

Small Sat Lasercom

Renny Fields

The Aerospace Corporation, El Segundo, CA 90245

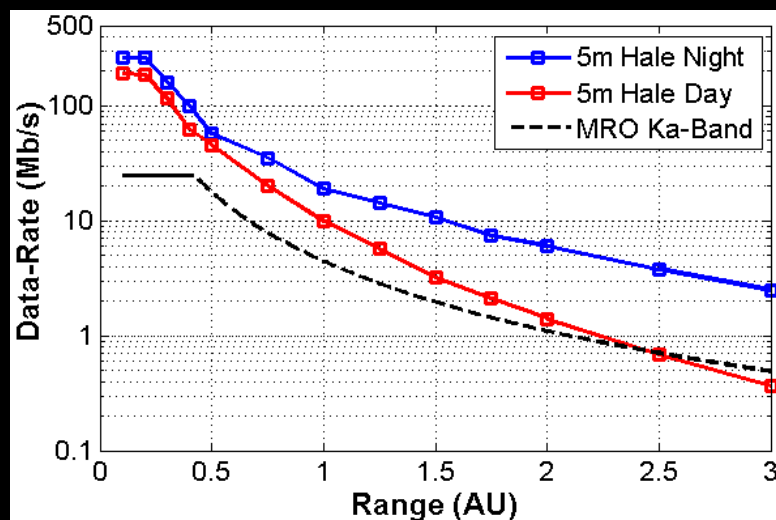
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Acknowledgements

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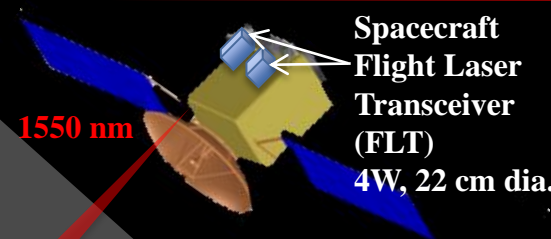
Deep-Space Optical Communications (DSOC)

Overview, Capabilities and Footprint



Performance using 4W average laser power w/22 cm flight transceiver to 5m ground telescope

Beacon & Uplink
 1030 nm
 292 kb/s
 @ 0.4 AU



CBE MASS (kg)	28
Mass margin (%)	30
CBE POWER (W)	76
Power Margin (%)	31
Optical Head: 45 x 45 x 49 cm (95E3 cc)	
Elect. Box: 29 x 23 x 23 cm (15E3 cc)	

Ground Laser Transmitter (GLT)
 Table Mtn., CA
 5kW, 1m-dia. Telescope



Ground Laser Receiver (GLR)
 Palomar Mtn., CA
 5m-dia. Hale Telescope



Optical Comm Ops Ctr.
 JPL, Pasadena, CA



Deep Space Network (DSN)



TBD MOC



DSOC Key Characteristics

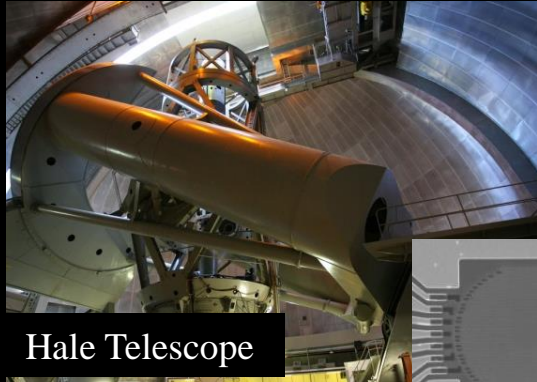


Silicon Carbide Telescope & Optics
(Front cover not shown)

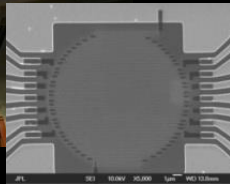
• Deep-space optical communications characteristics

- *Photon-efficient communications*
- *Pulse-position modulation w/ Near capacity achieving codes*
- *Laser beacon + Earth image assisted pointing from space*
- *Integrates new technologies* **green outline**

Ground Segment



Hale Telescope



Ground Laser Receiver (GLR)

