WHITE PAPER

Minimize Schedule Risk With Off-the-Shelf Technology for LRU Test

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Overview

The life cycles and operation of line-replaceable unit (LRU) test systems are governed by aerospace program cycles. Countless aerospace LRU testers are still in service because programs did not include the budget or time to update and extend the capability of deployed systems. When a test architecture can't meet all test requirements, proposing changes to the status quo solution can be difficult because the program must balance the schedule and cost impact of making alterations. This leads to decades-old test systems with few technology updates still in operation. Almost universally across the industry, deferring test infrastructure upgrades results in the accumulation of technical risk because each deferment increases the cost and risk associated with an upgrade on a subsequent program. This lack of technological readiness can limit an aerospace program's options for meeting its test and quality requirements and hinder its ability to be innovative and competitive.

NI and its ecosystem of partner companies are focused on accelerating the process of building an aerospace LRU test system so you can focus on what matters more: using your unique expertise to produce an optimized product.

The Inner Workings of a Test Architecture

Aerospace program officers are primarily concerned with meeting customer requirements and preventing any quality escapes rather than focusing on the inner workings of their test architecture. At the enterprise level, quality test involves better model-based design, greater test automation, the ability to share common architectures between phases of the life cycle, and requirements tracking. But these process improvements typically require modernizing the underlying test infrastructure, so they are sacrificed to complete the program's basic elements—like having a pin to test on—in accordance with the schedule.

To ensure a product-quality focus, a test architecture needs to be flexible enough to allow for continuous evolution from program to program. Paradoxically, the migration to this type of architecture must occur within a single program. Capital budgets outside a program are rare, and the need to upgrade typically arises in the middle of a program when you're most risk averse. Any path forward requires a clear understanding of a program's primary cost, risk, and schedule drivers. Factors like designing the test system, establishing point-to-point wiring, and building test adapters are essential to create a functioning test system. But they don't necessarily contribute to increased product quality. The percentages shown in Figure 1 are typical of many aerospace companies.

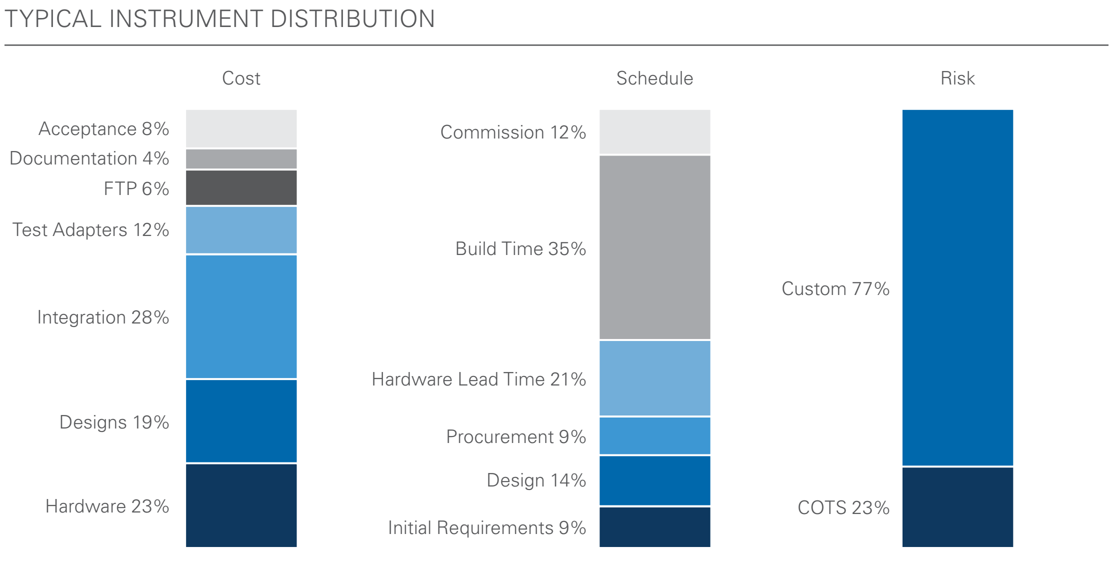

Figure 1. To architect and deploy a new LRU test system, you need to consider trade-offs in up-front cost, development time, and risk acceptance. The typical LRU tester deployed today is highly customized and has a long build time, both of which add significant risk to a program schedule.

