ITT

A Multi-Functional Fiber Laser Lidar for Earth Science & Exploration
NASA Grant No. IIP-04-0055

From the MFLL Team:

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The Project Team – Year 3

ITT Space Systems

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NASA AMES

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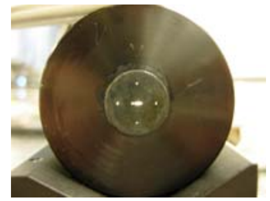
CK Shum

MFLL – A Robust Multi-pixel Mapping Instrument

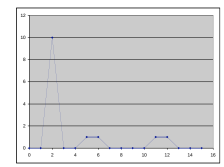
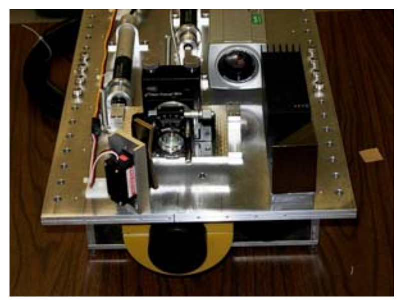
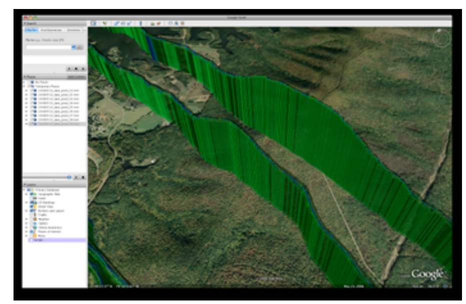
- Primarily for topographical mapping of ice sheets, can be used or optimized for many other surfaces and aerosols
- Forgoes scanning, using a DOE transmitter, fiber focal plane
- Transmits PN encoded signal, Decodes ranges with convolution
- Amplified by mature CW Ytterbium Fiber Amplifier technology - 500,000 hour MTBF
- Passive optical head can be positioned many meters away from active components – tethered by optical fiber
- Single pixel flight in 2006, Nine pixel geolocated flight in 2008, many future opportunities for infusion

Noisy Reflection

Reference Code

X

Ice Sheet Mapping – Requirements and Goals

- MFLL Cardinal Rules for High Reliability
  - –No mechanical scanner
  - –Use Telecomm CW High TRL optical chain
  - –Build for Modularity

Requirement	Low Altitude Airborne (Threshold)	Medium Altitude Airborne (Goal)
Range Precision	10cm	10cm
GSD	2 m	2 m
System FOV	± 0.61º	± 15º
Operational Altitude	500 m (2000m demo)	~7000m
Platform Velocity	75 m/sec (125 demo)	125 m/sec
Max Rate of elevation Change	10% Slope	10% Slope
Geo-Location Accuracy	<2 meter	<2 meter
Aperture	2 in	2 in
Wavelengths	1064nm	854, 1064, 1550nm
Unambiguous Range	100m (1024m demo)	1500 – 7500m (TBR)
Bandpass	0.5nm (3nm demo)	0. 3nm
Sample Time	20msec	20msec
# of pixels	9	~100
Payload mass/volume/power	Single Rack < 300lbs	POD 100 lbs
Platform	P3 (or other)	UAV

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INSTRUMENT ARCHITECTURE

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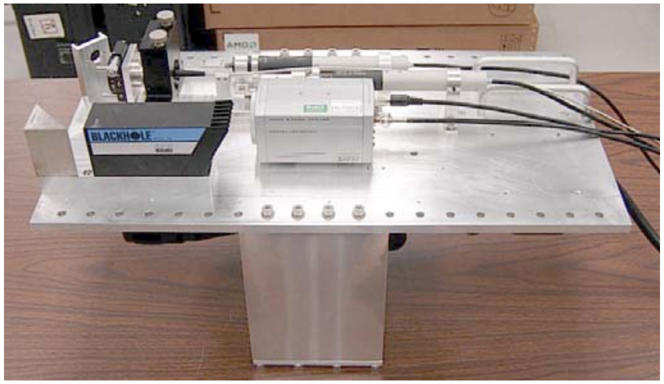
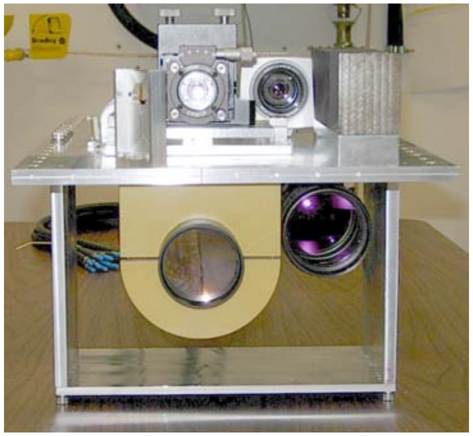
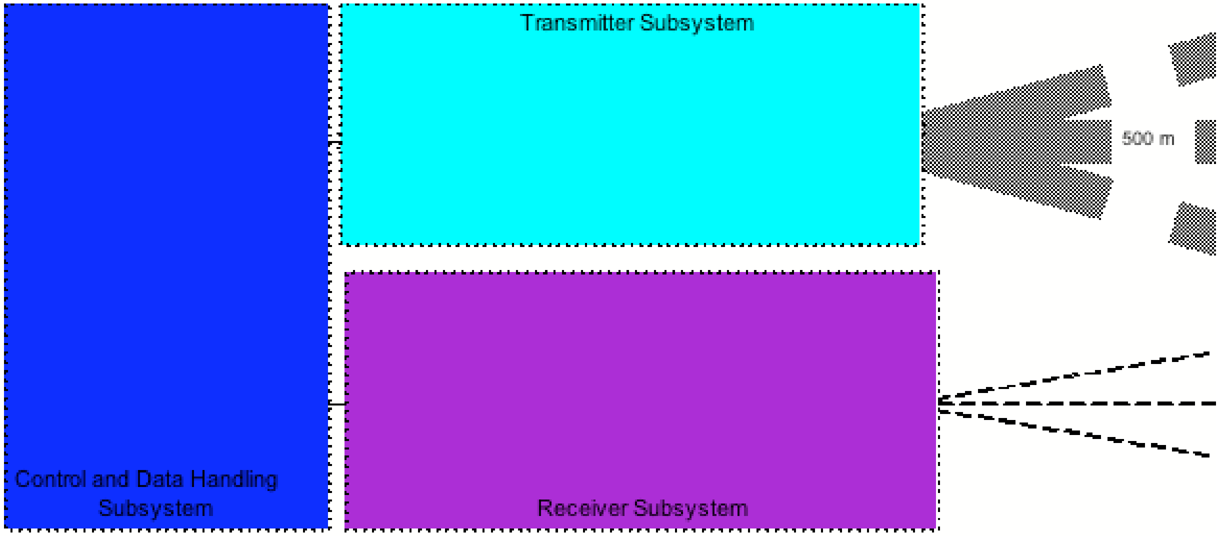
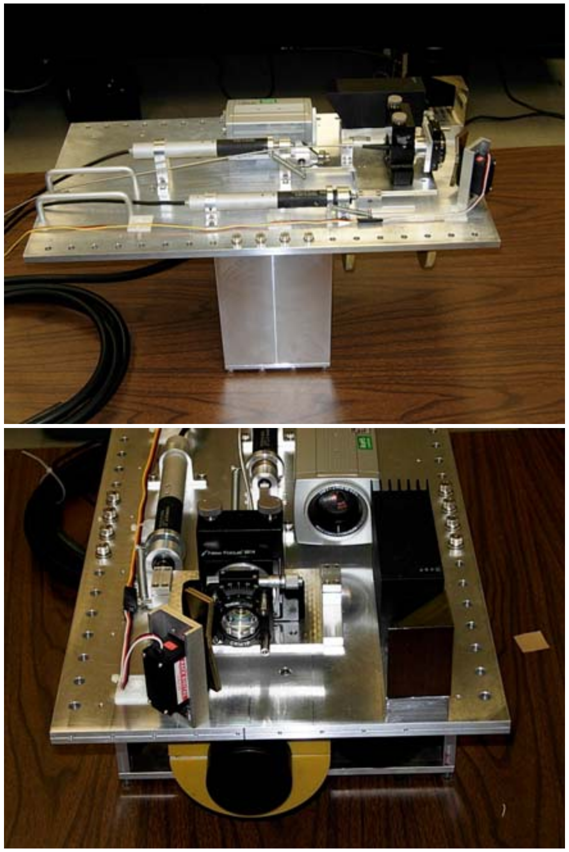
Top Level Block Diagram



