PACE Science & Application Team Meeting
Ocean Color Instrument Development Status

Eric Gorman
Chief Engineer

10/6/2021

PACE

Plankton, Aerosol, Cloud, ocean Ecosystem

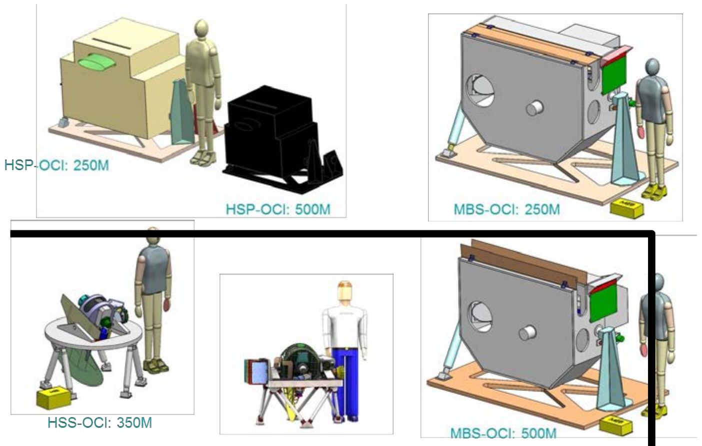
PACE Ocean Color Instrument

- hyperspectral scanning radiometer
- 340 – 890 nm, 5 nm resolution, 2.5 nm steps
- plus, 940, 1038, 1250, 1378, 1615, 2130, and 2250 nm
- 1 day global coverage
- ground pixel size of 1 km^2 at nadir
- ± 20^{o} fore/aft tilt to avoid Sun glint
- twice monthly lunar calibration
- daily on-board solar calibration
- built at NASA Goddard Space Flight Center

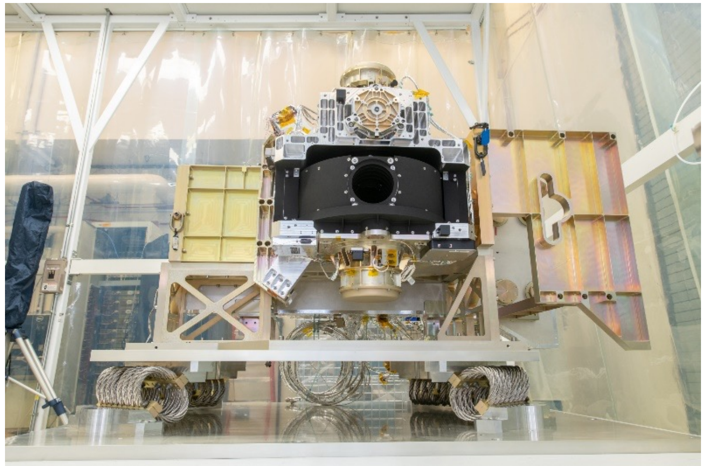
How Do You Transform Science Questions into an Operational Observatory?

Q's

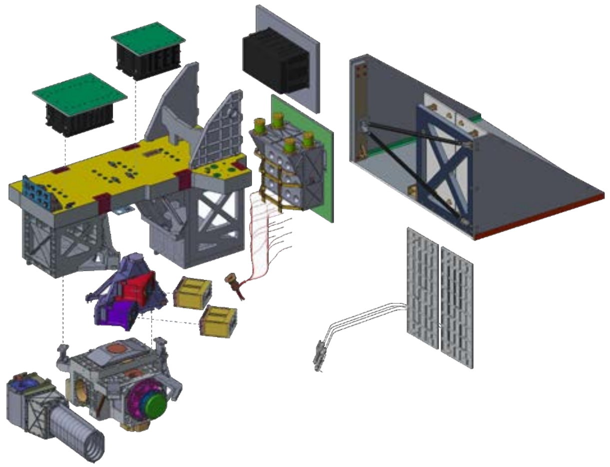
Science Questions



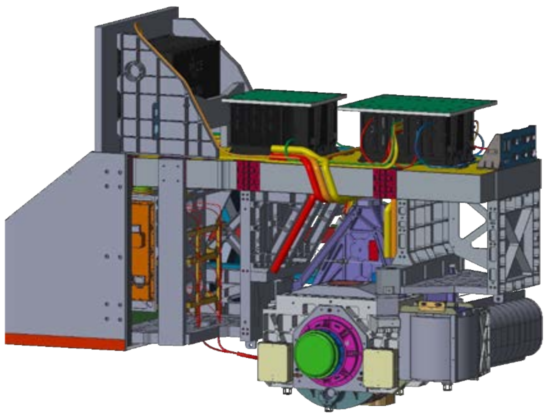
Requirements & Trades



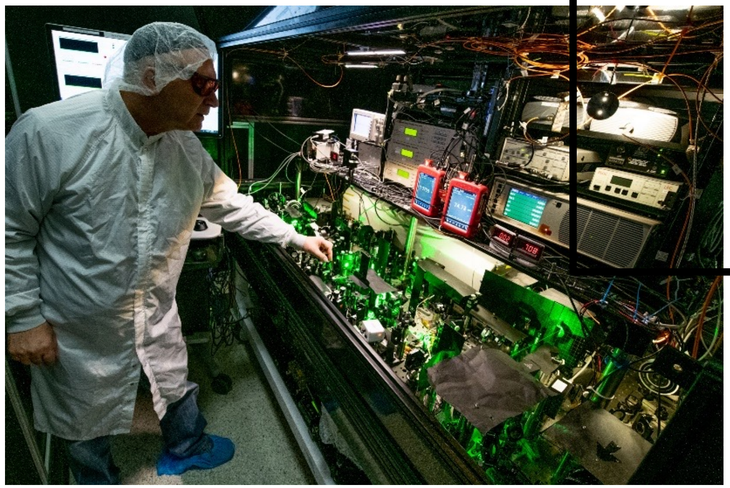
Prototype Testing



Flight Component Build



Integration & Testing



Ground Calibration

Launch

Commissioning & Operations

How Do You Transform Science Questions into an Operational Observatory?

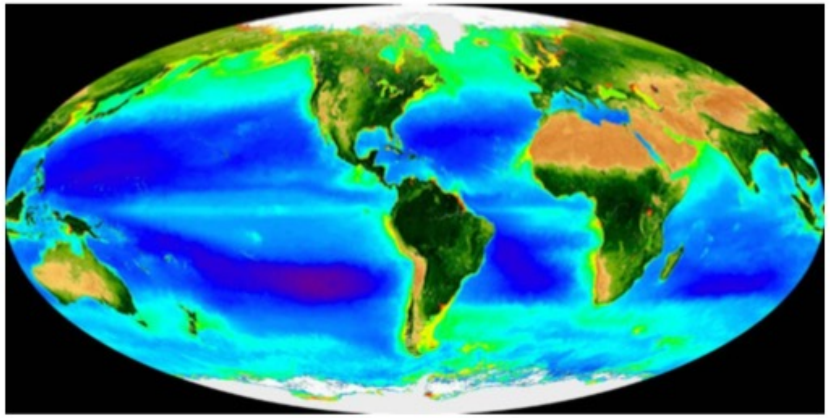
Q’s

Science Questions

Commissioning & Operations

Agree on the science questions that are worth perusing

Pre-Aerosol, Clouds, and ocean Ecosystem (PACE) Mission Science Definition Team Report



October 16, 2012

How & why are ocean biogeochemical cycles & standing stocks changing? How do they influence the Earth system?

How do physical ocean processes affect ocean ecosystems? How do ocean biological processes influence ocean physics?

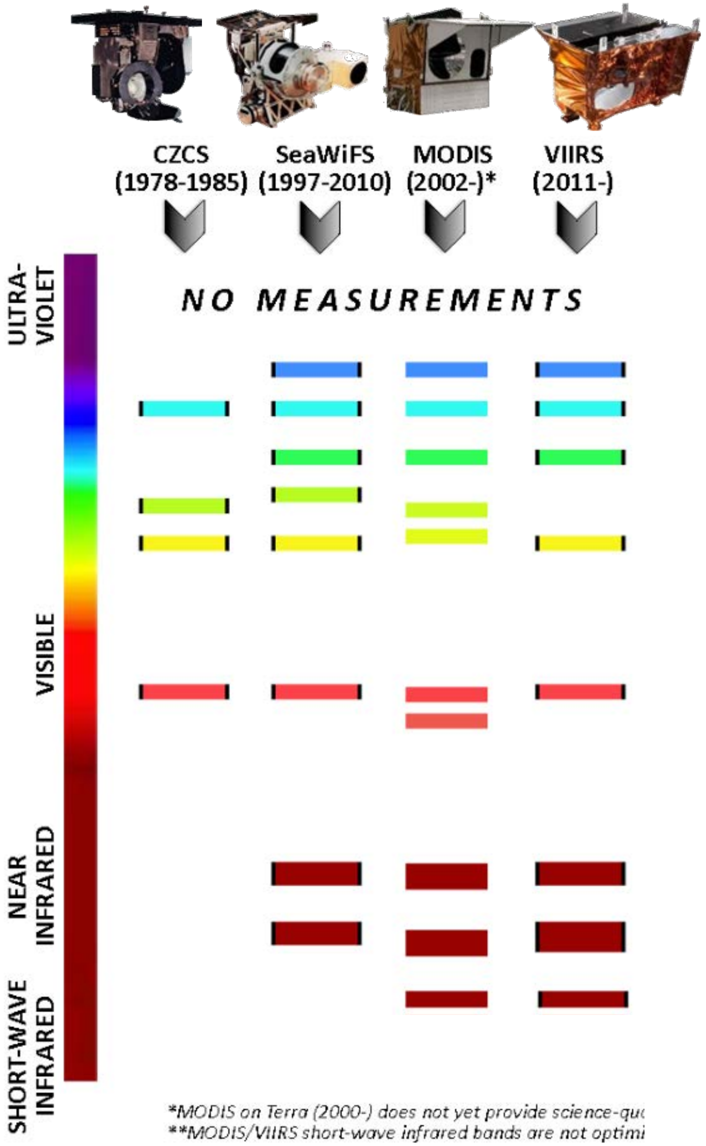
What is the distribution of both harmful & beneficial algal blooms & how is their appearance & demise related to environmental forcing?

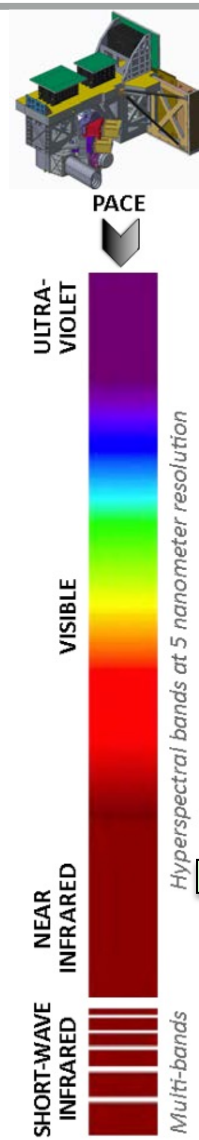
What are the long-term changes in aerosol & cloud properties & how are these properties correlated with inter-annual climate oscillations?

What are the magnitudes & trends of direct radiative forcing components?

How do aerosols influence ocean ecosystems & biogeochemical cycles? How do ocean biological & chemical processes affect the atmosphere?

Determine the measurements that are required to answer the science questions





Core ocean data products

concentration of chlorophyll-a
diffuse attenuation coefficients
phytoplankton absorption
non-algal + CDOM absorption
particulate backscattering
photosynthetic available radiation
concentration of particulate carbon

Advanced ocean data products

phytoplankton community structure & biomass
phytoplankton physiological parameters
photosynthetic pigments
primary/community production
dissolved carbon pools
particle abundances & size distributions
carbon fluxes & export
water quality & clarity

