My generation

A look into a variety of innovations being developed to help test engineers cope with the increasing complexity of structural testing

Christoph Leser PhD & Daniel Van Horn

Historically, it has always proven immensely time consuming and labor intensive to set up structural tests with large quantities of sensors. Component and sub-assembly tests with just a handful of actuators can employ dozens of strain gages to acquire stress and strain information. When testing large, full-scale aerospace structures, the numbers quickly multiply. Using tens to hundreds of actuators and thousands of strain gages that are wired throughout a structure is not uncommon, and they can often require several weeks, if not months, just for test set-up.

Over the years, there have been several key factors that drive the trend towards higher channel counts in Data Acquisition (DAC) during the test phase of large-scale aerospace structures.

One factor that is driving the increase in DAC channel counts is the need to gather the right type and amount of test data to correlate with enormous volumes of in-service information gleaned from the increased usage of onboard data recording devices. Designing test programs to more closely match operating environments gives test engineers greater confidence in the results they generate, ultimately benefiting end users with improved designs, more predictable performance and improved safety characteristics.

1. Next-generation software tools enable more efficient set-up and management of the high channel data acquisition systems

Another contributor is the continual pressure to increase aircraft performance, efficiency and versatility. Commercial airlines demand increased passenger loads and lower weights to defray rising fuel costs, while military operators strive for increased utility from multipurpose platforms. The use of new and innovative materials within aerospace structures also plays into this. Responding to these pressures, aircraft designers are demanding more and more data on test specimens to better understand the performance characteristics of materials, components, sub-assemblies, and full-scale structures.

Advances in data processing speeds, network capacities and disk storage space have also served to fuel the inexorable march upward of DAC channel counts. This, in combination with improvements in the ease-of-use and accuracy of DAC hardware, as well as the steady decrease in cost per DAC channel, has increased the pressure on test engineers to gain far greater volumes of more meaningful test information, in less time at lower overall costs.

Challenges of complex data acquisition

The deployment of increasingly higher numbers of sensors and DAC channels has naturally led to dramatic increases in the complexity of test programs. To overcome this, test engineers need more efficient and sophisticated tools for setting up and managing data acquisition for component, sub-assembly, and especially full-scale structural tests. Leveraging years of customer feedback and test engineering experience, MTS engineers are pursuing the development of next-generation test management software to meet these data acquisition challenges. Their efforts have focused on the following initiatives: Tightly integrating test control and DAC systems; facilitating efficient test definition and configuration, establishing tools to eliminate error; developing more meaningful data displays, and building automated data storage and analysis into the test system.

Integrated control and DAC

The ability to seamlessly integrate real-time data from the control system, which applies loads to the test specimen, with data obtained through the many sensors placed throughout the specimen is something every test engineer strives for. But, for most test labs, this is not a reality. Test engineers frequently juggle back and forth between two separate system interfaces, losing not only time and efficiency but also analytical power by having to manually integrate data from the two systems post test. By integrating the two systems through advanced software, test engineers gain a better perspective on what is actually happening with their test and are able to better meet certification standards and verify aircraft design.

When physically routing lead wires and strain gages throughout a test specimen, it is easy for test engineers to become confused as to whether the correct sensor is feeding into the correct input in the DAC system. Test engineers need a way to verify they are reading the proper channel, otherwise data is mixed up and they do not have a reliable way to make changes midstream to ensure the test is on the proper track.