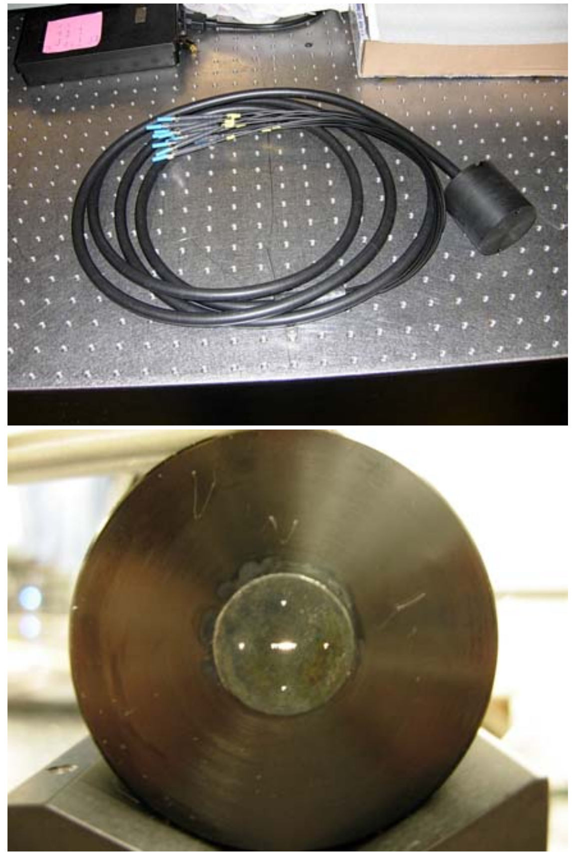




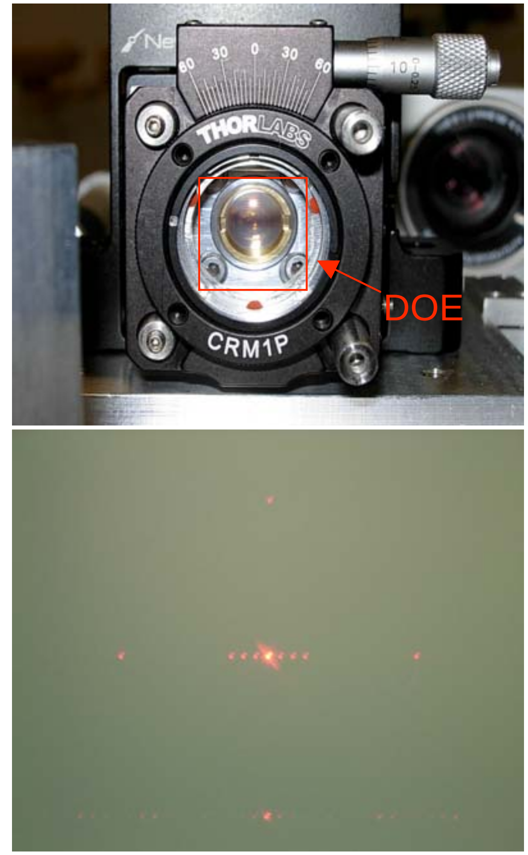
Optical Transceiver Head



Complete Optical Head



Fiberguide Array
for Focal Plane



Tessera Diffractive Optic
and Laser Output

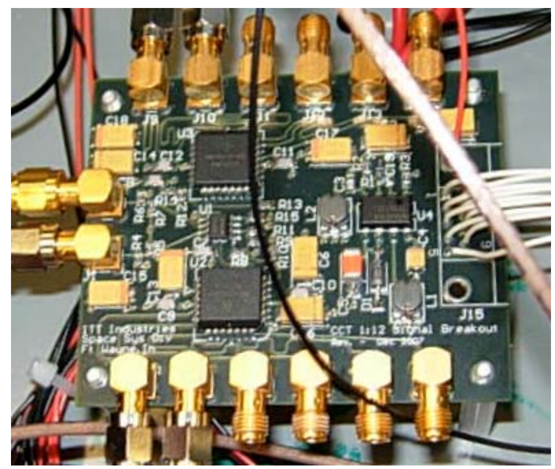
Fiberguide and Tessera components built to perfect spec – drop in solutions

