

Mission Overview and Status From Concept to Launch

SPIE Conference
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Advanced Measurements of the Earth and Sky

Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission

Phase E

Launch Date: 2/8/2024

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Plankton, Aerosol, Cloud, ocean Ecosystem

PACE is a mission of discovery across Earth system science.

PACE will revolutionize global marine and atmospheric science with its hyperspectral imaging radiometer and two multi-angle polarimeters.

PACE advances realized in Earth science relative to those from MODIS will be as profound as those achieved in astronomy moving from Hubble to JWST.

PACE is far more than an ocean color and aerosols continuity mission. It will provide a combination of atmosphere and ocean observations to benefit society in the areas of water quality, human health, fisheries management, ecological forecasting, disaster impacts, air

What is PACE?



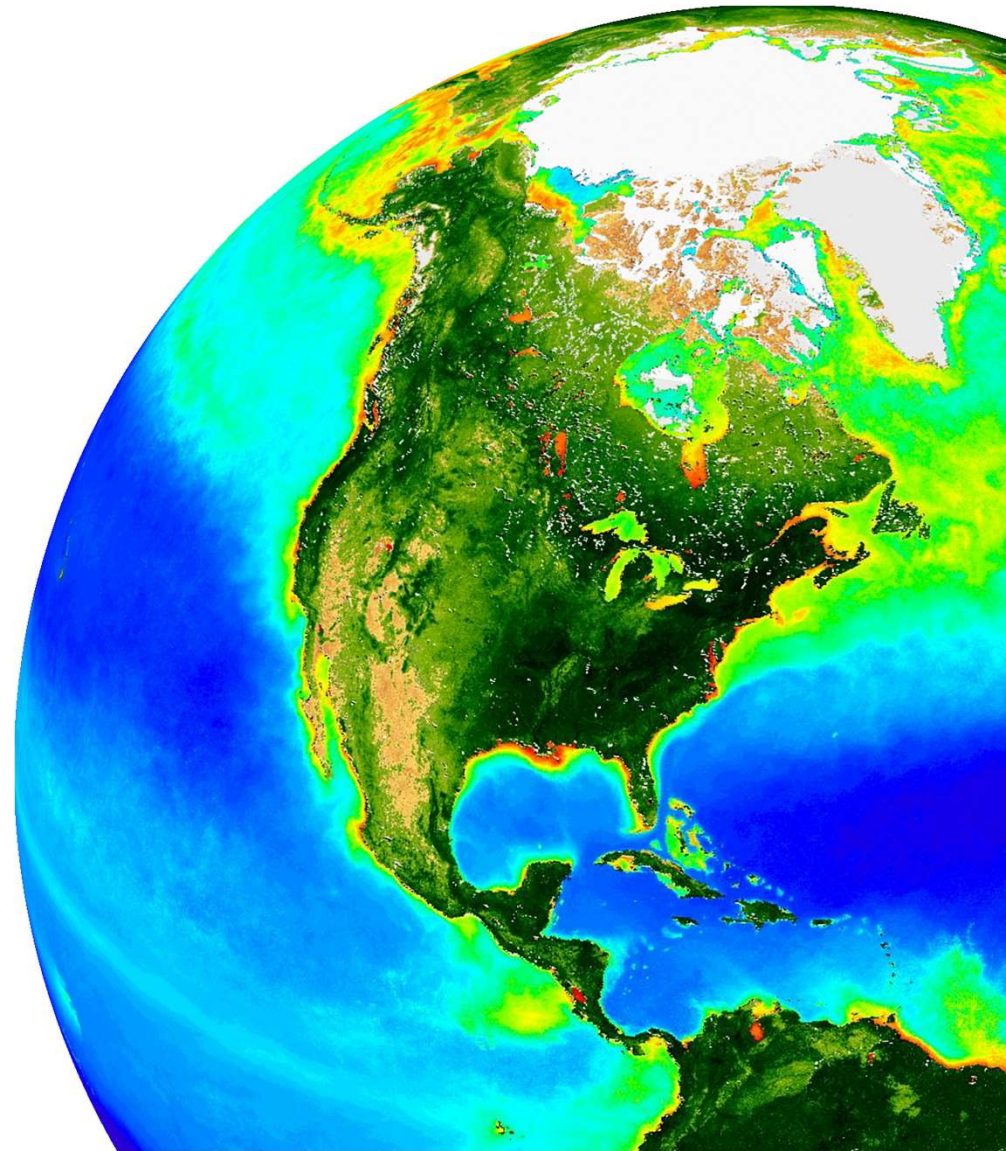
PACE science objectives

Extend key systematic **ocean** biological, ecological, & biogeochemical climate data records, as well as **cloud & aerosol climate data records**

