Multi-Slit Optimized Spectrometer ESTO IIP

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Co-I: Curt Davis – Oregon State University

Agility to Innovate, Strength to Deliver

OSU
Oregon State
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Ball Aerospace
& Technologies Corp.

1. **NASA ESTO quad chart**
2. **Concept review**
3. **Program**
4. **Developments and status**
5. **Data validation Plan**

MOS Team

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Multi-Slit Optimized Spectrometer (MOS)

PI: Timothy Valle, Ball Aerospace and Technologies Corp.
Co-I: Curtiss Davis, Oregon State University

Objective

- Design and develop a significantly smaller Coastal Imaging spectrometer that meets GEO-CAPE measurement requirements
  - Develop a MOS for geostationary (GEO) coastal remote sensing and test it in an operational environment
  - Develop a MOS, that can accomplish the ocean color mission with a small package, fast revisit time, and high SNR by producing hyperspectral images at multiple positions simultaneously

- Dramatically reduces payload size and mission risk
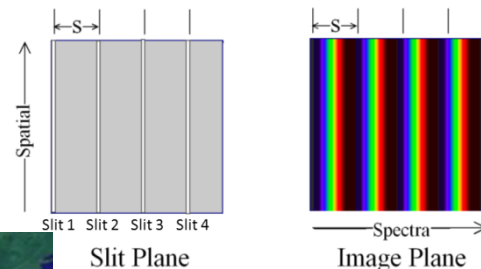
- 4 simultaneously operating imaging spectrometers

Approach

- Conduct trade study to analyze the design parameters of the MOS for geostationary coastal remote sensing
- Perform opto-mechanical and thermal design
- Characterize the performance in a thermal vacuum environment before and after vibration test
- Show traceability from the measured performance to the GEO-CAPE Event Imager mission

Key Milestones

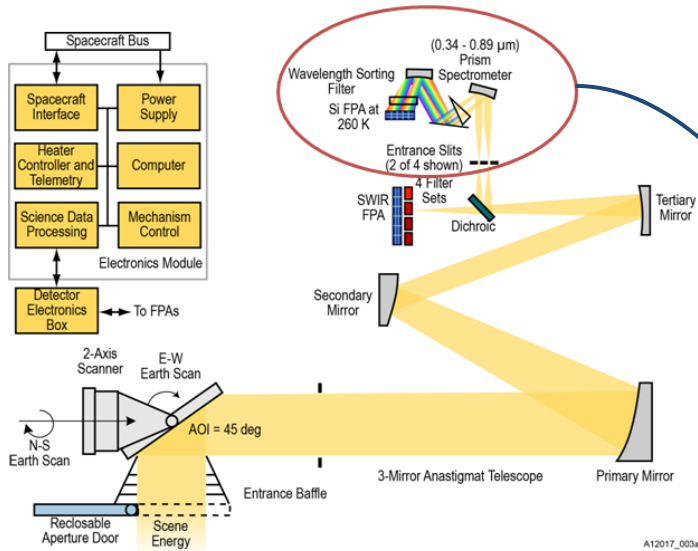|	
✓Complete conceptual design	12/11
✓Conclude detailed design	07/12
✓Complete relay optics	04/13
✓Perform FPA/filter testing	05/13
• Complete spectrometer assembly	07/13
• Complete system test	11/13
• Conclude post-vibration system test	02/14
• Document mission suitability studies	04/14

