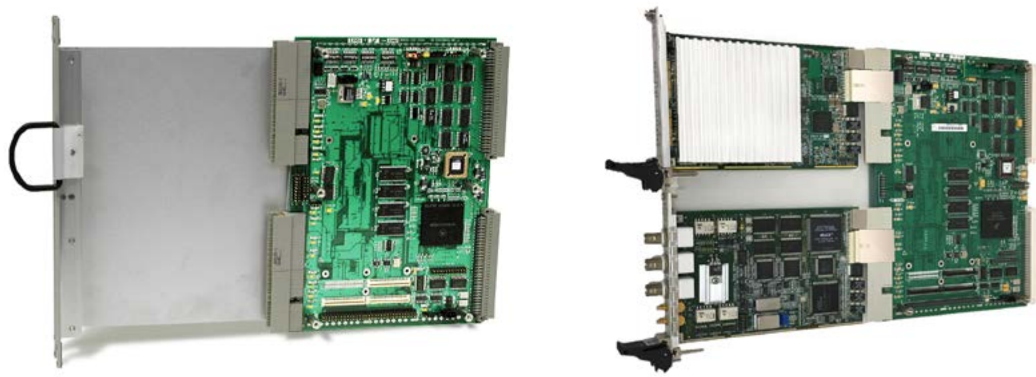


FIG 5 The Astronics VX407C and 6084H PXI-VXI adapters can help simplify the migration to a new platform. (Image courtesy of Astronics Test Systems.)

The advantage of the VX407C is simplicity: you map the PXI register I/O to a register location on the VX407C. The VX407C firmware transmits the data to/from the I/O space of the PXI module automatically. The resulting instrument DLL code changes are mostly cut and paste, so the cost to bridge a PXI DLL driver to the VX407C-hosted PXI module(s) is relatively small. This is a great approach for replacing register-based VXI modules.

The 6084H is more complex than the VX407C solution, but it is ideal if the original VXI is message-based *and* requires command-level compatibility. To use the 6084H without modifying and reverifying the system software, your PXI/PXI Express driver DLL must be embedded in the 6084H's firmware. Then you can avoid modifying and reverifying system software.

Learn more about the Astronics PXI-VXI carrier options.

Hiller Measurements: Large-Form-Factor PXI Chassis

One challenge with moving from VXI to PXI is the loss of physical space available to each module. Hiller Measurements (HM) has designed a unique solution to this challenge. The HM P-XLe chassis addresses VXI obsolescence by leveraging the open architecture of the standard 3U PXI platform. It was developed to accommodate measurement science that cannot be managed in the Eurocard PXI format and to work with the commercially obsolete VXI standard. Ideal for applications that require reconfigurable RF interface units, high channel counts, and I/O connectivity both from the front and rear of the chassis, the P-XLe allows cohabitation of standard 3U PXI modules and P-XLe modules.

FIG 6 | The P-XLe chassis was developed to accommodate measurement science that cannot be managed in the Eurocard PXI format. It is ideally suited for the commercially obsolete VXI standard. (Image courtesy of Hiller Measurements.)

A single-slot P-XLe module has a 3U region for circuitry that supports the PXI standard, including interface connectors for connection to a 3U PXI standard backplane as well as peripheral connections in the 3U region opposite the backplane for interface connectors. It also consists of a 6U region for circuitry that supports the expanded capabilities of the P-XL system with peripheral connections in the front and rear of the module.

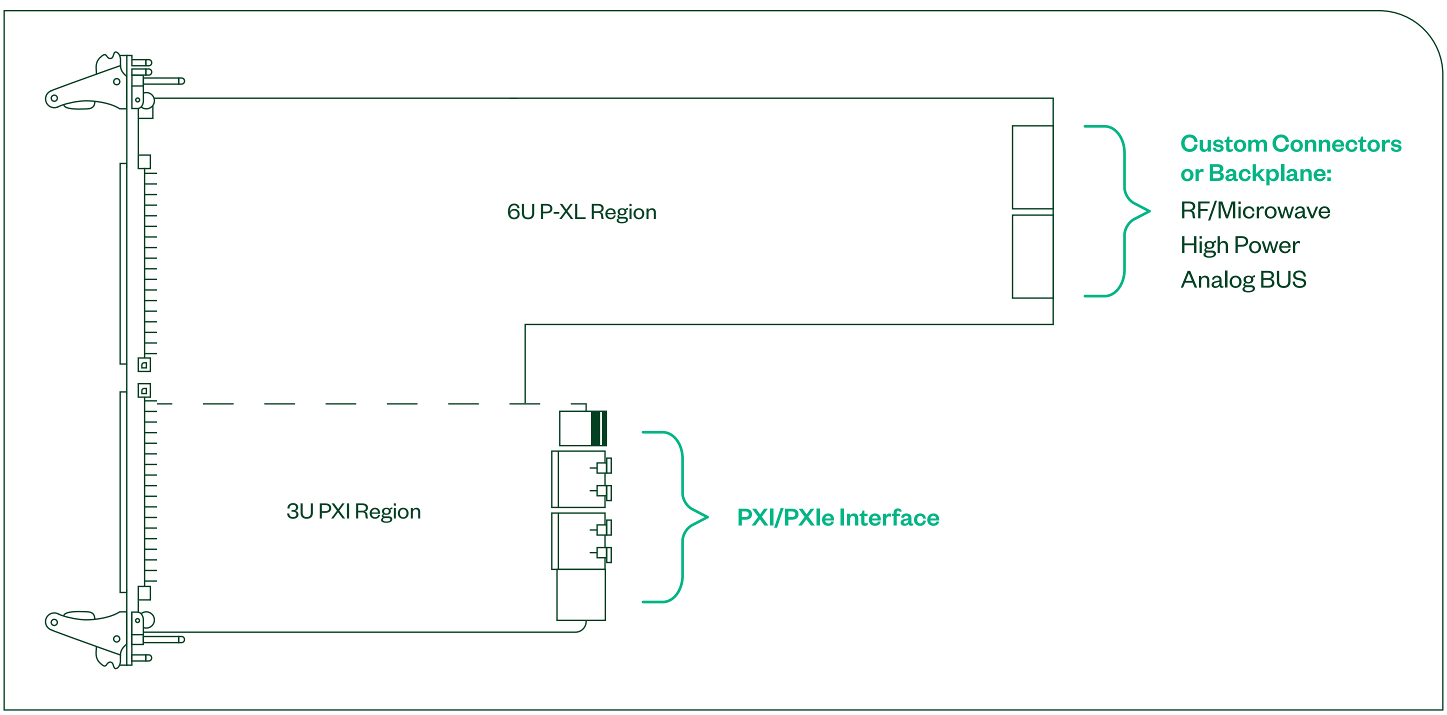


FIG 7 | P-XLe modules have a 3U PXI region and a 6U P-XL region in a single slot. (Image courtesy of Hiller Measurements.)