Agree on science requirements

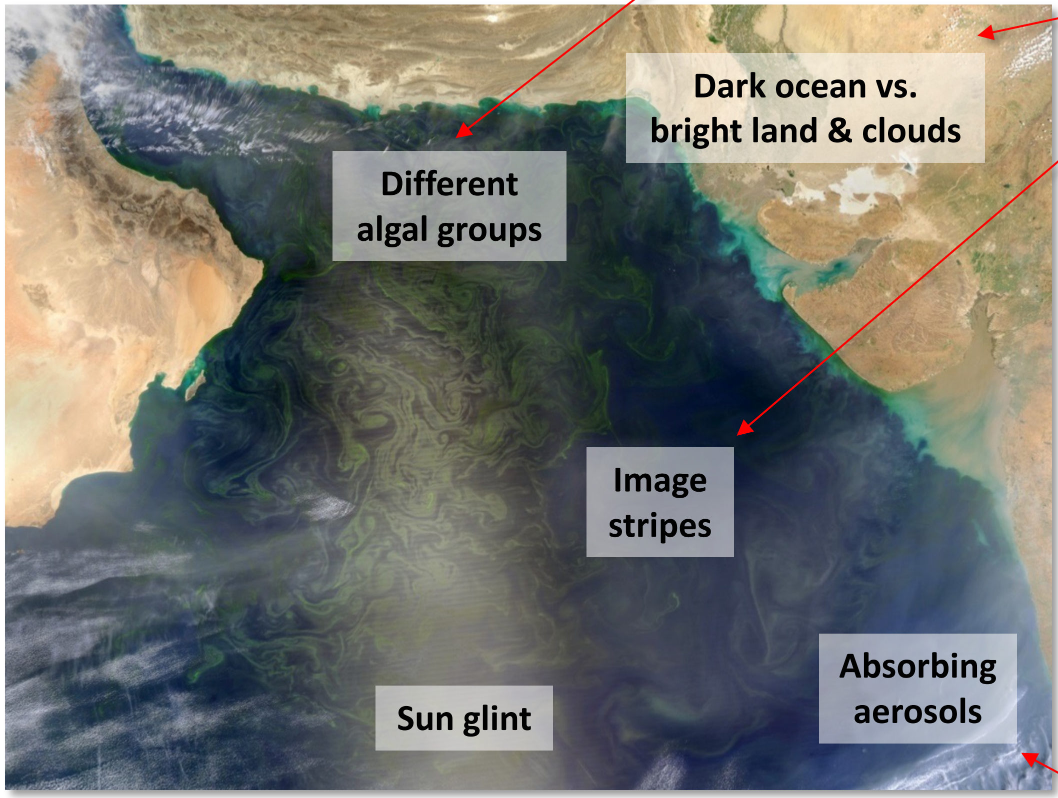
GSD of 1 ± 0.1 km^2 at nadir

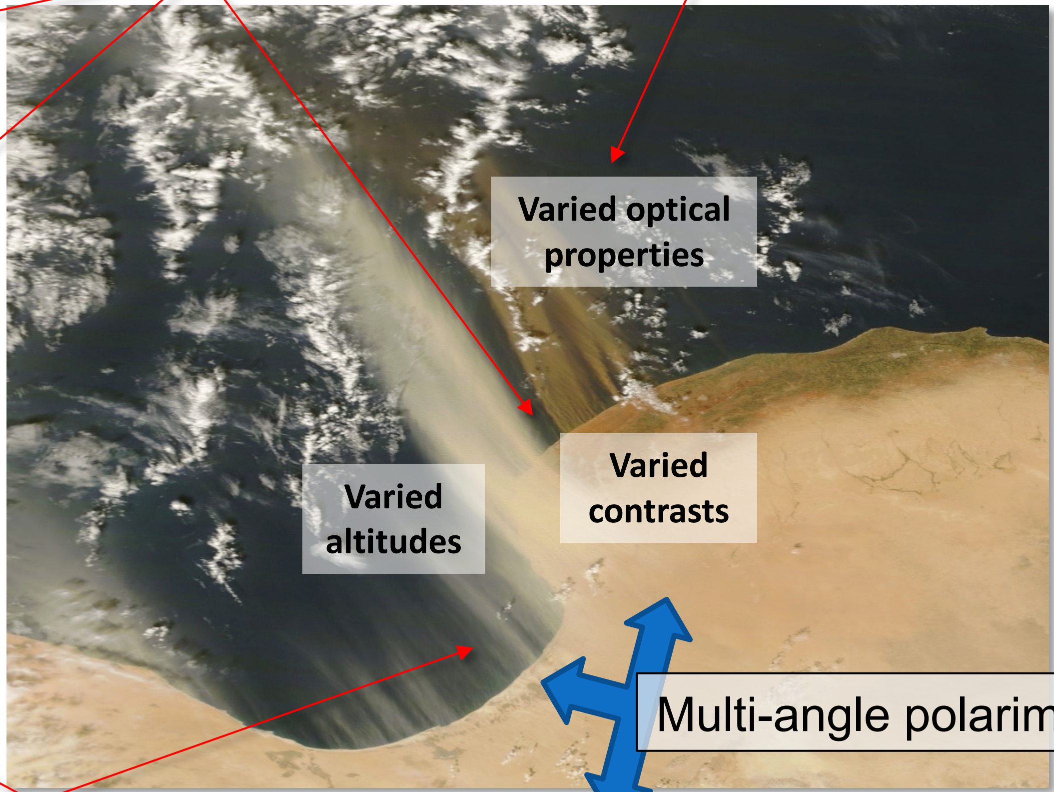
Twice-monthly lunar calibration & onboard solar calibration (daily, monthly, dim)

Spectral range from 350-865 @ 5 nm

940, 1038, 1250, 1378, 1615, 2130, 2260 nm

Instrument performance requirements





Multi-angle polarimetry

Tilt ± 20°

Spectral range goal of 320-865 @ 5 nm

Engineers and scientists leverage heritage data, instruments, and data products to agree on science requirements that will enable instruments measurements to answer mission science questions

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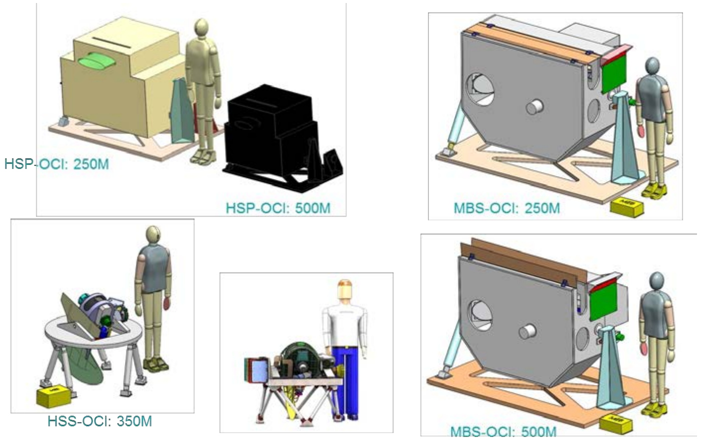
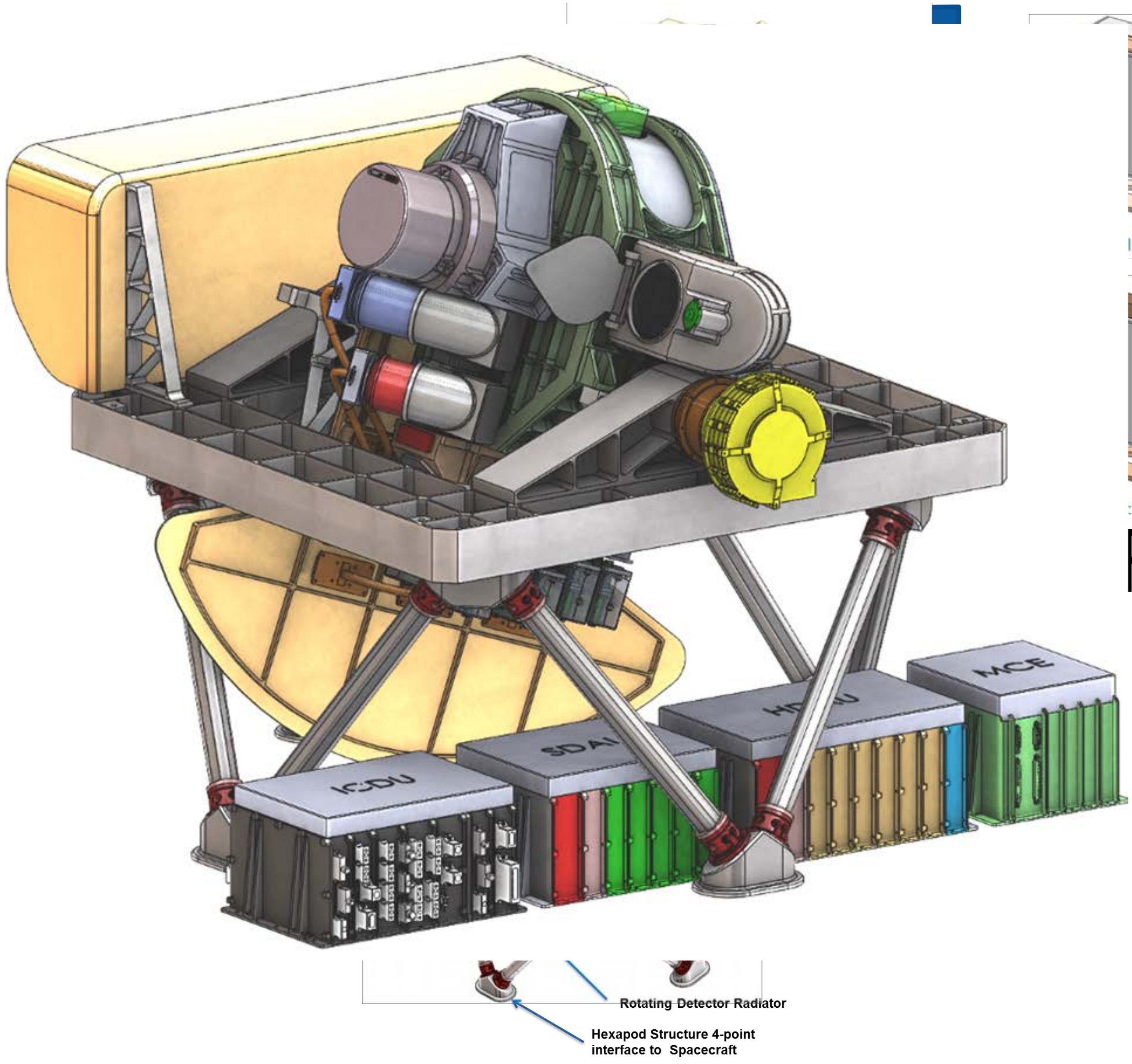
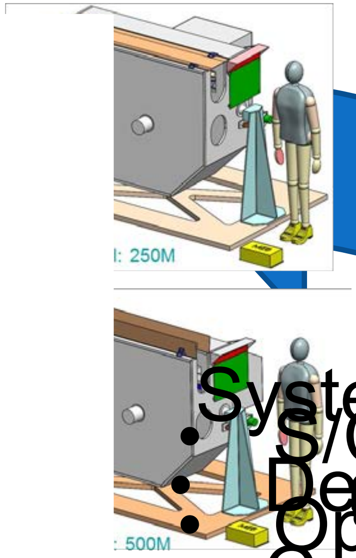


Requirements & Trades

Commissioning & Operations

Iterate engineering requirements and system design trades





Mission Concept Review

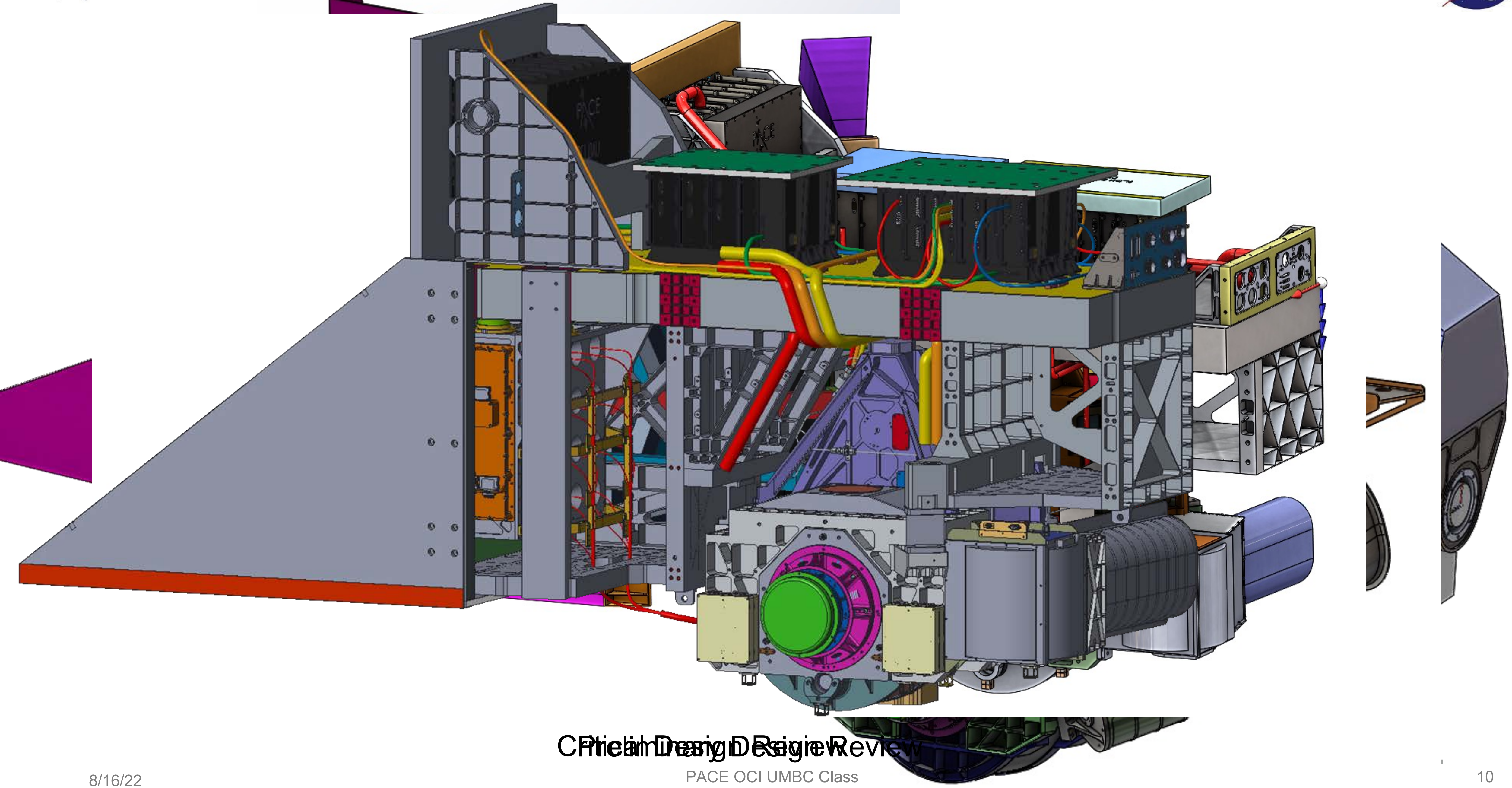
System Requirements Review

- S/C Proposal & System Trades
- S/C Location
- Launch
- Deep Dive System Trades
- Ceiling
- Optics and Mechanical Trades
- Mass
- Calibration & Noise

