MARITIME ATMOSPHERIC CHARACTERIZATION SYSTEM (MACS) AEROSOL TRANSMISSION MEASUREMENT (ATM) LIDAR

G.G. Gimmestad, T.A. Craney, M.M. Hosain, R.K. James,
N.D. Meraz, J.M. Stewart, C.R. Valenta, and J.W. Wood
Georgia Tech Research Institute
Atlanta, GA

Stephen Hammel and Terry Robinson
SPAWAR Systems Center – Pacific
San Diego, CA

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Problem Statement

- **T&E Need**
  - Navy HEL system testing is conducted on ground and at sea, but atmospheric characterization capability is inadequate
  - An environmentally-hardened shipboard aerosol profiling lidar is required for HEL tests conducted at sea
- **S&T Challenges**
  - Construct a portable aerosol lidar capable of
    - Long-term operation on the deck of a ship
    - Operation on a land-based test range
  - Meet required Navy certifications

MACS ATM is an outgrowth of IACS ATM; see last talk in Session C4.

Project Description

USS Paul F. Foster
Self Defense Test Ship

Cobham Mount

- **Goal: develop a rugged aerosol lidar capable of long-term operation in maritime and land-based test range environments**
- **Applications:**
  - Support land & sea-based Solid State Laser tests
  - Support other HEL and EO system tests
  - Develop maritime & test range optical climatology

Project Specifications

Parameter	Specifications			
	Current T&E Capability	Current Target	Ultimate Goal	Achieved
Aerosol optical depth (τ) accuracy	0.01 (from handheld MicroTOPS sun photometer)	$\pm$ 4% ($T \approx 1 - \tau$) Note 1	$\pm$ 2%	
Slant Range During Daytime	Total column only	0.1 km minimum 2 km maximum	0.1 km minimum 10 km maximum	
Slant Path Angle	Limited to path from sun photometer to sun	-5° to +90° in elevation, 90° in azimuth	-5° to +90° in elevation, 90° in azimuth	
Range Resolution	Total column only	100 m	50 m	
Measurement Rate	~0.1 Hz toward sun only	Eight Az-El combos in 10 min, 1 min per profile	Eight Az-El combos in 5 min, 30 sec per profile	

- Note 1: Based on IACS requirements analysis using Westerman and Mehta, "Atmospheric Characterization Issues for High Energy Laser Propagation through the Atmosphere," SPIE Proc. 1221, pp 294-304, 1990.

Project Schedule

Phase	2012		2013				2014				2015				2016			
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1st Phase: Simulation and Design																		
2nd Phase: Construction and Testing																		
3rd Phase: Integration																		
4th Phase: Deployment and Training																		

First Phase Overview

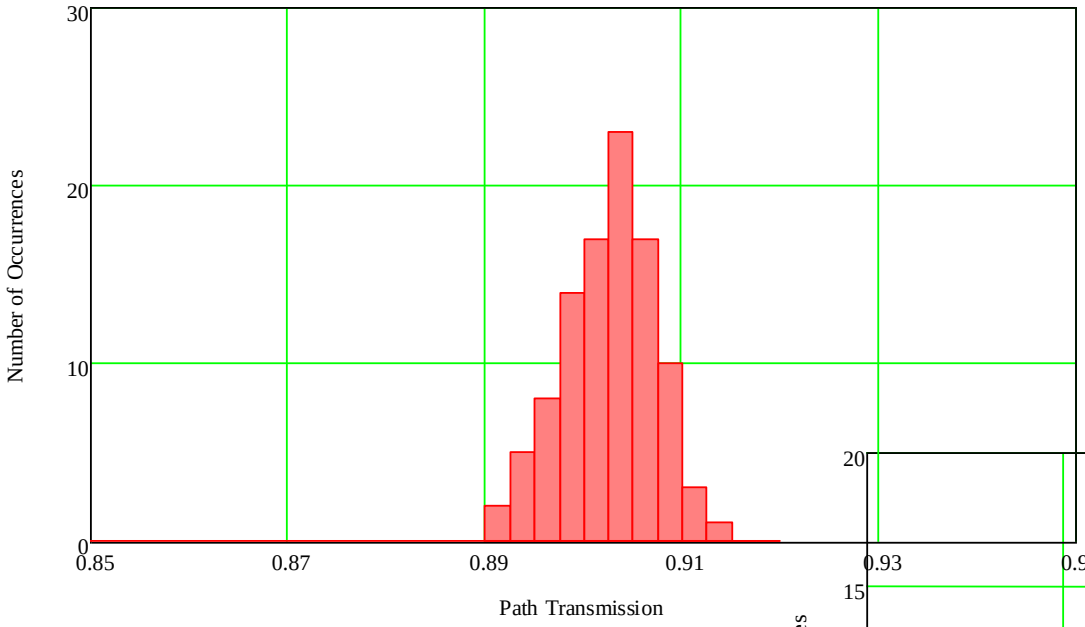
- **Requirements Definition**
- **Performance Simulation**
- **Risk Reduction Testing**
- **Optical/Mechanical/Electronic/Software Design**
- **Preliminary Design Review**
- **Deliverables:**
  - Monthly Reports
  - Phase Final Report
  - Presentation Materials (as required)
  - Project Execution Plan (as required)
  - MACS Requirements Document
  - PDR presentation materials