Receiver Electronics

Fully assembled detector box with Perkin Elmer SPCM modules

Perkin Elmer SPCM

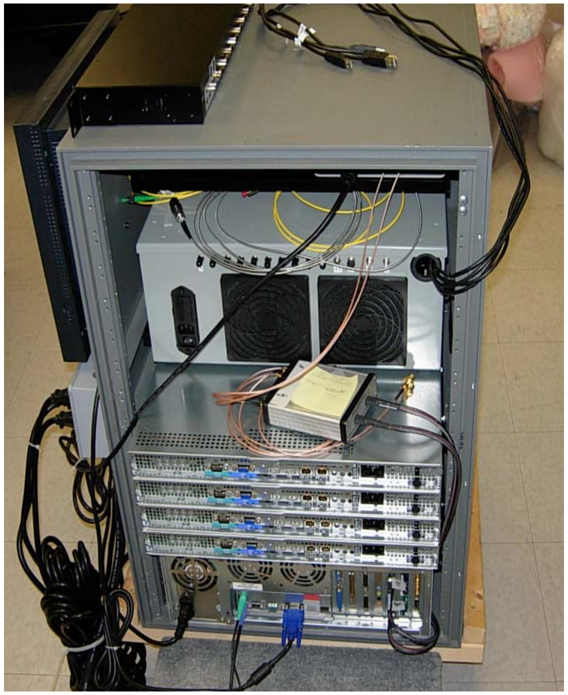
SensL HRMTime module – tallies time-histograms of photon returns



Time-sync card – used to send identical synchronization pulse for histogram loop to all 10 channels

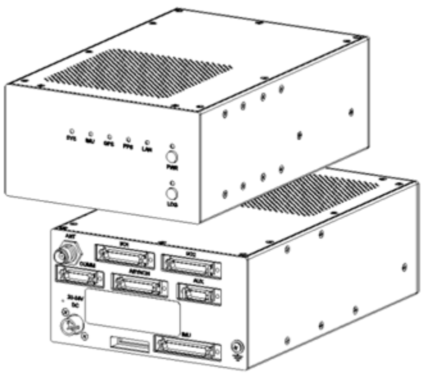
Active Transceiver Hardware

Top to Bottom: KVM, Seed Laser, YAM Head, YAM Amplifier, Detector/Timing Box, Blade Computers, Server

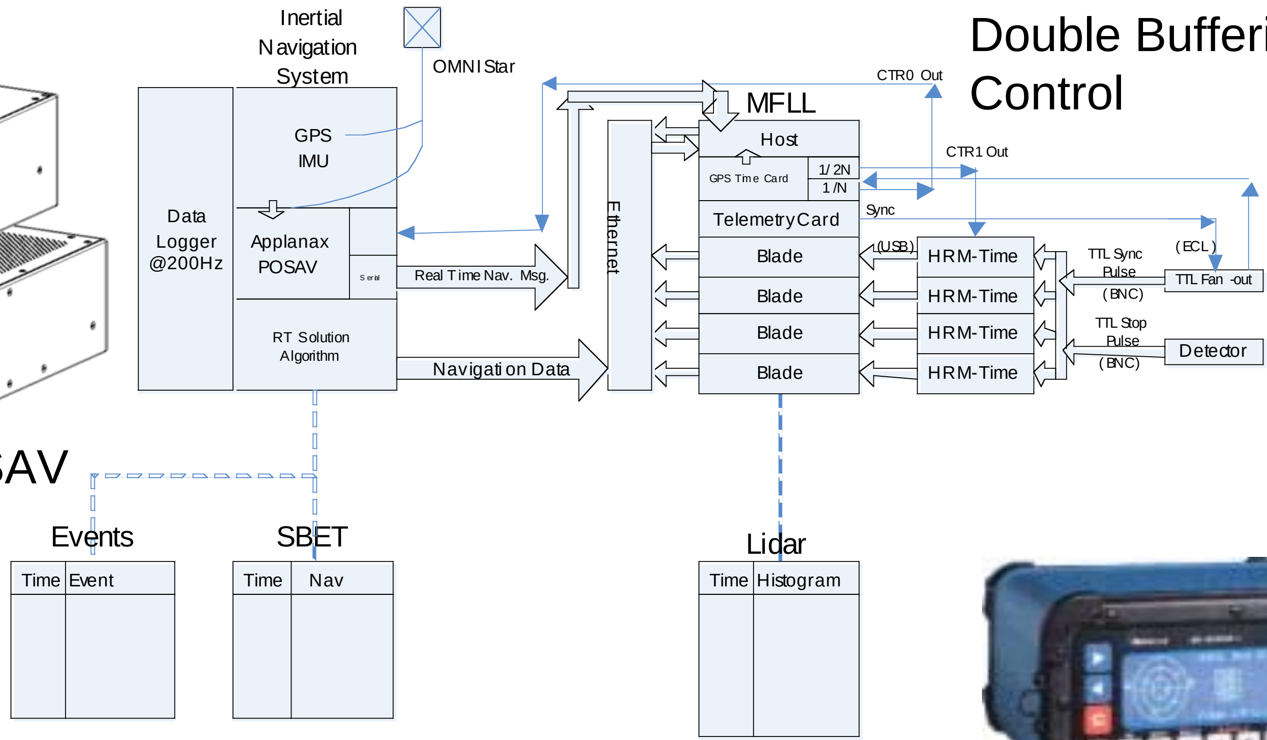


285 lbs, 24” x 24” x 30” plus additional room for cabling
Tethered to transceiver head only by optical fiber

Geolocation Subsystem



Applanix POSAV



Double Buffering Control

Ashtech Z12

Timing from the PN card controls both GPS logging and data collection.

