26D5 GEOSCIENCE LASER ALTIMETER SYSTEM (GLAS)

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Abstract: A space-based laser altimeter and lidar is being developed to profile the height of the Earth's ice sheets with 20 cm accuracy and measure global lidar profiles from space. It is scheduled to launch into a 705 km circular polar orbit in 2002 and is being designed for a 5 year lifetime.

Mission Summary: The Geoscience Laser Altimeter System (GLAS) is a space-based lidar being developed to monitor changes in the mass balance of the Earth's polar ice sheets. GLAS is part of NASA's Earth Observing System [1], and is being designed to launch into a 705 km circular polar orbit in the year 2002. The orbit's 94 degree inclination has been selected to allow good coverage and profile patterns over the ice sheets of Greenland and Antarctica as well as data comparison with other EOS instruments.

The present GLAS mission uses a small dedicated spacecraft, which has a design optimized as a very stable nadir pointing platform. The spacecraft, shown in Figure 1, derives ~ 10 cm accuracy orbit height from an on-board GPS receiver. The GLAS instrument design goal is to operate continuously for 5 years with ~ 85% probability. With a similar goal for the spaceacraft, the reliability goal for the successful 5 year mission is 70%.

Altimeter Measurements: Laser altimeters are very well suited to make precise height measurements from aircraft and spacecraft [2,3]. The GLAS instrument combines a 10 cm precision laser altimeter with a dual wavelength cloud and aerosol lidar. The 1064 nm altimetry channel will measure the range to ice and snow surfaces, where slopes are < 3 deg., with 10 cm resolution and 20 cm accuracy on every laser shot. Over the 15 year life of the EOS altimetry mission, repeated laser altimeter measurements over the polar regions should permit measurements of changes in the polar ice sheet volume on time scales longer than 1 month.

When over land, GLAS will profile the height of the Earth's land topography. This will allow the Earth's topography profiled to be referenced, for the first time, to a common global grid. Analysis of the GLAS echo waveforms will also allow remote measurements of the roughness or slopes of terrain and the heights of tree or other vegetation illuminated by the laser beam.

Lidar Measurements: GLAS also incorporates a dual wavelength atmospheric lidar which shares the transmitter, receiver telescope and the 1064 nm detector with the altimeter. The 1064 nm lidar receiver will be used to profile the heights of clouds and dense aerosols with 75 m vertical and 175 m horizontal resolution. The 532 nm lidar receiver will use a photon counting detector to measure the vertical distribution of optically thin aerosols. It will accumulate 40 consecutive measurements, producing an average lidar profile at a 1 Hz rate with 75 m vertical and 7 km along-track resolution.

Instrument Design: The GLAS instrument utilizes a frequency doubled ND:YAG laser transmitter [4], which is pulsed continuously at a 40 Hz rate. The present instrument layout is shown in Figure 2. The 100 urad laser beam divergence produces laser footprints which are 70 m diameter and separated along-track by 175 m. GLAS incorporates 4 identical laser transmitters, with each transmitter co-aligned with the nadir viewing receiver telescope. One laser is used at any one time, and three are available as spares. The ND:YAG lasers are Q-switched, diode-pumped, conductively cooled and emit 5 nsec wide pulses in a TEMoo beam. The transmitted pulse energy is ~ 100 mJ at 1064 nm and 50 mJ at 532 nm. The present breadboard laser design uses a low energy Q-switched oscillator, followed by two double-pass zig-zag slab amplifiers.

Laser Pointing Angles: Pointing the laser beam away from nadir biases the altimetry measurements, and accurate knowledge of the laser beam's pointing angle is critical [5]. Over sloped terrain, knowledge to ~ 10 urad is required to achieve 10 cm height accuracy. The GLAS design incoporates a stellar reference system to reference the laser beam pointing angle to the star field. The present design for the stellar reference system uses 2 star cameras which view the star field at local zenith.