Make **new global measurements of ocean color** that are essential for understanding the global carbon cycle & ocean ecosystem responses to a changing climate

Collect **global observations of aerosol & cloud properties**, focusing on reducing the largest uncertainties in climate & radiative forcing models of the Earth system

Improve our understanding of how **aerosols influence ocean ecosystems & biogeochemical cycles** and how **ocean biological & photochemical processes affect the atmosphere**



OCI

340-890 nm in 2.5 nm steps
7 discrete SWIR: 940-2260 nm
1-2 day coverage; $\pm 20^\circ$ tilt; 1km



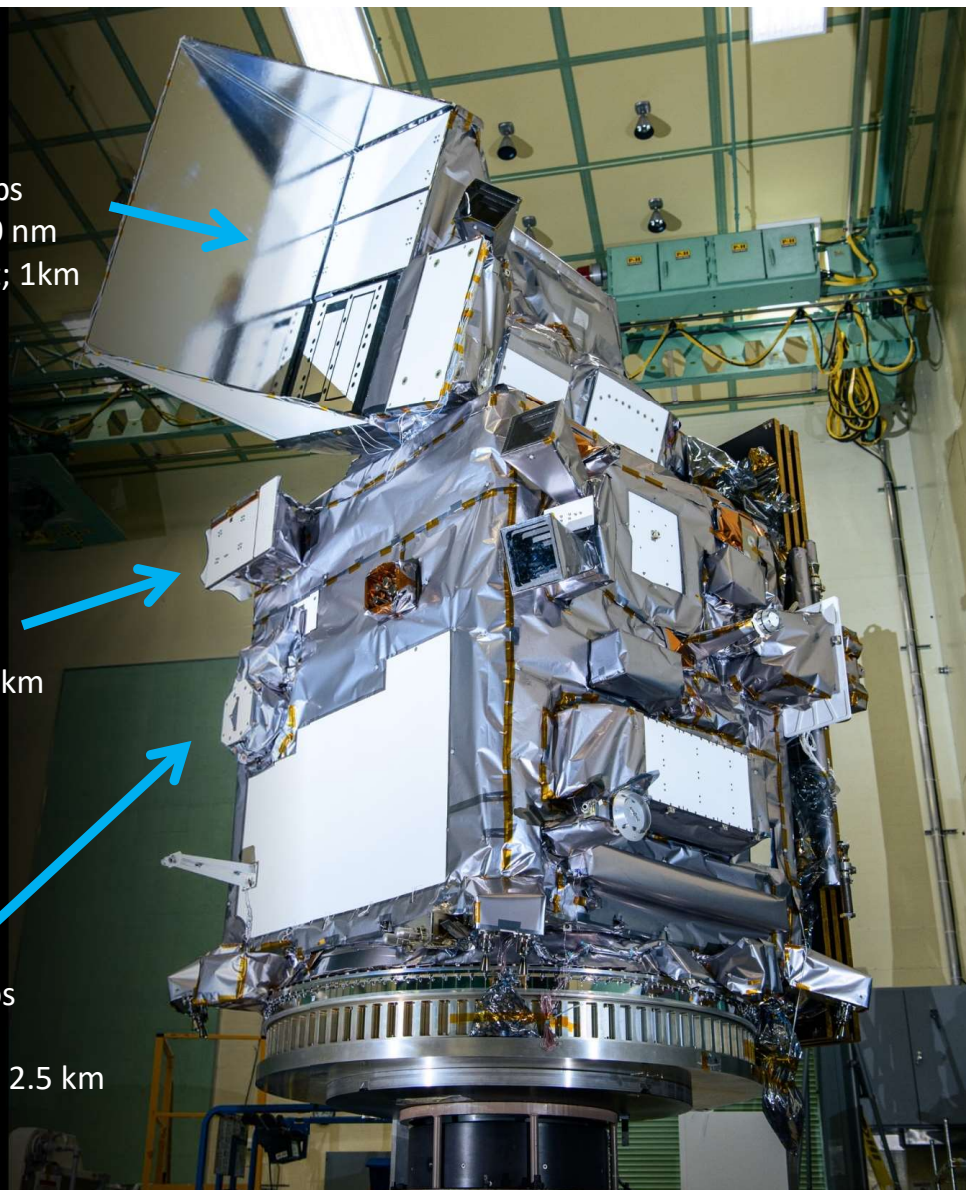
HARP2

440, 550, 670, 870 nm
10-60 viewing angles
wide swath polarimeter; 3 km



SPEXone

380-770 nm in 2-4 nm steps
5 viewing angles
narrow swath polarimeter; 2.5 km



PACE fills niches not currently addressed at home or abroad

Moving from multi- to hyper-spectral radiometry is essential for observing aquatic systems

No current or planned hyper-spectral radiometer provides **1-2 day global coverage**

UV & two 2-mm bands realize atmospheric improvements over heritage instruments