Both real-time GPS solutions and hard data are recorded for post processing.

Events Logged +/- 1 millisecond

GPS Time / Position +/- 1 millisecond

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TEST CAMPAIGNS

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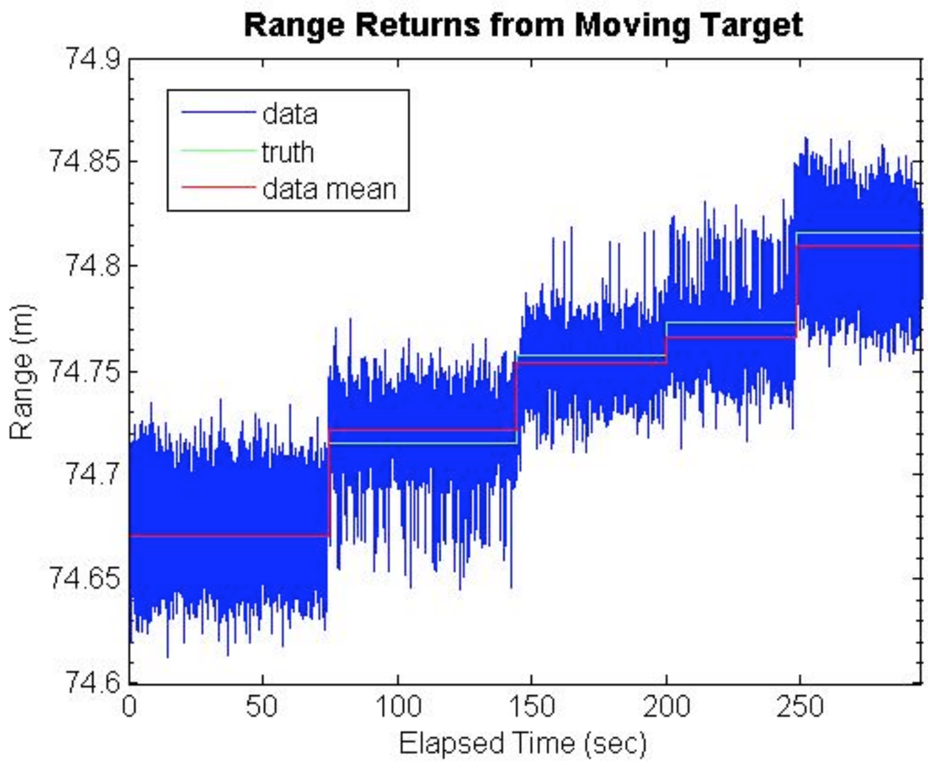
ITT LIDAR Test Range: Integration and Alignment

Fully Assembled Rack and Transciever Head

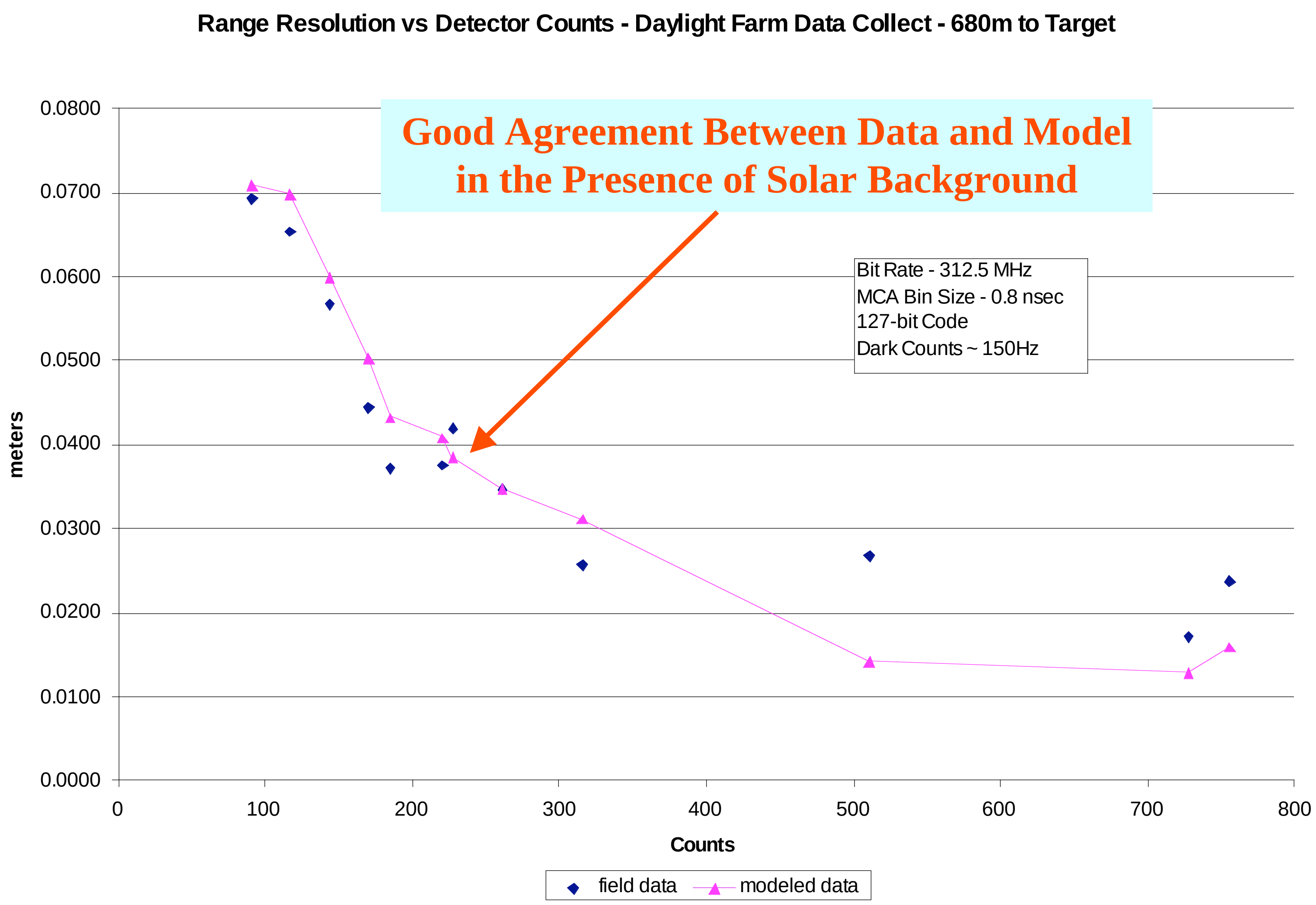
- Facility provides well-equipped, safe environment for LIDAR field testing
- Supports Cactus, Rattler, MWIR Digital, and ASCENDS, and ICE programs
- Telescope Bore sighting and performance profiling

