New global ocean color sensor: OCI on PACE

February 4, 2022

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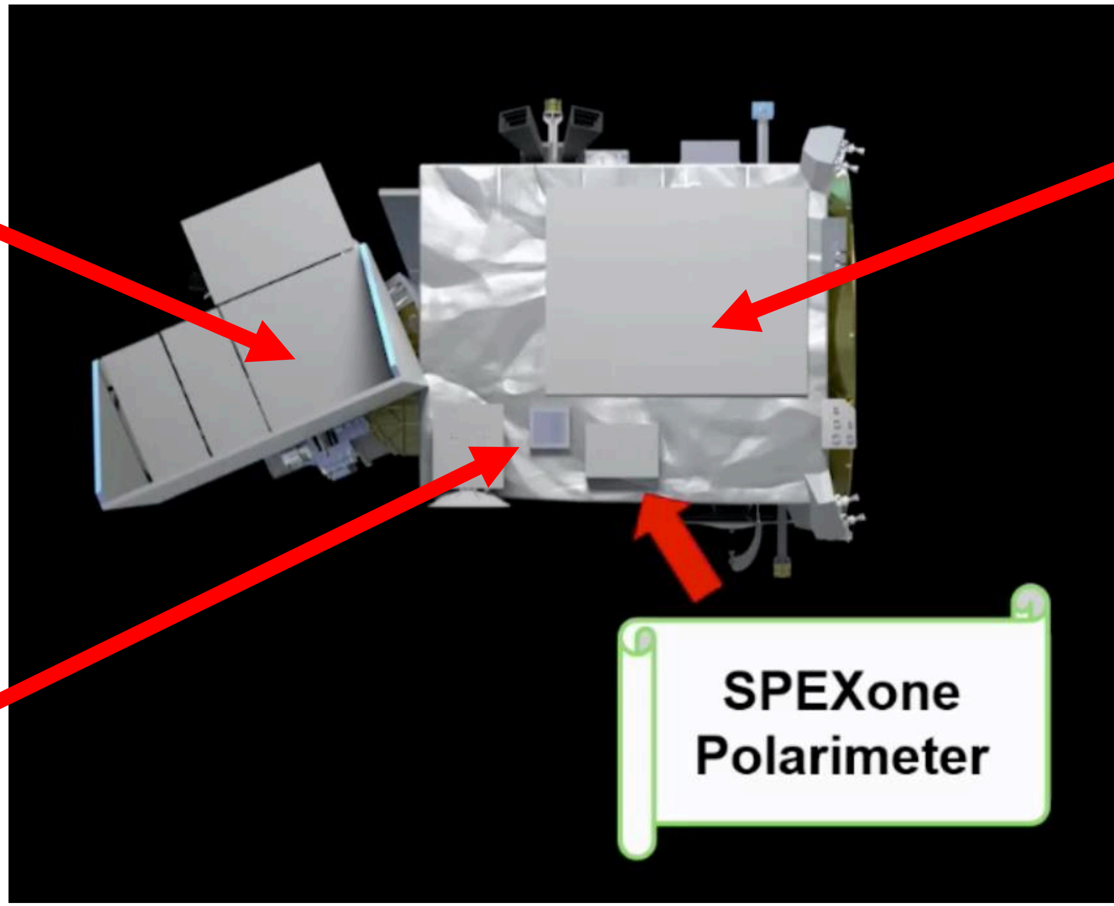
IOCCG Task Force: Satellite Instrument Pre- and Post-launch Calibration, Virtual Workshop