Hardware typically accounts for less than a quarter of the total cost, while the design and build labor accounts for the greatest impact to budget and schedule. Based on typical data, you can estimate $800 to $1,000 per pin of I/O with an 8- to 12-month schedule, depending on the size of the system. To make an impact, you must address both cost and time.

Different companies' LRU test systems often have large technology overlaps. If you use commercial off-the-shelf (COTS) components for these common system components, you are free to work on the niche test system pieces that only you can address and that greatly enhance your test.

> "Using the SLSC system further promotes our goal to focus the attention on building HIL test systems and rigs, not developing advanced hardware."
>
> Anders Tunströmer, Saab Aeronautics

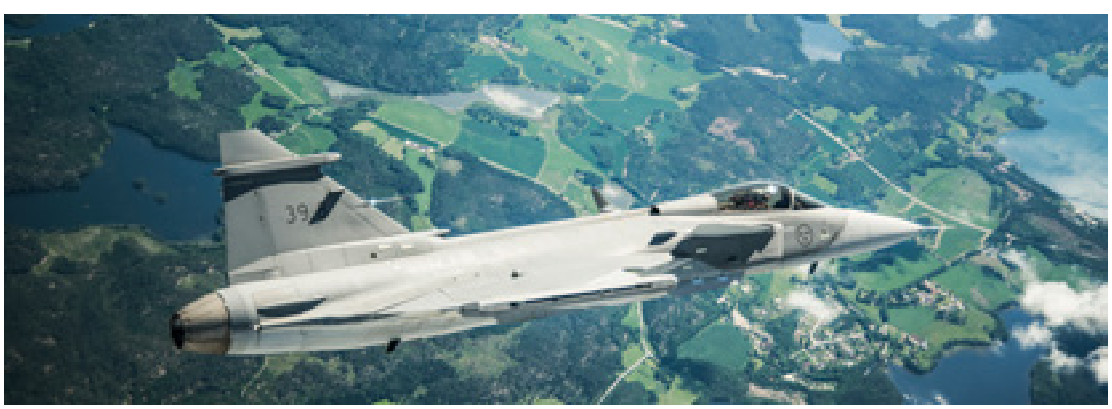

Figure 2. Saab Gripen E-Fighter System.

Commonalities of LRU Test Systems

A basic LRU test system consists of a unit under test (UUT) interfaced to a mass interconnect that is connected to simulation I/O driven by a test executive running the aircraft simulation. You can customize this basic setup by adding signal conditioning for sensor simulation and specific loads that need to be driven by the LRU. You also can add fault insertion for software testing. For integration lab testing, you need to connect to real devices that you are controlling as well as control LRUs. You also need to switch between real and simulated versions of devices. Additional customizations can involve a breakout box for manual faulting, signal injection and rerouting, and sense lines to know exactly what the LRU is seeing during all test phases. For your sense lines, you may need an instrument-grade measurement.