- Photon-counting ground detectors
- 50% Eff. WSi nanowire arrays

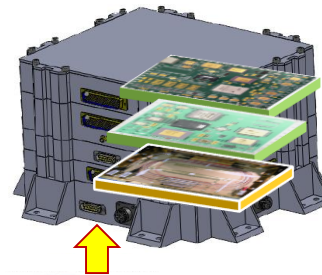


Ground Laser Transmitter (GLT)

- 1030 nm Ground Lasers

OCTL Telescope

Point-Ahead Mirror



Laser Transmitter

Electronics Box

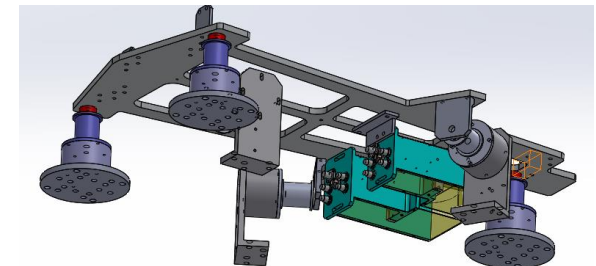
- 1550 nm Space Laser Transmitter
- Electronics processing & control cards, firmware, software, clock

Flight Laser Transceiver (FLT) Assembly

- Uplink receiver
- Downlink transmitter

Photon-Counting Space Receiver

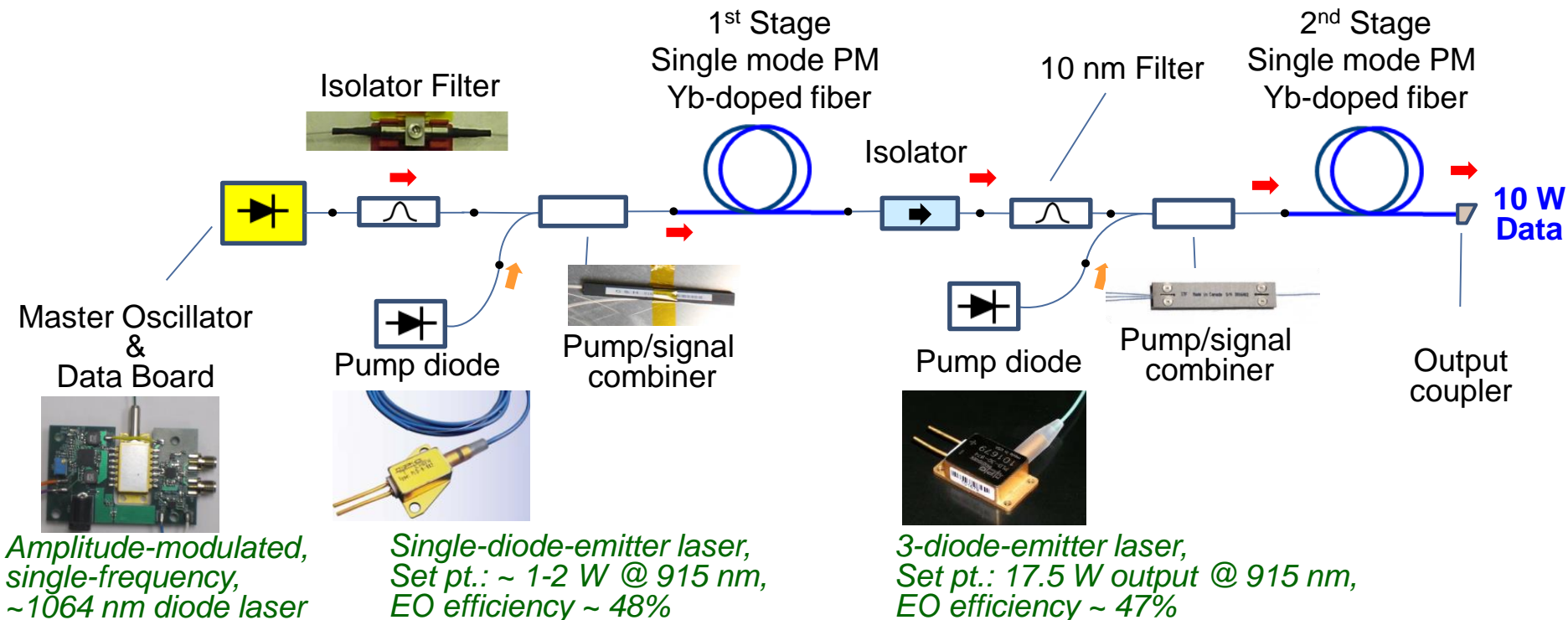
- 40% QE Rad Tolerant



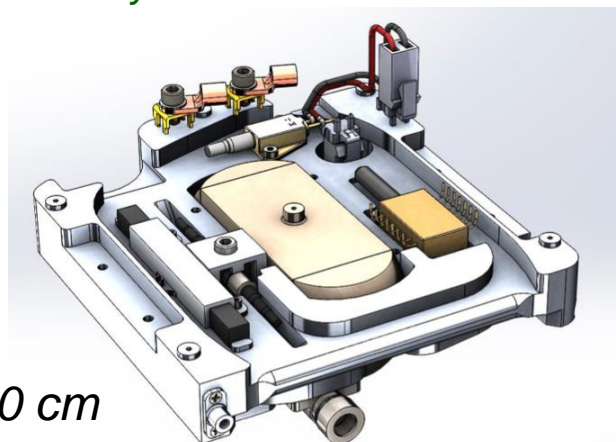
Spacecraft Disturbance Isolation Assembly

- 50 dB rejection

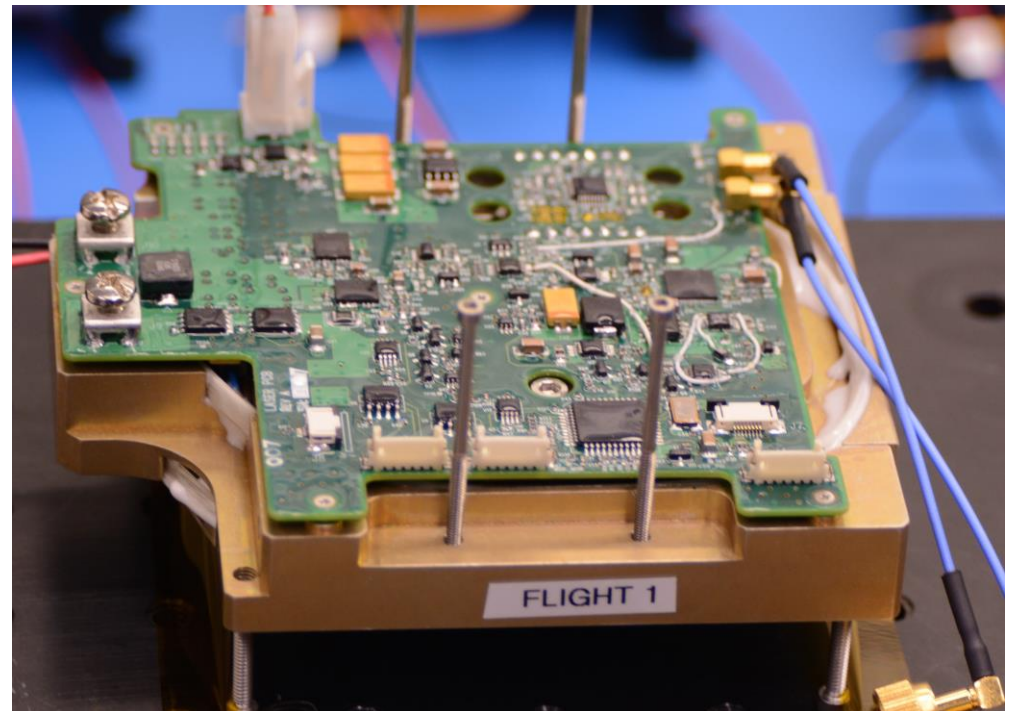
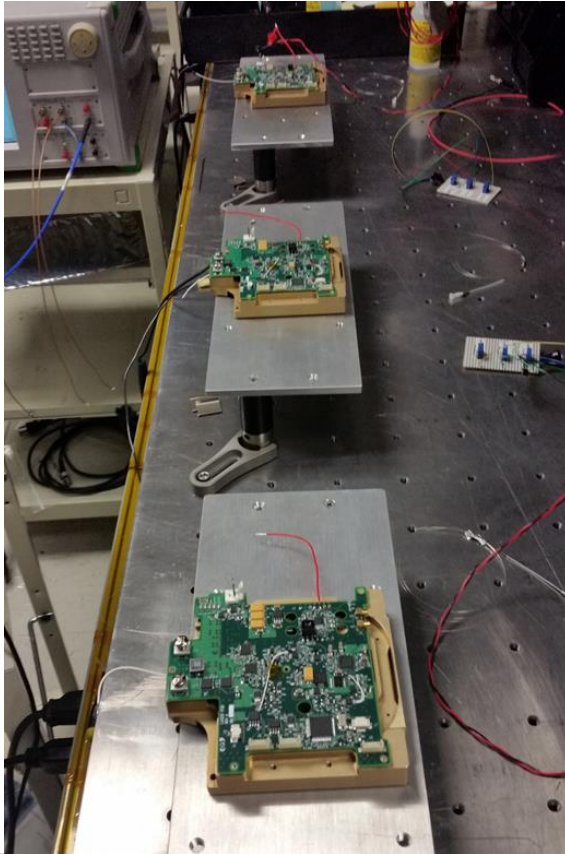
AC7 10 W Downlink Laser