Description of the PACE mission

PACE: Plankton, Aerosol, Cloud, ocean Ecosystem

OCI:
Ocean
Color
Instrument

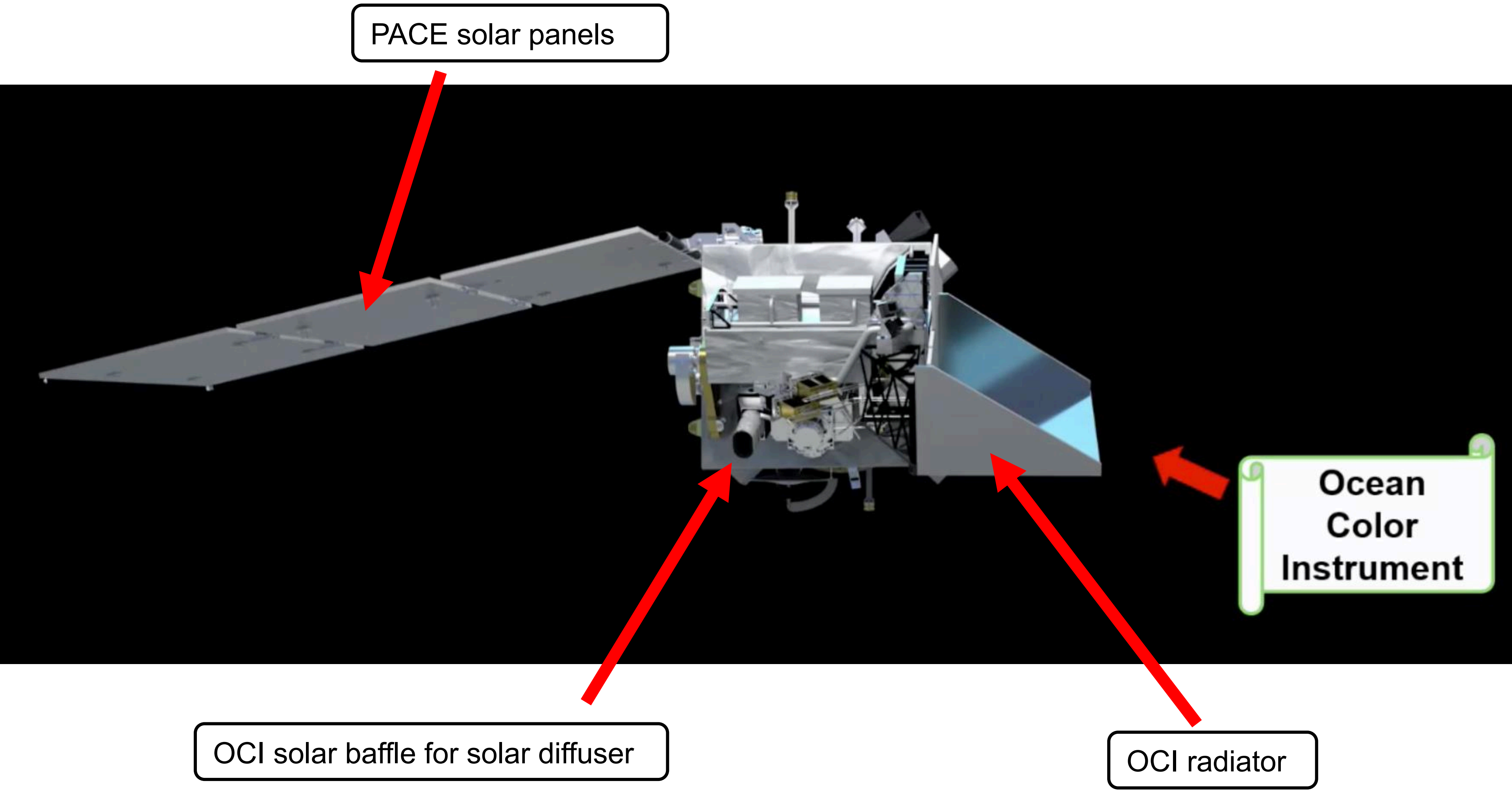
PACE