TRL$_{in}$ = 3   TRL$_{current}$ = 3

Earth Science Technology Office

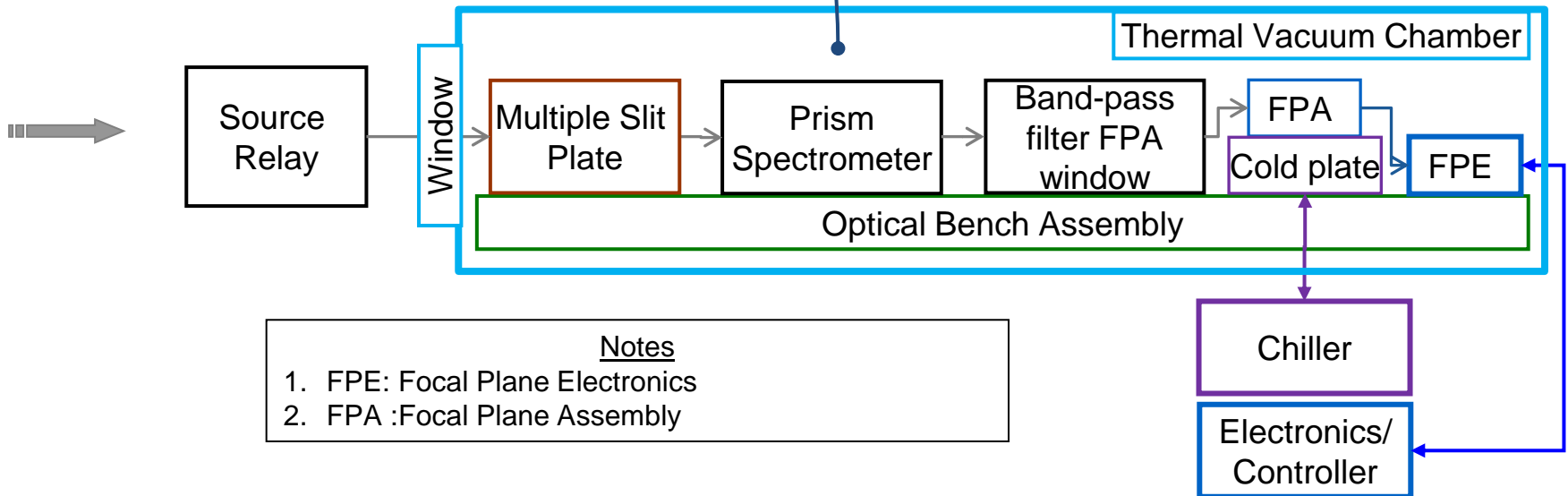• **NASA Common Instrument Interface Project: Hosted Payload Guidelines   Rev-A**
"The instrument should be less than or equal to 150 kg."

Feature	Benefit
Spectrum from multiple slits recorded simultaneously on area focal plane array	Geo application with fixed coverage time, able to reduce the time to cover the full field of interest at required SNR → Aperture reduction (F/#) → Mass reduction

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Spacecraft Bus

Spacecraft Interface | Power Supply
Heater Controller and Telemetry | Computer
Science Data Processing | Mechanism Control

Electronics Module

Detector Electronics Box → To FPAs

2-Axis Scanner | E-W Earth Scan

N-S Earth Scan

AOI = 45 deg

Reclosable Aperture Door | Scene Energy

Entrance Baffle

3-Mirror Anastigmat Telescope | Primary Mirror

Secondary Mirror

Tertiary Mirror

(0.34 - 0.89 µm) Prism Spectrometer

Wavelength Sorting Filter

Si FPA at 260 K

Entrance Slits (2 of 4 shown)

SWIR FPA

4 Filter Sets

Dichroic

A12017_003a

- **GEO-CAPE Oceans STM guides spectrometer requirements**
- **Event Imager schematic (left)**
- **MOS IIP block diagram (below)**

Thermal Vacuum Chamber

Source Relay → Window → Multiple Slit Plate → Prism Spectrometer → Band-pass filter FPA window → FPA

Cold plate → FPE

Optical Bench Assembly

Chiller

Electronics/ Controller
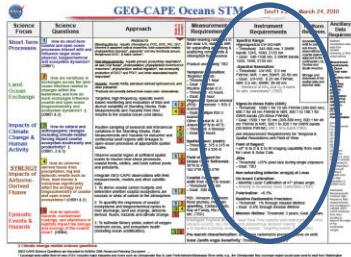
Notes
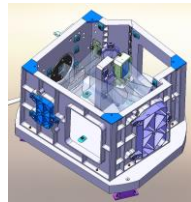1. FPE: Focal Plane Electronics
2. FPA :Focal Plane Assembly

MOS IIP at entry TRL 3

NASA Technology Readiness Level 6
Relevant operational environment (TVAC & Vibe) tests complete demonstrating performance matching analytical predictions
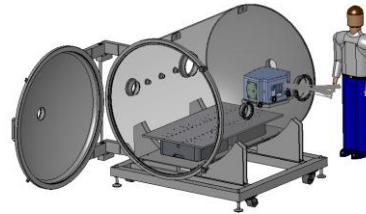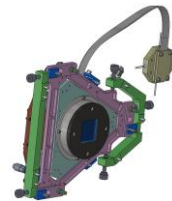
Requirements & Trades