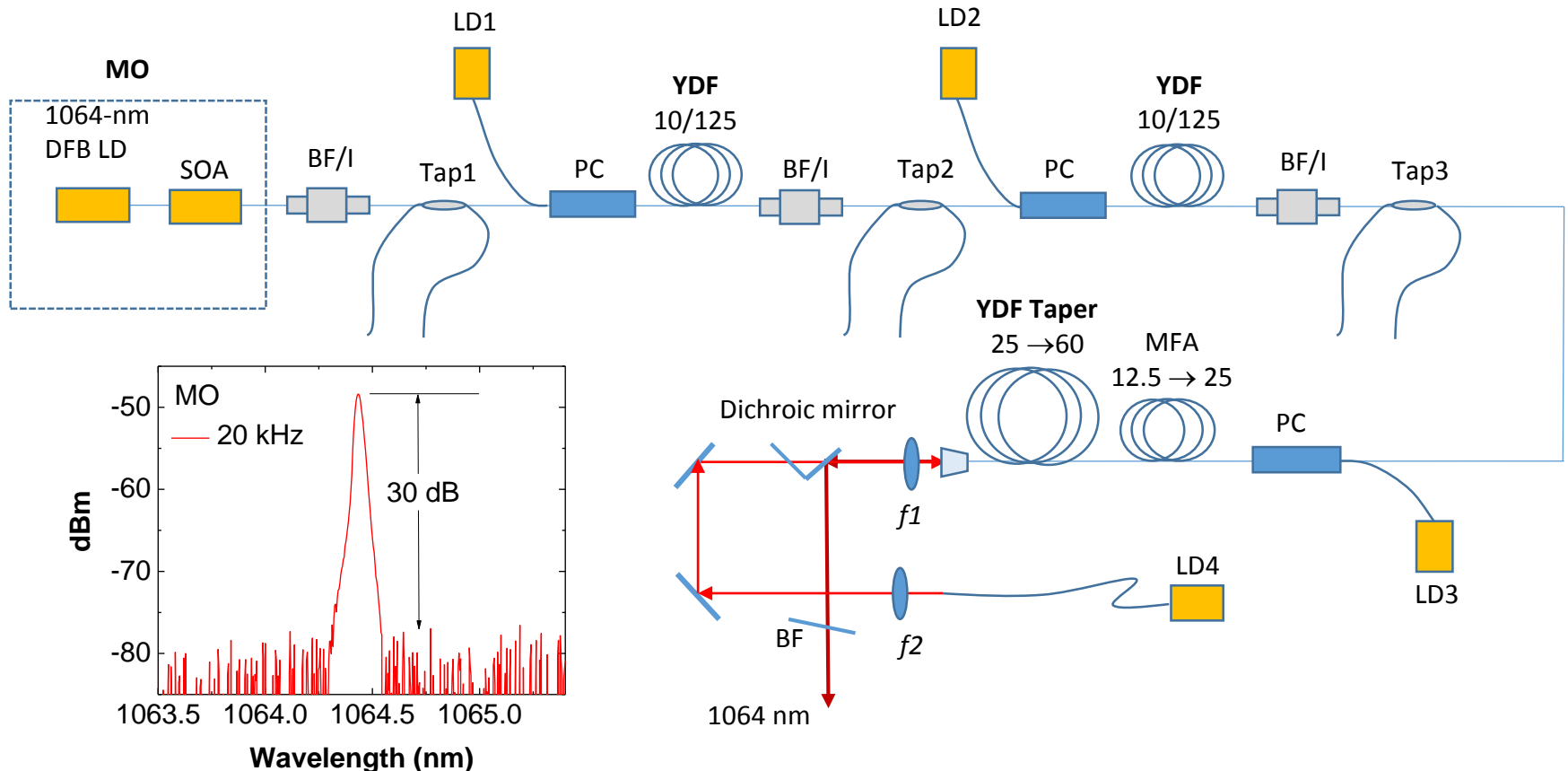
- **Gain-switched diode + 2-stage fiber amp**
- **Operation at 1.06 μm**
- **All-fiber design, 25% wallplug efficiency**
- **Passively cooled; ΔT capability ~25°**