TYPICAL TEST SYSTEM

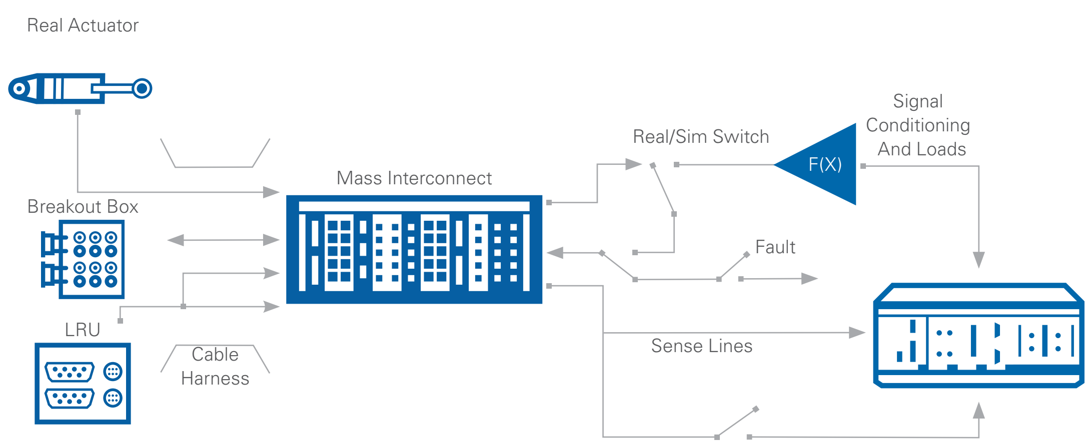

Figure 3. A typical LRU test system includes I/O instrumentation, signal conditioning, fault insertion, sense and switching lines, real and simulated stimulus signals, a mass interconnect, a breakout box and cable harnesses, real actuators, and the LRU under test.

Traditionally, NI helped customers by consolidating the measurement and simulation components of this setup into one measurement and computing platform. However, this does not address the signal routing components, which impact cost and schedules the most. If you take the industry-standard metric of three minutes per wire termination and $5,000 per week full-time equivalent (FTE) for labor rate, facilities, and oversight of a technician, then your system costs about $125 per I/O pin per hour. A full 600-pin system would be around 15 weeks at $75,000. This is without any design changes. So, in reality, the cost will likely be much higher.

Every LRU test system uses some variation of this basic setup, so why do so many companies use so much custom design and wiring? Maybe this is the cost of business, but what if it didn't have to be?

Freedom to Use Your Expertise

NI is challenging the status quo in industries where the signal handling follows established patterns like in LRU test. With the introduction of NI's switch, load, and signal conditioning (SLSC) add-on for the PXI and CompactRIO measurement platforms, you can transform and manipulate the signal paths in standard analog and digital I/O types to implement the kind of inline functions that form the core of an LRU validation architecture.

An open arquitecture for extending NI hardware with Switches, Loads and Signal Conditioning (S.L.S.C) targeted at embedded software, hardware, and system test.

- Enables larger switches for insertion
- Handles small to medium loads on a simple circuit card
- Adds custom signal conditioning
- Reduces signal routing complexity

Figure 4. NI SLSC hardware extends the PXI and CompactRIO instrumentation platforms to complete more of the LRU test system. NI SLSC hardware includes signal conditioning, fault insertion, and sense and switching lines that then pass signals to I/O instrumentation.

To help eliminate the need for customization, NI offers solutions for many of the most common signal types, including high-voltage digital waveform signals, resistive sensor simulation, and ARINC 429 and MIL-STD-1553 PXI interface modules. Many of these modules are designed by partner companies like Bloomy Controls and SET, which have direct expertise in this field, to cover most I/O needs. However, no vendor can know all your test requirements, so you may need some customization. With NI's open and flexible platform, you can design your own SLSC hardware with NI's SLSC module development kit (MDK). It provides all the information you need to customize unique circuitry that's compatible with the rest of the SLSC ecosystem. Alternatively, an NI Alliance Partner can create this custom module for you. Once you've created this module, you effectively have a COTS product that is compatible with the rest of the SLSC ecosystem. All SLSC modules have the same 44-pin D-SUB connector with the same pinout, which mitigates the need for point-to-point wiring between terminal blocks. You can replace terminal blocks with standard interface panels to connect signals to actuators, cable harnesses, and the LRU.