ITT LIDAR Test Range: Moving Target

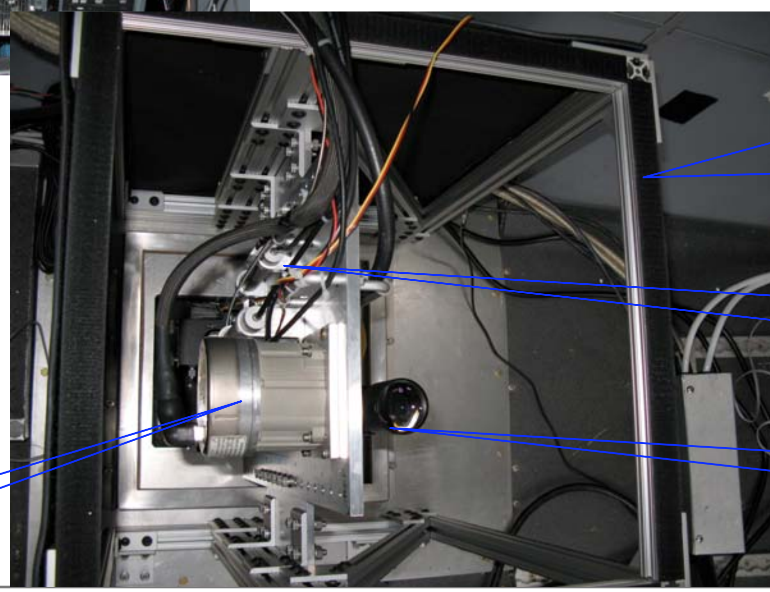
- Target was stepped during continuous data collect to demonstrate instrument range sensitivity
  - Measured data and truth data match to within ~1cm