Second Phase Overview

- Address problems identified at PDR
- Complete drawings for custom components
- Hold Critical Design Review
- Purchase COTS components
- Fabricate optics, mechanics, electronics
- Mount change from CTM to Cobham
- Develop software
- Test lidar in laboratory
- Build Remote Operators Station
- Integrate and test lidar, HPASS, and operators station
- Deliver to Cobham for integration with mount

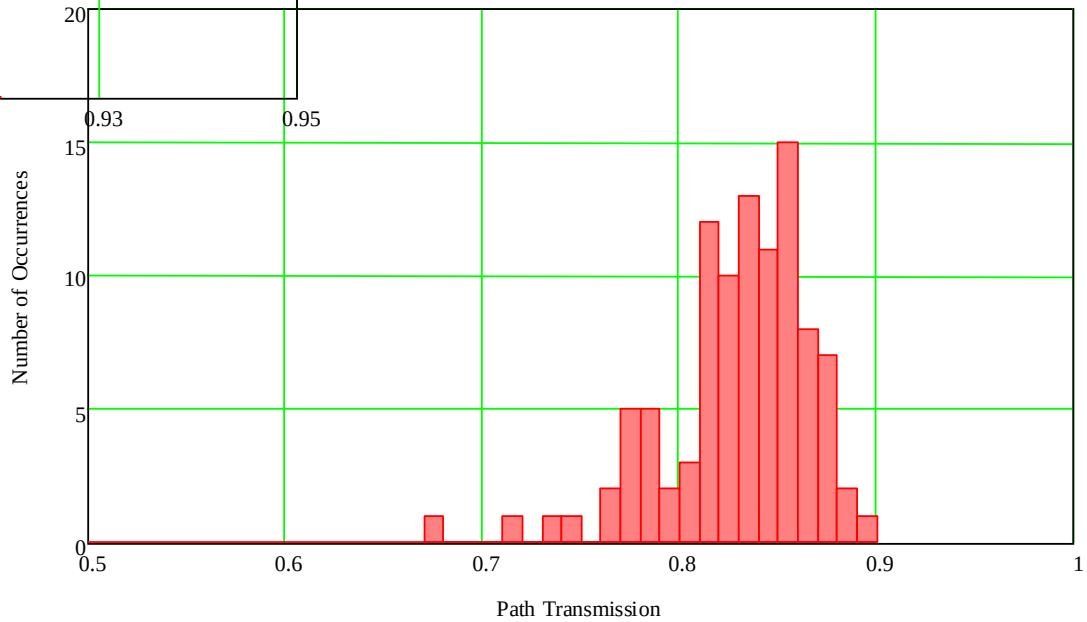
Simulation Results

Klett Retrieval, Vertical Path, Coastal Model

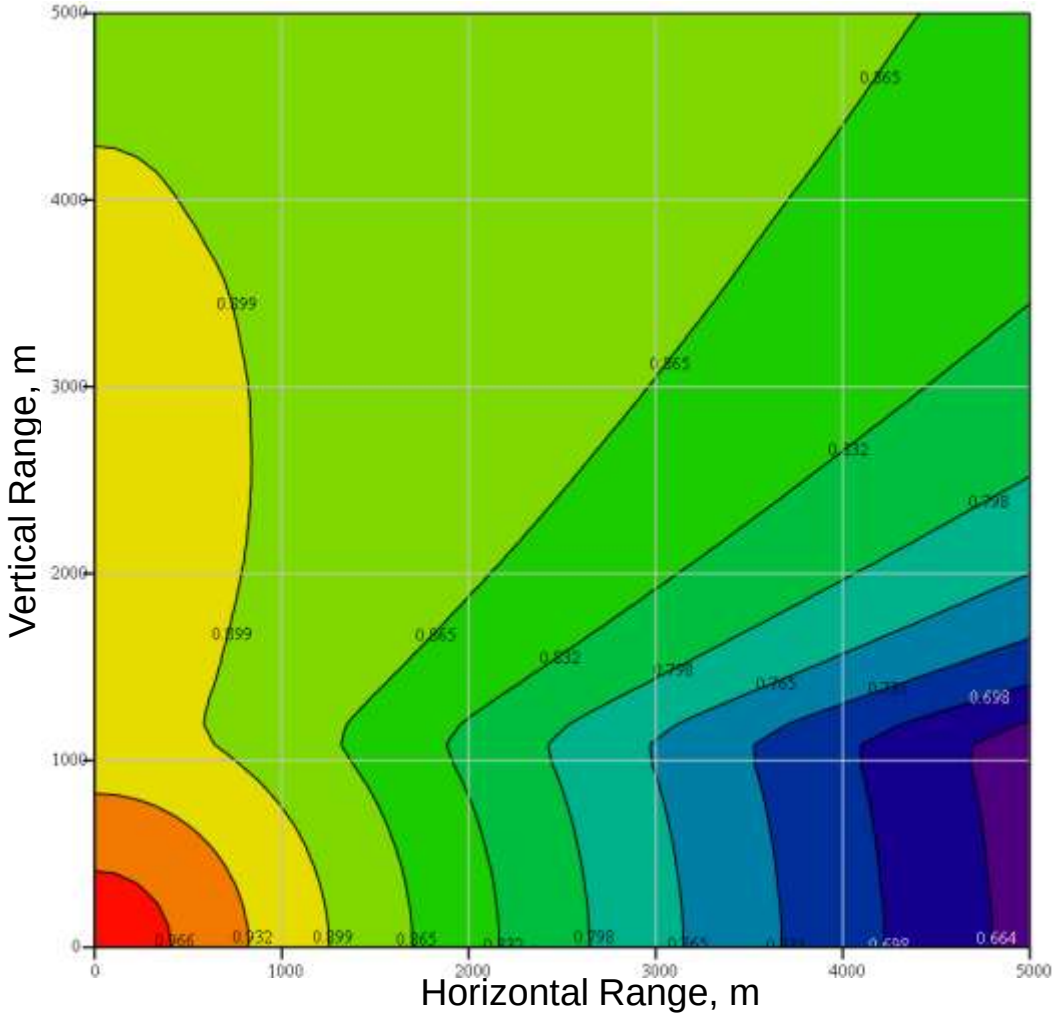


5 km path, 60 seconds

5 km path, 8 seconds

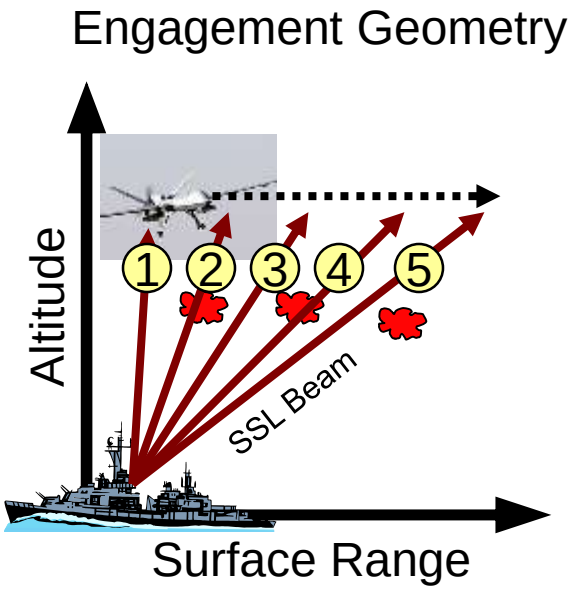


