NASA'S LASER RISK REDUCTION PROGRAM: A RISK REDUCTION APPROACH FOR TECHNOLOGY DEVELOPMENT

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ABSTRACT

The benefits of laser-based instrumentation for remote sensing of Earth have been established for many years. Lidar techniques enable measurement of atmospheric constituents, wind profiles, cloud cover, ice mass, and vegetation canopy. Also, laser-based instruments have been used to obtain high-accuracy altimetry data needed for topographic mapping of Mars and Earth and, for some missions, to perform ancillary functions such as ranging and point-to-point communications. For certain measurements, orbiting platforms provide an ideal vantage point for laser-based instrumentation because they enable scientists to conduct measurement campaigns at a global scale. A review of the National Research Council's "*Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond*" report shows that almost half of the measurements identified by the Academy will be performed using laser-based instrument systems.

Although laser instrumentation is routinely used in industrial; medical; telecommunications; military; and research applications here on Earth, deployment of lasers in space still presents significant challenges. By necessity, space-borne instruments must be small, lightweight, and as energy efficient as possible. To make matters worse, instruments operating in orbit must survive the mechanical shock and

vibration of launch; orbit insertion; and deployment, and are susceptible to degradation caused by factors such as orbital thermal cycles; spacecraft contamination; the vacuum of space; and ionizing radiation. Laser instruments are basically optical devices that transmit and receive energy trough lenses, fibers, filters, and other electro-optical components arranged in complex mechanical configurations that require, and must maintain, high-precision alignment to work properly. Also, laser instruments operating at orbital altitudes must transmit higher levels of power and require larger telescopes to overcome signal-to-noise limitations. Emerging measurement concepts require development of new space-qualified laser technologies (such as laser-beam emitters and amplifiers, detectors, frequency conversion systems, fiber systems, and supporting materials and coatings used in optical systems) to design and develop the next-generation of advanced laser instruments. These developmental challenges are compounded by the fact that many commercially available laser components that are precursors to high reliability space-qualified devices are designed and manufactured for environments or applications where concern for lifetime or reliability considerations is minimal. Clearly, an effective approach to mitigation or retirement of these risk elements would require a systematic study of current and future laser-capability needs and a well-focused development program.

In response to NASA mission failures caused by laser-system problems, an external Earth Science Independent Laser Review Panel was convened to investigate the situation and provide recommendations. Their key recommendation was that NASA should identify the root causes of failures in space-based laser systems space and develop laser architectures to support the requirements of future missions. Such an initiative would target and directly fund critical laser/LIDAR architecture and component developments. To address the recommendation, NASA implemented LRRP with the goals of a) identifying and addressing capability-gap areas where new technologies or manufacturing processes could yield high-reliability mission-ready components to retire or minimize technical risks, and b) to develop new components needed to advance the state-of-the art of laser-based instrumentation. LRRP was implemented in 2002 by NASA Headquarters as a collaboration between the Goddard Space Flight Center (GSFC) in Greenbelt, Maryland and Langley Research Center (LaRC) in Hampton, Virginia. These NASA centers were chosen for their expertise and unique capabilities in the areas of 1µ- (at GSFC) and 2µ-wavelength (at LaRC) laser development [1].

This paper is the first part of a three-paper presentation (Program goals and organization; 1µ developments and results at GSFC; and 2µ developments and results at LaRC) that outline LRRP’s program's goals, approach, management organization, and final results. Beginning with studies that identified critical technology-gap areas and the formulation of technology roadmaps that guided the group's activities, we will discuss the evolution of the program's technology developments from their inception to their planned infusion into NASA's missions [2].

REFERENCES

[1] Anne-Marie Novo-Gradac, William Heaps, Upendra Singh, "Overview of NASA's Laser Risk Reduction Program," IEEE 0-7803-8742-2, pp 676 -682, 2004

[2] William Heaps, "The Goddard Portion of the Laser Risk Reduction Program: Final Report," LRRP Final Report Submitted to NASA's Earth Science Technology Office in 2007.