STREAMLINED TEST SYSTEM WITH SLSC

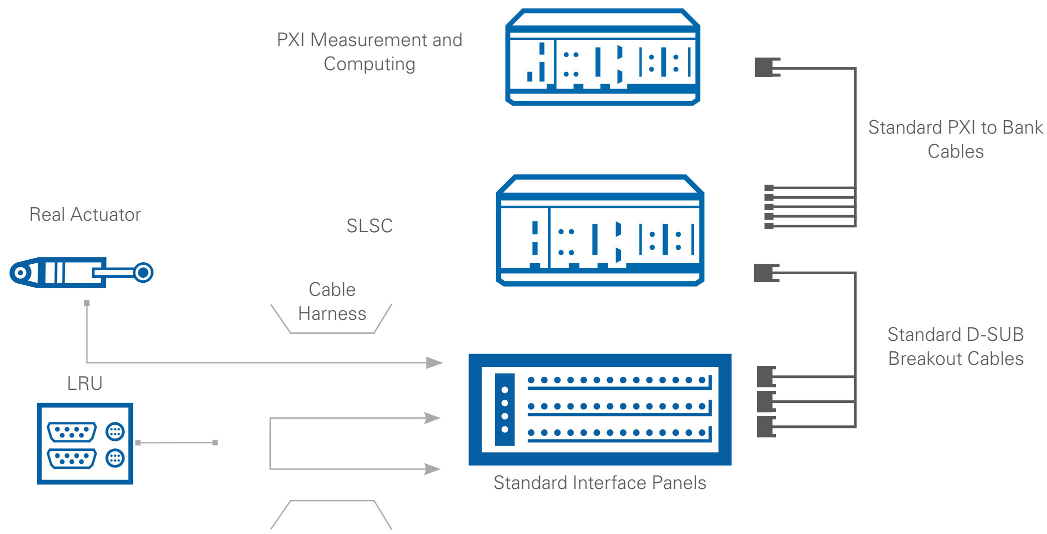

Figure 5. With SLSC and PXI hardware, standardized cabling and interface panels, and common test rack components, NI can deliver a COTS test system that replaces legacy or customized LRU test system components.

With this approach, you can replace custom design with configuration using COTS components. This may not cover all the signals in the system, but it removes the time, cost, and risk associated with building a custom solution for most of them. NI Alliance Partners, such as Bloomy Controls, can provide racks ready for use. They can deliver LRU testers ready for your customization or tailor them to your specifications by preconfiguring a software starting point. Featuring a minimum amount of custom design and nonrecurring engineering (NRE), these ready-to-use test architectures reduce lead time but are still part of NI's open and flexible platform. This means you can modify your system and avoid being locked into a black box solution.

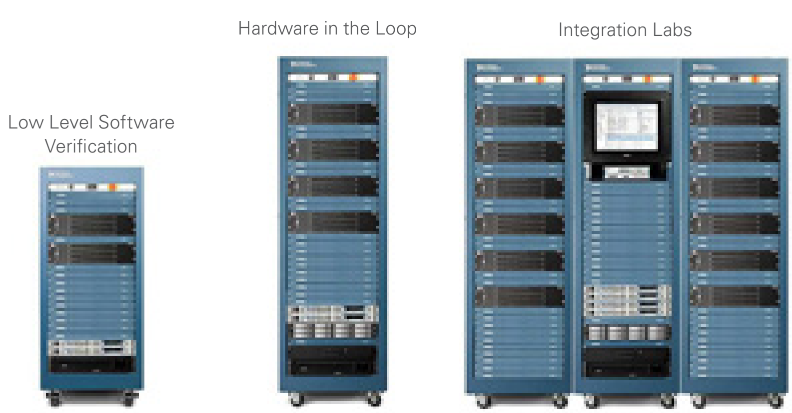

Figure 6. NI HIL Simulators are integrated using COTS rack components, from the programmable power supplies and power infrastructure to the HMIs and the 19 in. rack.

The Benefits of NI HIL Simulators

To invest in LRU test system enhancements, you must

- Ensure all changes occur within one program cycle
- Decrease or maintain NRE costs
- Move point-to-point wiring to test adapters and/or keep it as is
- Minimize all change costs and justify the cost associated with commissioning the system

By replacing custom engineering solutions with COTS components, you can

- Reduce costs by as much as 23 percent, resulting in $600 to $700 per I/O pin with a higher percentage of COTS components
- Move point-to-point wiring to test adapters, resulting in no change
- Decrease the risk of schedule impacts by 48 percent, resulting in a four- to six-month timeline
- Off-load maintenance burdens to a third party

With this approach, you can focus on areas that demand your unique expertise.

Learn More

Learn more about NI solutions for HIL test

See how NI HIL Simulators are ideal for aerospace programs

See how Saab uses NI HIL Simulators for defense test

Explore NI's solutions for aerospace and defense test