Two Flight Units and Spare Builds

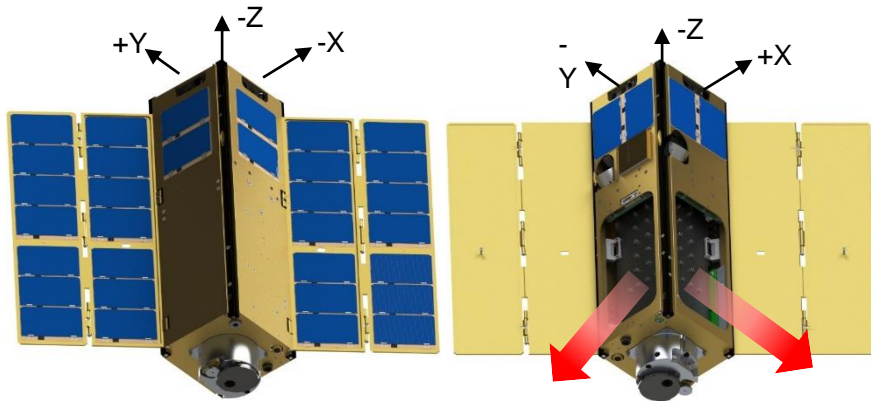


0.5 mJ fully spliced fiber MOPA system



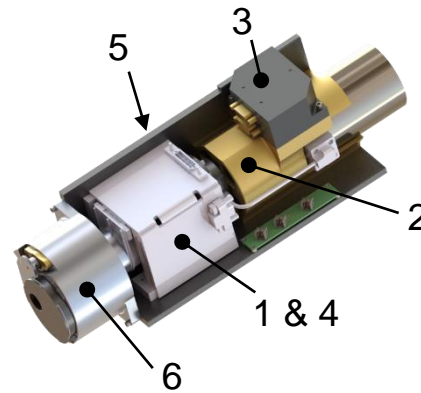
- Fully spliced MOPA system
- Tapered fiber final amplification stage for LMA and high beam quality
- Directly modulated MO signal

LMPC CubeSat – Aerospace AeroCube-9 (AC-9)



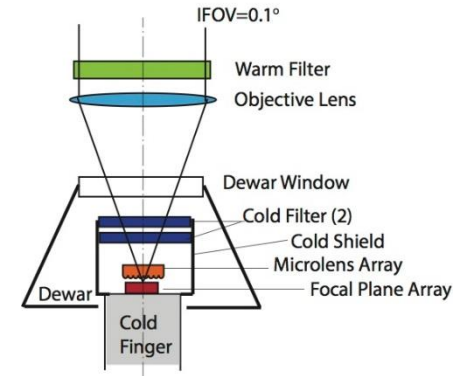
BUS

- HgCdTe responds from 0.4 to 4 microns to single photons (1000 electrons per photon)
- AC9 will use narrowband filters to pass 1.06, 1.55 and 2.06 microns for daylight operation
- Launch Nov 2016 (delivery Aug 2016)