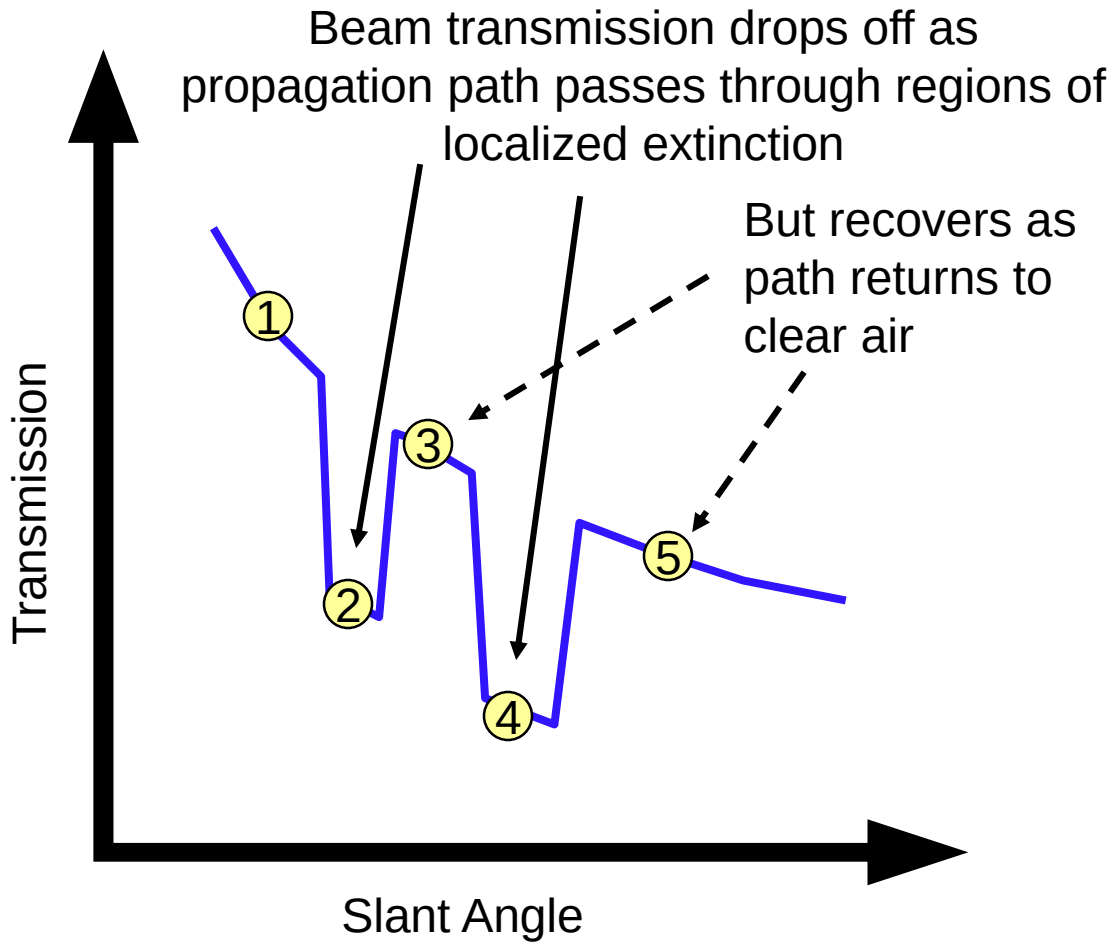
Simulated Data Product:
Transmission versus Angle



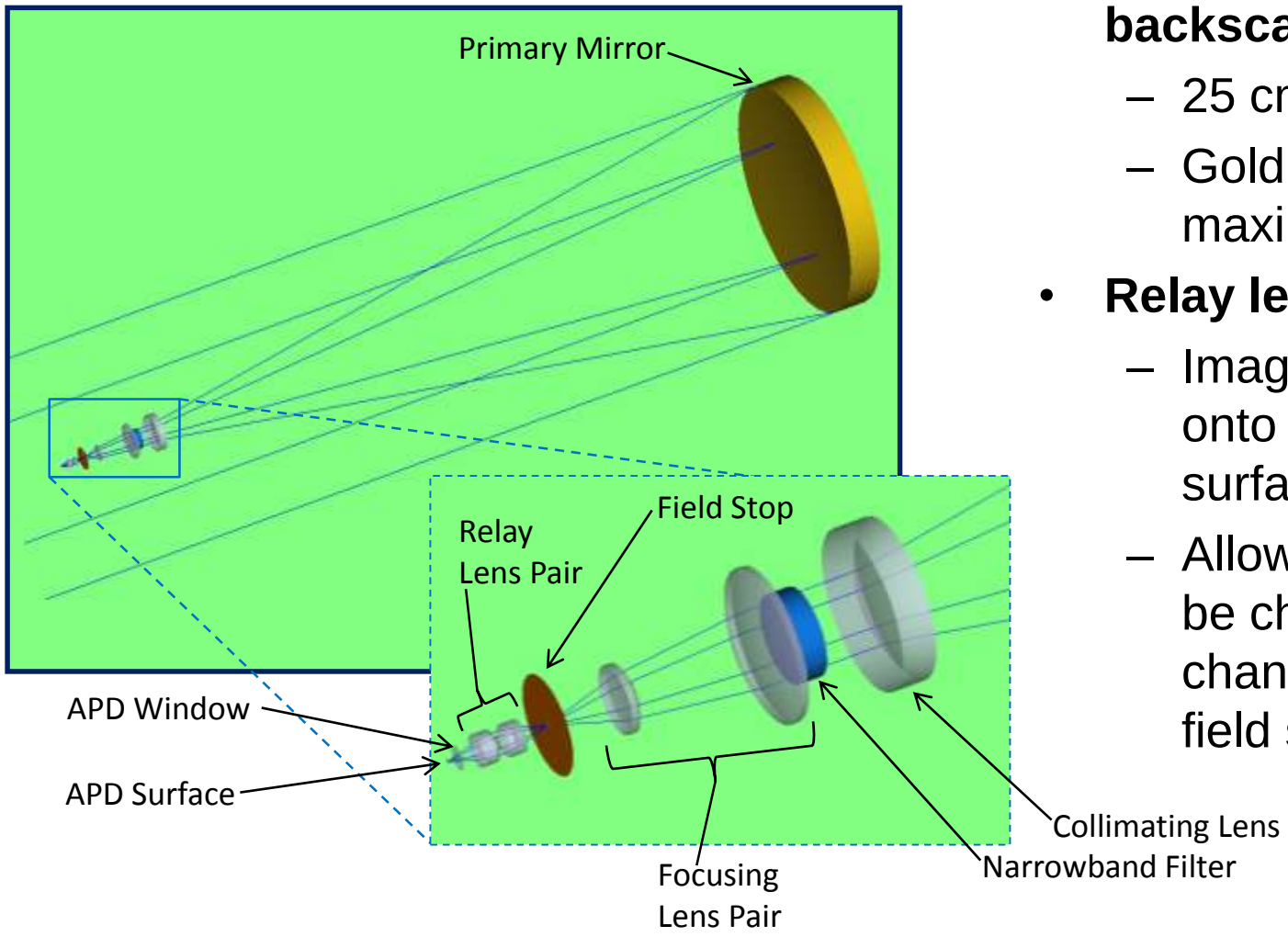
- **Contour map showing slant path transmission in vertical plane**
- **Generated from single vertical profile using Klett algorithm**
- **60 second signal average**
- **Assumes horizontal homogeneity**