The P-XLe chassis houses PXI and P-XLe modules and controllers simultaneously and connects them with a high-performance PXI backplane to provide all power, cooling, and timing and synchronization capabilities. Additionally, the P-XLe chassis offers easy integration with Virginia Panel Corporation (VPC) and Mac Panel hardware to accommodate the chassis and I/O.

> The majority of legacy VXI systems used our popular VPC 9025 and 9050 series receivers and have a large installed base of ITAs. Hiller P-XLe modules are designed to match legacy functionality, connector I/O, and pin maps. This aids in migration to new test systems supporting the existing ITAs. VPC can provide wire harnesses from the PXI/PXIe instruments to the test receiver to facilitate this migration.

Kevin Leduc
VP/GM of Sales, Virginia Panel Corporation (VPC)

NI: FPGA-Based Digital Interfacing

Many ATSs require interfacing with devices under test to communicate with them, or test their communication links between individual subsystems. That communication is sometimes over an uncommon or custom digital protocol. If any hardware in these applications is facing obsolescence, test engineers must find a replacement. An off-the-shelf replacement is unlikely—but if one exists, it's probably expensive. In this situation, FPGA technology can help. You can use FPGAs to define the hardware personality through software, which makes them a popular solution. But FPGA technology traditionally has involved homegrown, custom design, which comes with a significant maintenance burden and risk.

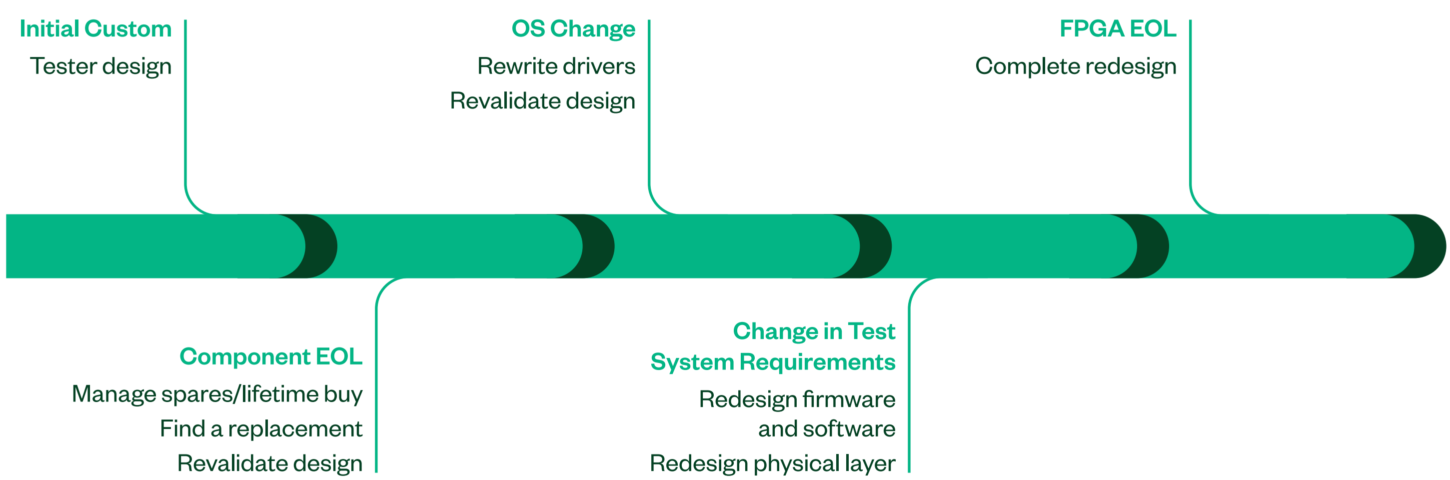


FIG 8 Managing the lifecycle of a homegrown FPGA-based system presents a significant maintenance burden and risk.

Instead, you should consider taking advantage of the FPGA-enabled PXI modules from NI. This approach bridges the gap between a fixed-function instrument and full custom design. With an off-the-shelf solution, you have a higher-level starting point. You also don't have to worry about the extra burden of designing and maintaining a custom solution.

With the LabVIEW FPGA Module, you can more efficiently and effectively design complex systems with a highly integrated development environment, IP libraries, a high-fidelity simulator, and debugging features. You can create embedded FPGA VIs that combine direct access to I/O with user-defined LabVIEW logic to define custom hardware for applications such as digital protocol communication.

When you're designing a replacement for a digital interfacing instrument, FPGAs offer a lot of flexibility for customization, but if you need to implement a standard protocol, a custom FPGA-based solution might not be right for you. Whether you are considering a generic interface like MIL-STD-1553 or ARINC-429, a high-speed or backbone interface like Serial RapidIO® (SRIO), or an application-specific bus like ARINC-818, NI and our network of partners have the tools you need.

One example of an organization we partner with for digital protocol IP is New Wave Design and Verification, or New Wave DV. New Wave DV currently has 14 off-the-shelf IP cores for highly complex communication protocols including Ethernet, Fibre Channel, 1394b, ARINC 818, and more—all of which can run on NI FPGA hardware. Rooted in the aerospace and defense industry, New Wave DV is a great source to consider for digital protocol IP.

DIGITAL AVIONICS INTERFACES FOR MANUFACTURING AND DEPOT TEST	
Generic Interfaces	▪ MIL-STD-1553 ▪ RS-232/422/485 ▪ ARINC-429 ▪ CANbus
High-Speed/Backbone Interfaces	▪ Fibre Channel ▪ Serial RapidIO ▪ ARINC-664p7/AFDX ▪ 1394b FireWire ▪ Ethernet (Up to 40 GigE)
Application-Specific Interfaces	▪ ARINC-708 ▪ ARINC-717 ▪ ARINC-818 ▪ SpaceWire ▪ DVI

TBL 1 Digital Avionics Interfaces for Manufacturing and Depot Test

Unlike competitors in the industry, NI's solution for integrating digital avionics into manufacturing and depot ATSs provides the most comprehensive coverage of PXI-based digital avionics protocol interfaces with the flexibility to choose the components you need.

Learn more about what is possible with LabVIEW FPGA.

Learn more about New Wave DV.

Plan for the Future: Solve Tomorrow's Obsolescence Management Challenges with System Design

Dealing with obsolescence is common for a test engineer in the aerospace and defense industry. Though you spend a lot of time examining and addressing the obsolescence challenges of today, you also need to consider the challenges of tomorrow. Test systems built to manufacture and support aerospace and defense platforms generally need to remain in service for the lifetime of that platform, or at least long enough to perform planned sustainment for 20 or 30 years. Unfortunately, most test systems are not built in a way that includes sustainment engineering as part of the initial design.

However, having the right processes in place when developing an ATS can help you mitigate obsolescence before it becomes a significant burden. Consider implementing these best practices in operations implementation, hardware acquisition, and software design to reduce the sustainment burden of handling obsolescence in test systems long before the equipment goes end of life. Following these best practices can cut the number of engineering hours by half, or more, and reduce associated costs by hundreds of thousands—or even millions—of dollars over the lifetime of the test system.

Focus on Sustainment and Obsolescence in Operational Decision Making

Designing a test system for long-life operation means making decisions with the entire lifecycle of the system in mind.

