



WHITE PAPER

When Data is the Mission: Dynerics Relies on DAQ System to Get Structural Test Data Right

Dynetics provides engineering, scientific, and IT solutions to the national security, cybersecurity, critical information, and space sectors. The solutions include services as well as software and hardware ranging from components to complex end-to-end systems. In 2019, to serve government and commercial space projects, the company opened its Aerospace Structures Complex in Decatur, Alabama, about 30 miles from its Huntsville, Alabama, headquarters.¹

The complex includes a 43,000 square-foot integration facility, which allows for the assembly and test of large aerospace structures. To provide structural qualification testing, the complex includes a test stand that is 60 feet long, 60 feet wide, and 100 feet high and has a hoist capability of 35 tons. An adjacent 4,000 square-foot test control center allows Dynetics engineers and customers to view live tests and analyze test data onsite.

Ben Beeker, a test engineer with a background in mechanical engineering with expertise in fluid, hydraulic, and compressible systems, said Dynetics engages in a wide array of programs, ranging from radar systems to satellites. The company also has expertise in propulsion, developing everything from engine components to full systems. On the test side, Dynetics performs various tests for various aerospace applications, including airframes, fluid systems, and heat exchangers.

At the new test stand in Decatur, Beeker's work centers on structural testing or tests of flight vehicles of various types, measuring how a structure reacts to applied loads. The test stand's concrete foundation has pilings that go down to the bedrock. It is equipped with a hydraulic system that is capable of controlling over a hundred actuators. The test stand also includes a data system with thousands of measurement channels from Hottinger Brüel & Kjær (HBK), as well as a dedicated control system that provides closed-loop control while ensuring safety from the previously-used data system. According to Beeker, some companies offer integrated data and control systems but rarely excel at both, "The choice is a control company that offered data as a side gig or vice versa." The optimal choice for Dynetics was the control system from another supplier and data system from HBK.

"With HBK, what really rang with us was that they weren't focused on control, but they had a control solution. They had worked with other suppliers previously and had all the infrastructure to make the connection [between the other supplier system and the data system from HBK] possible. It was already in existence." Beeker paraphrased HBK's pitch as being, "We're going to be your best at providing data, and we can integrate with your choice of the best at providing controls." Yet another advantage for HBK was that it could supply a large variety of electrical foil strain gauges and other sensors in the quantities that Dynetics needed and could also provide assistance on strain-gauge

installation.² Finally, HBK provided comprehensive training and continues to provide support.

The number of personnel needed to staff the test facility varies, Beeker said, ranging from a core group of half a dozen engineers and technicians to about 20 during buildup activities to accommodate a new structure under test, when subcontractors handle welding, cutting, and moving some of the test stand's large reaction structures. The core team includes Beeker himself, who serves as the test conductor, and his colleague Charles Heyligen, who serves as the data-system lead. A third engineer handles the hydraulic side of the control system, and a fourth handles pressure, water, and temperature systems.

Data acquisition system details

Heyligen, a test engineer with a background in mechanical engineering, instrumentation, and data systems, provided additional details on the data acquisition system. The system acquires data from more than 3,000 strain gauges and more than 300 full-bridge pressure transducers on the structure under test plus additional sensors, including string potentiometers, associated with the external equipment and a dedicated control system. Dynetics also makes available 10 workstations in the control center for customers, enabling them to observe tests and analyze results. Heyligen said the company has also implemented a VPN, enabling customers to monitor tests remotely – a particularly useful capability during the Covid-19 pandemic and associated lockdowns.

To acquire the data from all those channels, the Dynetics team selected the HBK MGCplus data-acquisition system, a versatile system that can acquire not only strain data but also force, displacement, torque, and temperature data as well as voltage and current. The MGCplus can include single- and multiple-channel amplifiers for almost all physical quantities and can scale up to 20,000 channels.

Heyligen described the MGCplus as one of the best compact data acquisition systems on the market. A particular advantage, he said, is that it works with HBK's CANHEAD system, which allows distributed amplifiers to be located close to the strain gauges or other sensors, offering significant savings in wiring and installation costs. A single cable for power and data further reduces cost and installation complexity. One MGCplus plug-in card accommodates up to 12 CANHEAD modules, and each CANHEAD module supports 10 channels. The MGCplus and CANHEAD combination can acquire up to 20,000 channels synchronously.



“With some competitive systems, you have to connect the strain gauge directly into the data system,” Heyligen said. “CANHEAD is a much cleaner system. Ideally, but depending on customer requirements, you can locate the CANHEAD very close to the strain gauge.” He also cited the HBK system’s modularity. “You can have one chassis to do one small test,” and concludes, “The system is really reliable. Once it’s set up right it’s very solid.”

DAQ software simplified

The team employed HBK’s catman Enterprise DAQ software to handle the large channel count. The catman Enterprise software complements the MGCplus with support for up to 20,000 measurement channels, making it particularly suitable for aerospace applications. The software offers several features to support high-channel count applications, including logical grouping of channels (for example, assigning sensors from an aircraft’s left wing into one group), offline channel parameterization, one-click function test for all strain-gauge channels, enhanced customization functionality through scripting, and an open server-client architecture that supports easy linking to third-party control systems, camera systems, and other hardware. catman Enterprise supports data export for analysis with HBK’s nCode Glyphworks or a customer’s own software.