MACS ATM provides crucial range specific detail



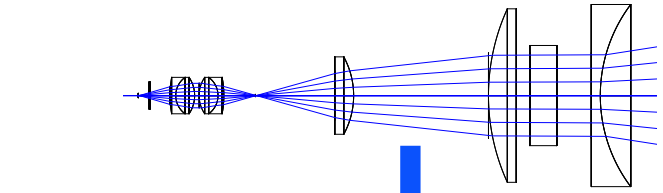


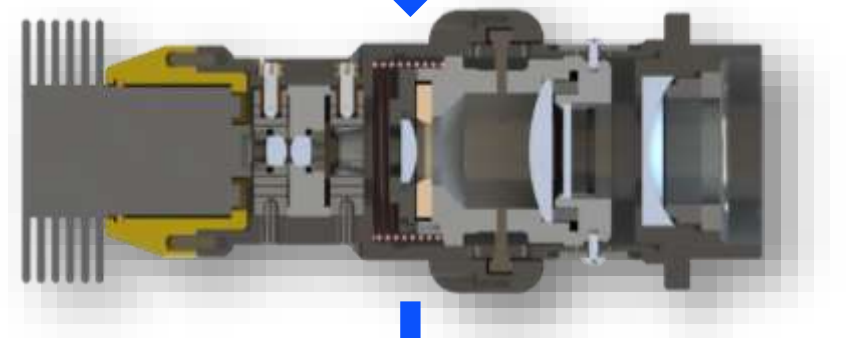
Optical Design: Long Range Receiver



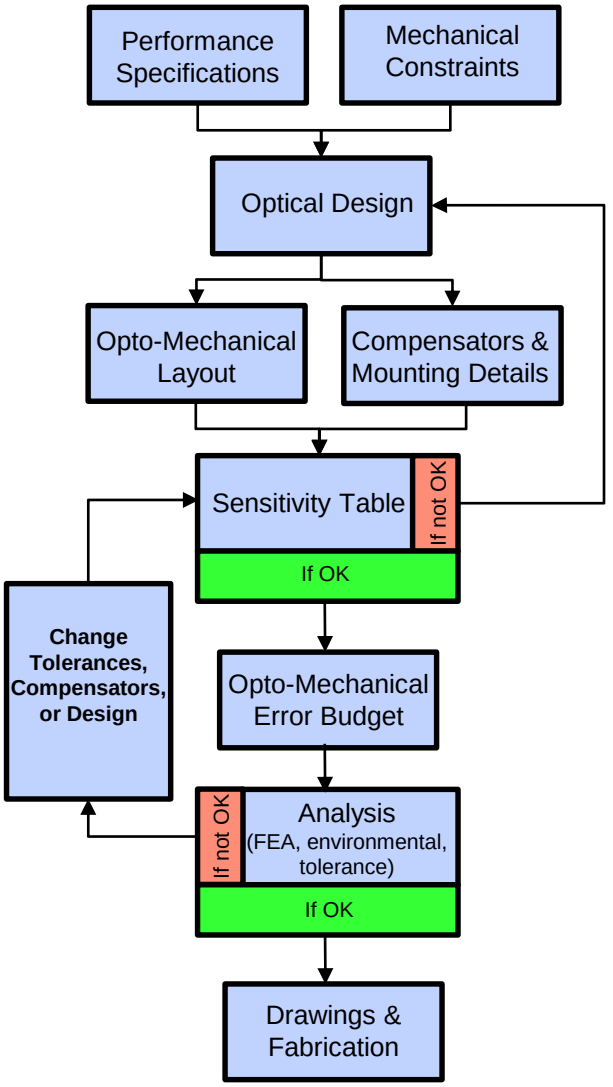
- **Spherical mirror collects backscattered light**
  - 25 cm diameter
  - Gold coated for maximum reflectivity
- **Relay lens pair**
  - Images the field stop onto the APD detector surface
  - Allows field-of-view to be changed by changing diameter of field stop