Choose Reliable Platforms and Vendors

One of the ways you can improve your obsolescence-readiness decision-making process is to choose the right lifetime-optimized products and vendors who emphasize engineering for a long-life cycle.

Two high-level best practices in choosing building blocks for your long-life test systems are to work with commercial off-the-shelf (COTS) tools and use industry-standard platforms that are managed by multiple vendors and end users. Several government associations, test and measurement industry committees, and private organizations are working toward standardized and interoperable platforms with many suppliers. Some examples are the Sensor Open Systems Architecture (SOSA) and PXI Systems Alliance (PXISA). Purchasing from vendors who cooperate with these organizations ensures the platforms you use have been vetted and offer multiple options for long-term sustainment.

Some engineering tools vendors have policies, services, and cooperative engagements. These policies can extend all the way to new product development. For instance, new PXI products and instruments developed by NI must support multiple releases of LabVIEW and maintain operational continuity from version to version. The PXI-4060 model of the PXI Digital Multimeter (DMM) that was introduced in 1998 uses the same "Fetch" function for measurements in the NI-DMM instrument driver as the PXIe-4081 PXI DMM that was released in 2017.

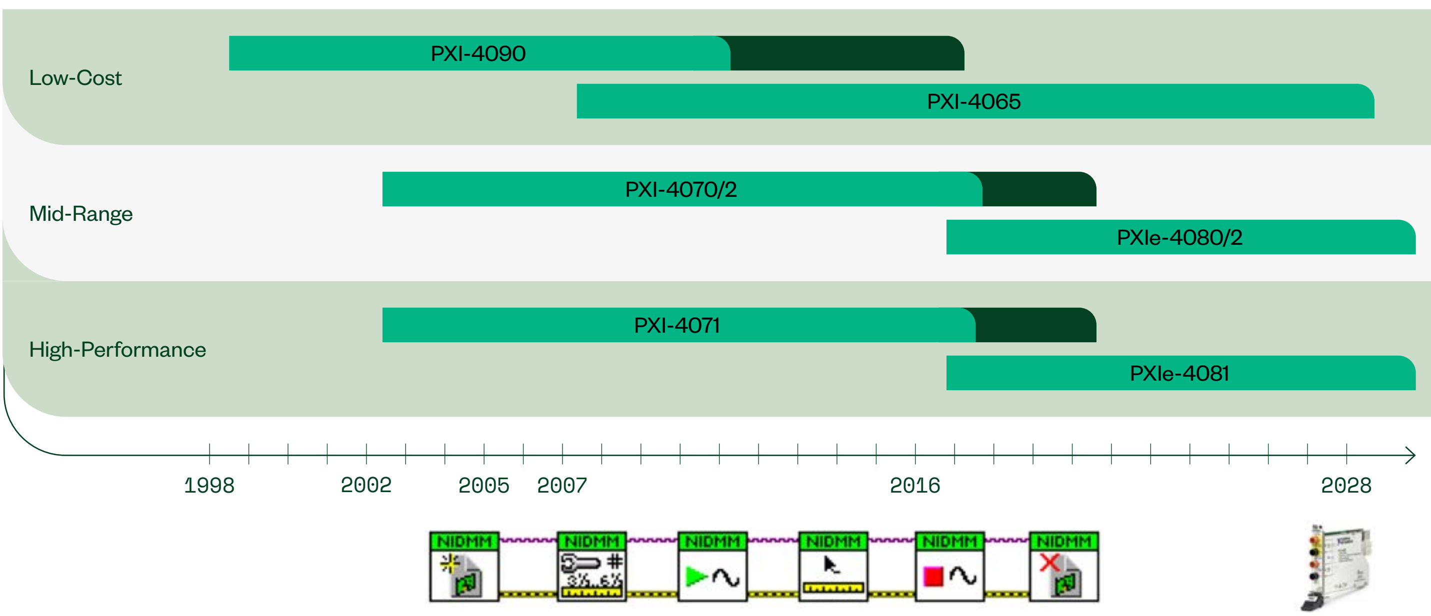


FIG 9 NI DMMs have used the same driver functions since the first one was released. The PXIe-4081 DMM operates with the same code that was written to work with the PXI-4060 in 1998.

Cooperate with Your Vendor

The best long-term test systems are built on platforms that feature sustainment plans continually updated with all the essential lifecycle information for the system's hardware components. Obtaining lifecycle information requires establishing a cooperative relationship and good communication with suppliers. It also requires diligent suppliers who create plans. Instrument vendors should empower you to plan for technology evolution in your system, even sharing roadmap information where possible. They should also provide services ranging from up-front consulting on product selection to long-term extended service agreements to meet your specific needs.

If you have decades-old products like the PXI-4060 DMM in your test system, NI is happy to regularly engage in a lifecycle review of that test system to measure the risk of obsolescence of each instrument and consider timelines for technology insertions. See Figure 10 for an example of a technology lifecycle review. By engaging in reviews like this, you can plan a single technology insertion project to replace multiple aging components at the same time. This reduces engineering effort and cost and helps prevent unforeseen obsolescence events. Then, instead of fighting fires, you can properly plan the headcount and budget you need to refresh technology and investigate new products and capabilities from the vendor to extend the features of your test systems.