Multi-angle polarimetry adds dimensions of information (as well provides a pathfinder)

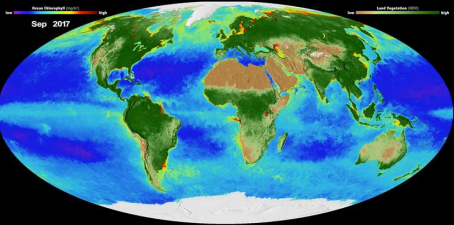
Tilt is essential for capturing marine system dynamics



~ 9 years from kick-off to launch



- PACE was directed to GSFC in December 2014
 - The primary instrument, the Ocean Color Instrument, will be built in-house
 - Project was directed to use a Design-to-Cost methodology
 - Maximize capabilities above threshold while remaining within cost constraints
 - Start with thresholds and cost cap, then set baselines; these are used to influence design
 - October 2012 Science Definition Report was the basis for the science objectives
 - HQ provided threshold requirements to the project (developed in conjunction with Project Science)
 - Overall budget cap set
- Kick-off meeting held at NASA HQ in January 2015
- Pre-Phase A began January 2015



PACE Science

New opportunities to monitor fisheries and respond to toxic algae blooms and key ocean and atmosphere data for forecasting air quality and weather that will improve our understanding of Earth's climate

Mission Commitments (Post-Pandemic Replan)