Spacecraft



HARP2
Polari-
meter

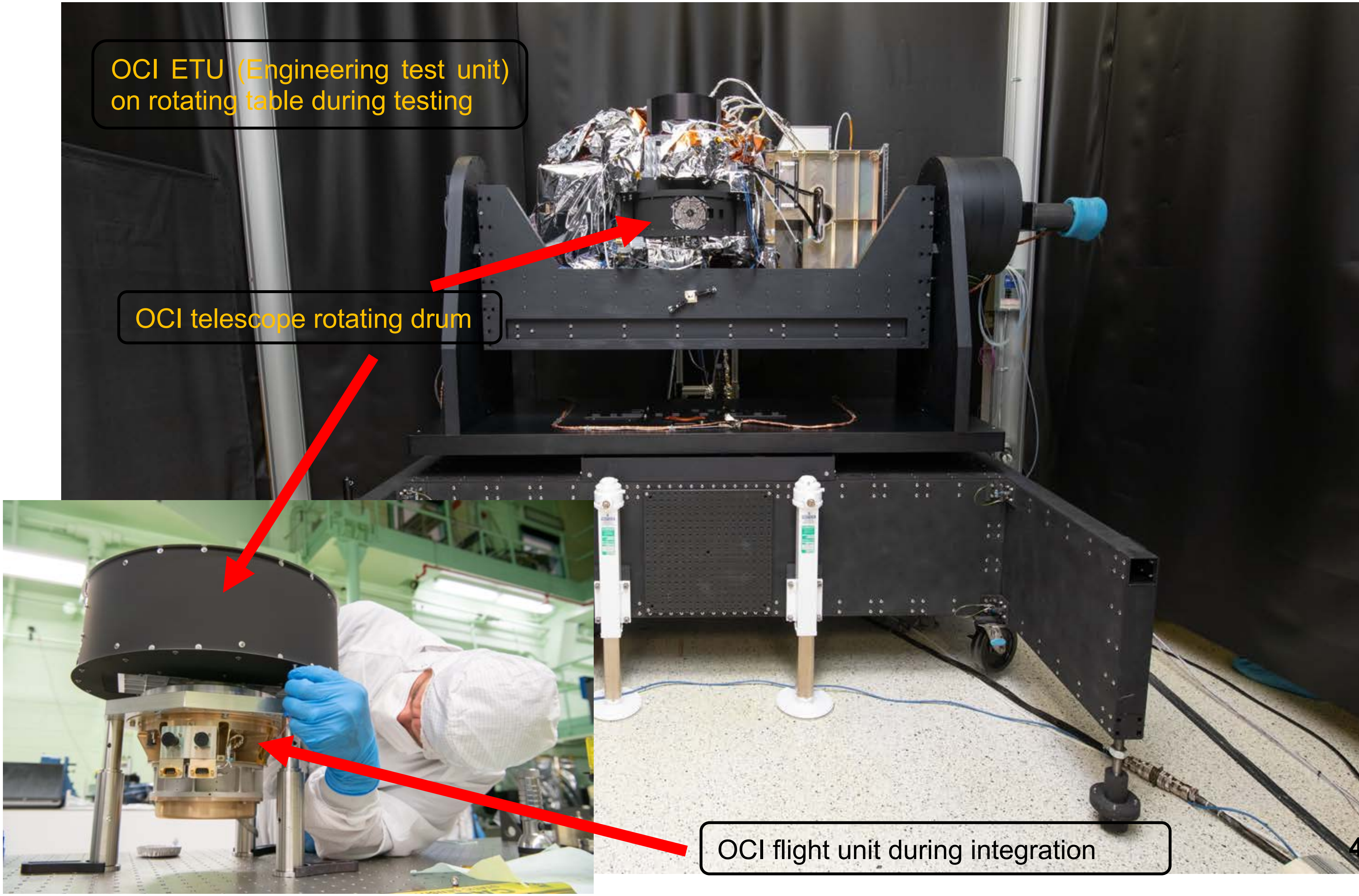
Source: Andre Dress, https://pace.oceansciences.org/docs/sat_oct21_dress.pdf