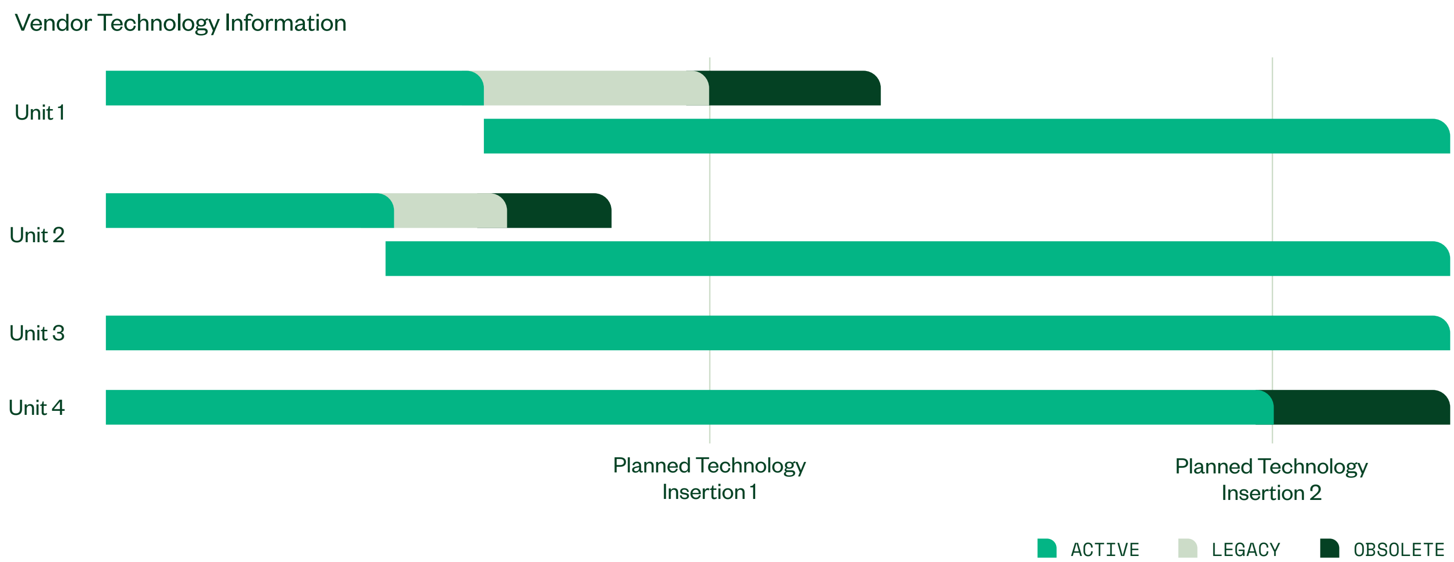


FIG 10 Example lifecycle review and the resulting plan for replacing instrumentation with more modern options. Planning technology insertions with your tools vendors reduces the downtime risk of your test system.

> CACI's relationship with NI has grown to a level of mutual trust as we work together to deliver high-quality, sustainable test solutions at affordable prices.

Paul Pankratz
CACI

Cooperate with Procurement

Once you have selected the right products and vendors, you can improve your decision-making operation by involving your acquisition team in defining the system. If you can identify critical equipment or vendor features that will save money on other tools and engineering effort over the lifetime of the system, you can work with the purchasing team to include those as requirements in the final system. That significantly simplifies the proposal and purchasing process.

Document an Obsolescence Management Plan

The last operational step to improve sustainability is to implement an obsolescence management plan in the documentation of the system at the time of delivery. This plan should offer information for replacing all system components including when they should be replaced, how critical each component is to the operation of the test system, and how much risk is introduced by the obsolescence or replacement of that component. The criticality and risk are the most important pieces of information to capture in this plan. The team designing the test system often knows far more about these issues than those maintaining the system 20 years later and can explain the effort needed to replace each component.

COMPONENT	PLAN OF RECORD	REPLACEMENT COMPONENT	TIMING	CRITICALITY AND RISK
Custom Cable	Drop-In Replacement (Vendor Change)	Custom Cable	Immediate	Medium and Low
1 kΩ Resistor Network	Drop-In Replacement (Vendor-Supplied)	1 kΩ Resistor Network	Immediate	Low and Low
Racal 4152A DMM	Replace with Similar (Vendor-Supplied)	NI PXIe-4080 DMM	Technology Refresh	Medium and Medium
Windows XP	Replace with New (Vendor-Supplied)	Windows 10	Technology Refresh	High and Medium
Virtex-2 FPGA	Last Time Buy	N/A	N/A	High and Low

TBL 2 A test system should have an obsolescence plan that describes how to handle the end of life for any component in the system. The plan should list all the factors that contributed to that decision including the criticality and risk of that component being obsolete.

Hardware Selection and Integration

You should always consider the sustainability of each piece of hardware you select when designing a new test system to operate for decades. Just as important, however, are the vendor services for sustaining the system and the skills needed to operate and maintain it over time.

COTS Components

The most sustainable test systems are built with COTS components. Using COTS products expands the user base for a given product, which improves the likelihood that the product will be properly maintained. Test hardware from large vendors has many users, so updates to firmware, drivers, and the hardware lifecycle are planned carefully to reduce impact across a wide user base.

Open Industry Standard

To ensure that your test system can be sustained over decades, you need to select a hardware platform that is continually growing as well. Then you can avoid completely redesigning a test system architecture when a single component goes end of life or when you need new measurement capabilities. Open industry platforms such as PXI, VXI, and GPIB deliver the benefits of multiple vendors who are innovating on the hardware platforms through instrumentation hardware competition. This competition fosters healthy platform growth and a constant supply of new products to meet the needs of advanced test systems.

The PXISA includes more than 70 test and measurement vendors who oversee the maintenance and innovation of the PXI test hardware platform, which is an open-standard platform. Growth of the PXI platform has been rapid since the adoption of the standard in 1998. In addition to a vast product offering, PXI is expected to continually grow for the forseeable future, as previously shown in Figure 3, making it an ideal platform for use in long-term test systems.

Plug-In, Modular Hardware Architecture

Open standards that have modular, plug-in components further reduce system costs by maximizing component reuse and reducing technology insertion effort. Replacing a traditional instrument means accounting for size, heat generation, power consumption, and other factors. Upgrading or replacing a modular instrument is as easy as removing the old instrument from its slot in the carrier and replacing it with the new one.

Plug-in architectures also simplify test system expansion. Test systems built for longevity are often required to incorporate more I/O over time to test new features or line replaceable units (LRUs). Having test systems that can stand the test of time requires an instrumentation platform with a large portfolio of products that can perform tests on DC, analog, digital, and RF signals at various levels with accuracy and speed.

Synthetic or Software-Defined Instrumentation

Test hardware in modern test systems often needs to perform many measurements and tests. Instruments with software-configured measurements have the flexibility to take the right measurement and get the results needed. Many times, these instruments have extensive code compatibility with other instruments using industry-standard APIs, like VISA or IVI, or well-engineered vendor-defined APIs. Combining the right complementary hardware and software tools can facilitate the design of long-term test system architectures.

Instruments with open FPGAs add another level of compatibility by helping you design the firmware of an instrument and reuse that firmware on compatible instruments as necessary. This type of customization isn't always necessary, but it can help promote important features that could go obsolete over time.

