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PERFORMING A MULTI-MILLION DOLLAR UPGRADE TO THE CUSTOM TEST SYSTEM FOR THE U.S. NAVY'S MK 41 VERTICAL LAUNCHING SYSTEM

THE CHALLENGE

Upgrading an aging automated custom test system for the U.S. Navy's MK 41 vertical launching system (VLS) that has more than 300 analog channels and providing a full wrap-around test system that covers more than 800 points.

THE SOLUTION

G Systems served as a one-stop-shop for the VLS custom test system development, from analyzing requirements to providing schematics and blueprints to construction of the actual test systems and implementation of all the necessary software.

Figure 1. A Tomahawk missile released from the MK 41 VLS (photo courtesy of U.S. Navy)

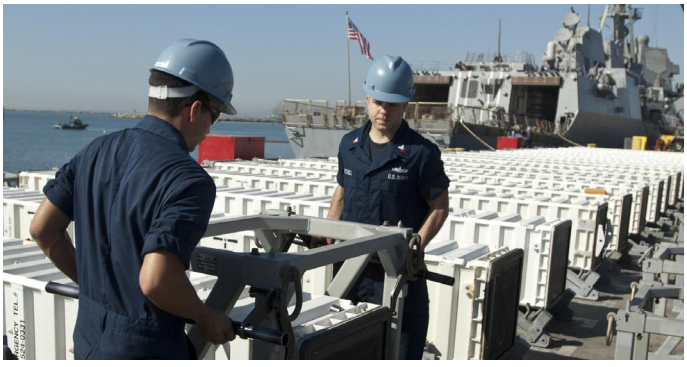

Figure 2. Crew prepares to load missile canister

BACKGROUND AND APPROACH TO DESIGN OF THIS CRUCIAL, CUSTOM SYSTEM

When a defense contractor found that its automated test equipment (ATE) for the U.S. Navy's MK 41 VLS was running slow and had many parts that were quickly becoming obsolete, the company reached out to G Systems to put together the most cost-effective approach to upgrading its aging

infrastructure. The MK 41 VLS is a modular, below deck missile launching system that was originally designed for the Navy's Aegis-equipped guided missile cruisers to provide air threat protection for naval battle groups. The MK 41 VLS is a multi-missile, multi-mission launcher, capable of launching several types of missiles such as the SM-2, SM-3, SM-6, ESSM, Tomahawk, and Vertical Launch ASROC missiles.

Among their design requirements was a need to assess several hundred analog signals with voltages ranging from 40V to -40V and the ability to have a full wrap-around self-test system with 100 percent coverage. To measure these voltages with an NI PXI multifunction I/O module, the voltages needed to be scaled down. Thus, we designed an integrated circuit board to perform the scaling operation and reduce the signals to the ±10 V range, which was suitable for acquisition with the selected PXI module.

To reduce the effects of the resistor tolerances, we developed a self-calibration routine using NI TestStand software and LabVIEW code modules driven by NI-DAQmx and NI digital multimeters (DMMs). The self-calibration routine injects a signal into each PXI channel and then calculates a slope and offset for each analog input (AI) channel, which our LabVIEW program then applies to all subsequent readings of the PXI channels. Using a calibrated digital multimeter as a basis for the calibration operation means that all 300 AI channels can be tested routinely with only the PXI and power supplies requiring independent calibration.

We also used high-performance switch modules for our test system development to produce the wrap-around self-test system with 100 percent coverage. Since the custom test system required testing of more than 800 test points to ensure safe and accurate operation, we combined multiple NI PXI modules spread across several different interface panels.

Figure 3. A loaded canister is lowered into one VLS module

Figure 4. Each VLS module contains eight missile-loaded canisters

Our design can connect the DMM in two-wire and four-wire modes. We used DMM was used assess DC and AC voltages, small and large resistances, and diode operation, so it was essential to have a structure that supported both two- and four-wire connections. Setting up this type of structure was possible because of the flexible topologies offered by the PXI modules. Additionally, the flexible wiring and the convenient terminal block we selected allowed us to use a PXI relay module to provide isolation between the high- and low-voltage systems, as well as to control that polarity of the DMM, which dramatically increased the usefulness of our 800 independent test points.

In a system that is large enough to have 300 analog channels across 250 different relay legs, organization is important. We saved a lot of time using NI TestStand to manage and organize the myriad of tests that needed to be performed during the self-test and self-calibration procedures. By leveraging NI TestStand expressions, we created a system that constantly tracks which components of the self-test system are being used. When an error is found, a message is displayed, which allows the operator to quickly isolate where the error occurred and list all involved components. Since this system is so large, this can save operators an immense amount of time when troubleshooting issues.

Upgrading the VLS custom test system using NI TestStand sequences and associated LabVIEW code modules not only provided the U.S. Navy with a great system, it also saved us an immense amount of time during our test system development process. For example, a completed code module we developed reduced an 80 man-hour post-fabrication ring-out test to just a few minutes. Additionally, we were also able to repurpose our calibration VIs to conduct similar time-saving measures in assessing the quality of the completed scaling boards.

Learn more about G Systems' approach to rugged custom test system development for the harshest environments by downloading this white paper.

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CAGE Code: 3HPP5 **NAICS:** Primary 541330, Secondary 541511 334515 334519 335999