Optical Path

1. Dewar
2. Stirling cycle cooler
3. IDCA controller
4. FPA conditioning circuits
5. Radiator structure
6. Warm filter and objective lens

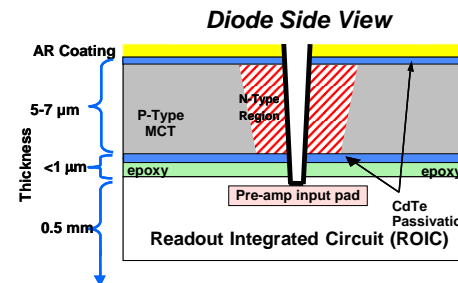


Optical Path

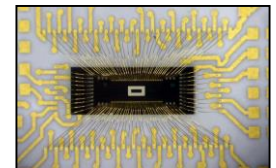
- Filter wheel with 5 settings
- 3 Bandpass filters
- 1 blank (opaque)
- 1 open

HgCdTe electron initiated avalanche photodiode (e-APD) array

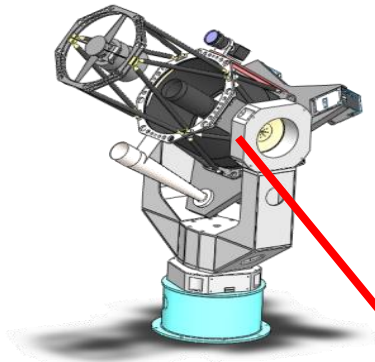
- Developed by DRS Technologies in Dallas TX
- 2x8 pixels with built in read-out integrated circuit (ROIC), 20 μm diameter active area, 64 μm pitch, with μ -lens array F/7 optical path, 7 mm diameter entrance aperture
- 90% quantum efficiency
- >1000 APD gain, more than sufficient to override ROIC noise
- Linear mode photon counting (LMPC) detectors from visible to mid-wave infrared (VIS/MWIR) wavelength range.



Top View



Upgraded Mt. Wilson Facility

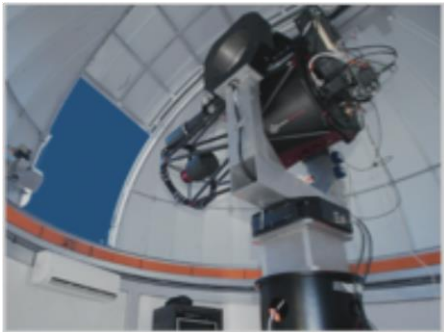
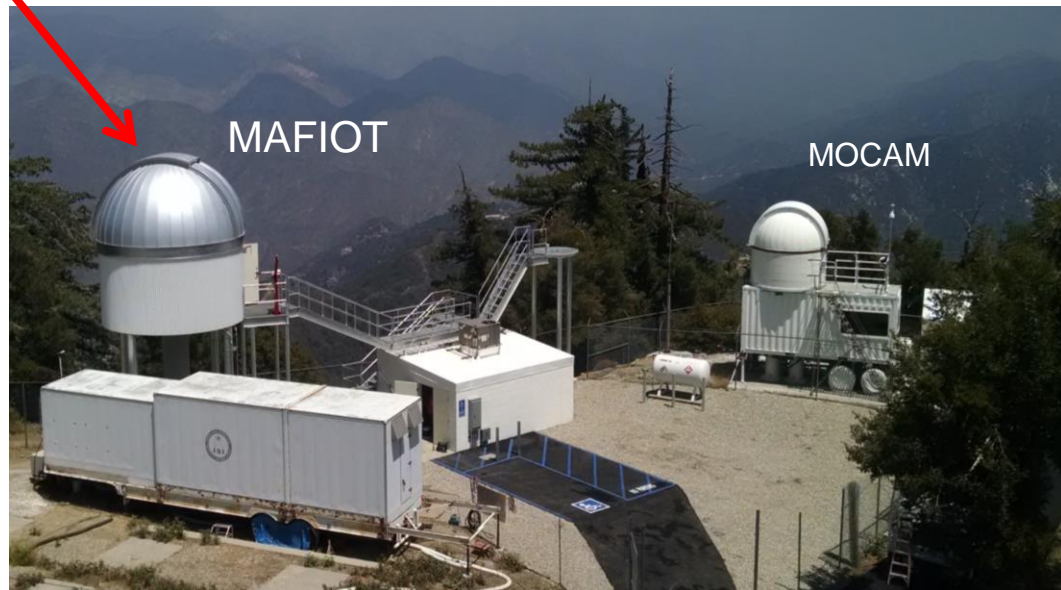