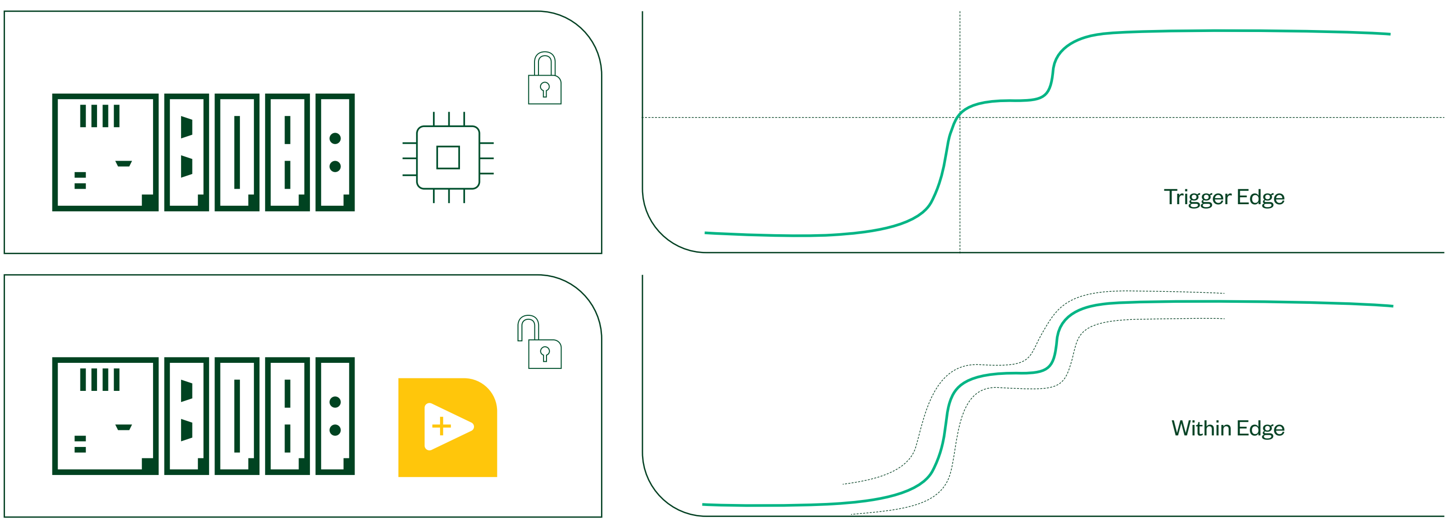


FIG 11 NI devices with programmable FPGAs help you create custom measurement features like triggers and signal processing as well as interoperative device firmware.

Hardware Platform Investment and Support

Another sustainability step is to ensure that test products are manufactured by vendors who have strong track records for continual bug fixes and software support updates as well as the ability to provide replacement products for aging ones. Without vendor support, you may have difficulty troubleshooting technical issues and unforeseeable problems in the system.

A good hardware vendor also provides options for warranties on instrument function, calibration services and instructions, repair plans, and even the ability to reserve spare hardware to ensure minimal downtime if instruments in the test system break down. NI offers several levels of service contracts, from coverage on a single instrument to system-wide coverage that lasts up to 20 years.

*Available durations depend on hardware lifecycle phase at the time of purchase.

FIG 12 | Collaborate with NI on a service program that extends the lifecycle of your NI products for up to 20 years. You can use this preconfigured program as is or customize it to meet your specific application needs.

Software Tools and Architecture

The test software architecture you select may be even more important than the software platforms you choose to build a sustainable test system.

COTS Software Tools

As mentioned, using COTS software tools can significantly increase the sustainability of test systems. COTS tools have wide user bases and are maintained by large, specialized software development teams. This means your software organization's maintenance effort is significantly reduced. Consider an older application built to work on Windows XP that needs to be ported to Windows 10 as a result of Department of Defense mandates. If the application development environment (ADE) used to develop the code does not support Windows 10, the test program must be completely reconstructed.

Companies that sell high-volume enterprise software tools can also offer tailored purchasing agreements and software subscriptions that meet specific billing needs or defined terms and conditions.

Test Software Toolchain and Interoperability

The ideal software package should minimize the effort to develop and expand the test program and, thus, streamline the productivity of software engineers while minimizing their sustainment effort over the lifetime of the test system.

To match the pace of technology acceleration, maximize engineering efficiency, and minimize software maintenance effort, test systems must be flexible and use ADEs that can withstand structural changes by working with multiple hardware and software platforms. Software developers may be forced to use multiple ADEs for different projects if the tools do not meet the needs or interoperate with the tools of each project. Imagine that your test program requires a new measurement performed by an instrument that is not in the test set. If your development software does not support this new hardware, then you may have to substantially change the application.

To incorporate these changes into the test program easily and quickly, you need scalable software. Examples of tools that improve the programming experience include easy-to-use APIs that minimize the need to learn hardware caveats and ready-to-use example code that serves as a starting point for any application. Software tools should also simplify performing new analysis on data acquired from hardware by providing analysis functions or delivering interoperability with tools like MathWorks MATLAB® software or Python, which offer complex data analysis.

Software tools should also include features that maximize the ability to reuse code. Some software tools do this by helping you create libraries or code repositories through interactive configuration utilities or by supporting drivers that use a standard communication protocol to help you program multiple instruments with the same API. NI instrument drivers are built to support multiple families and generations of instrumentation to maintain code compatibility over time.

Modular Software Architecture

Don't get locked into an inflexible test program by building a monolithic architecture; instead, plan ahead by building layers that perform separate test operations. In a monolithic architecture, the test program for the unit under test (UUT) includes code that manages test flow control, test execution, UUT stimulus, measurement analysis, limit checking, result logging, operator user interfaces, and instrument resource scheduling. This single source of functionality means that any new test requirements that arise because of an obsolescence event force you to revalidate the entire test system.

Instead, create a modular software architecture that has separate code bases for all critical test system functions. Test management software like TestStand handles common test program tasks such as test flow control, test execution, result logging, limit checking, operator user interfaces, and instrument resource scheduling. Test code should be responsible for tasks specific to the UUT like stimulus, measurement, and analysis functionality.

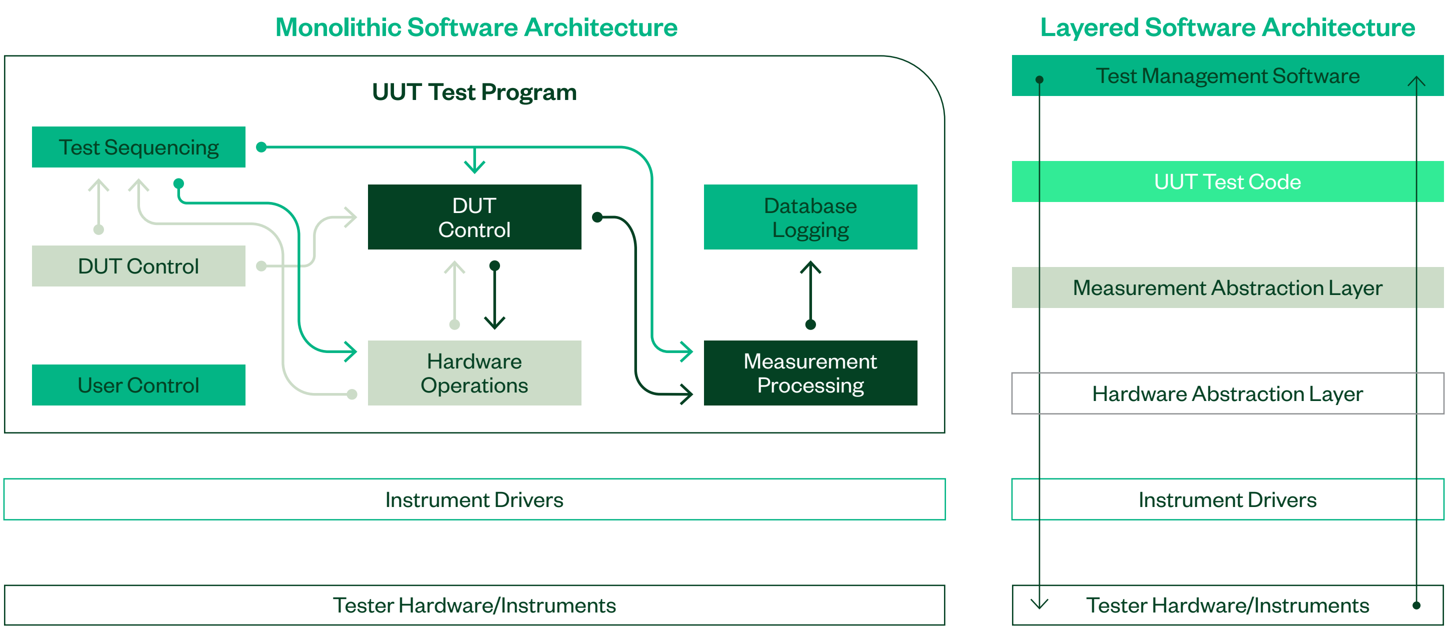


FIG 13 A single code base to handle all test program tasks seems like a good way to develop until it becomes inflated and difficult to change or repair. Using smaller, modular code bases for different tasks keeps a test system more extensible.

