



Sub-system and System Level Testing and Calibration of Space Altimeters and LIDARS.

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Overview



- Space LIDARs and Altimeters
- Testing Challenges
- Sub-system testing and qualification
- System testing and calibration
 - -Radiometry
 - -Time of Flight
 - -Boresight Alignment





- Laser Altimeters have been in space since since early 1970's (Apollo program).
- Successful altimetry and atmospheric missions have mapped Mars and other planetary bodies and atmospheres.
- Primarily based on high peak power pulsed lasers (mostly YAG) and sensitive Si-based detectors.
- Future missions will almost certainly involve more complicated systems (transmitters, receivers, scanners, fiber lasers, etc.).





- Test Environments
- Test Configurations & Safety
- LIDAR Simulations (Atmospheric and Ground Echo Returns)
 - Radiometric Calibration.
 - Requires absolute knowledge of spectral radiances
 - Time of Flight Measurements (for Altimeters).
 - Requires stable, coordinated time bases
 - Boresight alignment.
 - Requires stable, repeatable alignment ground system.



Challenging Test Environments





Photo Courtesy of BATC



TVac Chambers

Photo Courtesy of Spaceflightnow

Launch Sites

Test Configurations



Test configurations will change.

Need for cross calibration between test setups.

Independent verification of test equipment.

Laser safety is an issue.

GLAS Main Target





Sub System Testing



Sub system testing must verify all functional requirements of the subsystem.

Long term testing is a must

"Test as you fly" is desirable but is not always possible (some conditions, e.g. 0 g, can not be simulated).

Data connectivity (data rate, formats, etc) should with conform with system testing.

Calibrations necessary before system integration: Alignment, radiometry (receiver sensitivity), timing.



NASA's satellite ICESat is scheduled to launch Wednesday on a mission to study Earth's atmosphere and polar ice sheets. Scientists will use this

new tool to answer questions on global warming and to record melting of polar ice.

Laser light show

The heart of ICESat is an instrument that uses sophisticated lasers to measure features in the osphere and on Earth's surface



🜖 The light reflects and scatters when it hits air partic les and Earth's surface A telescope in the GLAS receives both opes of reflected light High, thin cloud the sun's **ICESat contributions** This satellite will help scientists understand the

's radia

so the air

relationship between changing polar ice masses global warming and changing sea levels AT MOSPHERE ICES at will measure the air absorb the

height, thickness and vertical structure clouds and analyze particles in the air. These factors show the warming and cooling of the air, which is key to accurate weather prediction

For more

information

sun-sentinel.com/

Learn about

Low clouds reflect the WATER Researchers will compare changes in polar ice and coastlines sun, causing Earth's surface to sea levels

GLAS instrument at left **ICESat** rotects a protects a telescope that detects reflected light from Earth. The Ice, Cloud and Land Elevation Satellite will be launched from the Vandenberg Air Force Base in California IN ORBIT ICESat will orbit 373 miles above Farth for the thre to five-year mission. White Calculating crisscrossing lines show its place

🜖 The

satellite

records and

sends the

light's trave

specifics to

one of five

tracking

station arrou unci the world

Particles in the air

LAND AND SEA ICE For the first time, researchers will

nave continuous recordings of the thickness and area

of ice on land and sea. This information will be used

to predict the rate of ice melt at the poles and its affect

on climate and global sea leve

timeandothe

and

in space

Star Tracks

An infrared

light and a

visible greer

light are sent

at each pulse

urface area

2 30 feet in

diamete

toward a

ANTARCTICA its route The satellite will circle the globe every 100 minutes at 17,000 miles an hour recording 96 percent of the arctic and Antarctic io

Meltina of polar ice

Recent findings report record levels of sea ice melting in the arctic, at a rate of nine percent a decade. Temperatures in the area are increasing 2.2 degrees a decade

Ninety percent of the planet's fresh water is frozen in the Greenland and Antarctic ice sheets The current trend in global warming may cause Greenland's massive ice cap to melt in the next 150 years, creating a three- to six-foot rise in sea leve



to rise 260 feet. circulation around the Sea ice normally covers 2.4 million square miles of the Arctic Sea. This summe sea ice only covered 2 million :

LAND ICESat will help produce three nal maps that will show sea vels, vegetation and mountains Scientists will document cumulative anges in vegetation and the

ICESat Description

Surface Altimetry:

- Range to ice, land, water, clouds
- Time of flight of 1064 nm laser pulse
- Laser beam attitude from startrackers, laser camera & gyro Atmospheric Lidar:
- Laser back-scatter profiles from clouds & aerosols at 1064 nm & 532 nm
- 75 m vertical resolution
- Laser Transmitter
- < 6 ns pulsewidth</p>
- 40 Hz rep rate
- 75 mJ at 1064 nm & 35 mJ at 532 nm Receiver
- 1 m Beryllium telescope (475 μrad FOV)
- APD with AGC at 1064 nm
- Photon Counters (SPCMS) at 532 nm



ICESat Test Systems



- Simulate and monitor ground echo, clouds and background signals at 1064 & 532 nm - all independently adjustable over several orders of magnitude in amplitude and width.
- Measure Time of Flight at 40 Hz, 24/7 using GLAS Start Pulse and BCE ground echo pulse.
- Simulate orbits and provide a ground echo based on a Digital Elevation Model (DEM).
- Monitor Laser parameters:
 - GLAS laser energy (1064 and 532 nm @ 40 Hz)
 - GLAS laser pressure
 - GLAS laser rep rate and shot count
 - GLAS laser wavelength at 532 nm
- Field of View sweep (Boresight alignment) 1064 nm ONLY
- Monitors GLAS oscillator referenced to GPS.
- Synchronize and verify event timing for all subsystems based on GPS.
- Transfers GPS time to GLAS and BCE for data alignment.



System Testing – ICESat example





Laser Fiber Electrical



Radiometry and Laser Diagnostics

Laser Diagnostics

- Divergence and Absolute Laser Energy difficult to measure especially in TVAC.
- Calibrate detectors!
- Receiver Radiometry very difficult to verify especially in TVAC
 - Showerhead used for radiometry (provides alignment insensitivity but hard to calibrate and monitor).









Time of Flight (TOF) Measurement



- Uses Time Interval Unit and High Speed Digitizers
- Accurate to 2.6 cm (= 85 ps)
- Uses Rb time base (referenced to GPS)
- Low drift less than 15 cm (500 ps)/day
- TOF measurement @ 40 Hz 24/7 during testing
- Tested independently with a waveform generator and Time Interval Unit





ICESat Launch and On-orbit Data