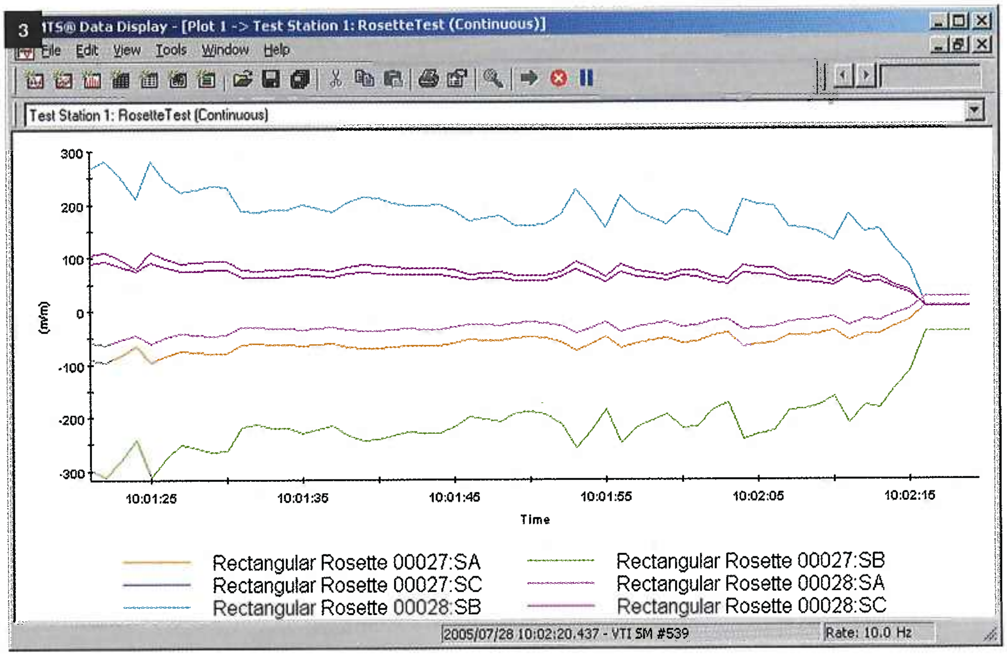
An automated method, such as transducer identification, is one way to solve a potentially costly problem. This allows the software to identify each sensor and apply the correct set-up parameters for all hardware inputs, regardless of how the sensors have been placed on the test specimen and routed back to the DAC system. Identification is made after the routing takes place, ensuring test engineers see the right data from the right channel.

2. Demands for higher performance and advances in data processing speeds have all increased the complexity of structural testing

Test engineers also need the ability to track historical settings for their test programs. Setting up large tests requires several months of effort. Different portions of the test may be prepared at different locations or at different points in time. To facilitate this activity requires the ability to manage sensor offsets, including the ability to archive and retrieve offsets quickly for some or all inputs in a test. The ability to load, save and compare calibration information from a number of calibrations is imperative.

Tools for eliminating error

Within any test program, there are numerous opportunities for the introduction of error. Some of these, of course, are the result of user error. Others, however, occur through no fault of the test engineer, factors such as the physical characteristics of strain gages or lead wires can contribute to the collection of inaccurate data. Being able to automatically compensate for these errors through the use



of advanced software applications is critical.

Developing, inputting, and editing equations is a large part of any test program, which can potentially open the door for inadvertent user error. Test engineers need the ability to easily keep track of often-used values, such as materials properties, to ensure a level of consistency and accuracy with their data. Some software applications provide central locations where all of the engineering units are stored, making it easy to keep track of values and increase the confidence of test data.

As with any sensor, strain gage readings are affected by fluctuations in temperature and material deformation. To get the most accurate reading from sensors, test engineers need to know what is happening with the sensor itself, as well as the conditions and environment around the sensor. Software applications can automatically account for these items, helping the test engineer to correct things such as lead wire resistance, high strain non-linearity, and temperature and transverse sensitivity, to name but a few.

Other tools, such as custom templates or links to external programs, allow test engineers to integrate custom equations to see their data in a different perspective. Without adequate test management software, an engineer would have to perform such calculations after the test. These kinds of tools give users a consistent, easy-to-use method to apply corrections to measured values and derive additional engineering quantities.

Meaningful data display

In the past, test engineers were hampered by the limitations of their test system display, not able to make informed decisions based on data streaming into the DAC system from the test specimen. Test engineers would analyze data post test, and only then realize they needed to retest the specimen because adequate compensations were not made in time.

Test engineers are now able to employ software that allows them to make crucial decisions on the fly, turning data into reliable information. Test data can be displayed continuously throughout the test at any location, giving engineers in the control lab the ability to solicit outside perspectives from colleagues at remote locations around the world.

3. Real-time data displays allow test engineers to make crucial decisions, and share data simultaneously with colleagues around the world

4. Structural testing has become more complex with real operating environments

Automated data storage and analysis

Storage and analysis of data is an essential element of any structural test. Stored data allows test engineers to satisfy regulatory requirements, as well as make it easier to perform post test analysis. With archived data, test engineers have the freedom to perform a wide array of analytical procedures they may not have conceived of before running the test. It is desirable that much of the storage and analysis is automated within the test system, as it gives test engineers a level of confidence in their results they may not have otherwise.

Whether testing individual aircraft components, subassemblies or full structures it is critical for test engineers to easily define sensors, configure tests, and display all relevant stress and strain information in real time for storage and subsequent analysis. Due to the increasingly large number of channels involved in these types of testing, the capabilities to automate test set up, quickly determine where problems might exist, and efficiently sort through enormous quantities of data loom more important than ever to the success of all aerospace test programs. ∎

Christoph Leser PhD is an aerospace application engineer with MTS Systems Corporation, while Daniel Van Horn is a senior software engineer for the same organization.