Functional Abstraction Layers

Perhaps the most significant software technique to protect a test system against inevitable hardware obsolescence events is using hardware abstraction layers (HALs) and measurement abstraction layers (MALs).

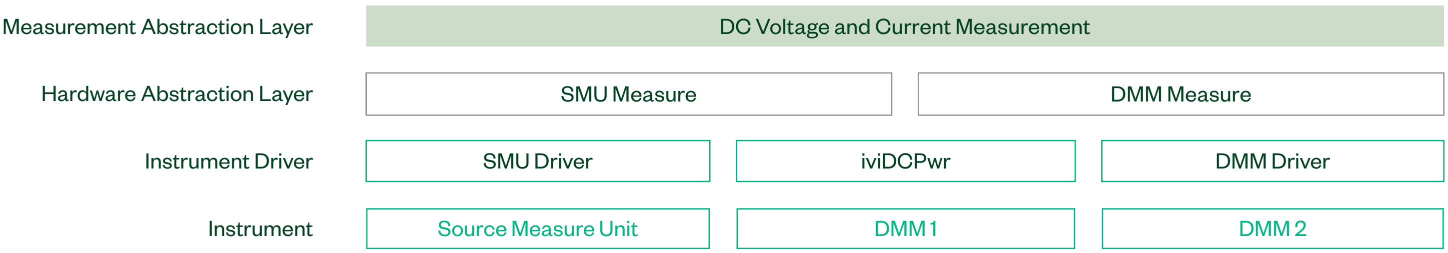


FIG 14 A MAL and HAL empower test engineers to choose the test result needed and allow the test system architect to maintain instrument driver and hardware operability.

Industry-standard instrument drivers like IVI can provide a quick and easy starting point for function abstraction, but they often fall short when you want to use specific features of new instruments that do not conform to standard driver function calls.

MALs help you develop high-level code that performs necessary functions without your defining specific instrument settings or communication. They also give the test system the ability to choose the correct and available resource to deliver a given test function. In some cases, a function in the MAL translates to a specific instrument, but some instrument functions overlap and could be used to complete tests in place of a busy or malfunctioning device. A good example of this is taking current measurements with a DMM. You can use a source measure unit (SMU) to take that measurement in many cases more effectively.

For a MAL to operate properly, you need an abstraction layer that handles instrument selection and communication. This layer is the HAL, which enables the code base to execute the function in the MAL from any specific instrument and device configuration in the system. Building these layers into your code gives you the flexibility to change instruments without altering measurement analysis code, the tester's user interface, or the overall test structure.

Technical Support and Training

A best-in-class vendor has on-demand technical support engineers to assist with resolving any obstacles you may encounter or with getting started using hardware. NI offers on-demand technical support, classroom and online courses, and skills certifications programs. Certifications help you as a team leader measure the skills of developers on your team and give you a method to evaluate new engineers or contractors who may join your teams to help complete projects.

NI Is Here to Help

Test is a vital business function that ensures the quality and reliability of your mission-critical assets. The extremes of building and maintaining test assets to support long-life programs and identifying test assets that can keep up with commercial aviation, vehicle, and weapon system design require an experienced business partner. Test engineering leaders must manage cost and risk when building test capability and managing legacy programs. Aerospace and defense organizations across the world are being asked to learn and integrate new technologies, manage new and often unbudgeted corporate or government mandates, and maintain legacy test equipment for years longer than originally planned.

For decades, the aerospace and defense industry has used NI's modular instrumentation and application software to reduce the overall cost and risk associated with the test and support of its products. NI has worked with thousands of engineers and leadership teams to manage risk and generate a sustainable market advantage through advancements in test engineering and operational support.

- **Deliver automated test sets on time and on budget** with a customizable off-the-shelf platform.
- **Proactively manage technology insertion and lifecycle management strategies** to reduce the burden of maintaining legacy and obsolete equipment.
- **Meet demanding technical requirements** with industry-leading measurement accuracy, processing performance, and timing and synchronization capabilities.

Along with commercial tools, NI has developed a deep knowledge of the challenges test teams face in technical development, requirements changes, and business impact. NI's expertise includes not only the aerospace and defense industries, but also semiconductor, transportation, life sciences, and consumer electronics—just to name a few. This wealth of knowledge and test strategy insights from best-in-class test organizations across a diverse set of industries puts NI in a unique position to assist you and your test organizations to overcome the key challenges are facing today.

NI can help you modernize your test equipment and your approach to dealing with obsolescence. We can evaluate your legacy designs and assess your existing resources to determine gaps for migration and provide you with a quantified ROI of updating or migrating test systems allowing you to fully evaluate alternative approaches. We can help you develop a complete plan and prioritize the list of implementation steps. And finally, if you choose, you can leverage NI and our network of test engineering professionals to perform the migration on your behalf freeing up your valuable engineering resources.

Electronics Manufacturing Test

Reduce the cost and risk associated with developing and maintaining automated test sets (ATSs) that must last the lifecycle of your test system. Future-proof your software architecture by accounting for the inevitability of instrumentation obsolescence.

Customer Needs

01

Develop a modular software architecture and reusable libraries to accelerate development across multiple projects and programs.

02

Collaborate with numerous and often geographically dispersed developers who are working in multiple languages.

03

Minimize the time and risk associated with adding new system capabilities or managing obsolete instrumentation.

NI Solution

01

Develop comprehensive hardware and measurement abstraction layers, code modules, and fully customizable sequencing engines and automation frameworks with LabVIEW, LabWindows™/CVI, TestStand, and world-class hardware integration tools such as Switch Executive. All are designed for automated test applications.

02

Monitor and interactively debug system errors using InstrumentStudio™ software.

03

Create deployment packages, manage system configurations, streamline data aggregation and insight, and connect to MESs using SystemLink™ software.

> The innovative LM-STAR approach to standardized test system development based on COTS software has yielded many cost-saving benefits for [Lockheed Martin], harmonization suppliers, and the US government.