A small fraction of the laser beam is folded into each star camera's field-of-view with two cube corner assemblies. Each cube corner has a nearly transparent face. The outgoing laser beam passes through one cube at this face, and the star camera views the stars through the other cubes transparent face. The first cube to folds the laser beam angle into the second cube, and the laser signal appear as a fixed spot in a moving star field. Referencing the laser image relative to the star images permits the laser's firing angle to tbe determined relative to the star field.

Receiver Design: The laser backscatter from terrain, cloud and aerosols is collected by the receiver telescope. The present telescope is an all Beryllium Cassegrain design, with a diameter of 90 cm and a field-of-view of ~ 200 urad. The 1064 nm detector is a silicon avalanche photodiode with ~ 100 MHz bandwidth, and the 532 nm detector is a photomultiplier capable of > 200 MHz photon counting rates.

The laser beam's terrain echo is spread in time due to the finite slope and roughness of the terrain surface [5]. To accomodate these effects in altimetry measurements, the range to the surface is measured in two parts [2,3]. A coarse timing unit, consisting of threshold detectors and a 3 GHz time interval unit, is used to measure the time from the laser's firing to the echo's leading edge. As in the MOLA receiver [7,8], the received signal first passes through adjustable threshold and range gate circuits [9]. The receiver algorithms minimize the receiver's detection threshold while maintaining a fixed false alarm rate under changing optical background conditions [10].

To improve the terrain timing estimates, a 3 Gsample/sec digitizer samples and records each echo waveform. Fine timing algorithms [6] are used to calculate the mean arrival time correction to the leading edge measurements for every shot. The echo's pulse width and pulse energy are also measured.

The lidar electronics utilize a 2 Msample/sec analog to digital converter, which operates over the lowest 30 km in range. The lidar reflections at 1064 nm are reported for every laser firing. At 532 nm, the sum of 40 profiles measured by the photon counting detector are reported once per second.

The measurement capabilities of the altimeter and lidar have been estimated by using analysis and simulations. Both the altimeter and lidar have > 3 dB performance margins. The details of the mission, instrument requirements, design and results of analysis and simulations will be presented.

References:

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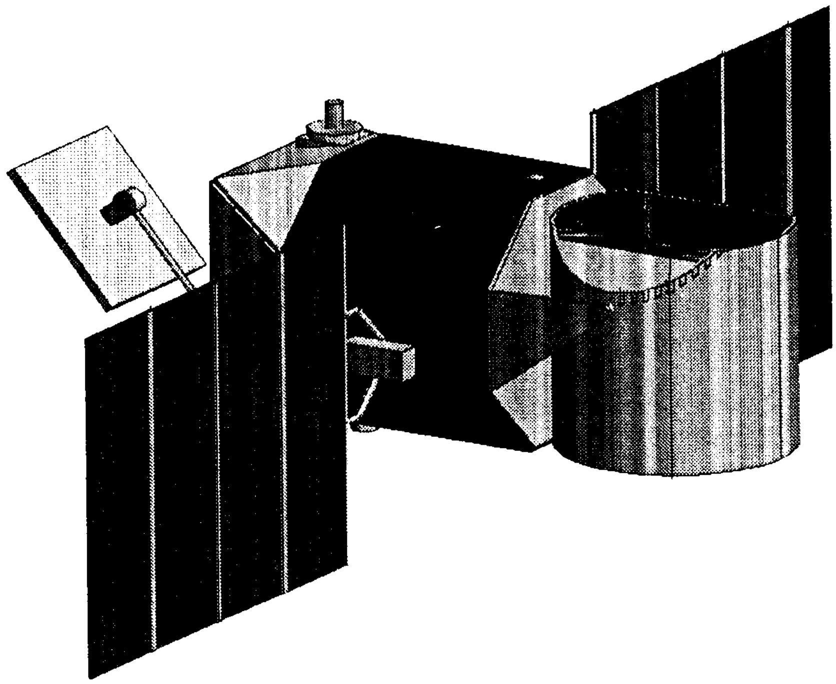
Geoscience Laser Altimeter System
On-Orbit Configuration



GLAS Instrument Layout