Optical-Mechanical Workflow

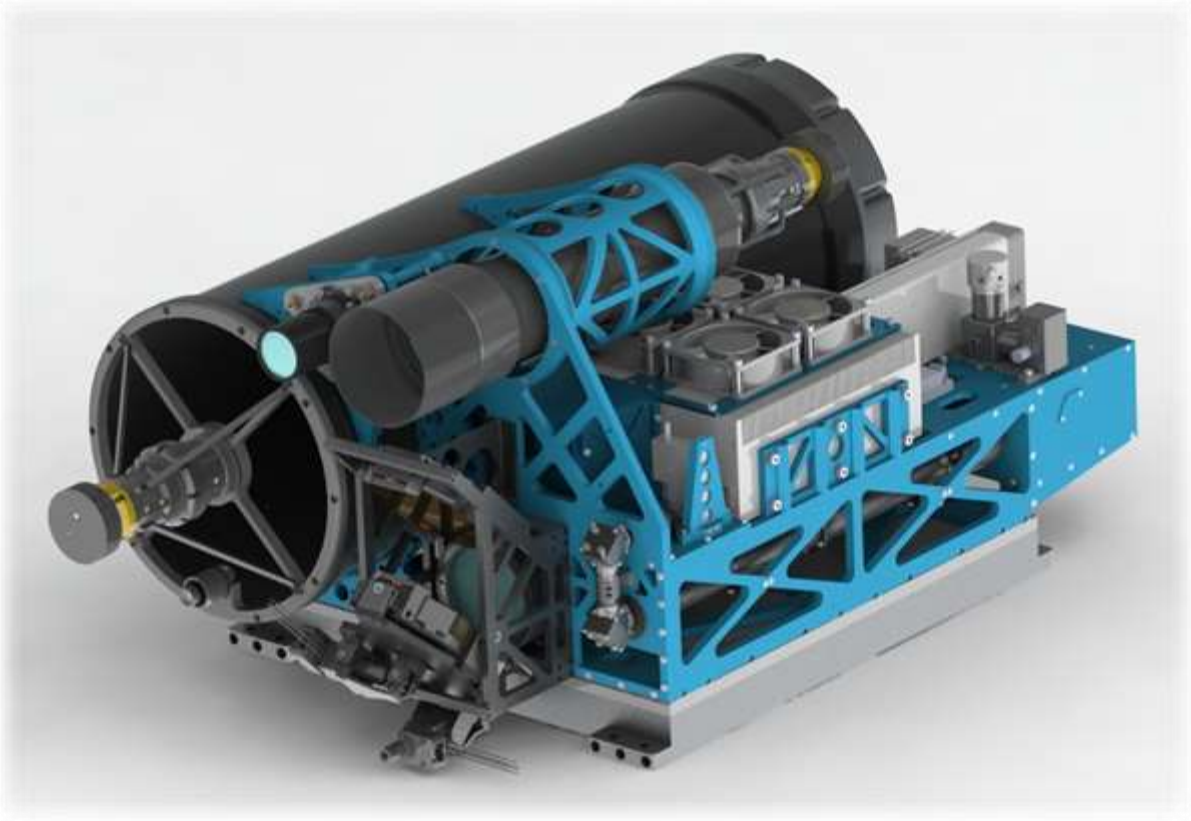




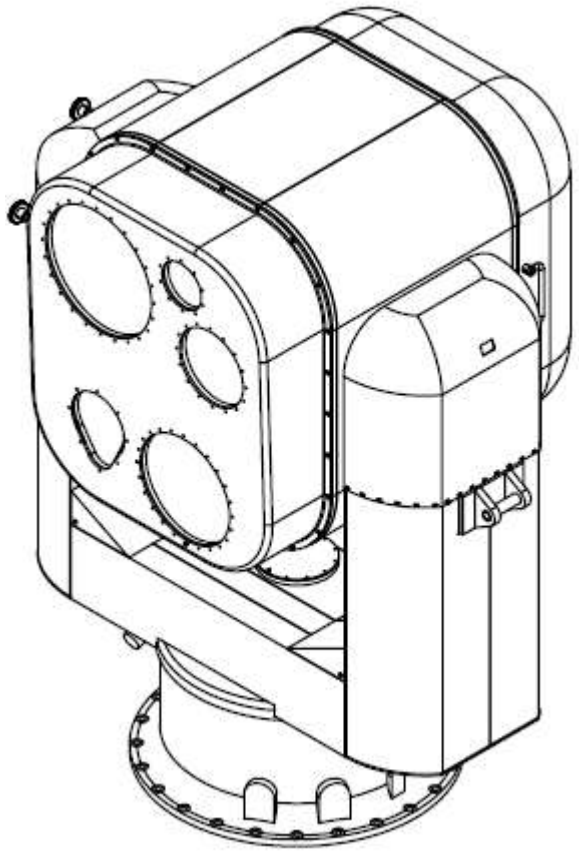
Opto-Mechanical Workflow



Mechanical Design



Optics Assembly

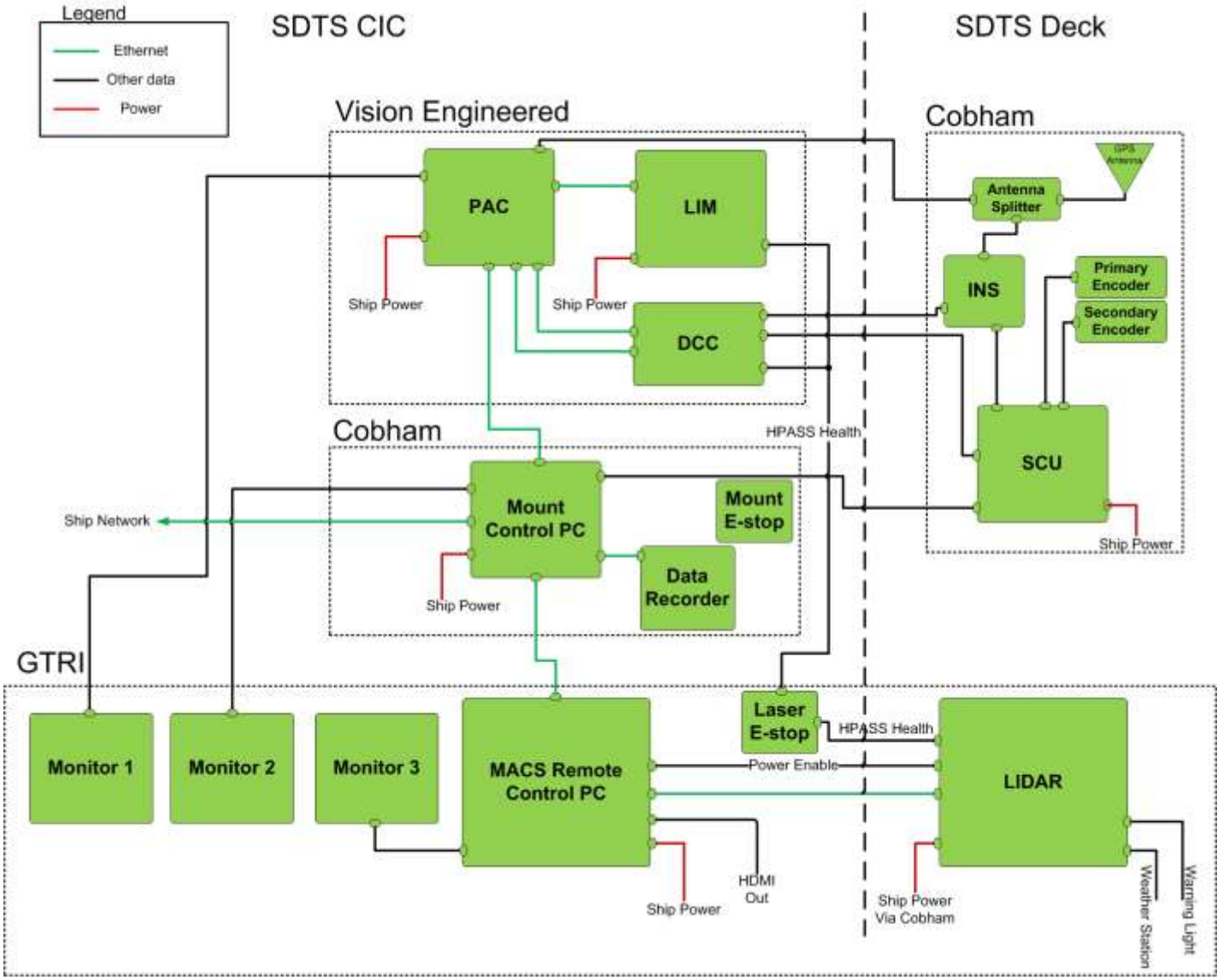


Cobham Stabilized Mount

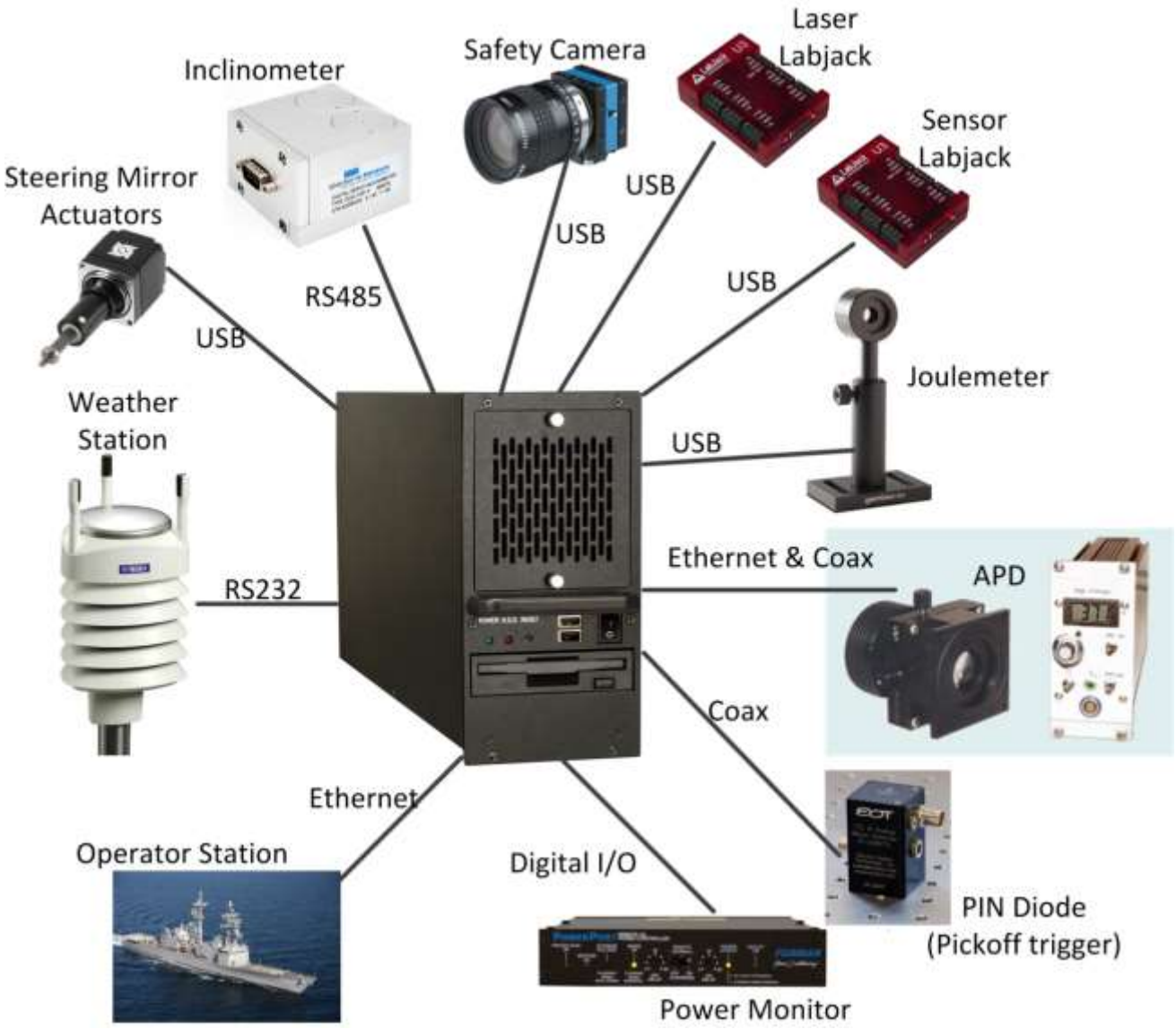
Opto-Mechanical Assembly

Opto-mechanical engineers with the long- and short-range receiver telescopes, under a roof hatch.

System Interfaces



MACS Electronics
Lidar Head



Way forward for Atmospheric Profiling

- **Current Navy on-path transmissometer systems are:**
  - Dual-ended
  - Require cooperative target
  - Cannot provide on-call assessments
  - Will not provide basis for a local climatology

- Solution: develop MACS
  - MACS can provide long-term climatology, either at land-based test site or installed on test ship
  - **Provides range-specific extinction predictions**
  - Critical for assessing all slant-path scenarios
    - maritime near surface extinction is height dependent
    - Top of boundary layer can exhibit a high-extinction layer

Conclusions

- **The MACS ATM project is developing a rugged aerosol lidar capable of long-term operation in maritime and land-based test range environments**
  - The lidar is an evolution of the IACS ATM lidar system
- **Re-design near completion, optical construction nearly complete**
  - Lidar delivery (for mount integration) scheduled for November 2015
- **Pending issues**
  - Subcontractor interfaces remain a challenge

Acknowledgement & Disclaimer

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