Requirements

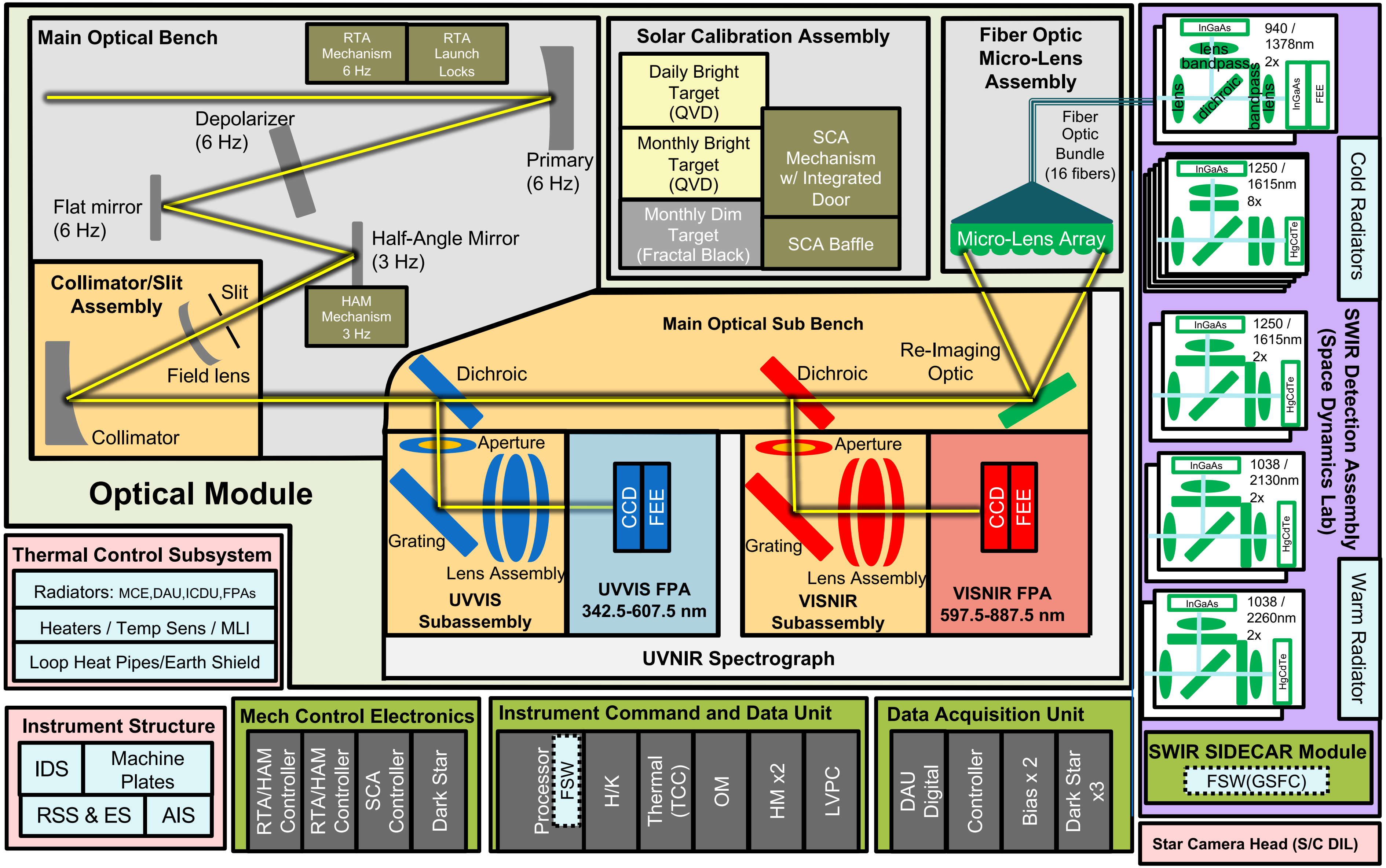
- Electronics Trades
- Power
- Tilt Trades
- Volume
- Thermal Trades
- Optics and Detector Trades

Iterate engineering requirements and system design trades



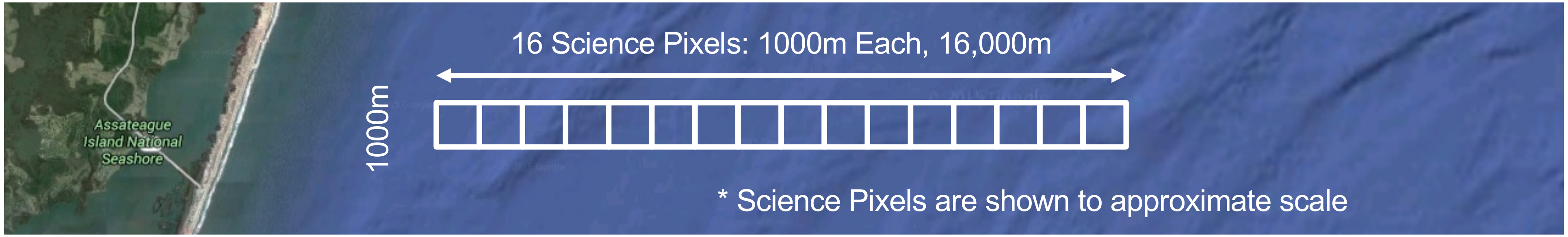
Critical Design Review
Preliminary Design Review

What is OCI & how does it work?

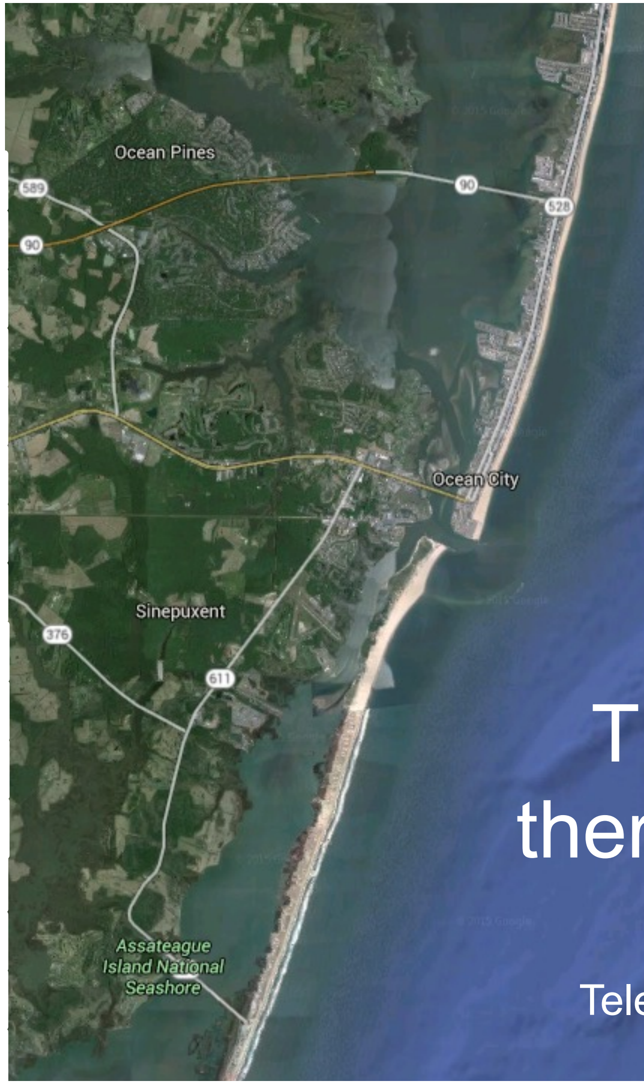


OCI Telescope Ground Coverage

- 1 Science Pixel = 1000m x 1000m at Nadir
  - Elongates at all other cross track and along track angles
- The OCI rotating telescope projects 16 science pixels at once onto a slit
  - This results in 16,000m x 1000m of instantaneous ground area imaging
- The slit image is re-imaged onto the detectors of the OCI detection system
- If you stop the telescope from rotating, OCI will only see 16 science pixels on the ground
- The rotating telescope continuously moves the 16 science pixels across the slit so that it scans across the full field of regard in the cross track direction



OCI Rotating Telescope Ground Coverage

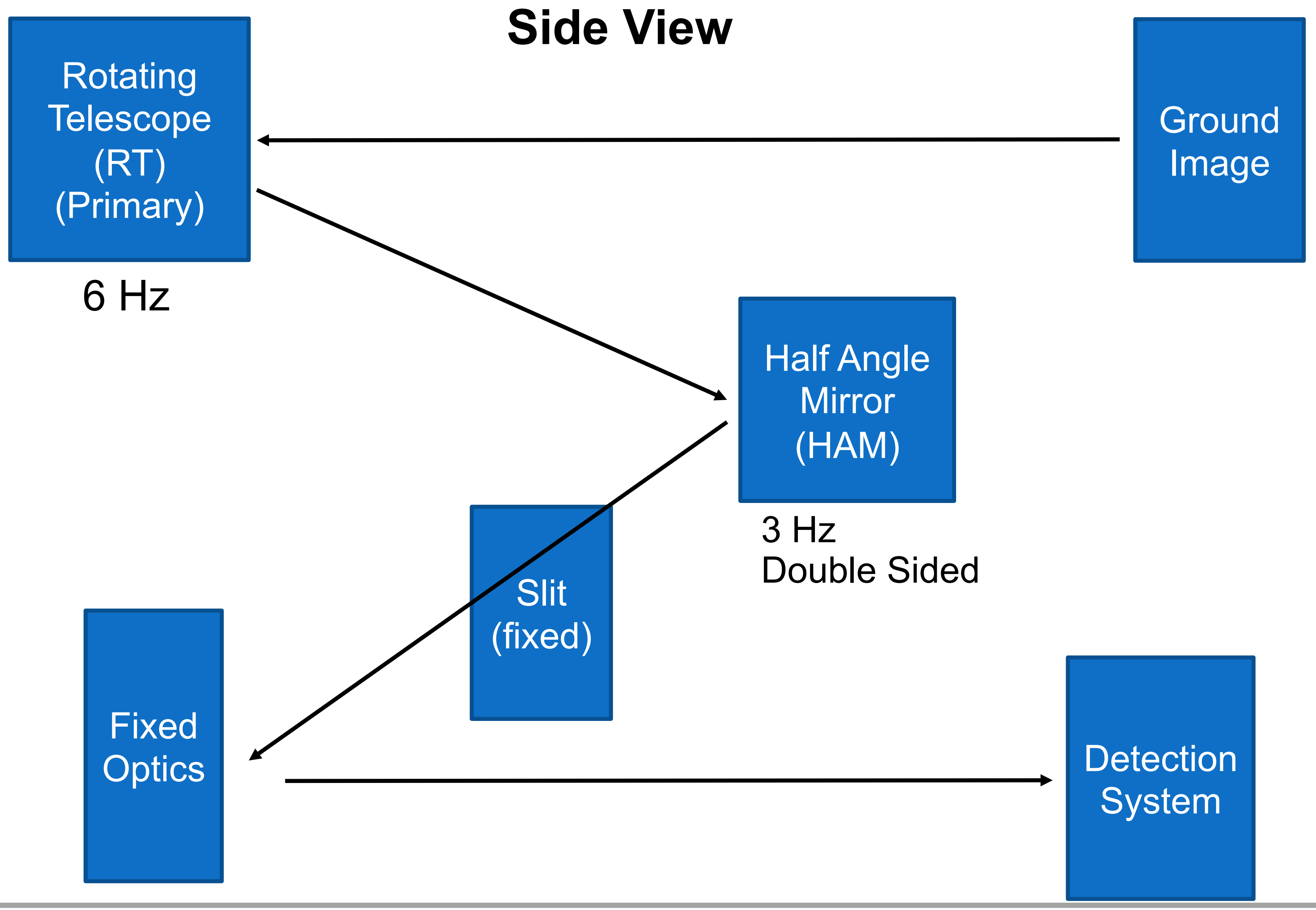


The rotating telescope continuously moves the image of the 16 science pixels in the cross track direction across a slit to cover the full field of regard. The slit is continuously reimaged onto a detector

The telescope rotates fast enough so there are no gaps in coverage per scan

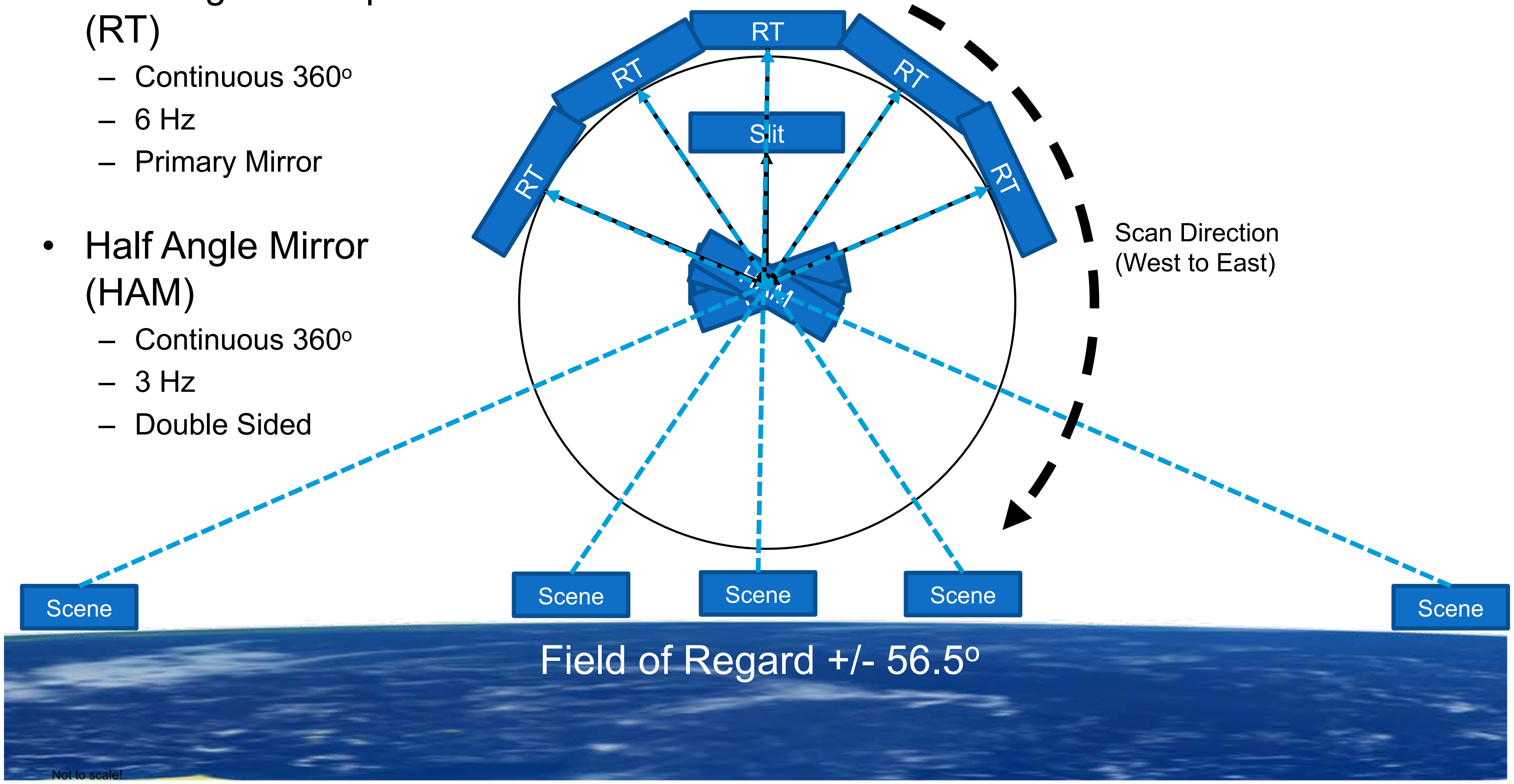
Telescope Rotation Rate = Ground Velocity / Ground Sample Distance