Robert Dixon
Lockheed Martin STS

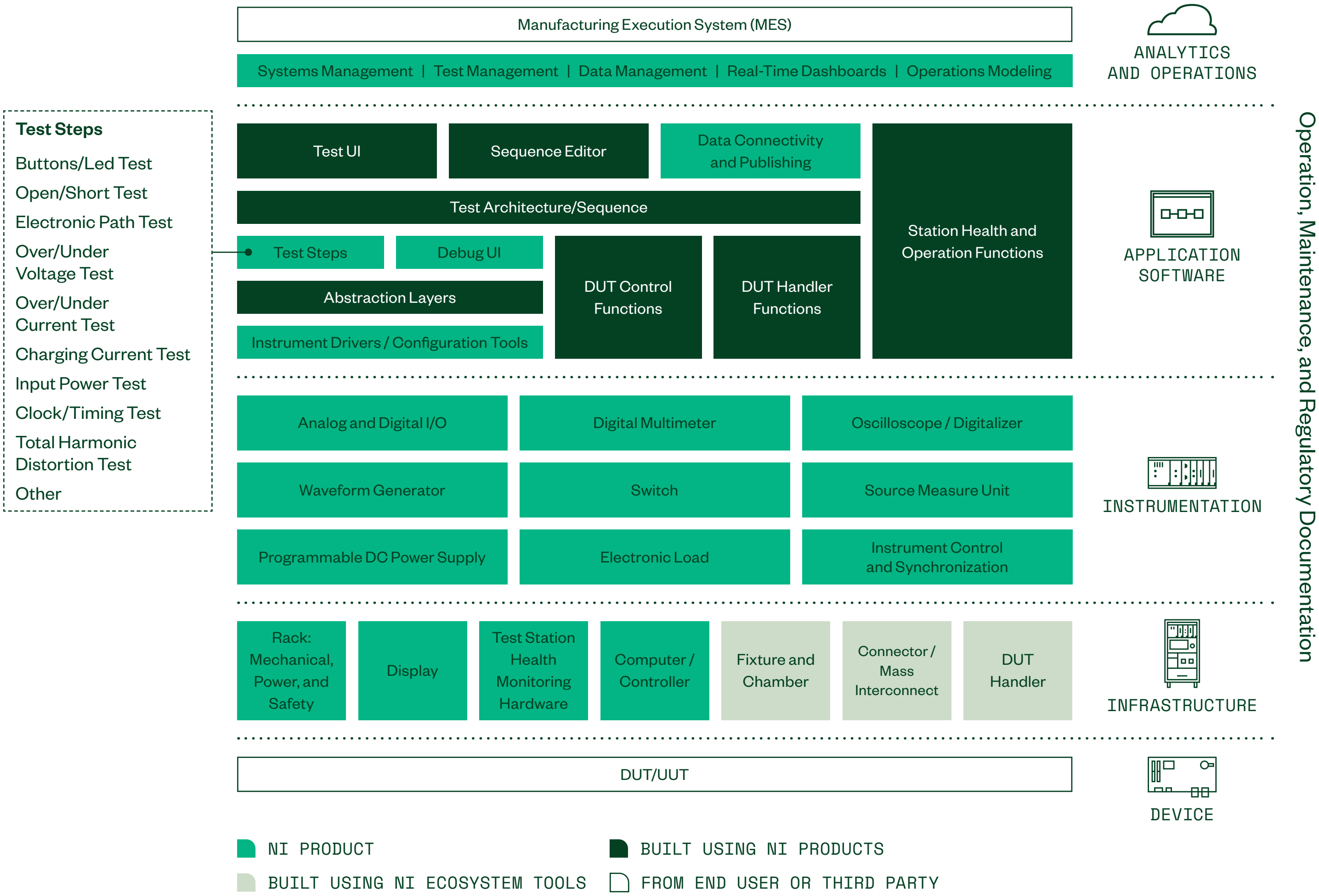


FIG 15 Key Hardware and Software Components for an Electronics Manufacturing Automated Test Set

THE NI ADVANTAGE

- Remember that NI is the only vendor to offer a full suite of tried-and-tested modular software components, from world-class hardware integration to code modules and test executives to system management and manufacturing execution system (MES) integration.
- Accelerate your learning with our user community and company-specific and geographic user groups. Also build proficiency with extensive online and in-person training options for both new users and certified architects in NI tools.
- Integrate hardware from different vendors and code from different languages into a single TPS.

KEY SPECIFICATIONS	
LabVIEW	**Connect**: Drivers for virtually any instrument **Develop**: Libraries and code modules included **Open**: Ability to call Python scripts natively, import C/C++/C# or .NET UI: Data display, test interaction, and sequence editing
NI TestStand	**Sequence**: Ability to develop, debug, deploy, and execute test sequences as well as configure parallel test calling code modules written in any language **Report**: Results logging to a report or database **Debug**: Deployment utility and debugging tools for efficient troubleshooting
SystemLink™	**System Management**: Software deployment, device management, health and performance monitoring and notification **Data Management**: Data standardization, search, analysis, and report generation **Data Visualization**: Secure remote operator interfaces and dashboards
PXI Platform Components	**Instrumentation**: DMM, scope, switches and multiplexers, power supplies, SMU, digital I/O, communication, multifunction DAQ **Infrastructure**: Rack, power/safety infrastructure, instrument chassis, controller/computer, power supplies, screen, keyboard

Avionics Interfaces for Manufacturing and Depot Test

When building automated test sets (ATSs) for manufacturing or depot test, one type of instrument that is often overlooked for deeper consideration is the digital avionics bus interface. These range from generic interfaces like MIL-STD-1553 or ARINC-429, to high-speed or backbone buses like Serial RapidIO® (SRIO), to application-specific buses like ARINC-818. In some cases, the device under test (DUT) requires a non-standard or custom protocol—which if not addressed appropriately can lead to significant increase in risk and maintenance cost over the life of the ATS.

Customer Needs

01

Combine DUT control with other test plan measurement and stimulus requirements.

02

Generate responses for protocol aware applications dynamically or algorithmically.

03

Integrate non-standard or completely custom protocol IP while minimizing maintenance costs.

NI Solution

01

In addition to traditional instrumentation, NI offers digital avionics interfaces both directly and through our network of partners.

02

Support includes generic interfaces like MIL-STD-1553, and ARINC-429, high-speed interfaces such as Serial RapidIO, and application-specific interfaces like ARINC-818.

03

For modified or custom protocol applications, NI tools incorporate a user-programmable FPGA for maximum customization to meet application requirements.

THE NI ADVANTAGE

- Leverage the most comprehensive coverage of PXI-based digital avionics protocol interfaces with the flexibility to choose only the pieces required for your application.
- Develop your own IP libraries or use IP from NI and our diverse network of partners. Program graphically in LabVIEW or in VHDL with Xilinx Vivado.
- Use a modular approach to instrumentation. Adapt your ATS based on your requirements and integrate under a single software and hardware platform.