Description of the PACE mission



Source: Andre Dress, https://pace.oceansciences.org/docs/sat_oct21_dress.pdf

Actual Images of OCI

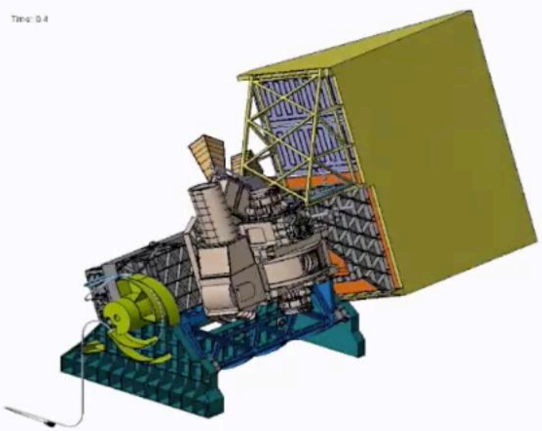


Description of the PACE mission

PACE Instrument(s) Critical Parameters

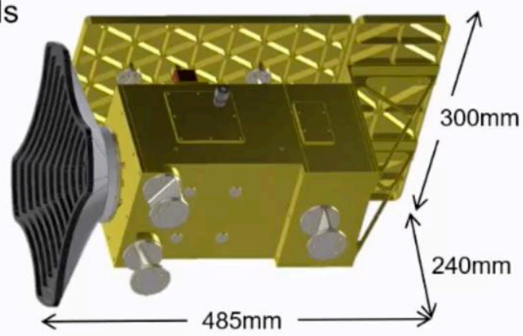
Ocean Color Instrument (GSFC):

- 340nm – 890nm at 5nm bands
- SWIR bands 940, 1038, 1250, 1378, 1615, 2130, 2260 nm
- Wide swath ±56° cross
- 1km GSD
- Avg Data Rate: 20 Mbps
- Mass ~ 260 kg CBE (includes portion of tilt structure)
- ±20 deg tilt for Sun glint avoidance



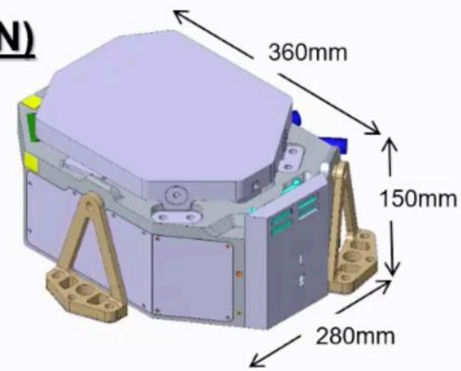
HARP2 Polarimeter (UMBC)

- 440, 550, 670 & 870nm Bands
- 10-60 viewing angles
- Wide swath ±47° cross-track
- GSD 700m binned to 3km
- Avg Data Rate 10 Mbps
- Mass ~10 kg CBE