Rotating Telescope and Half Angle Mirror Fundamentals

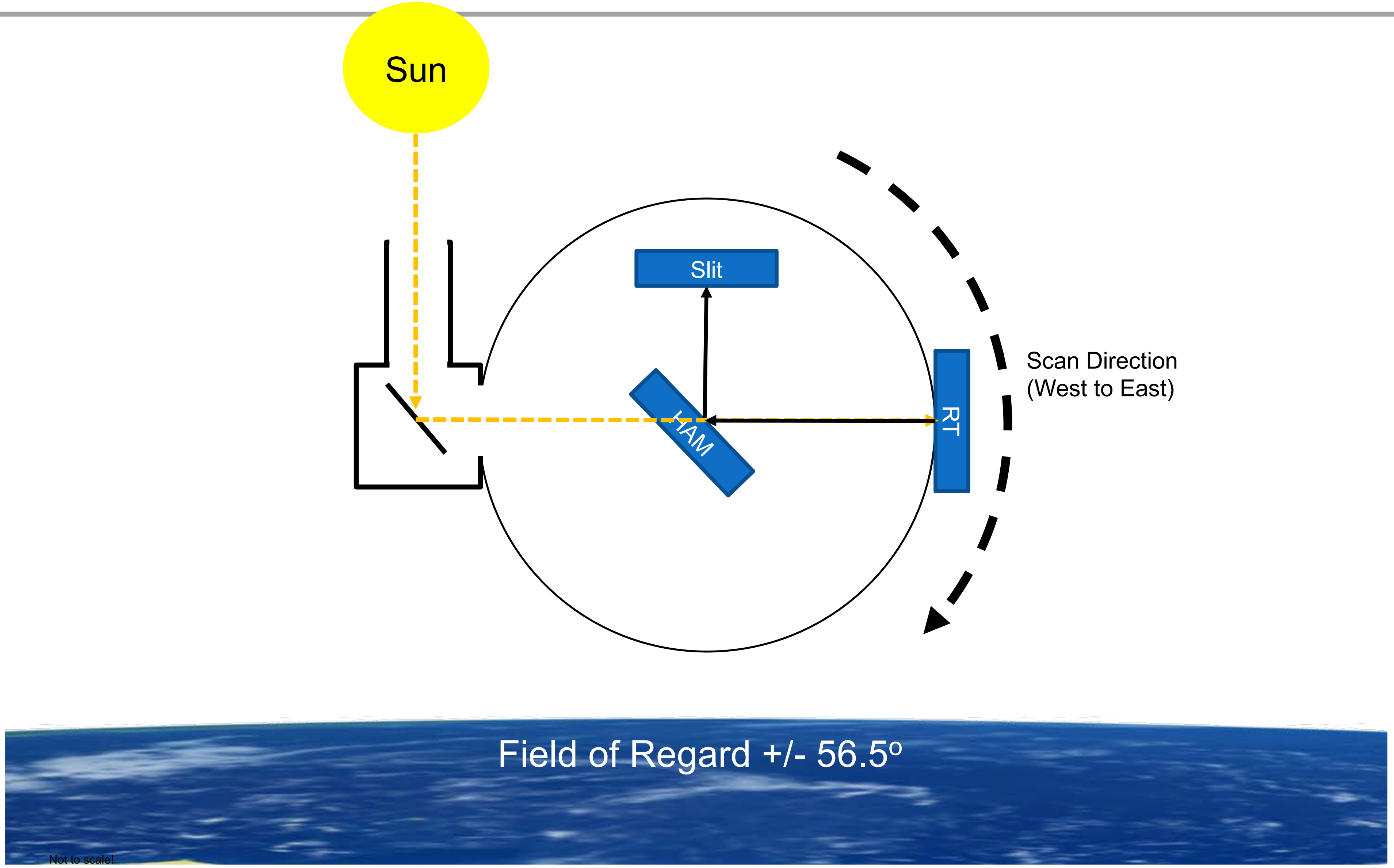


Rotating Telescope and Half Angle Mirror Fundamentals

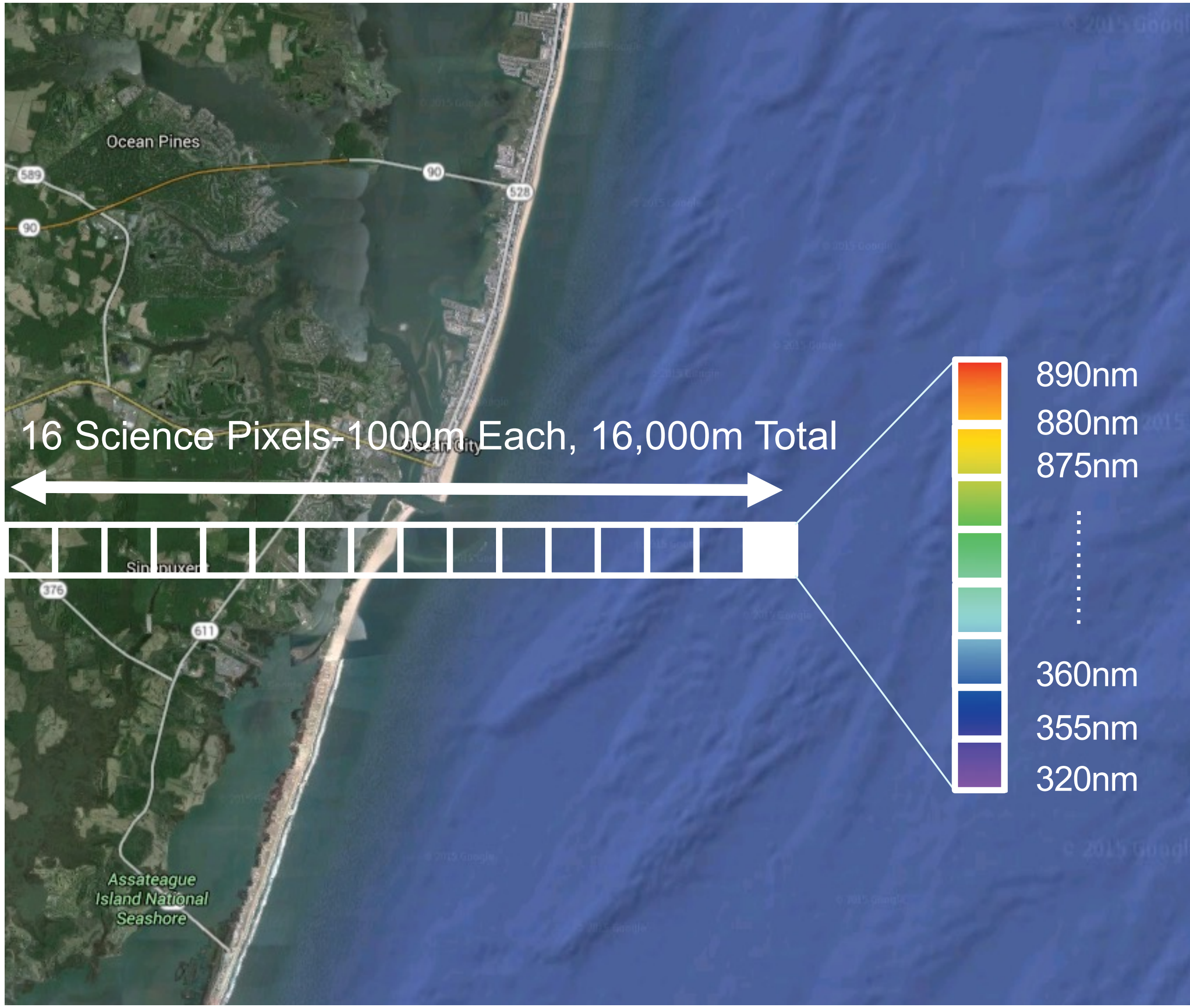
- Rotating Telescope (RT)
  - Continuous 360°
  - 6 Hz
  - Primary Mirror
- Half Angle Mirror (HAM)
  - Continuous 360°
  - 3 Hz
  - Double Sided



SCA Rotating Telescope and Half Angle Mirror Fundamentals



OCI is a Slit Grating Hyperspectral Spectrograph in the UVNIR



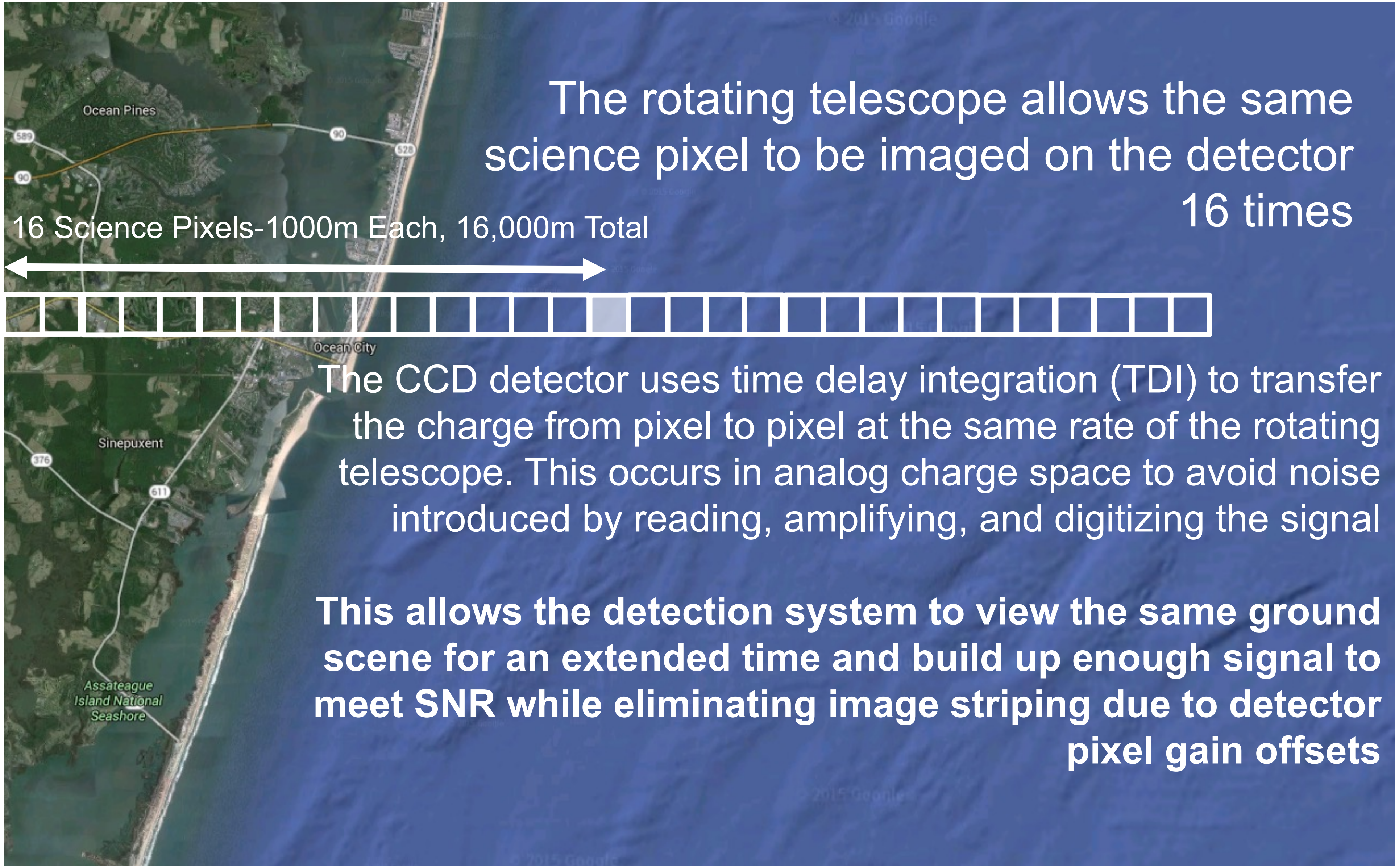
The optics are designed with a grating that splits the incoming light from each 1000m x 1000m ground scene into individual wavelengths.

Each 1000m x 1000m ground scene is comprised of over 100 science pixels.