Farm Data and Model Comparison



MFLL Installed in B90 Aircraft



MFLL Avionics & GPS Rcvr's

MFLL Optical Head over Camera Port

Applanix POS-AV Display

Laser Tx Optics

Rx Optics

IMU

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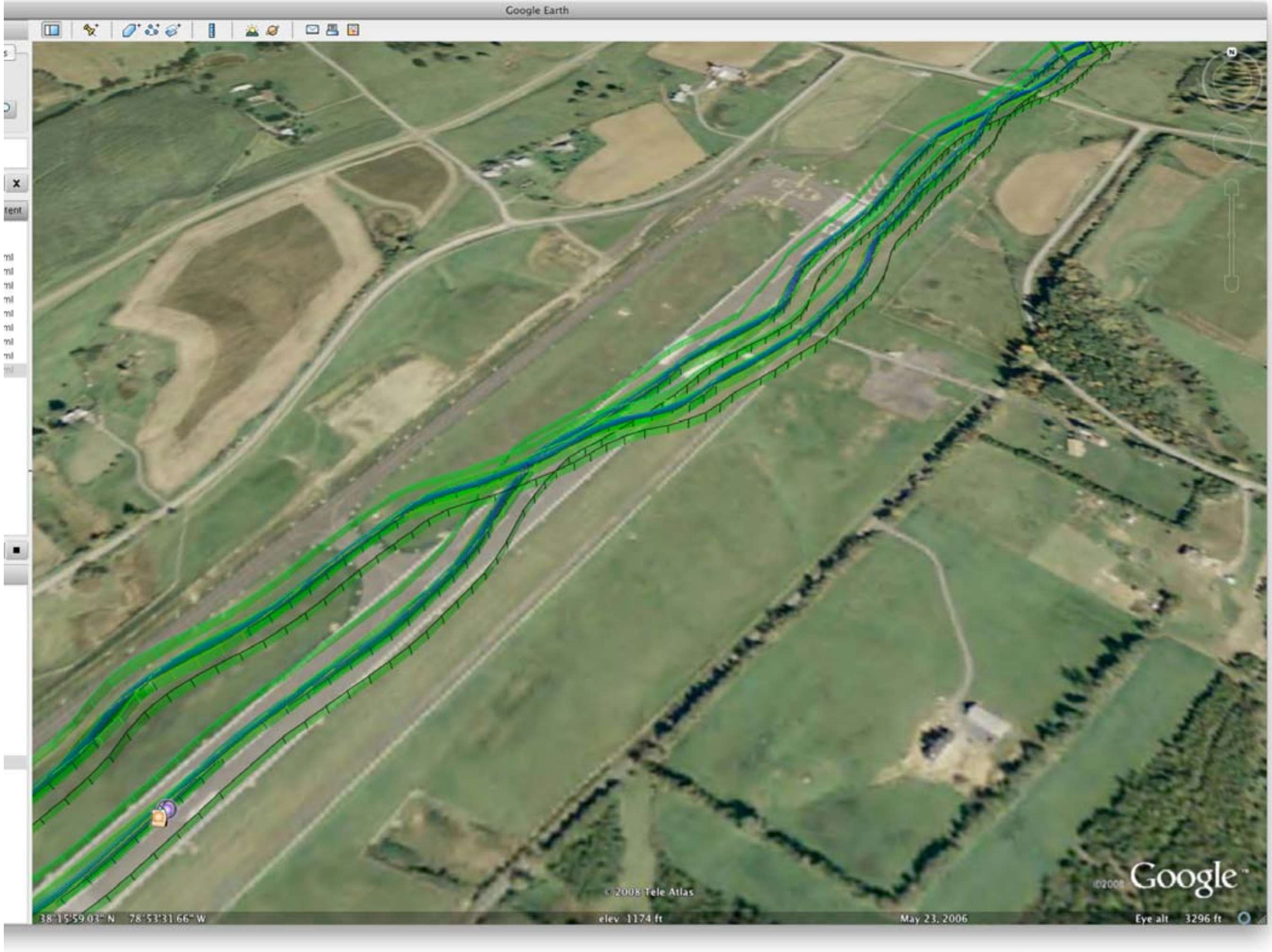
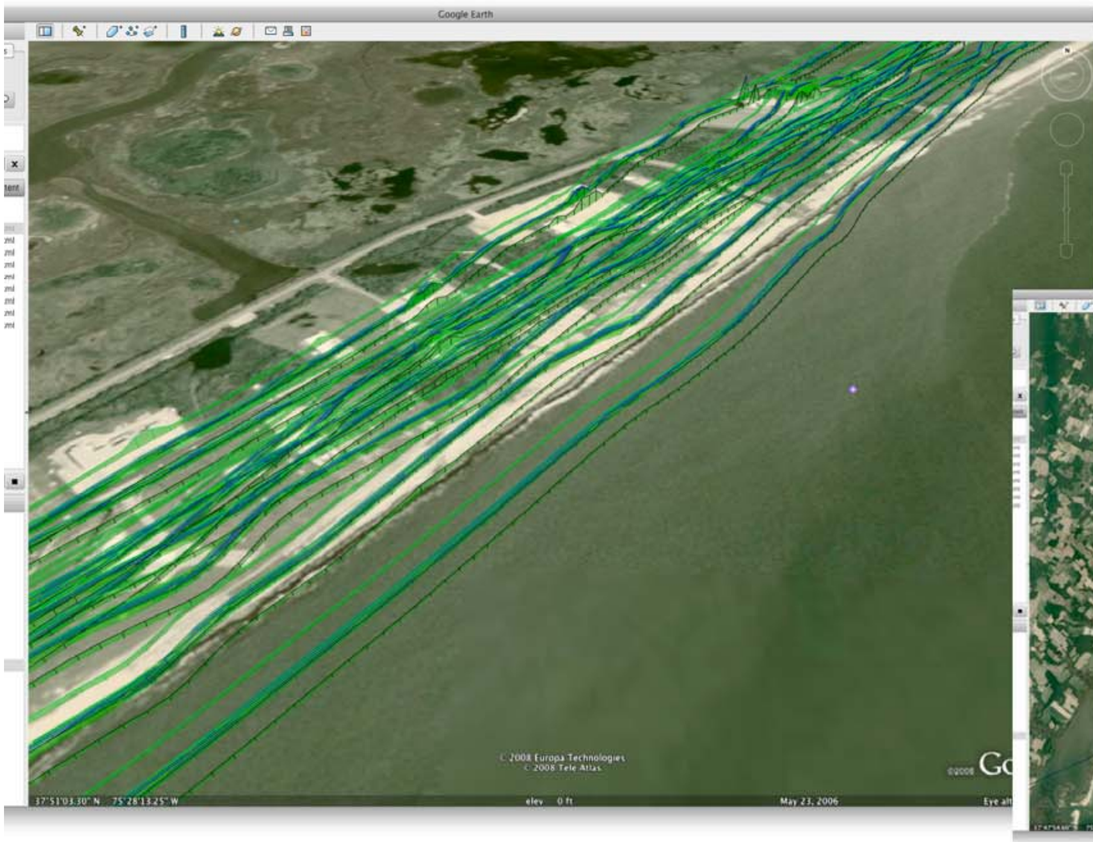
Shenandoah Airport

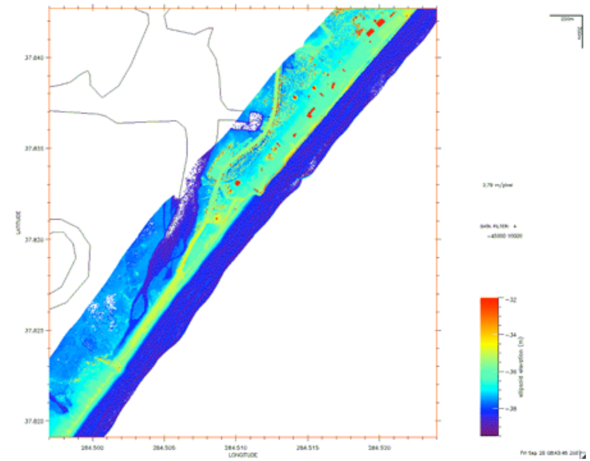
- Well-surveyed runway for bias-angle calibration
- First Pass Validation
- Data presented at 1/5 horizontal data rate in Google Earth