Design, fabricate & plan tests

Focal plane array

Assembly Integration & Test
T-Vac, vibe, T-Vac

Coastal Water Impact Studies: spectral sampling out-of-band SNR

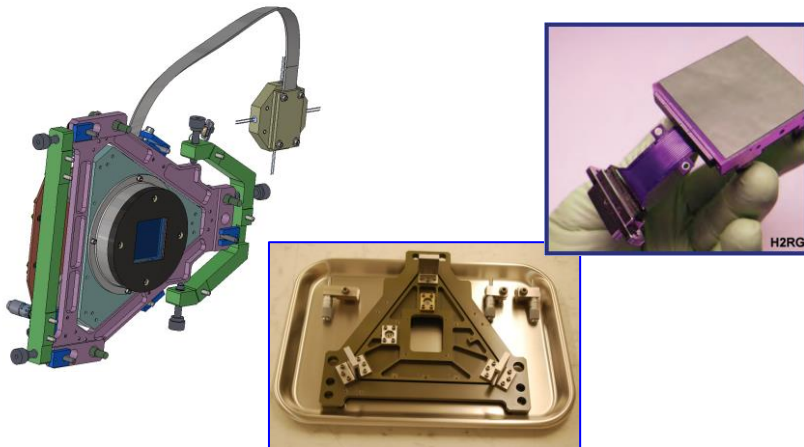Mission Suitability Validation

3 year program
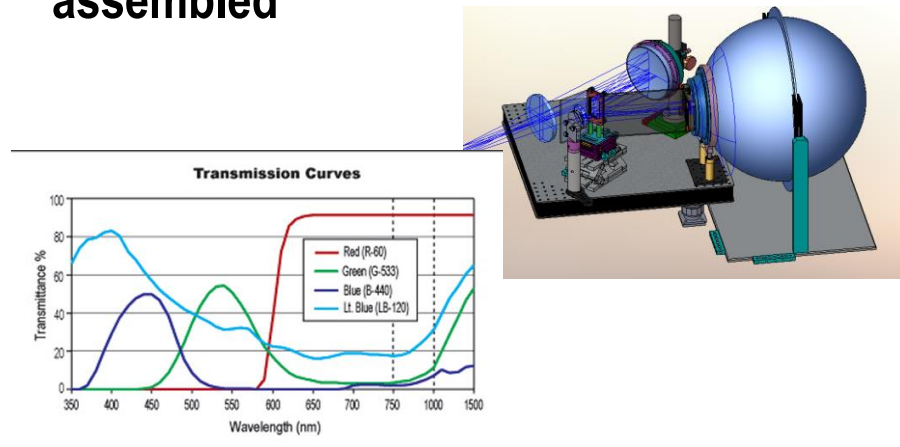
- **Mirrors tested, structure near completion**

- **Thermal vacuum chamber equipment ready for use**
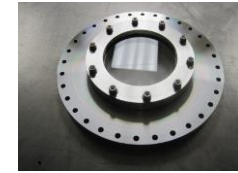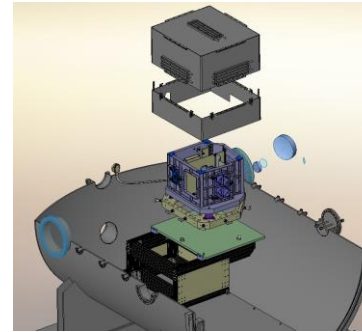
- **FPA packaged tested**

