

Photon-counting lidars for contiguous high resolution topographic mapping of planets and moons

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Planetary scientists have long expressed interest in obtaining globally contiguous, high resolution (few meter horizontal, decimeter vertical) 3D topographic maps of planets and moons. For example, the goal of NASA's LIST mission, scheduled for launch in the 2016-2020 time frame, is a globally contiguous, 5 meter resolution, topographic map of the Earth. Unfortunately, achieving such a capability through a simple scaling of the laser power and/or telescope aperture from prior art NASA laser altimeters (e.g. MOLA, GLAS, and MLA) is not practical. This is especially true of laser altimeters destined for orbit about distant planets or moons where instrument mass and prime power usage is severely constrained. Photon counting receivers permit each range measurement to be made with a single received photon, even in daylight, and the surface sampling rate of an orbiting altimeter can be increased by three to four orders of magnitude by emitting the available laser photons in a high frequency train of low energy pulses instead of a low frequency train of high energy pulses typical of past spaceborne lidars.

The feasibility of the photon-counting approach in the presence of a strong solar background was first successfully demonstrated from a high altitude aircraft under NASA's Instrument Incubator Program in 2001. Sigma Space Corporation has subsequently developed a second generation of scanning 3D imaging and polarimetric lidars for use in small aircraft and Unmanned Aerial Vehicles (UAV's). Future space applications include: (1) decimeter vertical resolution topographic mapping of extraterrestrial terrain from orbiters, balloons, or other aerial vehicles for determining safe landing sites; (2) monitoring the terrain in real time and increasingly higher resolution during spacecraft descent; or (3) for truly contiguous few meter resolution imaging of planetary terrain

on a global scale from orbit. Targets of particular interest to NASA are the Earth, Moon, Mars, the Jovian moon Europa, and the Saturnian moons, Titan and Enceladus.

A recently completed study for NASA's Jupiter Icy Moons Orbiter (JIMO) mission concluded that the three primary Jovian moons (Ganymede, Callisto, and Europa) could be contiguously and globally mapped, at few meter horizontal resolutions, by a photon-counting lidar in a matter of months from orbital altitudes of 100 km. Work is also underway to include a technical demonstration of a photon-counting lidar ("Swath Mapper") on NASA's ICESat-II mission, which is scheduled for a 2011 launch into a 600 km orbit. Swath Mapper would use a single low energy, high repetition rate laser (nominally 1 mJ@ 10 kHz = 10W) to measure surface topography along 16 uniformly spaced ground tracks spread over roughly 2.1 km.