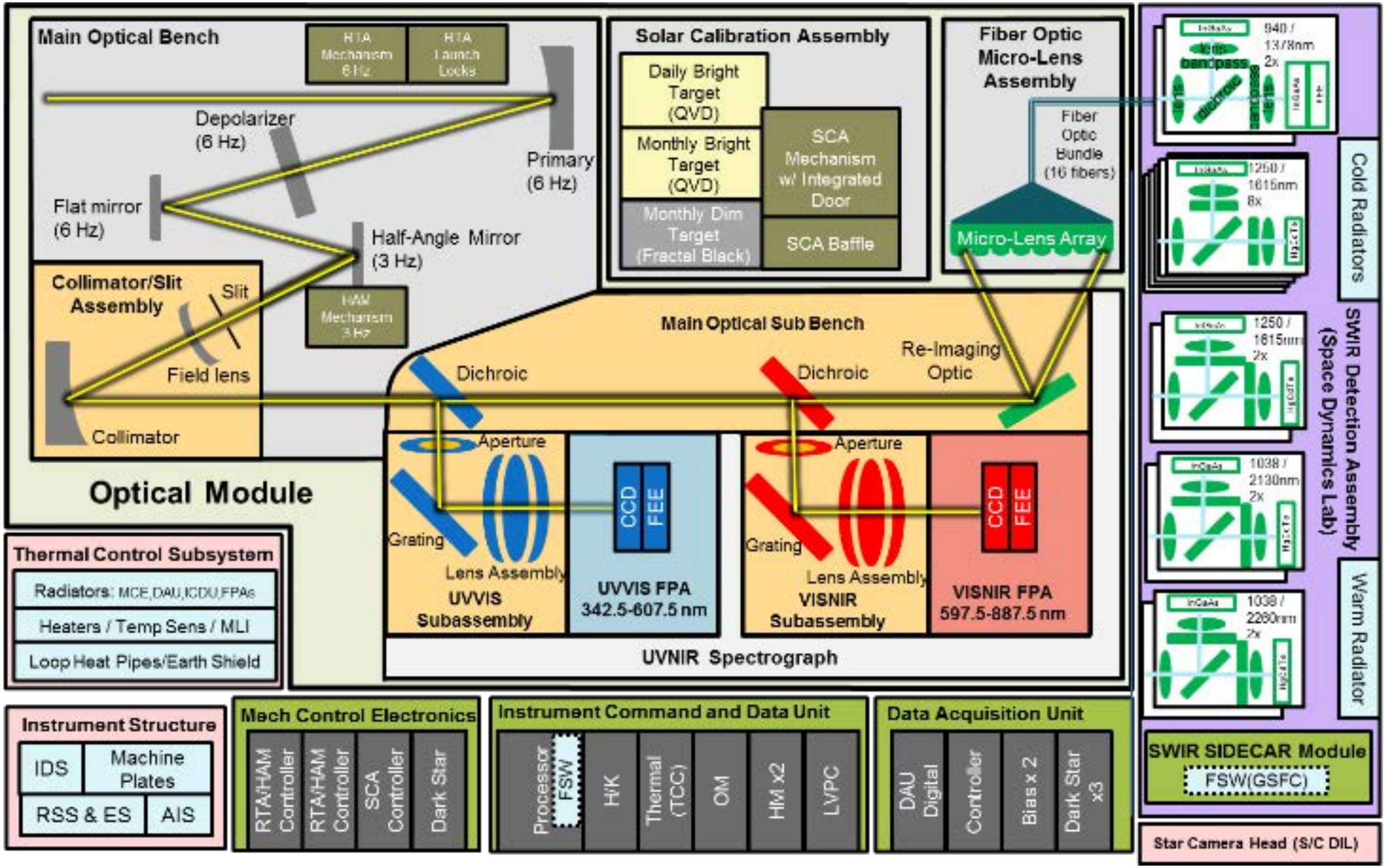
SPEXone: Polarimeter (SRON)

- 385 to 770nm at 2nm Bands
- 5 viewing angles
- Narrow swath ±4.5° cross
- GSD approx. 2.5km
- Avg Data Rate 5.3 Mbps
- Mass ~ 11 kg CBE