Ultraviolet to Near Infrared in 5nm increments

Each science pixel has the spectral content of 1 wavelength at a 1000m x 1000m resolution

UVNIR Time Delay Integration

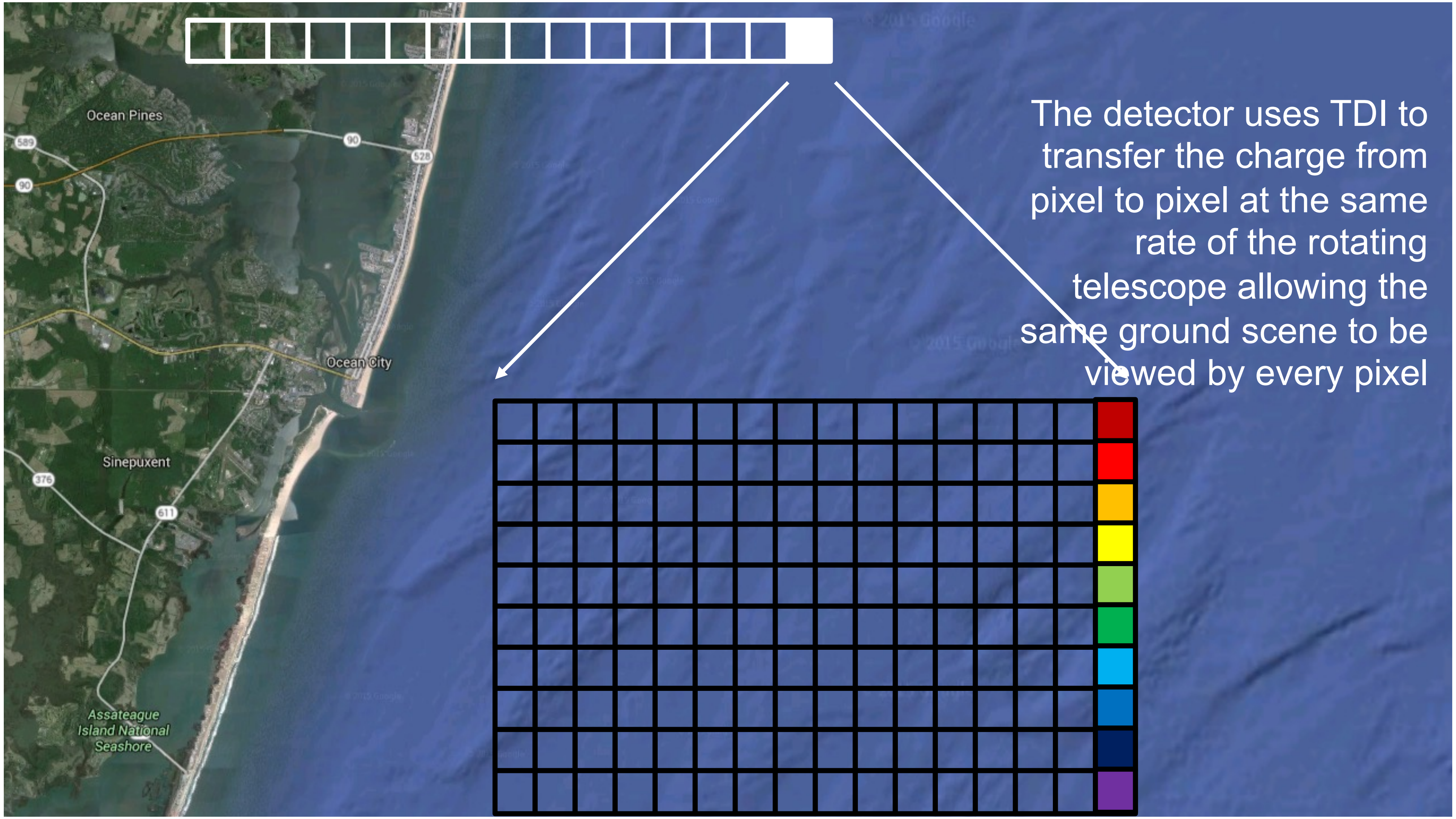


The rotating telescope allows the same science pixel to be imaged on the detector 16 times

The CCD detector uses time delay integration (TDI) to transfer the charge from pixel to pixel at the same rate of the rotating telescope. This occurs in analog charge space to avoid noise introduced by reading, amplifying, and digitizing the signal

This allows the detection system to view the same ground scene for an extended time and build up enough signal to meet SNR while eliminating image striping due to detector pixel gain offsets

UVNIR Time Delay Integration



The detector uses TDI to transfer the charge from pixel to pixel at the same rate of the rotating telescope allowing the same ground scene to be viewed by every pixel

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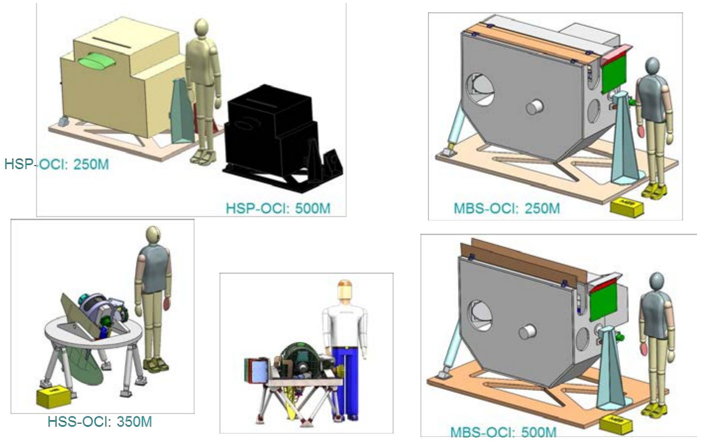
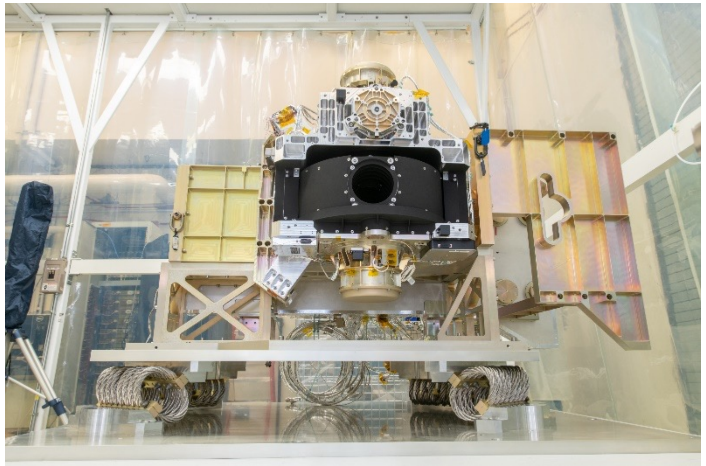
Q's

Science Questions



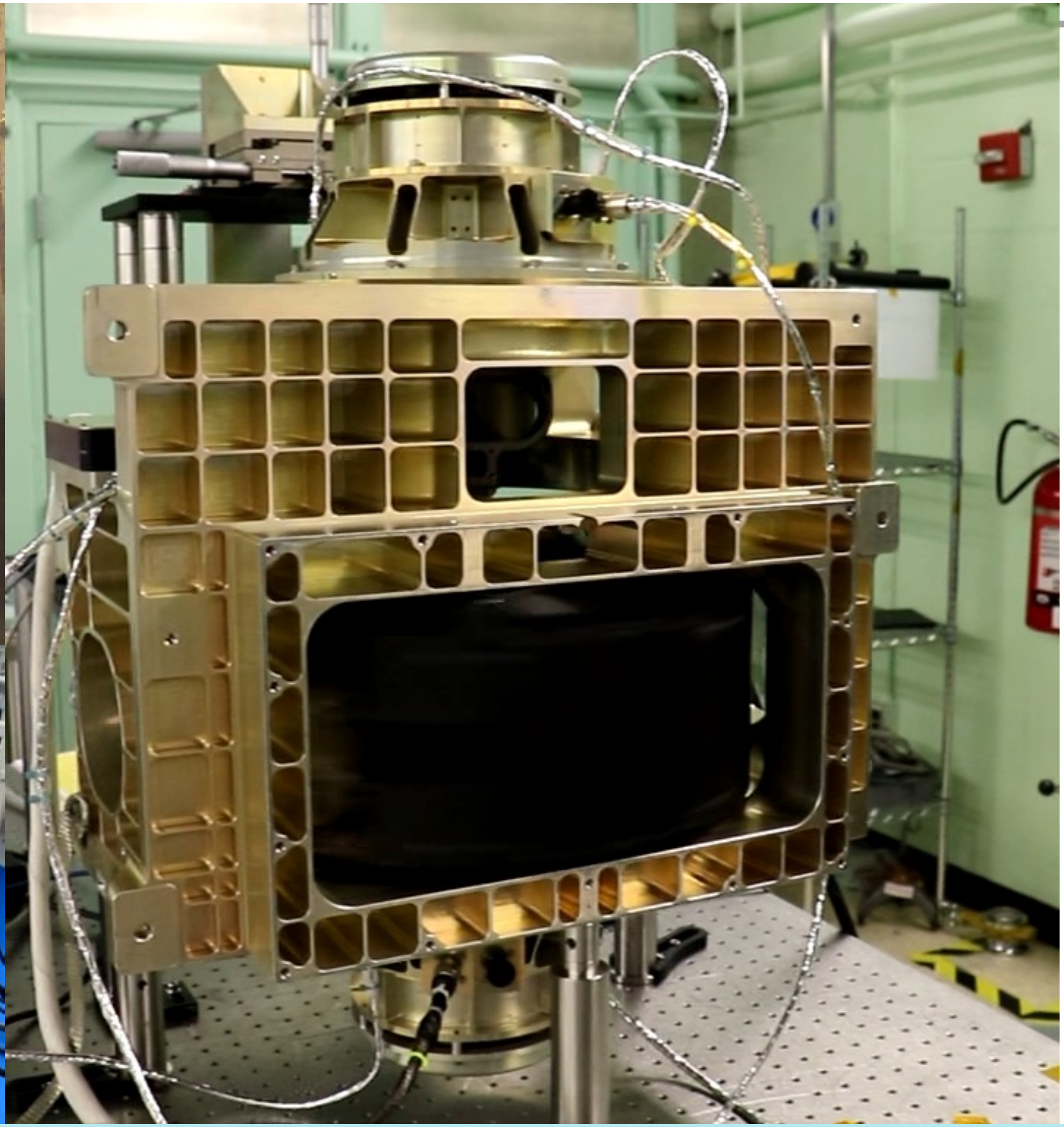
Requirements & Trades



Prototype Testing

Commissioning & Operations

Its time to cut metal



Building & testing a prototype enables the team to improve design, testing, and build process for flight

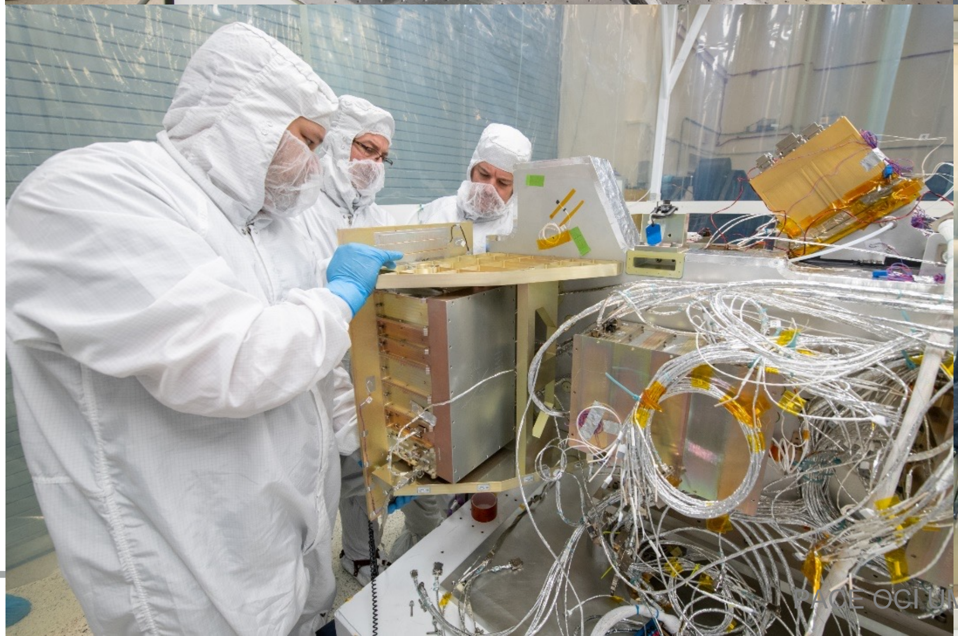
You don't know what you don't know until you build and learn