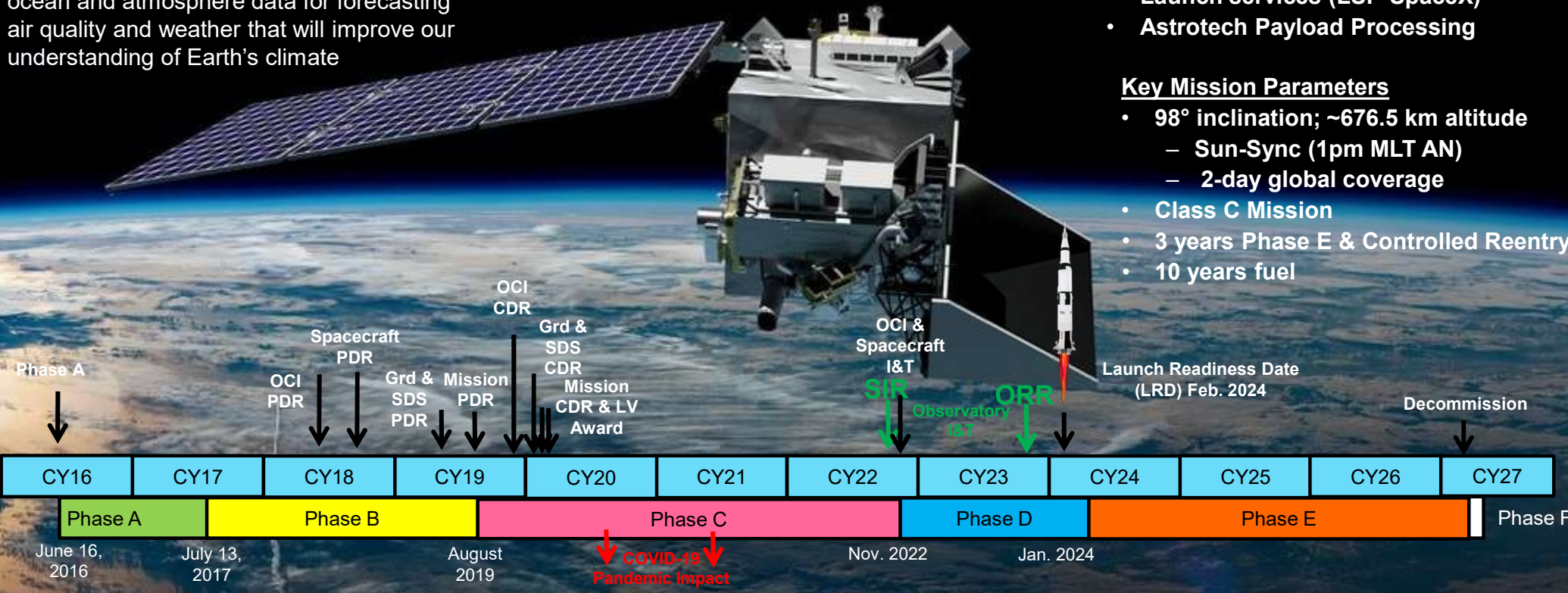
- Management Agreement
 - LRD February 2024
 - Cost Capped Budget
- Agency Baseline Commitment
 - Launch Date of May 2024
 - Cost Capped Budget

Mission Elements (Organization)

- Completed Science Team (NASA ESD)
- Vicarious Calibration (NASA ESD)
- Science Data Analysis (GSFC)
- Ocean Color Instrument (GSFC)
- Spacecraft – (GSFC)
- Polarimeters – (SRON, UMBC)
- Mission Operations – (GSFC)
- Launch services (LSP-SpaceX)
- Astrotech Payload Processing

Key Mission Parameters

- 98° inclination; ~676.5 km altitude
 - Sun-Sync (1pm MLT AN)
 - 2-day global coverage
- Class C Mission
- 3 years Phase E & Controlled Reentry
- 10 years fuel





