Near-infrared laser systems for monitoring forest dynamics from space pass final tests

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All systems are go for launch in November of NASA's Global Ecosystem Dynamics Investigation (GEDI) mission, which will use high-resolution laser ranging to study Earth's forests and topography from the International Space Station (ISS).

The scientific mission seeks to answer questions about how much deforestation has contributed to atmospheric carbon dioxide concentrations and how much carbon forests would absorb in the future. It is led by a research group at the University of Maryland, which is working in collaboration with a team at the National Aeronautics and Space Administration that is designing the laser for GEDI.

During The Optical Society's Frontiers in Optics + Laser Science APS/DLS conference being held 16-20 Sept., 2018, in Washington, D.C., NASA Goddard Space Flight Center laser engineer Paul Stysley and colleagues Barry Coyle, Erich Frese and Furqan Chiragh will present their work designing and building the laser systems for the GEDI mission. They will describe the extensive testing that the systems were required to pass for both transport and subsequent operation in low-Earth orbit.

The presentation will be part of the "Novel Devices Manufacturing and Testing" session, to be held at 10:30 a.m. on Monday, 17 September in the Jefferson West ballroom of the Washington Hilton hotel.

"We wanted to design a laser that could enable LIDAR-based remote sensing for Earth science and planetary exploration missions," said Stysley.

The team designed a laser system that "is comparatively simple, has appropriate margin on performance specifications, and is well understood," he added. "This, in turn, allows it to be efficient and adaptable to different missions, as well as robust in a space flight environment."

Using light detection and ranging (LIDAR) technology, researchers shoot laser energy pulses at the Earth's surface and precisely record their return timing. This data produces a 3-D image in the form of vertical observation or a full-waveform that shows the world's forest canopy and the topography of the ground beneath it.

This is possible because the transmitted laser light pulses are reflected by the ground, trees, vegetation or clouds, and then collected by GEDI's receiver. The returning photons are directed toward detectors, which convert the brightness of the light to an electronic voltage that's recorded as a function of time in 1-nanosecond intervals. Time can be converted to range (distance) by multiplying it by the speed of light, and then the full waveform can be calculated by the recorded voltage as a function of range.

The laser system allows full-waveform data to be collected, which will provide the ground elevation and vegetation canopy height measurements on a global level. "The canopy and 3-D waveform data products are based on ones that have already been provided by NASA's Land, Vegetation, and Ice Sensor facility on airborne LIDAR missions," Stysley said. "The GEDI lasers were internally designed, fabricated, assembled and tested by the Laser and Elecro-optics branch at NASA-Goddard."

"Our design is easily adaptable for follow-on vegetation LIDAR missions or for planetary missions that need an efficient laser altimeter," Stysley said.

When designing the laser system, Stysley said the NASA group had to ensure it would be able to survive the extreme heat and vibrations of being blasted into space on a rocket, as well as endure the harsh environment of space once installed on the Japanese Experiment Module-Exposed Facility outside the ISS.

The group put the lasers through thermal vacuum testing for near-space flight simulation to ensure that the lasers can function and survive in space, as well as vibrational qualification testing of the lasers' final assembly.

Stysley and his colleagues were somewhat surprised by how much you can learn about a laser as it undergoes space-flight environmental testing.

"No matter how well you know a laser design, it's important to appropriately test it at the environmental requirements levied on you by a mission and to have enough performance margin on your design to be able to compensate for any minor 'surprises' that come up during testing," said Stysley. "Subtle changes in things like temperature profile can expose new things about how your laser behaves in relatively unusual situations and, often, resources—money, time, and technical relief—will be needed to meet requirements."

The GEDI mission, scheduled to launch in November, will operate on ISS for up to two years.

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