Source: Andre Dress, https://pace.oceansciences.org/docs/sat_oct21_dress.pdf

OCI components and optical path



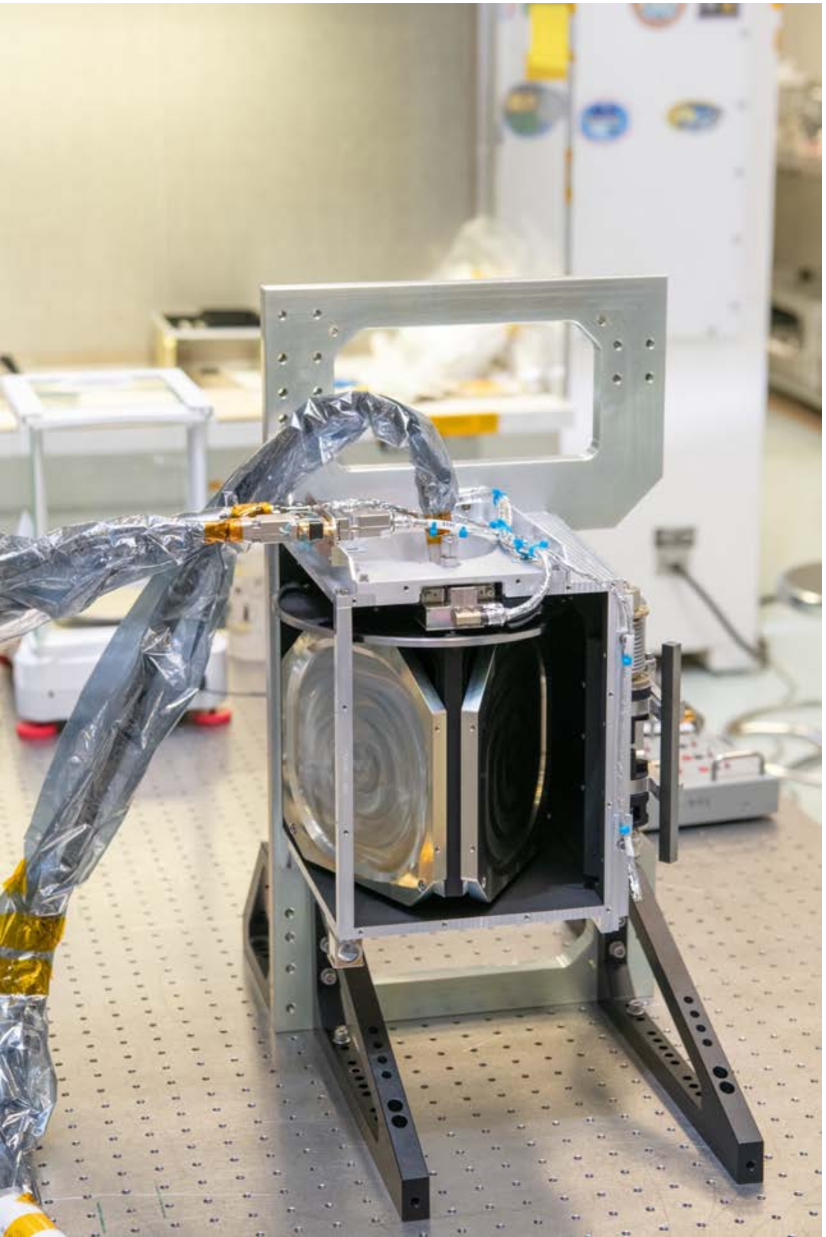
Source: Gorman et al., 2019, Proc. Of SPIE Vol. 11151, 111510G-3

On-orbit calibration

Several calibration approaches:

- Daily solar diffuser gain trending
- Monthly solar diffuser gain/spectral trending
- Monthly dim diffuser linearity trending
- Bimonthly lunar gain trending
- Bimonthly lunar hysteresis trending
- Monthly earth view spectral trending

Solar Calibration Assembly (SCA)



SCA description:

- The SCA contains 3 solar diffusers: daily bright calibration target (BCT), monthly BCT, and dim calibration target (DCT)
- Incidence angle is 58deg, view angle 38deg, azimuth around 180deg (forward scattering)
- Calibration will occur at northern terminator
- Spacecraft maneuver will keep incidence angle constant throughout measurements (~1 minute)
- A baffle tube (directed towards sun) will eliminate earthshine
- A door will close to protect calibration targets from degradation when not in use
- Approach using 2 BCT for OCI gain trending is described in chapter 6 in Vol. 7 of NASA TM-2018-219027: https://pace.oceansciences.org/docs/TM2018219027Vol.7.pdf

Bright Calibration Target (BCT)

TNO innovation for life

DOC.NO.	:	OCI-TNO-BCT-TR-0001
ISSUE	:	9
DATE	:	2020-09-01
PAGE	:	1 of 125
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Space Systems Engineering

