NASA's ATLAS thermal testing: You're hot, then you're cold

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The door of a thermal vacuum chamber at NASA's Goddard Space Flight Center in Greenbelt, Maryland, closed behind the ATLAS box structure (an instrument for the ICESat-2 mission) on Feb. 5, 2015, after final checks from the thermal, electrical, fiber-optics, mechanical, contamination, instrument and quality assurance teams, among others. Credit: NASA Goddard/Kate Ramsayer

Once in orbit, the Ice, Cloud and land Elevation Satellite-2 will go from basking in the heat of the sun to freezing in Earth's shadow every 90 minutes. And every second in that orbit, it will need to take thousands of precise measurements of the height of the surface below.

So before launching the satellite into the harsh environment of space, engineers at NASA's Goddard Space Flight Center in Greenbelt, Maryland want to make sure that the laser instrument onboard works consistently day and night, whatever the temperature.

Last month, the team worked around the clock to test part of ICESat-2's instrument in a temperature-controlled vacuum chamber at Goddard, ensuring that its interconnected components worked together and functioned as expected.

When we do these tests, we want to confirm that in the worst-case conditions on orbit, both hot and cold, with no air, you can still expect the performance that you want from the instrument," said Melody Djam, system engineer at Goddard. "It's an extreme test."

The instrument aboard ICESat-2 is called the Advanced Topographic Laser Altimeter System, or ATLAS. Laser altimeters like ATLAS measure the distance between the instrument and the ground by timing how long it takes the light to travel to Earth, bounce off the surface, and return to the instrument. Using this distance, the satellite's location in space, and the speed of light, the ICESat-2 mission will be able to precisely determine the height of Earth's surface below.

While ATLAS has three main functions - send light to the ground, make sure things are aligned to catch the photons that return, and then record those photon returns - it is a complicated system of more than 20 different components, each with multiple subcomponents.

The engineering team will comprehensively test the entire instrument when it's assembled in 2016. But to save time and catch potential glitches before that, in February 2015 they tested the instrument's avionics - the electronics, detectors and photon counting electronics that make up the light-receiving part of the instrument.

"Because our integration and testing process is so long and involved, and because there are so many electronic interfaces, we really wanted to get most of those electronics together in the thermal vacuum tests to see how they all behaved," said Cathy Richardson, ATLAS instrument project manager at Goddard. "Problems that we might find now, we wouldn't have otherwise found for another year. It's a significant risk mitigator for us."

The vacuum chamber - a cylindrical blue vault surrounded by a mess of wires, pumps and controls - is one of several in Goddard's integration and testing building complex. Crews lowered the ATLAS box structure, with electronics attached, into the chamber; after ensuring that everything was in working order they closed the heavy, pipe-backed, circular door.

For the test, engineers calculated how hot the instrument will get on orbit either in full sun or in Earth's shadow - then went 5 degrees Celsius beyond that to cover all bases in a 'survival' test. With liquid nitrogen and heaters, the thermal vacuum then cycled four times between 55C and

-25C.

At each of those maximum or minimum temperatures, test engineers sent laser signals through a specially designed fiber optic cable that simulates laser light bouncing off Earth and returning to the spacecraft. The science team had designed different scenarios that reflect light in different ways - a glacier in summer, for example, results in different photon returns than a forest in fall or an ocean under cloudy skies. And the instrument also has to tell the difference between laser photons that it needs to count, and the static of background photons from natural sunlight. Plus, it has to do this under the different temperatures that could cause materials to expand or contract.

Specifically designed ground support equipment, or test, fiber optics and lasers simulated all these scenarios, testing not only how the ATLAS detectors and electronics perform, but how the computer programs that will receive the data on Earth interpreted those returns.

"We really needed to see how everything plays off each other," Richardson said. "What you care about is the flight hardware working together."

And the avionics system performed well, she said, returning data that correlated with what the scientists expected to see. The computer systems that collect data from the instrument were slow at some points, which is something that the team will improve in the coming months, before the entire instrument is tested, and well before the complete ICESat-2 satellite flies in late 2017.

"We're looking three years ahead, and seeing how we are going to operate this instrument on orbit," Djam said. "We're checking it out in here, to understand the behavior of the systems."

More information: icesat.gsfc.nasa.gov/icesat2/

Provided by NASA's Goddard Space Flight Center