- **Test concept developed & hardware assembled**

Focal plane assembly
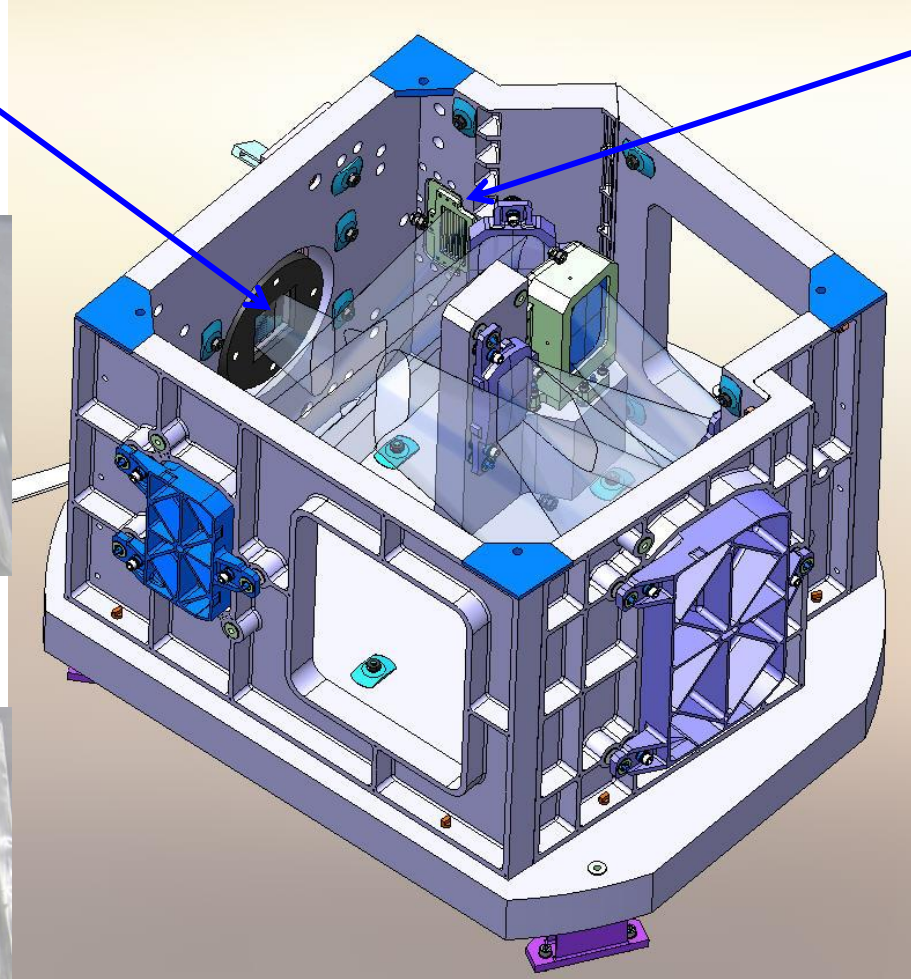
Slit assembly

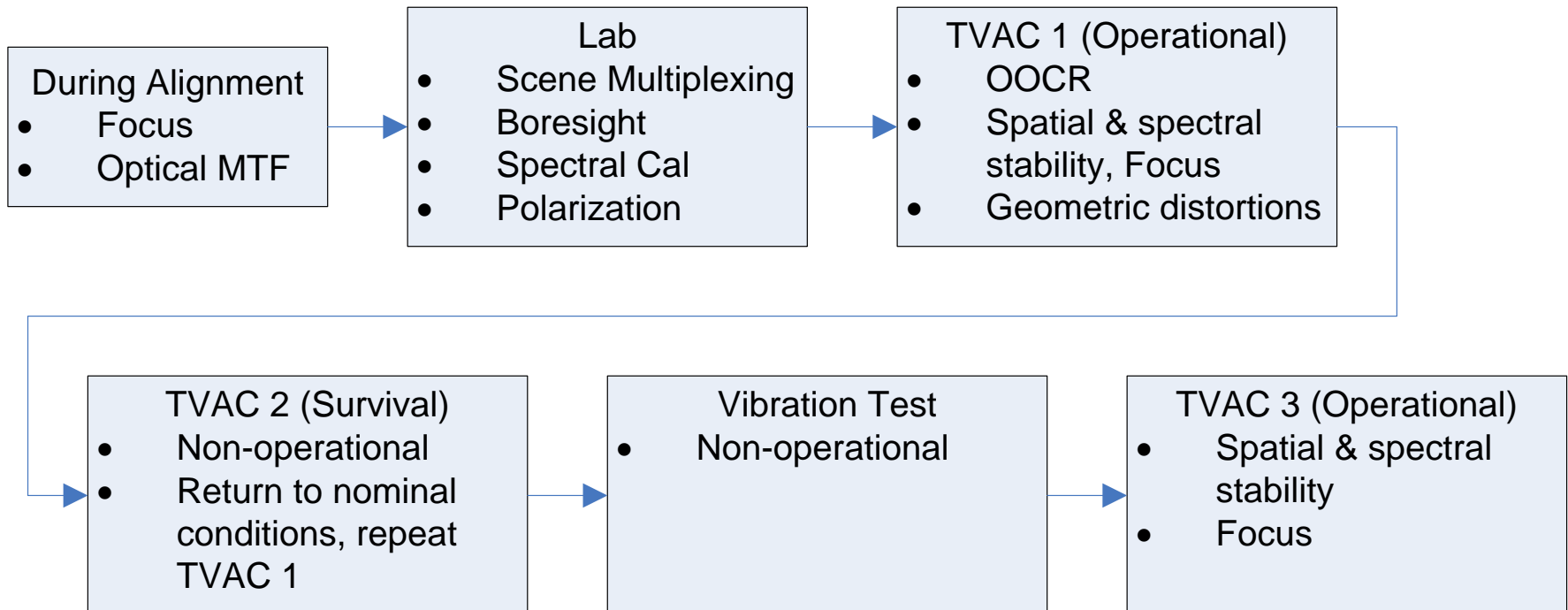| Parameter	Requirement (µm)	Prediction (µm)
Spatial Stability	<5.5	2.0
Spectral Stability	<1.4	0.14
Defocus	<34	6
Keystone	<8	0
Smile	<27	0.4