Bright Calibration Target

BCT description:

- The BCT reflecting surface is a quasi-volume diffuser (QVD), produced by TNO, Netherlands
- Material: quartz
- Scattering occurs on rough surface and inside
- Extremely low reflectance degradation expected in the UV over mission life time (OMI heritage)

BRDF measurements at TNO:

- Limited angular range (+/-1deg for incidence/view zenith angles)
- 2cm FOV measurements initially at 5 spots; full coverage (~30 spots) later because **center is brighter**
- 2cm FOV measurements validated at GSFC (preliminary, measurements ongoing); full OCI FOV (9cm) BRDF measurement at GSFC pending; expected OCI FOV BRDF accuracy better than 2%
- BRDF is a bit brighter than expected (0.2-0.3 1/sr, or 60% to 90%, brightest in the SWIR)

Dim Calibration Target (DCT)

No picture available, same as BCT but dark

DCT description:

- The DCT reflecting surface is Acktar fractal black (company in Israel)
- Typically used for straylight suppression
- Used to check OCI linearity via progressive TDI mode (blue and red FPA only)

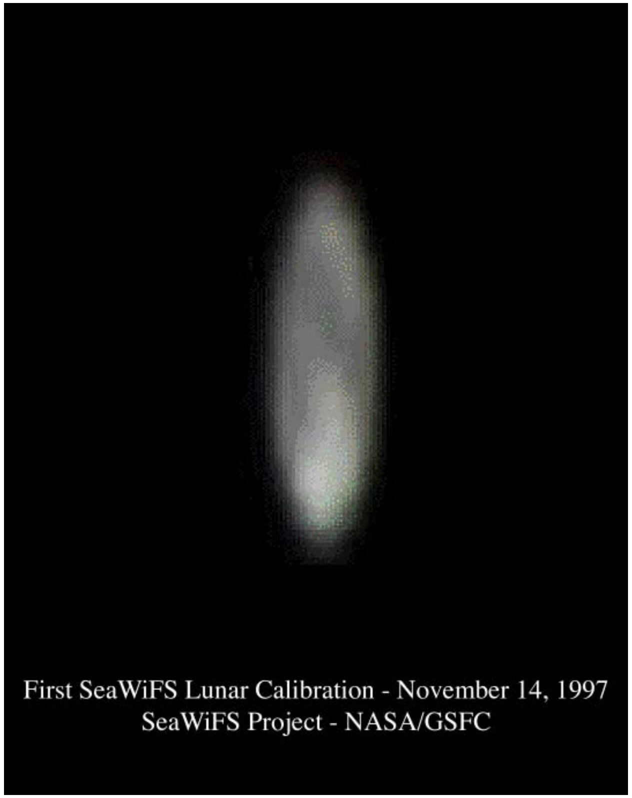
BRDF measurements at GSFC:

- Measurements were performed with various IFOV (1cm, 2.5cm, 7cm, 9cm)
- Random variations in 1cm IFOV measurements average to acceptable levels for 9cm IFOV
- BRDF is brighter than expected (0.025 1/sr, or 8%)
- All results preliminary

Lunar measurements

Dedicated maneuver:

- Twice a month, PACE will backflip on the dark side of the orbit
- Lunar phase angle will be close to 7deg
- Spacecraft attitude control will provide an image with well defined oversampling in track direction (x4)
- Lunar irradiance will be calculated and compared to ROLO model



Picture on the left:

- Source: https://oceancolor.gsfc.nasa.gov/SeaWiFS/BACKGROUND/Gallery/moon.jpg
- SeaWiFS determined oversampling from image analysis
- We expect an accuracy for OCI trending of about 0.1% after 3 years, see chapter 7 in Vol. 7 of NASA TM-2018-219027: https://pace.oceansciences.org/docs/TM2018219027Vol.7.pdf

Additional stare measurements:

- Moon provides excellent contrast ratio
- PACE spacecraft will stare at the moon while OCI scans for ~1 minute
- Results will be used to trend hysteresis of SWIR bands

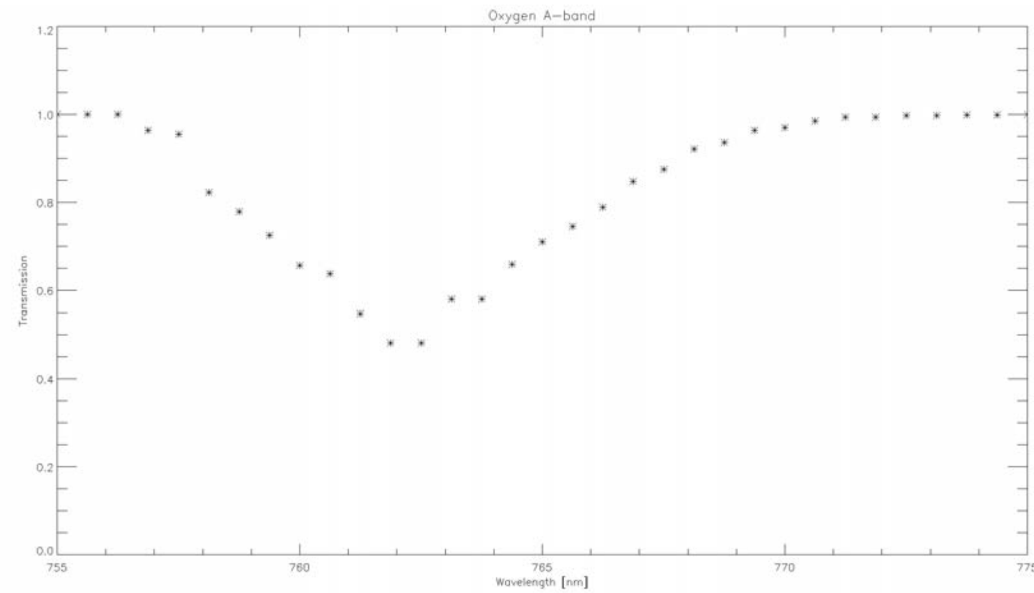
Earth view spectral trending

Special aggregation mode for earth view spectral measurements:

- Performed during tilt maneuver (every orbit during subsolar point, close to equator)
- Limited scan angle range (~30deg vs 110deg) due to data bandwidth limitations
- We will identify at least two clear absorption lines in the atmosphere (or Fraunhofer lines) per CCD (340nm to 600nm and 600nm to 890nm)
- We will trend over time either a constant shift or a linear change (gratings/alignment are not expected to produce higher order changes); zero change expected
- Similar approach as for MERIS/OLCI
- Spectral trending not needed for SWIR bands (spectral filters)

Plot on the right:

- Transmission of the Oxygen A-band, simulated with OCI bandwidth and maximum spectral sampling.



Summary

- OCI will provide TOA radiances at ~1km spatial resolution, from 340nm (315nm?) to 2260nm, hyperspectral from 340nm to 890nm, 2 day global coverage
- OCI will continue and enhance NASA's earth system data records for ocean color (heritage sensors: SeaWiFS, MODIS, VIIRS)
- OCI flight unit is close to being ready for testing (planned for March 2022 to September 2022)
- OCI ETU (Engineering Test Unit) completed testing summer 2021, results look promising (see next presentation)
- On-orbit calibration will combine successful trending approaches from previous sensors (2 solar diffusers, QVD, lunar gain trending, spectral trending)
- New calibration approaches for OCI: large QVD, dim diffuser for linearity trending, lunar hysteresis trending
- OCI will be characterized prelaunch with an ambitious goal of 0.5% relative uncertainty; absolute uncertainty will be about 2% (before vicarious calibration); expected on-orbit gain trending accuracy is 0.2% or better
- More info on PACE and OCI can be found at https://pace.oceansciences.org/