80 cm Rx telescope
Co-boresighted hp laser

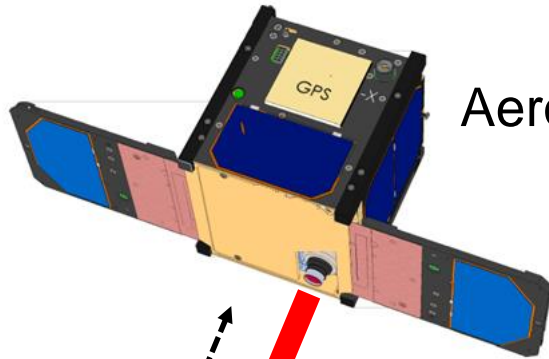
30 cm Rx telescope
Lasercom & atmos. meas.

MAFIOT- Mt. Wilson Aerospace
Facility for Integrated Optical
Tests

MOCAM- Mt. Wilson Optical
Communication and Atmospheric
Measurements



Pre AC7: AC4 Ground Target Laser Diode Illumination

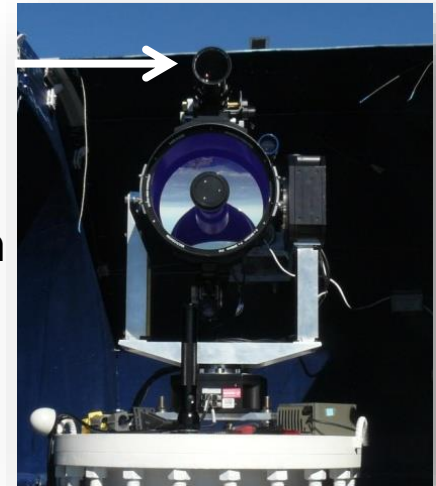


AeroCube

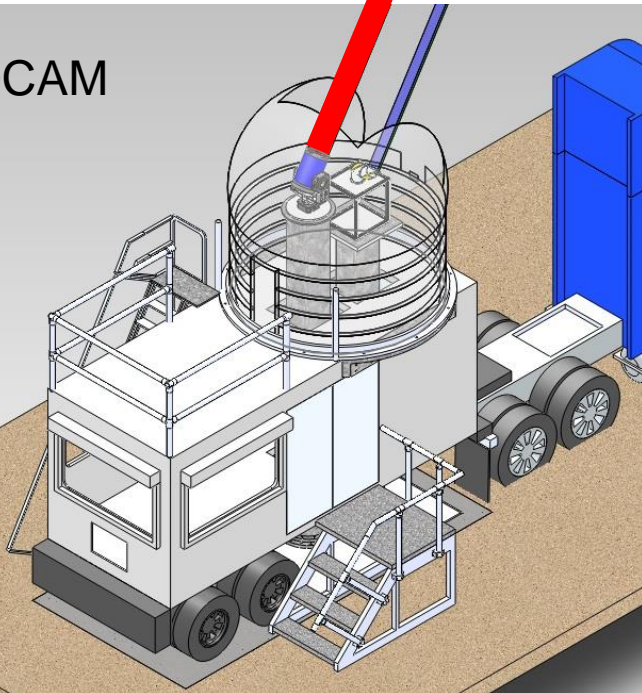
WFOV Acq. Scope

Mt. Wilson
Receive Telescope 30 cm

Range 650 - 775 km



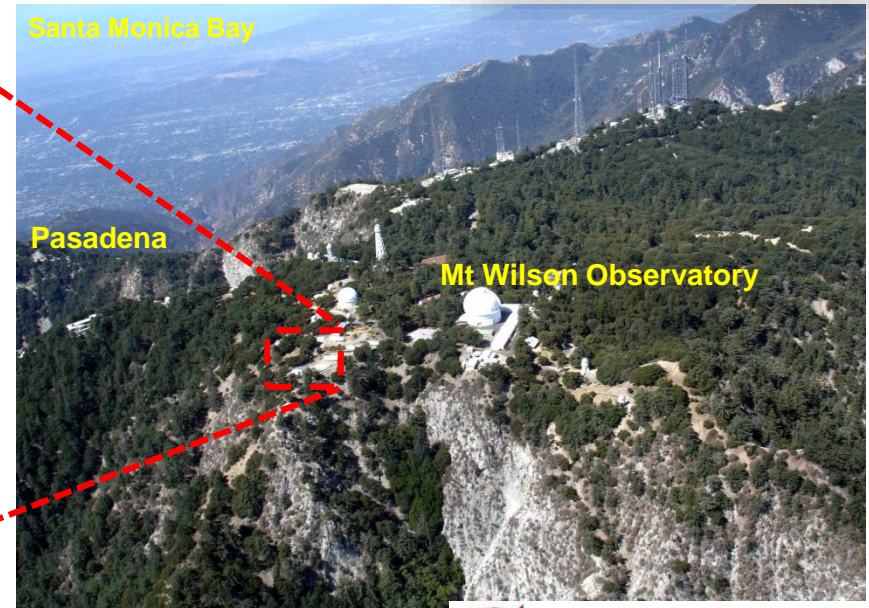
MOCAM



Santa Monica Bay

Pasadena

Mt Wilson Observatory



Beaconless Attitude Determination and Control System

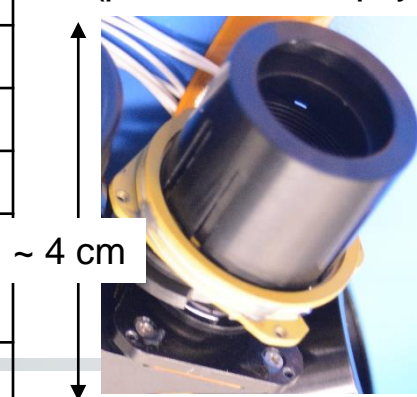
- The Attitude Control System is designed to point the downlink laser to within 0.04 Degrees (3σ) of the optical ground station