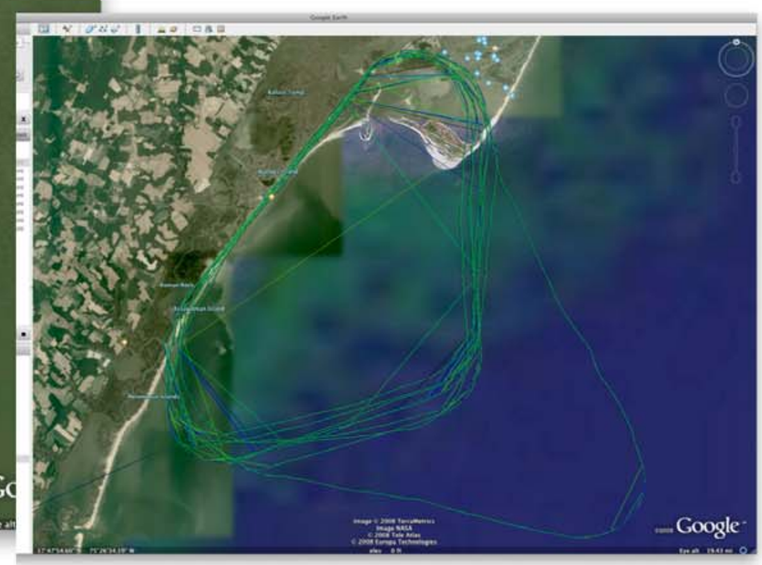


Wallops Island

- Ocean tracks for further bias-angle calibration
- Land tracks previously surveyed by William Krabill