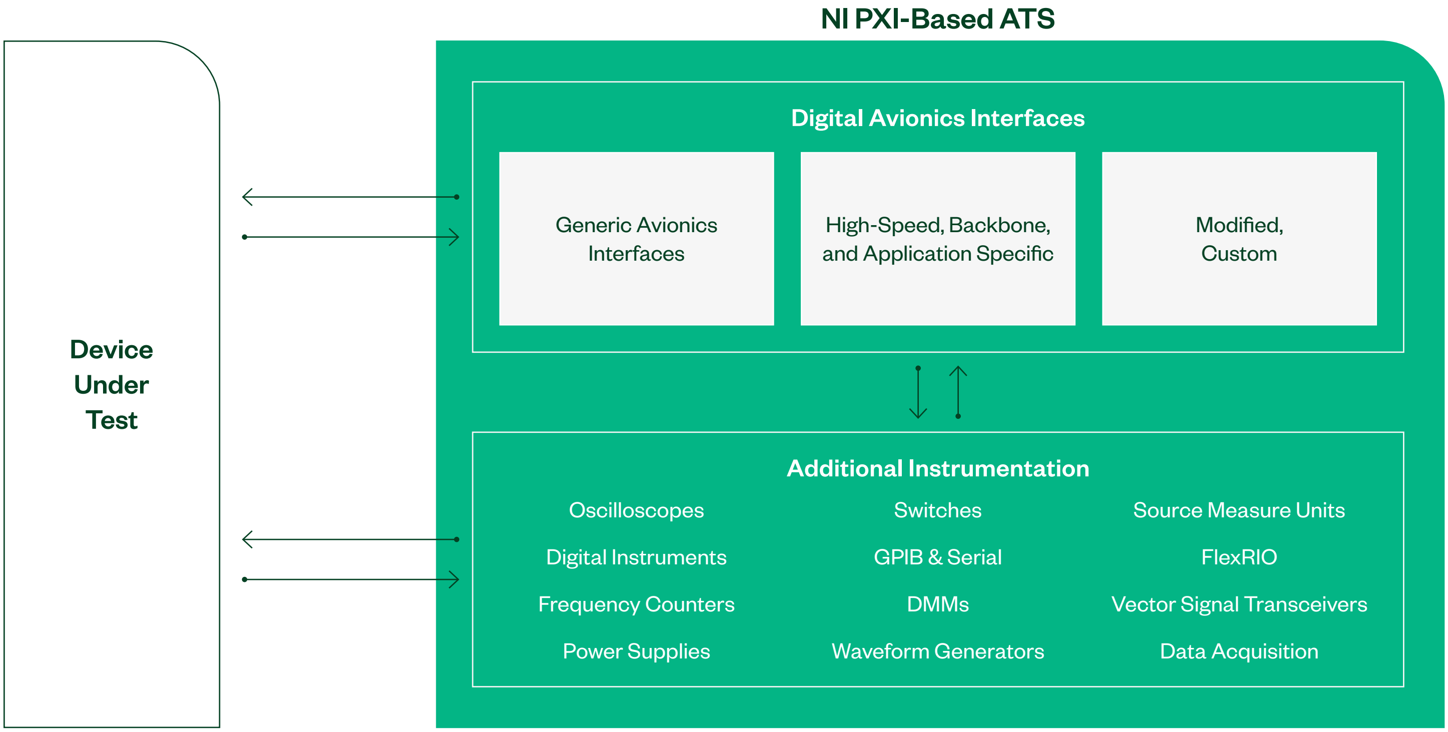


FIG 16 Digital Avionics Interfacing options based on NI PXI-based ATS

DIGITAL AVIONICS INTERFACES FOR MANUFACTURING AND DEPOT TEST		
Generic Interfaces	▪ MIL-STD-1553 ▪ RS-232/422/485	▪ ARINC-429 ▪ CANbus
High-Speed/ Backbone Interfaces	▪ Fibre Channel ▪ Serial RapidIO ▪ ARINC-664p7/AFDX	▪ 1394b FireWire ▪ Ethernet (Up to 40 GigE)
Application-Specific Interfaces	▪ ARINC-708 ▪ ARINC-717 ▪ ARINC-818	▪ SpaceWire ▪ DVI

INTERFACING HARDWARE FOR GENERIC AVIONICS PROTOCOLS	
PXI AVIONICS INTERFACE MODULES	
	▪ Support for MIL-STD-1553 and ARINC-429

FPGA-BASED DIGITAL INTERFACING HARDWARE FOR HIGH-SPEED/ BACKBONE, APPLICATION-SPECIFIC, AND CUSTOM PROTOCOLS	
MULTIFUNCTION RECONFIGURABLE I/O	
	▪ 128 SE digital I/O lines up to 80 MHz per line ▪ Xilinx Kintex-7 FPGA ▪ Selectable logic levels including 1.2 V, 1.5 V, 1.8 V, 2.5 V, and 3.3 V ▪ Import up to 4 external clocks, up to 80 MHz each ▪ Optional onboard DRAM up to 512 MB
NI FLEXRIO	
	▪ Up to 54 digital I/O lines with data rates up to 1 Gbps ▪ Xilinx Kintex-7 FPGA ▪ Selectable logic levels including 1.2 V, 1.5 V, 1.8 V, 2.5 V, and 3.3 V, as well as LVDS/mLVDS ▪ Support for RS-422/RS-485 ▪ Optional onboard DRAM up to 2 GB ▪ Develop custom physical layer with Module Development Kit
HIGH-SPEED SERIAL	
	▪ Up to 24 channels with data rates up to 28 Gbps ▪ Xilinx Kintex Ultrascale+ FPGA ▪ Onboard DRAM up to 8 GB ▪ High-speed data streaming up to 3.2 GB/s to host, disk, or other PXI Express modules

Minimize Cost of Technology Insertion and Migrations While Mitigating Risk

In the aerospace and defense industry, test-system lifecycle often is measured in decades, but that of individual system hardware and software components is much shorter. Test engineers spend as much as 50 percent of their time (or even more, in some cases) actively dealing with obsolete hardware and software.

Customer Needs

01
Aging test equipment is increasing maintenance and support costs and cannot support evolving needs.

02
Cost of updating equipment is not well understood compared to ballooning maintenance costs of existing equipment.

03
Budget for migrating legacy systems can be difficult to justify.

04
Organizations lack engineering resources or expertise to create and develop new test architectures.

NI Solution

01
Modernize test equipment with a modular design and interoperable software compatibility.

02
Evaluate legacy designs and assess existing engineering resources to migrate technology. Quantify the ROI of updating or migrating test systems and evaluate against alternatives.

03
Develop scope and prioritize implementations. Deconstruct migration projects to allocate changes to specific programs or cost centers.

04
Free up engineering resources and leverage NI expertise by outsourcing migration.

THE NI ADVANTAGE

- Quantify the value of updating legacy test equipment and thoroughly evaluate alternatives.
- Justify expenses with detailed action plans that define project scope, detailed timelines, and cost estimates to implement the test solutions.
- Allow development teams to focus on new projects while improving maintenance cost and sustainability of existing testers.

Based upon a 15-year proactive management strategy, CACI [has] selected many NI instruments for the core of the CBATS test system based on the relationship with the company and the quality of its products. CACI's relationship with NI has grown to a level of mutual trust as we work together to deliver high-quality, sustainable test solutions at affordable prices.

Paul Pankratz
CACI