“What I like about the software is that it’s simple. It’s based on a Microsoft® Access database, which I can tweak easily,” Heyligen said. “Some companies have software with a lot of GUIs and things like that. It looks fancy, but it can get in the way of getting the data out, which is what we want to do because the data is the end-product for our customers. So far, I have never had any loss of data, which is my big fear. If I lose data, it’s a bad day for me.” With the HBK system, he continued, “I am confident that I can look at what is going on in real time and be sure I will get the data at the end of the day.”

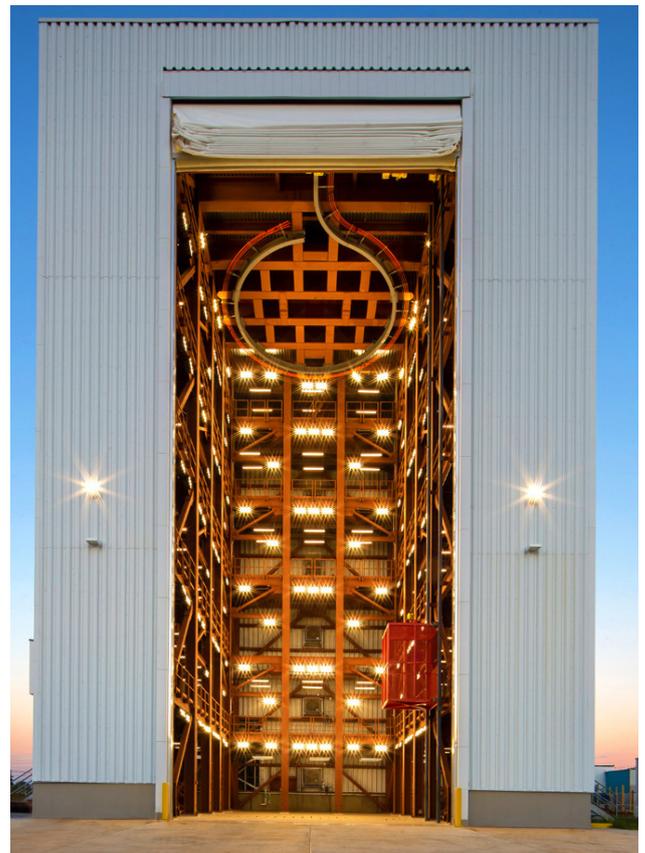
Beeker commented that the Dynetics team has been successful in getting its new customers up to speed on the software. “I think that speaks to its usability – we don’t have to spend a week training our customers to acquire data and get plots. Some of the finer details will come with time, but you can get somebody up to speed pretty quickly. It’s fairly intuitive software.”

Heyligen added, “We also get good customer support from HBK. I know that I can call the HBK engineers in Germany, and I will get a response quickly. They can remotely access our computer if necessary. And we get regular software updates, which our customers appreciate because they get more plot options and other features. Customer support is ongoing, which we appreciate.”

Dynetics structural test projects and more

Projects at the complex include a structural test of the United Launch Alliance Vulcan Centaur booster to evaluate the vehicle’s ability to handle the extreme forces it will experience during flight. In addition, Dynetics is the prime contractor for NASA’s Universal Stage Adapter (USA). The USA will fly on NASA’s evolvable Space Launch System rocket during future Artemis missions and will integrate the Exploration Upper Stage (EUS) with the Orion spacecraft, providing structural, electrical, and communications paths. The Dynetics complex is located on the Tennessee River, so large structures such as the USA can be delivered by barge to NASA’s Kennedy Space Center in Cape Canaveral, Florida.

Beeker elaborated on the USA, noting that it will be manufactured in the integration facility next door to the test control center and test stand in Decatur. “The integration facility has its own test cell that is linked to our test control center, so we have the option of running tests in the integration facility’s test cell from our test control center. We will do various tests on the hardware, some of which will happen in the integration facility, and some of the acceptance load testing will happen in our test stand.”



When asked about specific tests conducted by the team, Beeker said, "We've done just about every test you can imagine." That includes direct-field acoustic testing (DFAT), which subjects aerospace structures to sound waves created by an array of acoustic drivers; model testing, essentially a calibrated hammer-tap test; and structural testing via hydraulic loading. "Our facility is capable of reacting to 6 million pounds of equivalent load at the ground floor and 4 million pounds at the ceiling structure," he said. "We can have all our hydraulic loads acting simultaneously."

Beeker added, "We also have gravity on our side. It might sound trivial at first, but when we fill our tanks with water, we can get a million-plus pounds of load just due to the water weight. And then we also have a pressure-control system that actively controls the pressure in the ullages of the tanks. So, in a given structural test, we're controlling pressure, temperature, localized temperature, and hydraulic externally applied loads."

Beeker cited a unique feature of the Dynetics facility. "A lot of places have performed high-instrumentation-count, high-actuator-count structural tests," he said. "That's not uncommon. What's special here is that we can perform a fully integrated booster qualification test. We're qualifying multiple pieces of hardware at once, which is great, but at the same time, it adds a level of complexity that's not seen in most places."

He added, "We have interfaces with six-plus actuators connected to them, so for just one interface, we are controlling all those actuators at the same time to get a very specific load vector. That is different from just having a large quantity of actuators all acting in the same direction. I think that's pretty special here."

References

1. Moseley, Brandon, [Dynetics opens rocket-testing facility in Decatur](#), *Alabama Political Reporter*, October 17, 2019.
2. [Video Tutorial: Installation of Strain Gauges](#), HBK.