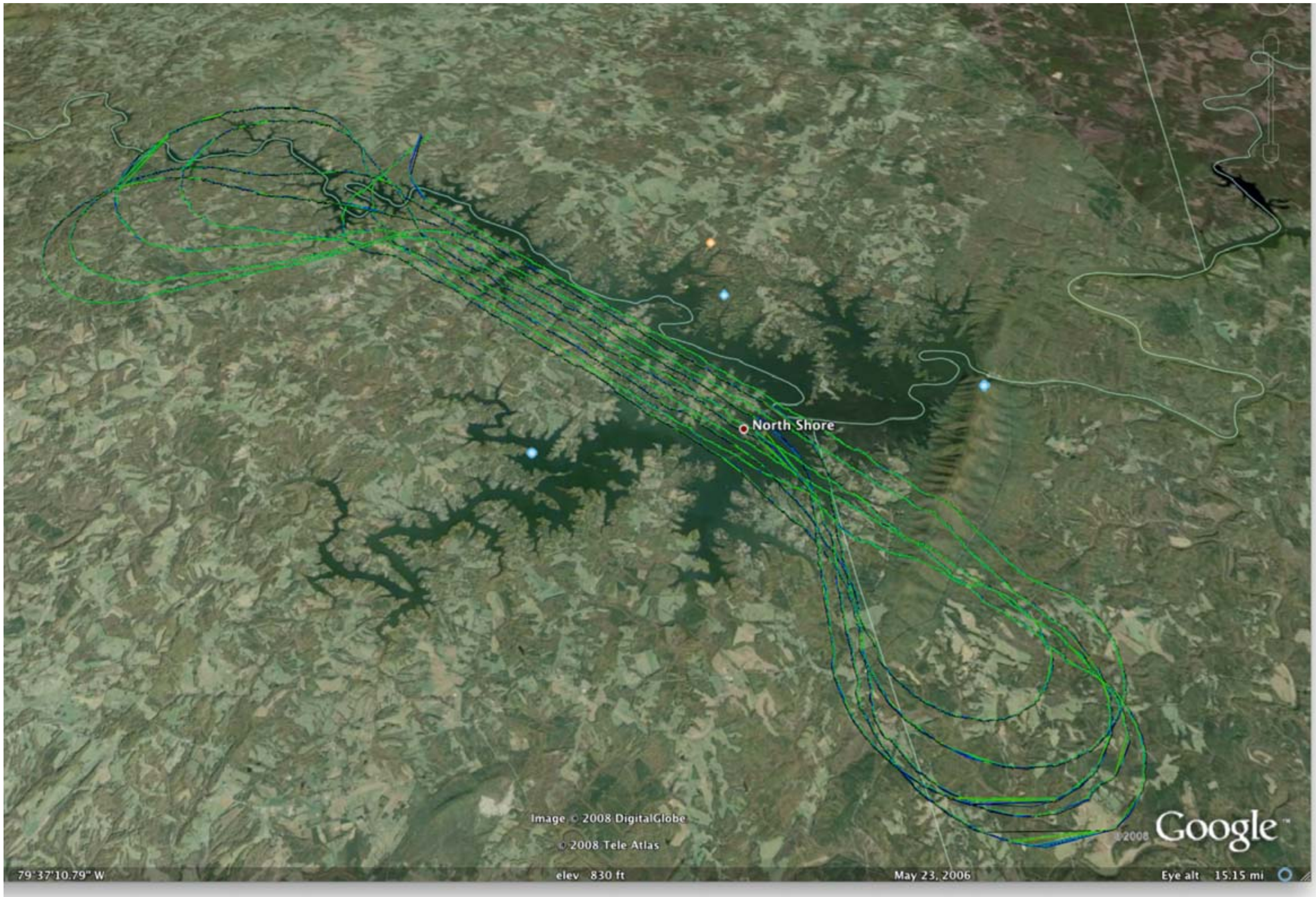






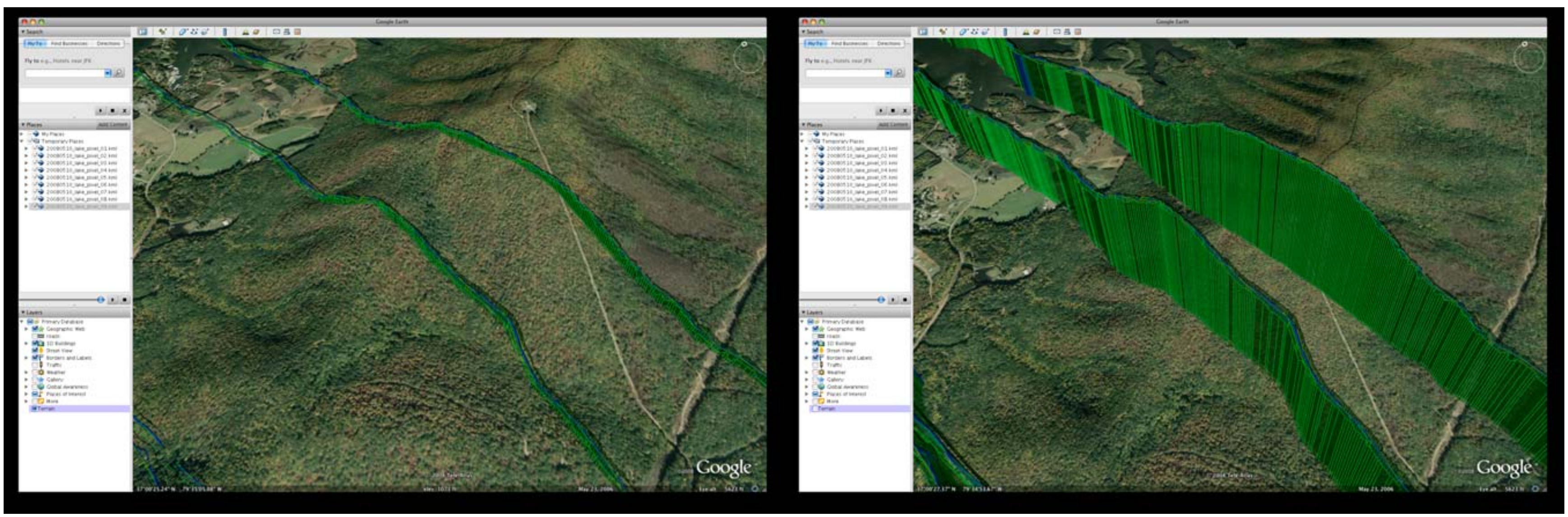
Smith Mountain Lake

•Demonstration for hydrology missions



Fun Shots:

- Right: Chicken Coop Rooflines show geolocation agreement
- Below: Hill cross-sections with and without Google DEM demonstrate visualization



Technology Infusion Opportunities

[redacted]

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Technology Readiness Level

- Instrument System
  - End-End PN Altimeter System became TRL 6 upon completion of May flight campaign
  - PN Laser Ranger (Altimeter without Geolocation) was TRL 6 in June 2007.
- Transmitter
  - Transmitter Components such as DFB Seed Laser, Modulators and Fiber Amplifier are TRL 6 per NEPP
  - Prior work by ITT in 2001 qualified DFB and Fiber Amplifiers.
  - On-going work in 2007 and 2008 by LaRC and ITT provide additional qualification data
- Receiver
  - The Perkin Elmer Detector is TRL 7+ per deployment on GLAS
  - PN Range Signal processing is TRL 8 per deployment on GPS

Mission Infusion Opportunities

- Missions in need of few pixels, and what MFLL can add:
  - ASCENDS – aerosol profiling, CO_2 LIDAR
  - ICESatII – 4 pixel bias angle correction
  - ACE – Low resolution aerosol profiling
- Missions in need of 3-D topographic imaging
  - ALHAT – terrain correlation and obstacle avoidance on regolith
  - ALIST – 5m terrain accuracy
  - DESDynI – 25m terrain accuracy
  - ClimateHawk – UAV platform with many environmental sensors

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New Sources

- Aculight Micropulse Lasers, 1550 and 1100nm

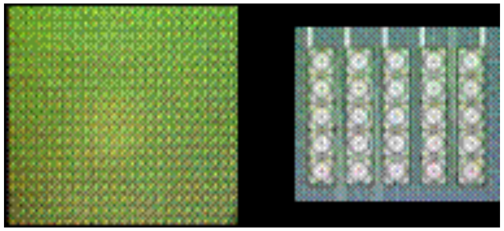
- QPC high-power pump diodes, 792-1550nm solutions

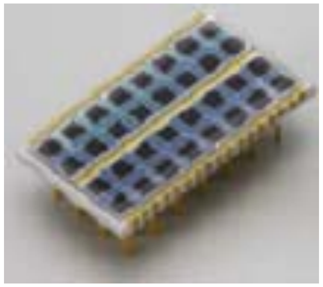
- Difference Frequency Generation in Photonic Crystals for MWIR, 2-3um

New Detectors

- Required: Large pixel areas for high sensitivity and telescope coupling
- SensL - new high efficiency arrays for visible wavelengths
- Hamamatsu - new high efficiency SWIR arrays good to 1100nm
- Hamamatsu – new PMT for 1550nm
- Intevac – new intensified photodiode, models for 800, 1100, 1500nm

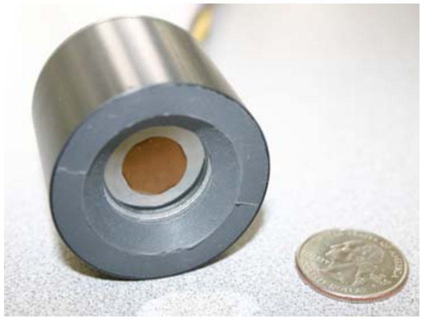
SensL DigitalAPD 256x16 Si APD Array





Hamamatsu S8550 32 element Si APD Array

Hamamatsu H10330-75 PMT Module



Intevac IPD

MFLL Thanks You!

- For their geolocation expertise and hardware:
  - NASA AMES - Robert Billings, Rose Domiguez
  - NASA Wallops - William Krabill, Earl Fredrick, John Sonntag
- The can-do aircraft team at Dynamic Aviation:
  - Steve Scates, Laura Laster, Philip Burke and pilots Steve Durkley and Jessica Jackson
- And NASA ESTO for this opportunity – Janice Buckner

MFLL – A Robust Multi-pixel Mapping Instrument

- Primarily for topographical mapping of ice sheets, can be used or optimized for many other surfaces and aerosols
- Forgoes scanning, using a DOE transmitter, fiber focal plane
- Transmits PN encoded signal, Decodes ranges with convolution
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