Setting the Programmatic Context for PACE



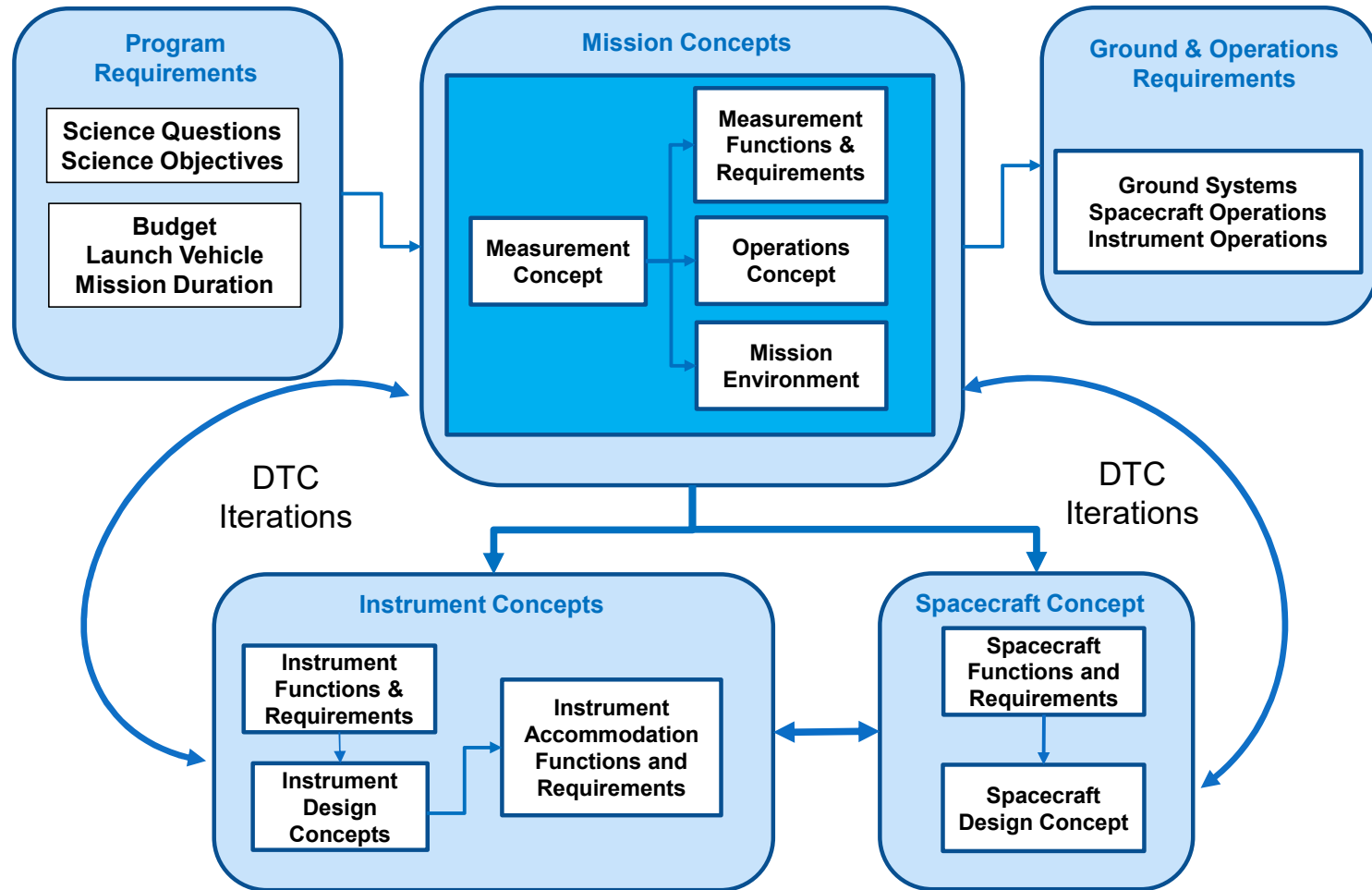
- PACE is: **Systematic, Directed, and Cost-Capped**
 - **Systematic** (vs. PI-led) => HQ and project are involved in establishing mission capabilities collaboratively
 - **Directed** (vs. competitively selected) => We know who's responsible
 - **Cost-Capped** (vs. completely requirements-driven) => Sets the boundary
 - Having all 3 attributes together is a unique approach for a flight mission
- Science community's desires have been taken into consideration
 - October 2012 Science Definition Report was the basis for the science objectives
- HQ provided minimum (threshold) requirements that are design drivers
- Design-to-Cost principles
 - Maximize capabilities above threshold while remaining within cost constraints
 - Start with thresholds and cost cap, then set baselines; these are used to influence design
- In pre-formulation, and continuing through formulation, project worked closely with stakeholders to perform trade studies
 - During 17 months, performed >50 studies



Establishing Mission Requirements

- The Design to Cost (DTC) process dictates that the capabilities are part of the trade process
- The Science Definition Team (SDT) Report provides a set of objectives to be evaluated by the project
- HQ provided a set of threshold requirements
- At this beginning phase of the mission, ***no agreed to baseline requirements have been established (per DTC process)***
 - Notional baseline capabilities have been established for the preferred mission concept and cost
 - The project uses the DTC process to determine what set of baseline capabilities are achievable within the budget cost cap and at the 65% cost confidence
 - This process continued in Phase A and Phase B and was codified at KDP-C

PACE Design To Cost is an Iterative Process from Science Objectives to Requirements and Concepts