Assembly of prototype focal planes, optics, and electronics

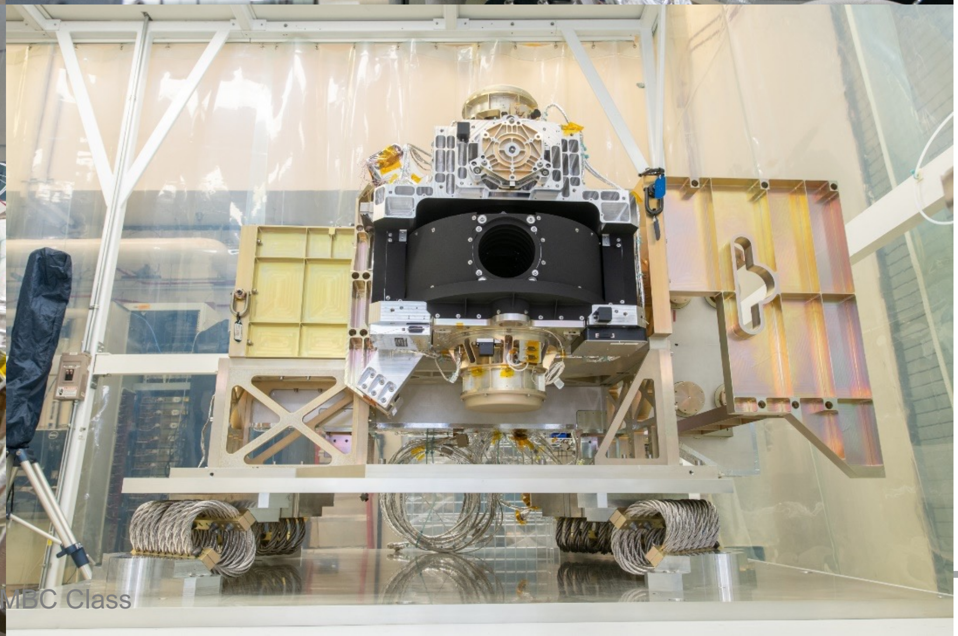
Optical Module Alignment

Focal Plane Integration

Electronics Integration

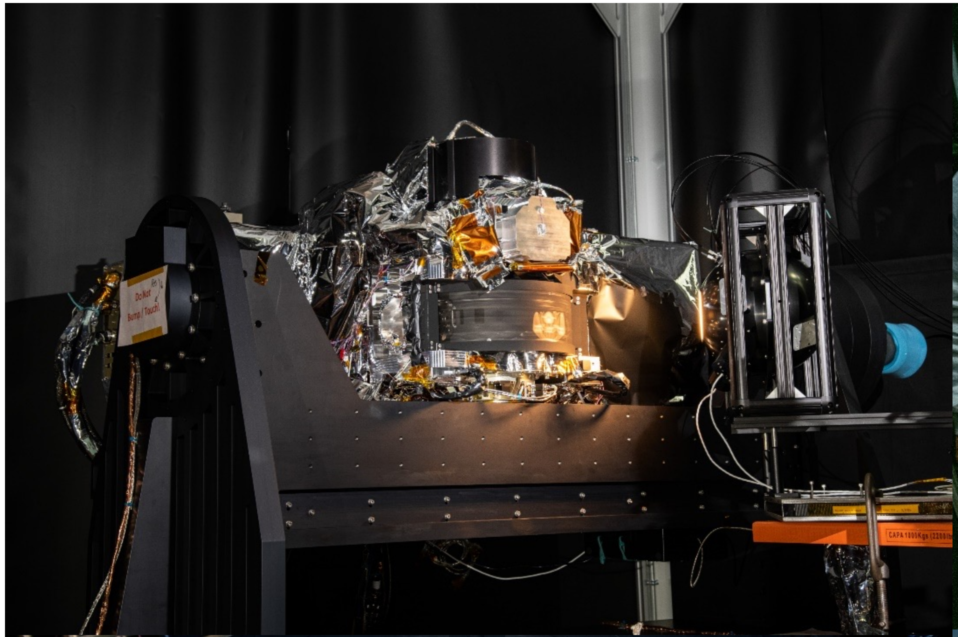


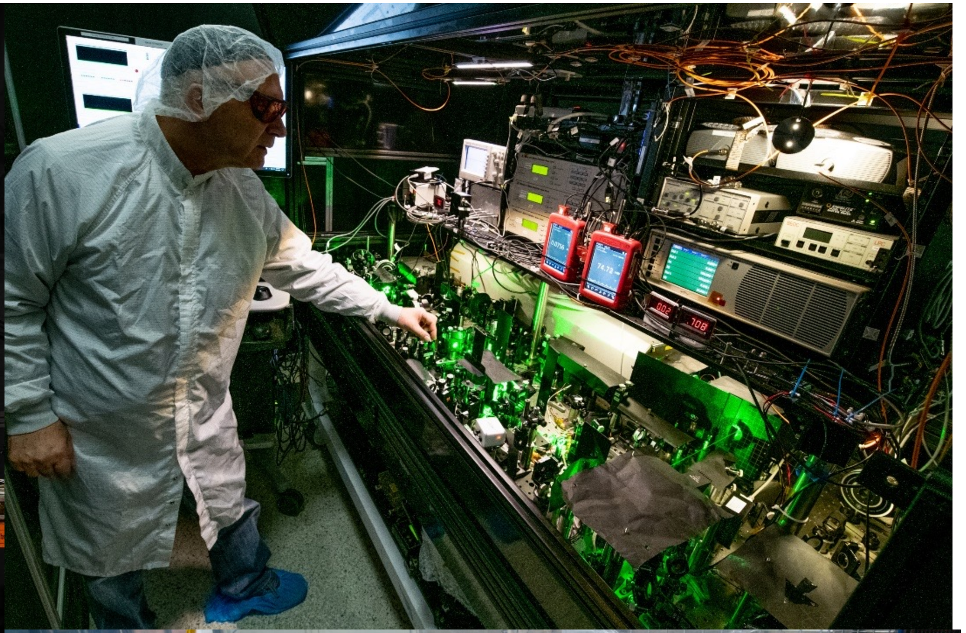
Ready for System Testing



Testing the prototype OCI

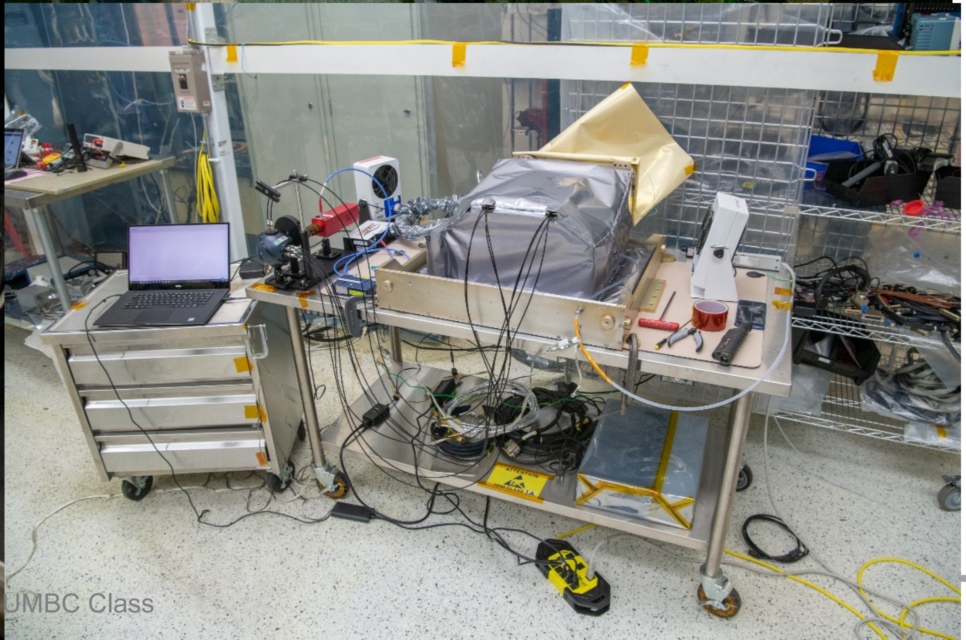
Ambient System Testing





Tunable Lasers for Calibration

Thermal Vacuum Testing



SWIR Detection Assembly

OCI Engineering Development Status
Engineering Test Unit SDA Integration, TVAC Round 2, & Stray Light Characterization

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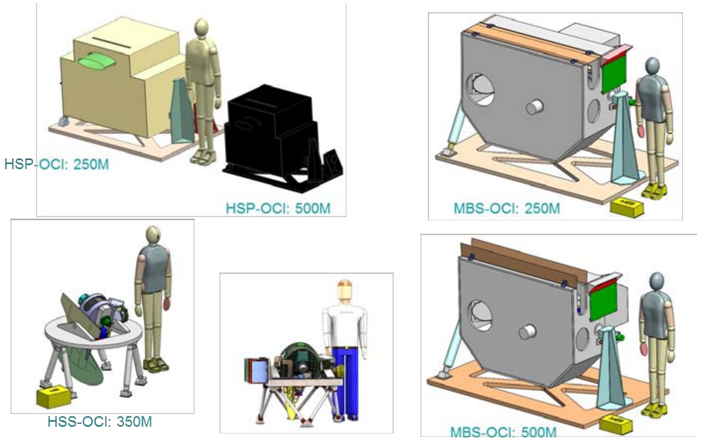
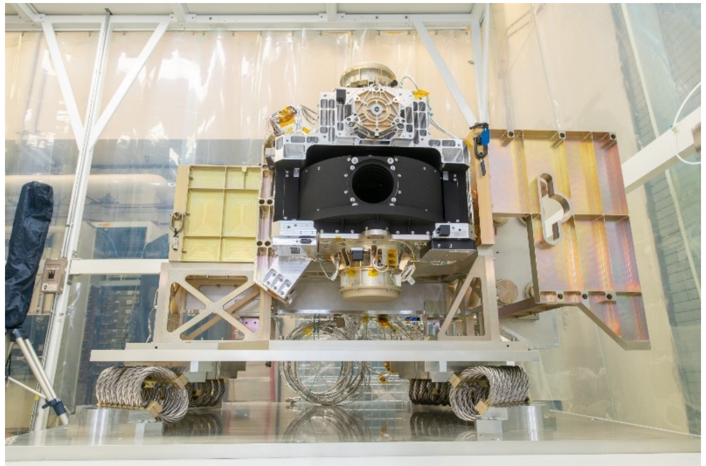
Q's