Keystone & smile below measurement uncertainty

- Out of channel response (OOCR) is the critical test to validate the MOS concept
- Simulated scenes (multiplexed scenes) passed onto OSU to validate science data products
- Other tests address TRL 6

During Alignment	Lab	TVAC 1 (Operational)
• Focus • Optical MTF	• Scene Multiplexing • Boresight • Spectral Cal • Polarization	• OOCR • Spatial & spectral stability, Focus • Geometric distortions

TVAC 2 (Survival)	Vibration Test	TVAC 3 (Operational)
• Non-operational • Return to nominal conditions, repeat TVAC 1	• Non-operational	• Spatial & spectral stability • Focus

Scene Simulator

MOS Simulator

Product Generator

$$L_u = L_a + L_r + L_w$$

$$L_a(\theta,\phi,\lambda)$$

$$L_r(\theta,\phi,\lambda)$$

$$L_w(\theta,\phi,\lambda)$$

$$L_t(\theta,\phi,\lambda) \quad L_u(\theta,\phi,\lambda)$$

Graphic design from Mobley, Ocean Optics

FPA Coordinates in millimeters of "Output"

Output image of FPA from MOS Simulator
FPA Vertical Distance (x mm)

FPA Horizontial Distance (y mm)

Scene of the San Francisco Bay Area processed with the MOS Simulator
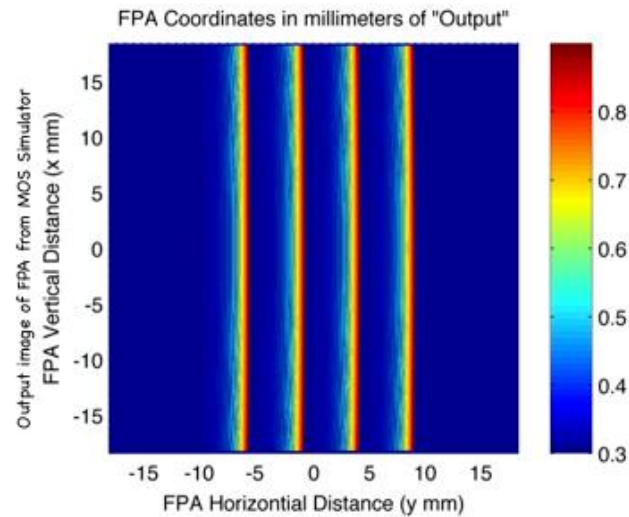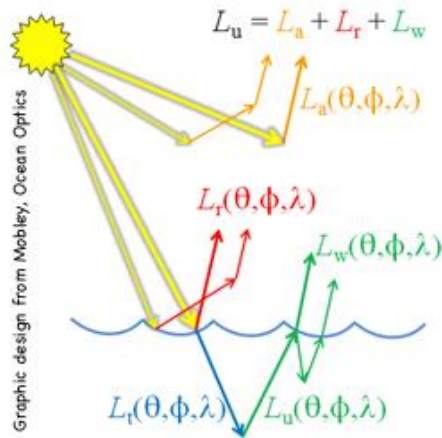
The MOS Simulator is a tool that enables:

1. Producing products at 'First Light' for MOS
2. Tracking uncertainties at all stages along imaging and product generation
3. Making informed design trade-offs using (2)
4. Creating and testing new signal correction and product methods

Thanks for your attention.

Questions