- A combination of custom designed attitude sensors (sun and earth) and star trackers are used to meet stringent power, size and performance requirements
- Miniature Reaction Wheels and Torque Rods are used for actuation and momentum control

**Sun Sensor
Quad Cell**

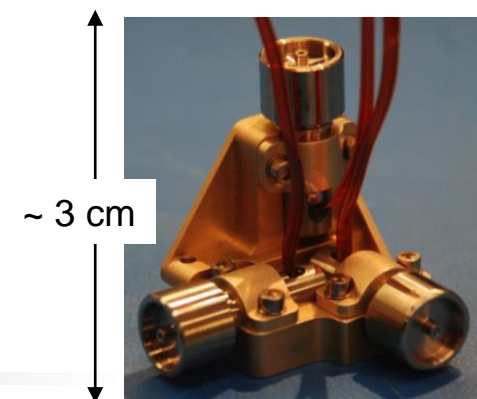


Error Sources	Pointing Error 3σ (Deg)
Payload to AD Frame Alignment (post-cal)	0.010
Real-time Clock Drift	0.002
Orbit Determination / Ephemeris Error	0.003
Attitude Determination Error	0.030
Attitude Control Error	0.030
Total	0.044
Spec	0.200

Miniature Star Tracker
(photo with baffle deployed)



Miniature Reaction Wheels



Potential Communication Demo between AC7 and AC9

- Input Assumptions:
 - 10 Watts in a 0.1 degree beam full width
 - 2000 km range
 - 2.5 cm receive aperture
- Anticipate near Gbit rate