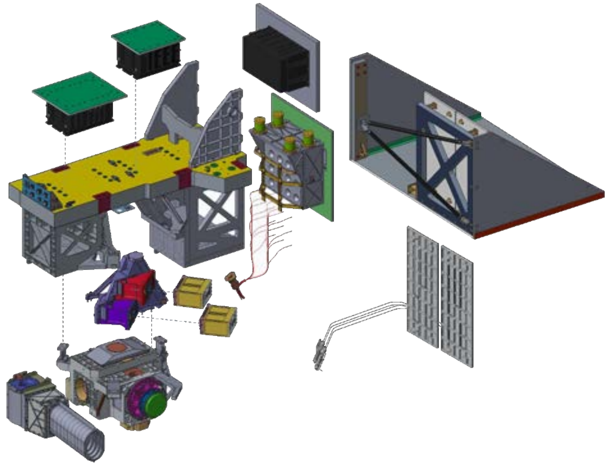
Science Questions



Requirements & Trades



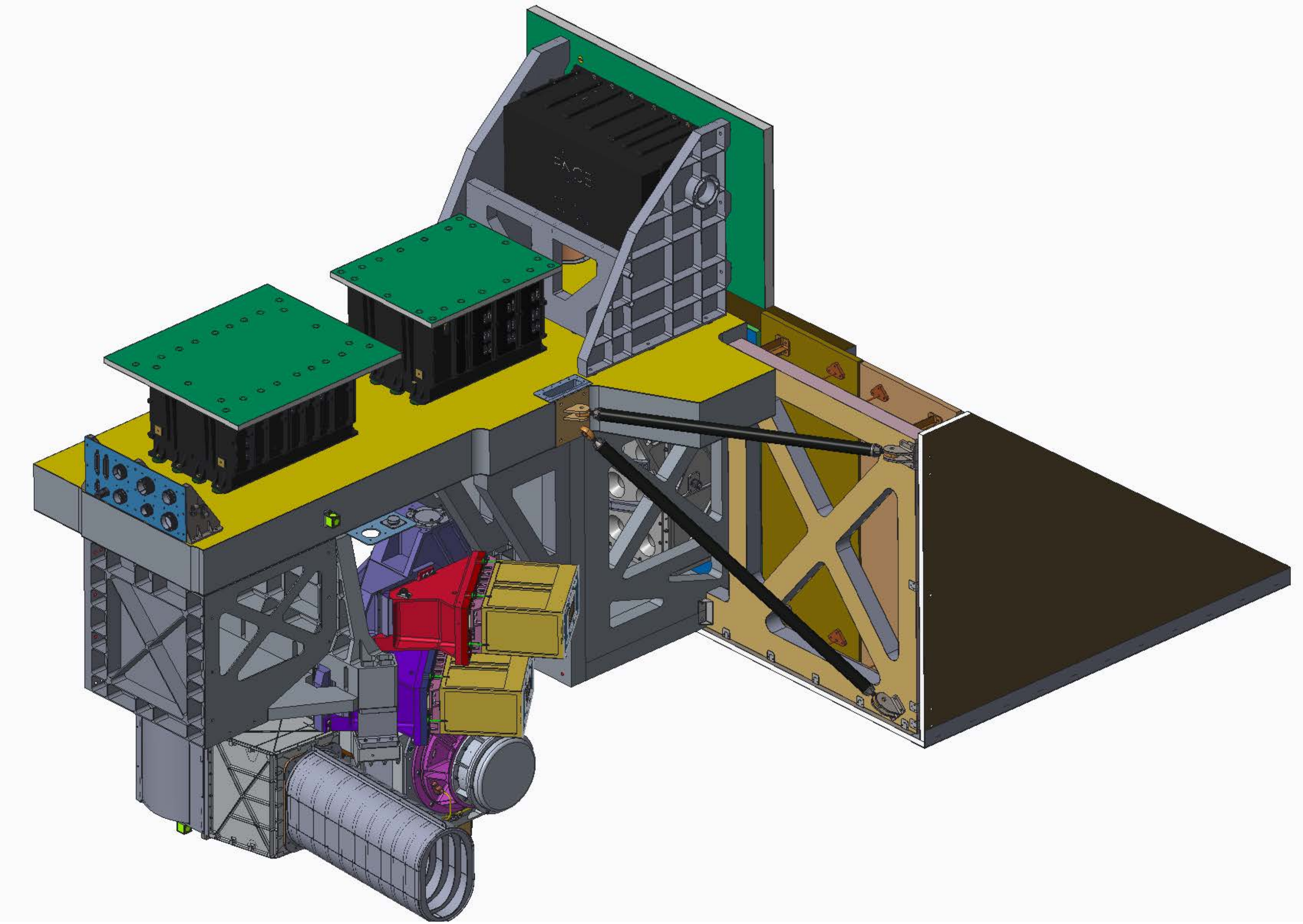
Prototype Testing



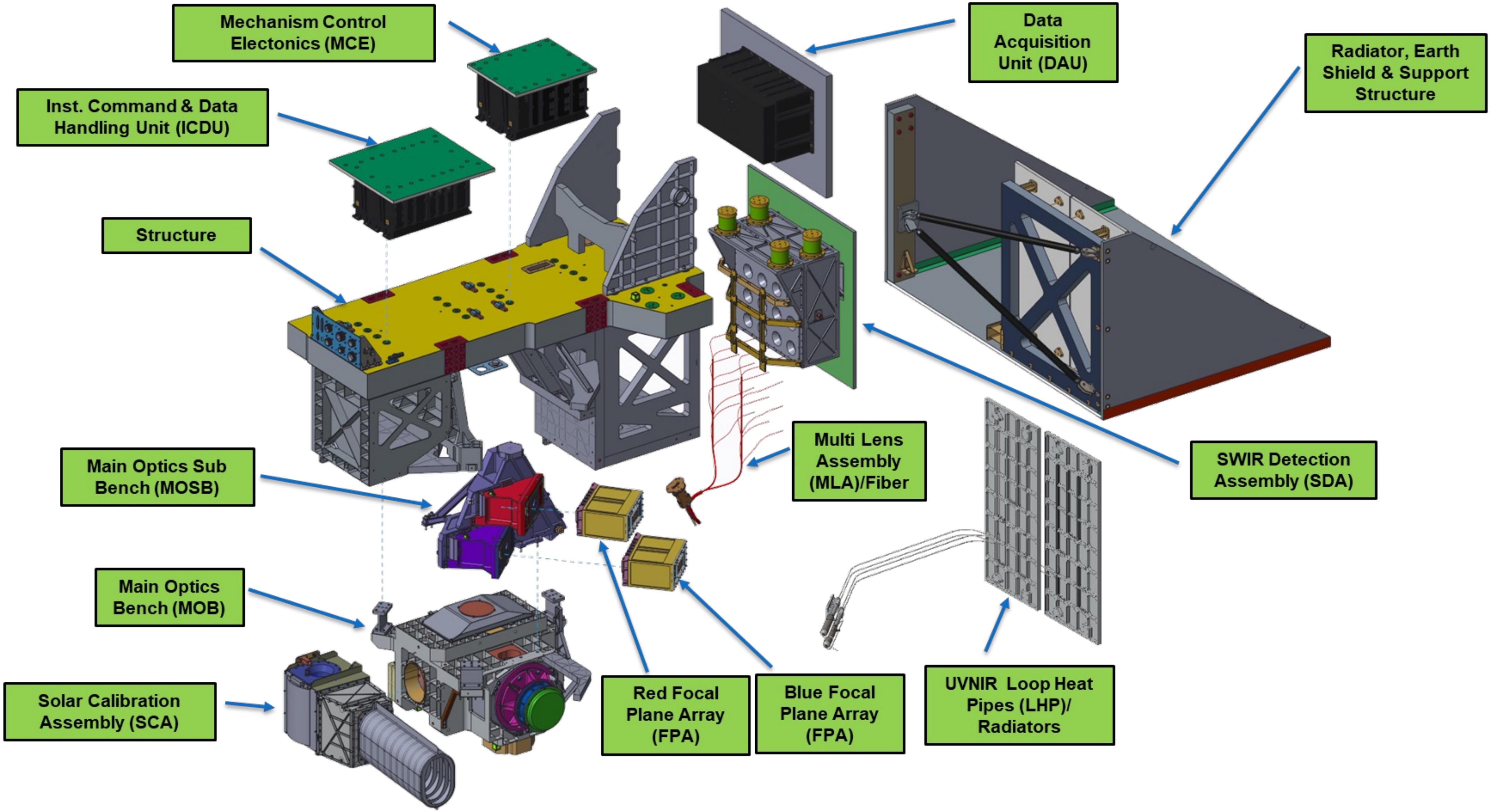
Flight Component Build

Commissioning & Operations

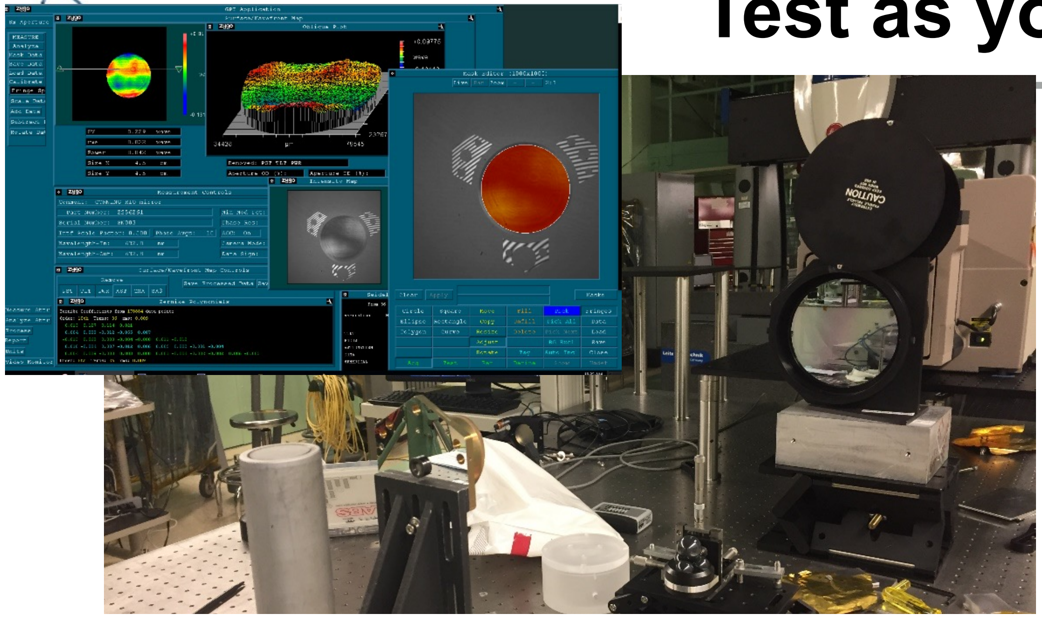
How do you build a flight instrument that will reliably operate in space?



Break it into smaller pieces & test test test

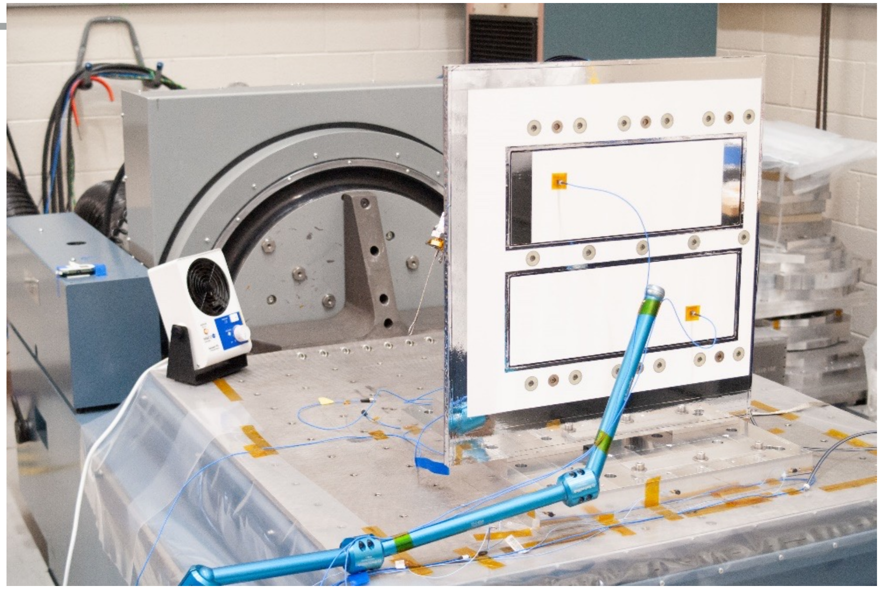


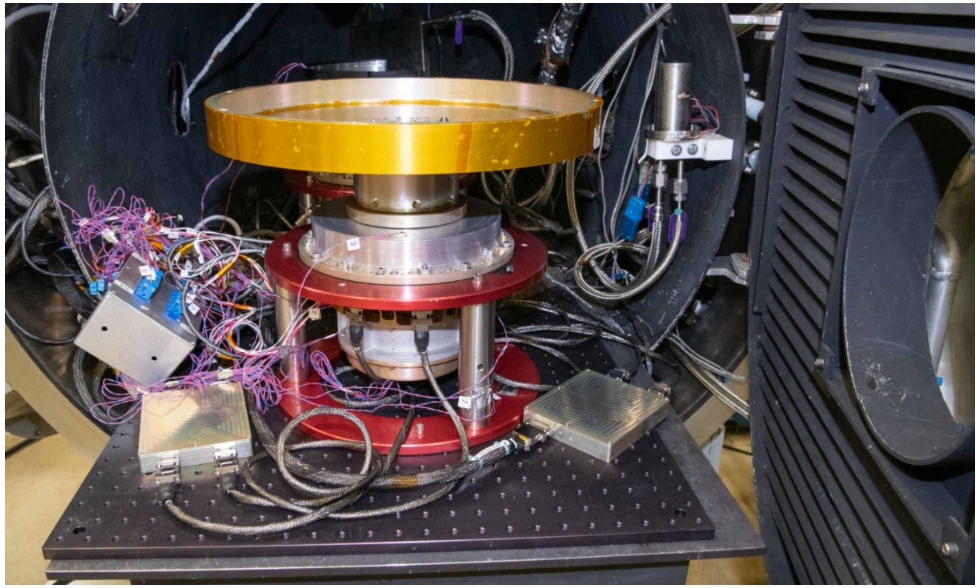
Test as you fly & fly as you test



Optics Characterization

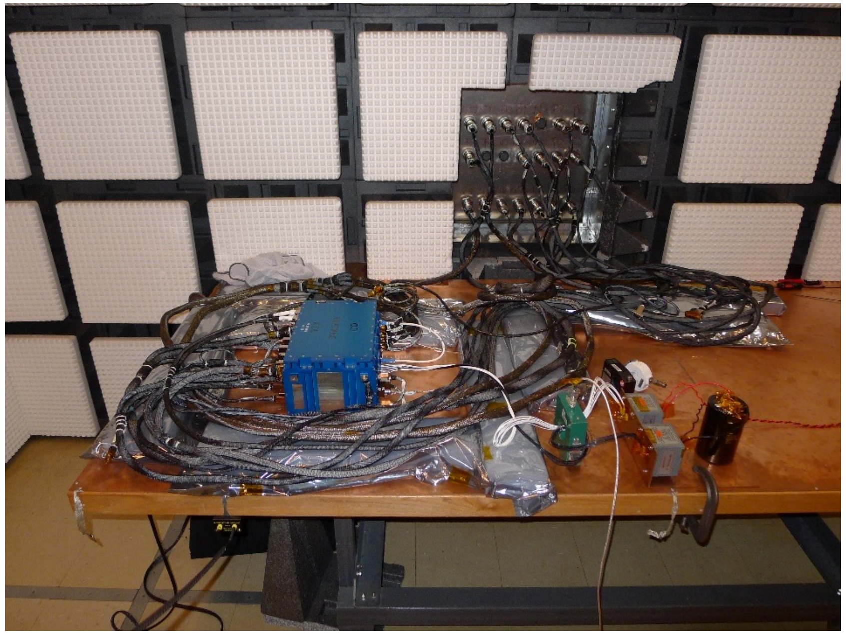
SWIR Detection Assembly Vibration





RT/HAM Actuator Thermal Vacuum Testing

ICDU EMI Testing



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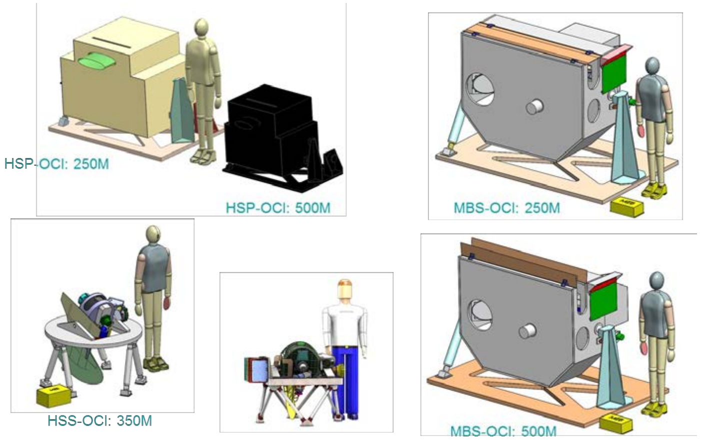

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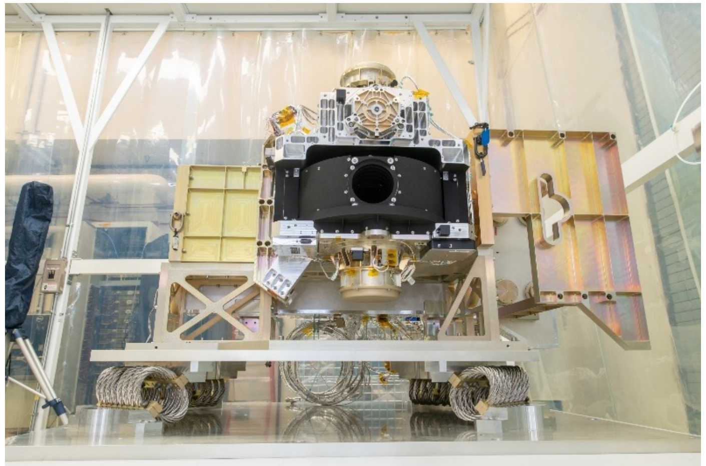

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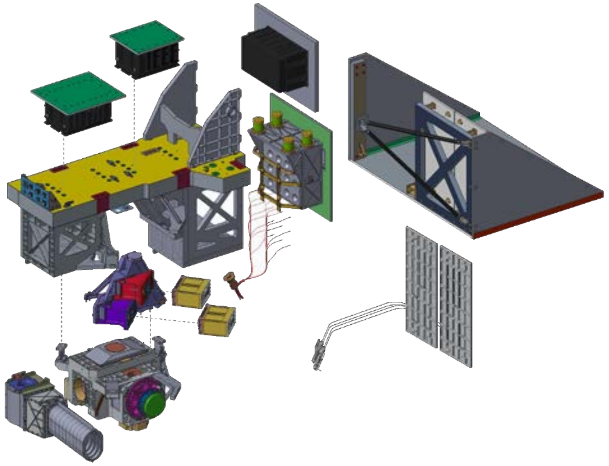
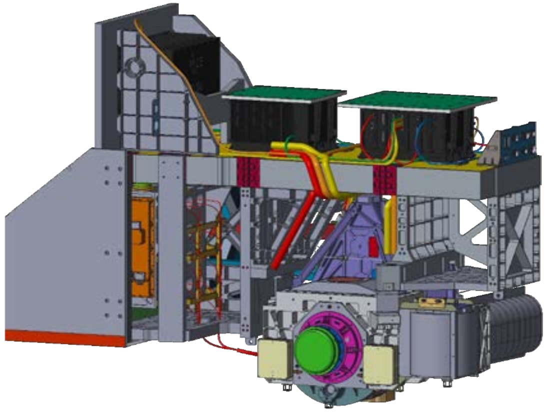


