NASA's New Laser Risk Reduction Program

For Future Space Lidar Missions

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The Opportunity

NASA has been performing ground, airborne, and space-based scientific measurements since it was formed in 1958. Initial ground and airborne measurements were made with in situ instruments. By necessity, initial earth observation space-based missions were accomplished with passive remote sensing. Active microwave radar was added to the sensor repertoire in the late 1970s. A few key measurements important to NASA remain unaccomplished, however, despite the passive and radar successes. These critical measurements include space-based altimetry; and high spatial resolution profiling of aerosol properties, wind velocity, clouds, and molecular concentrations. Fortunately, a new technology, active optical radar or laser radar or lidar, has matured to the point that the last decade has seen a growing consideration of lidar for space missions. Part of the surge in consideration of lidar has been the tremendous progress in solid-state lasers fueled by advances in crystal growth quality and pump laser diode technology.

The combination of earth orbit and lidar remote sensing offers the advantages of:

- Global coverage
- No inaccessible regions
- Low operational cost
- Excellent vertical and horizontal resolution
- Relative (to passive) independence from natural light sources
- Choice of optimum optical wavelength, pulse shape and duration, and polarization
- Ability to scan the scene if desired

The Problem

However, getting lidar systems into space has not been a smooth road. Approximately half of NASA's space lidar missions have encountered some sort of difficulty. Some missions have been cancelled due to cost growth. The Lidar In-space Technology Experiment (LITE) on the space shuttle was highly successful, but had laser pulse energy degradation in both of its lasers; a worrisome result for long lifetime missions. Other missions have carried on despite the lack of replacement parts due to lack of vendors; causing higher than desired risk. The difficulty and cost of space qualifying lasers and other lidar components has often been greater than estimated.

These problems prompted NASA's Earth Science Enterprise to convene an independent review panel. The panel's report provided many recommendations to NASA including:

- Consider identification and intensive development of critical fundamental technology elements that could be used, either directly or with slight modification, for multiple missions
- Rigorously test engineering flight models in their final configuration
- Require increased use of performance modeling
- Require evidence that a science-technology tradeoff has been considered
- Maintain internal laser expertise within the research centers
- Address the diode laser issue
- Insist on an advanced technology readiness level before final approval of missions
- NASA, USAF, NOAA, NSF, and DOE should form a technology alliance for the development of active sensors and related enabling technologies such as lasers

The Solution

In response to the Independent Laser Review Panel, NASA began the Laser Risk Reduction Program (LRRP) in FY02. This joint LaRC-GSFC program is addressing space-qualified laser issues such as:

- 1-micron solid-state pulsed laser for altimetry
- 2-micron solid-state pulsed laser for tropospheric wind profiling
- Pump laser diodes for both laser types
- Wavelength conversion technologies to translate 1 and 2-micron photons to both lower and higher wavelengths for DIfferential Absorption Lidar (DIAL) measurement of molecular concentration profiles, and for wind velocity profiling.
- Space hardening engineering investigations for all the above technology including radiation, contamination, optical damage, lifetime, and packaging

An overview of this program, its accomplishments to date, and future plans will be discussed.