Flight Component Build



Integration & Testing

Commissioning & Operations

Flight Ocean Color Instrument (More I&T Details In Veronicas Section)

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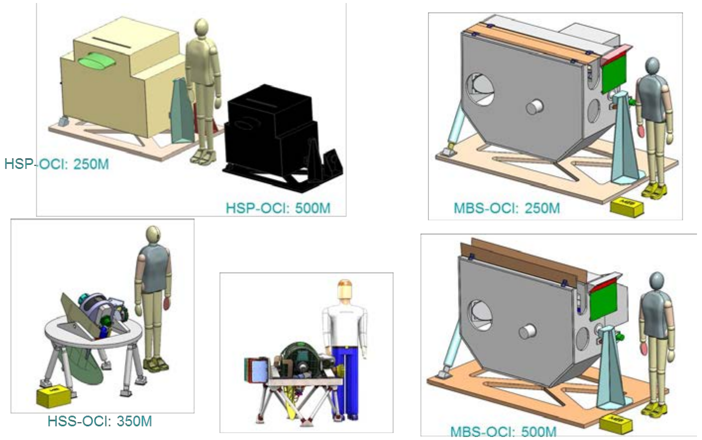

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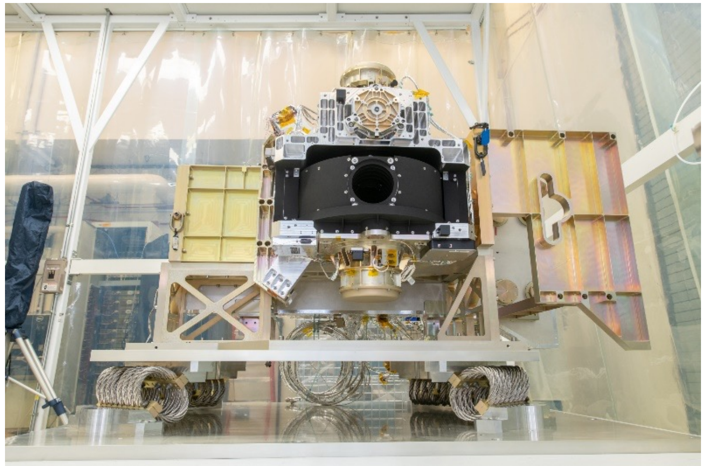

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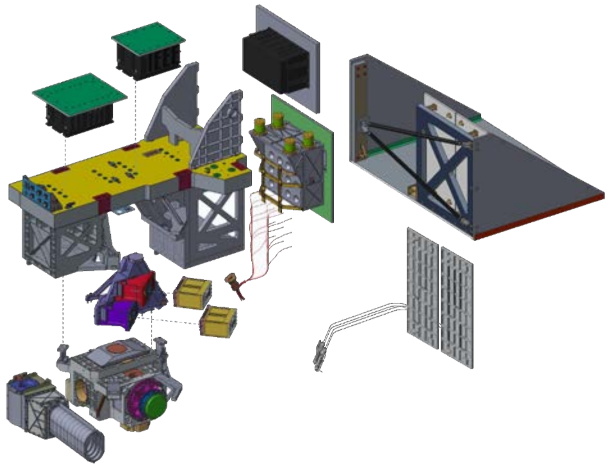

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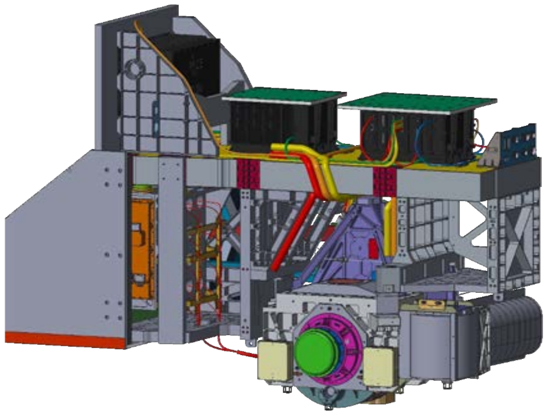

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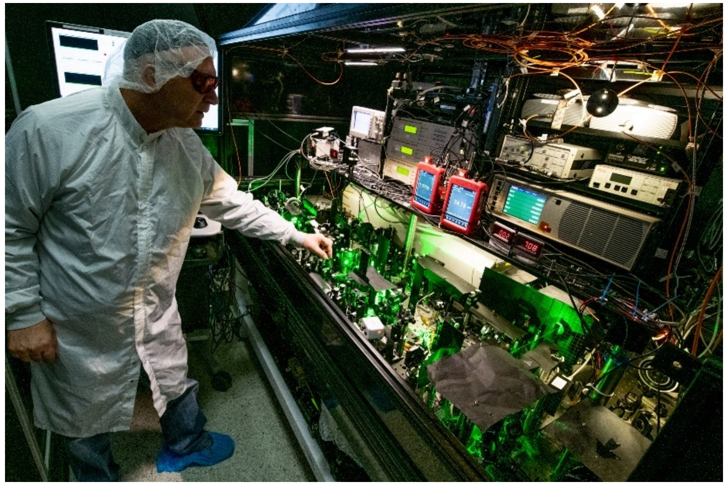

Ground Calibration

Commissioning & Operations

The OCI Team Has Spent Years Preparing for Pre-Launch Calibration

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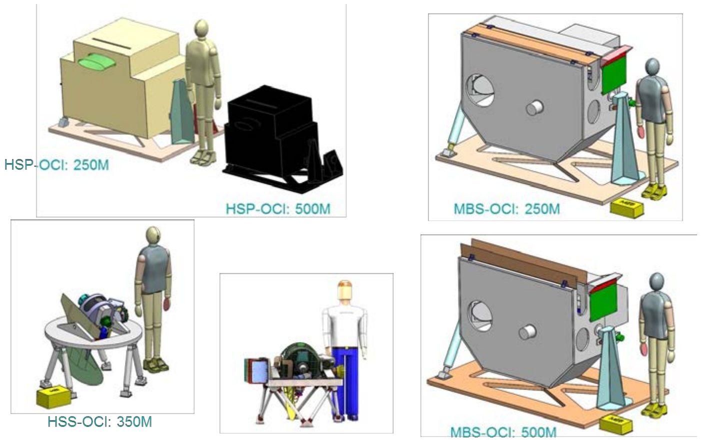

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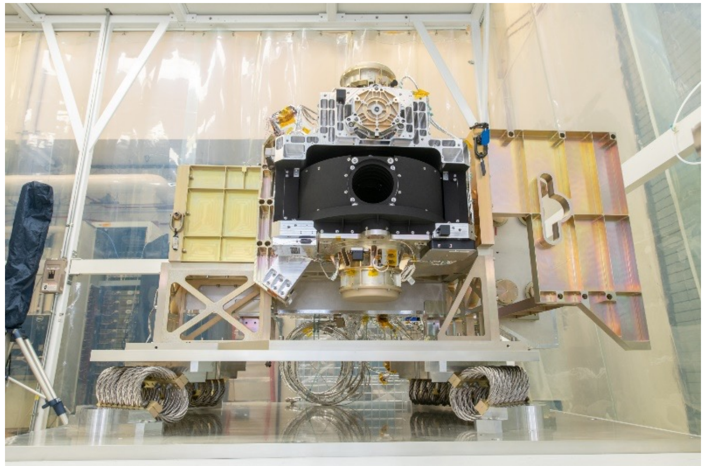

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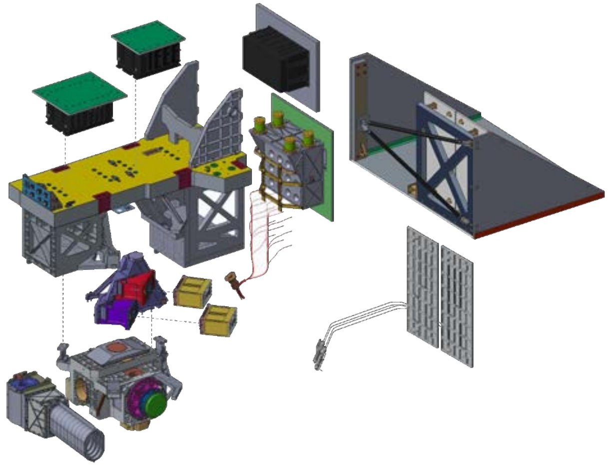

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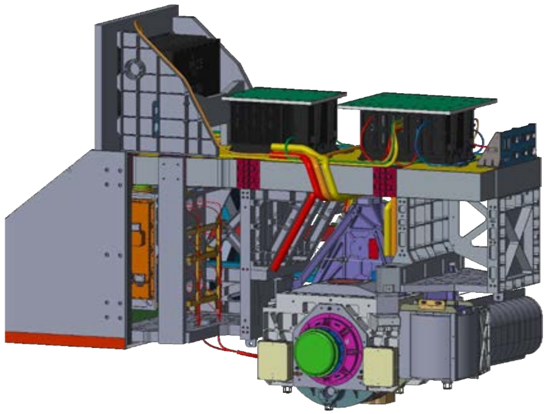

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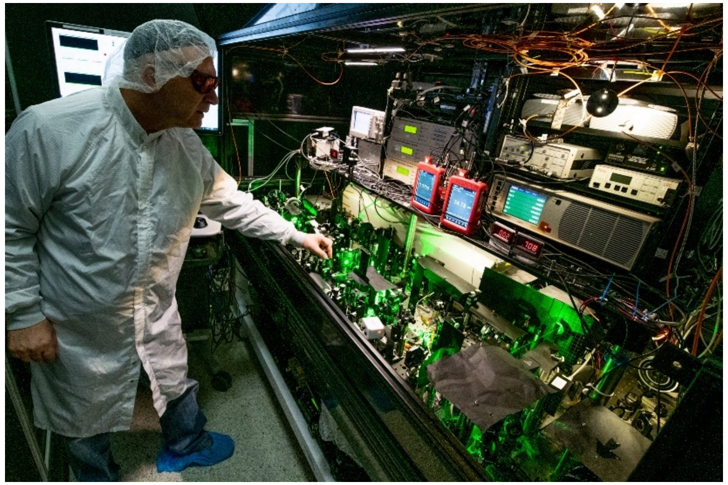
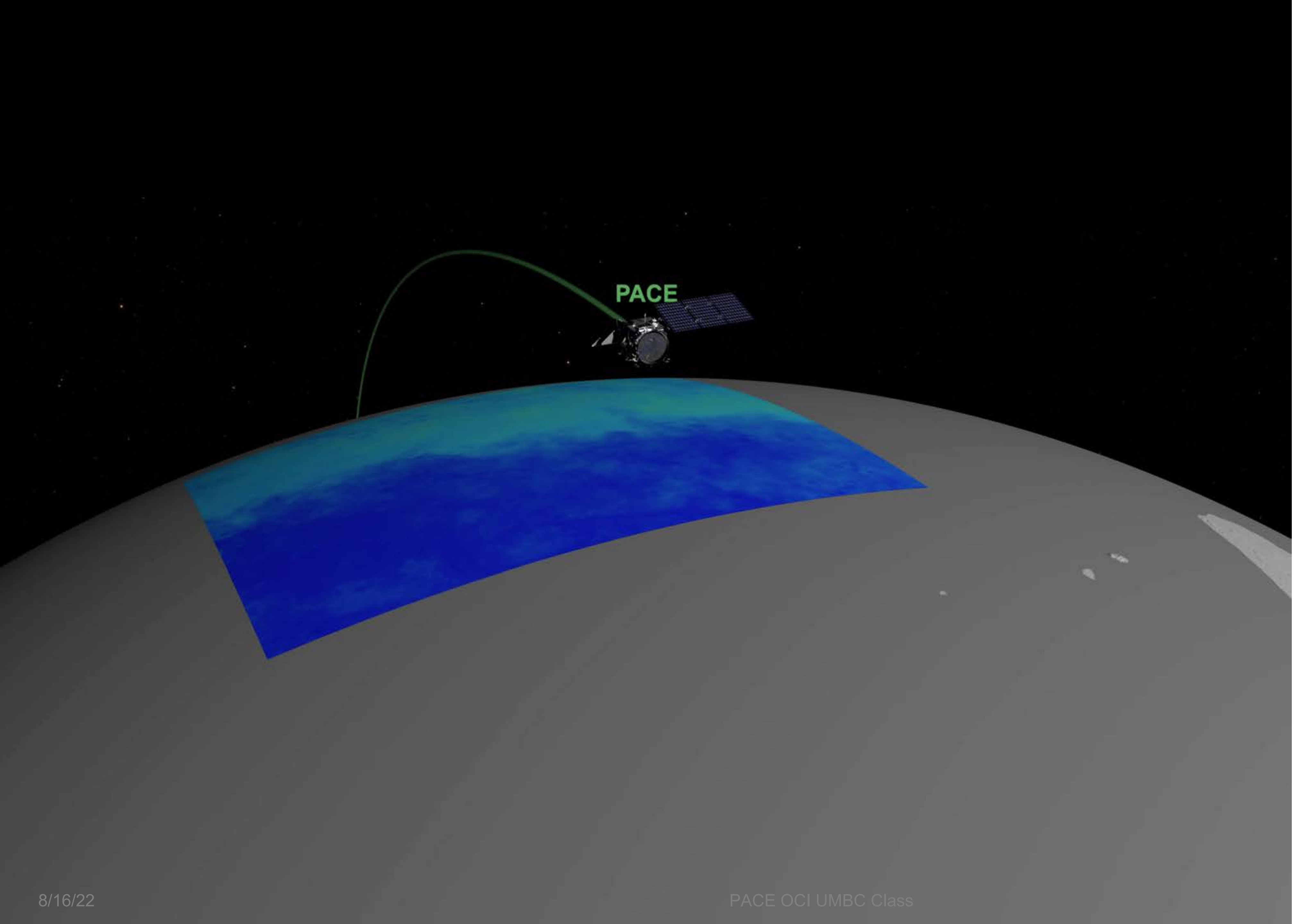


Ground Calibration

Launch

Commissioning & Operations



Questions