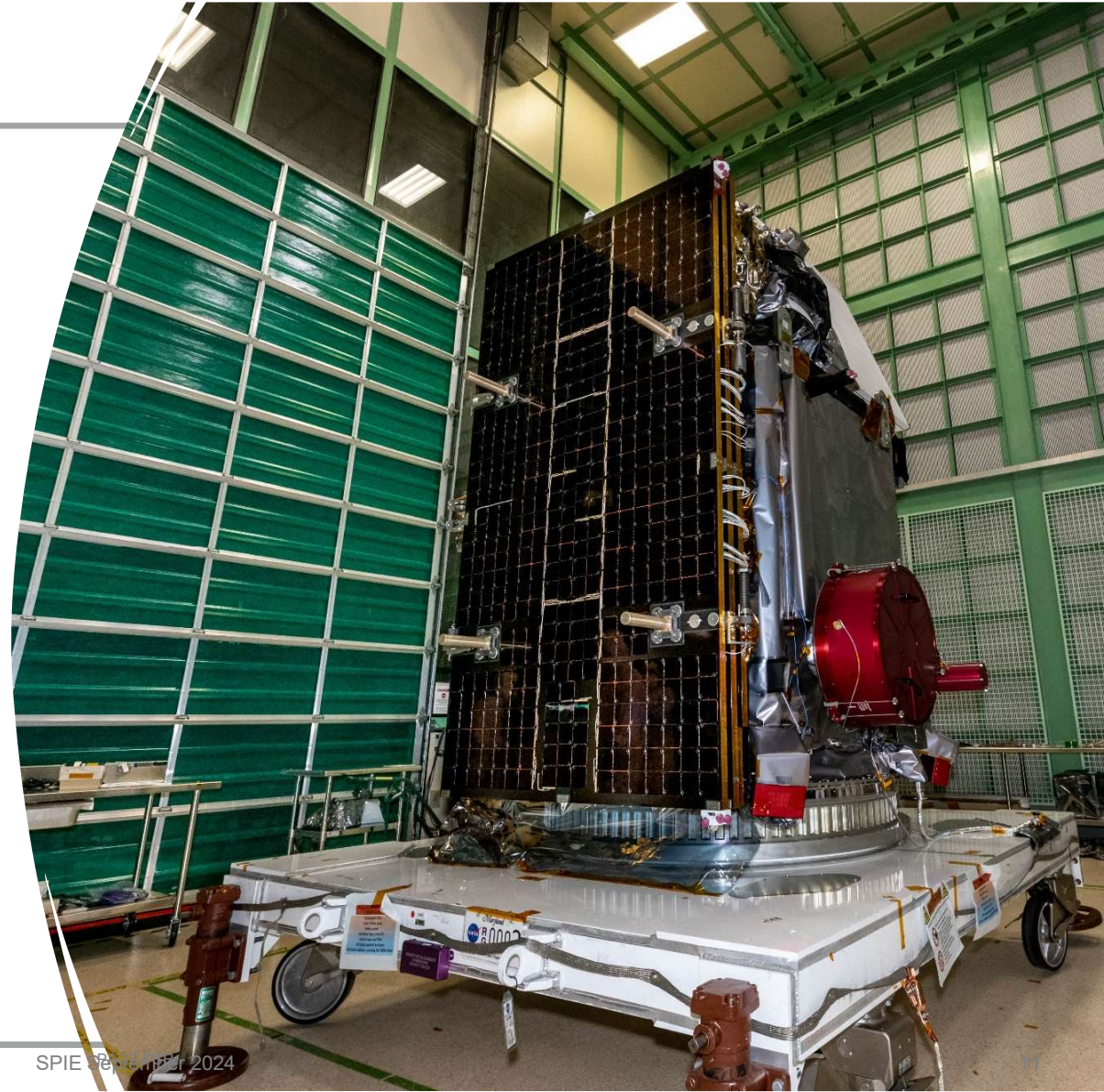


Significant Design to Cost Decisions

- Ocean Color Instrument:
 - Extended the instrument performance to the UV range (320nm)
 - Selected the 2 additional SWIR Bands 1250 & 1615nm
 - Added solar diffuser for daily calibrations
 - Selected orbit, ground spatial distance (GSD) & signal-to-noise (SNR)
 - Defined Threshold and Baseline SNR levels that link directly to the number of SWIR channels
 - Selected Fiber Optics solution for SWIR bands
- Polarimeter:
 - Eliminated procured option
 - Pursuing contributed instrument
- Spacecraft:
 - Delayed spacecraft start
 - Momentum compensation on the bus



Integrated PACE Observatory



PACE Lift onto Vibe Table



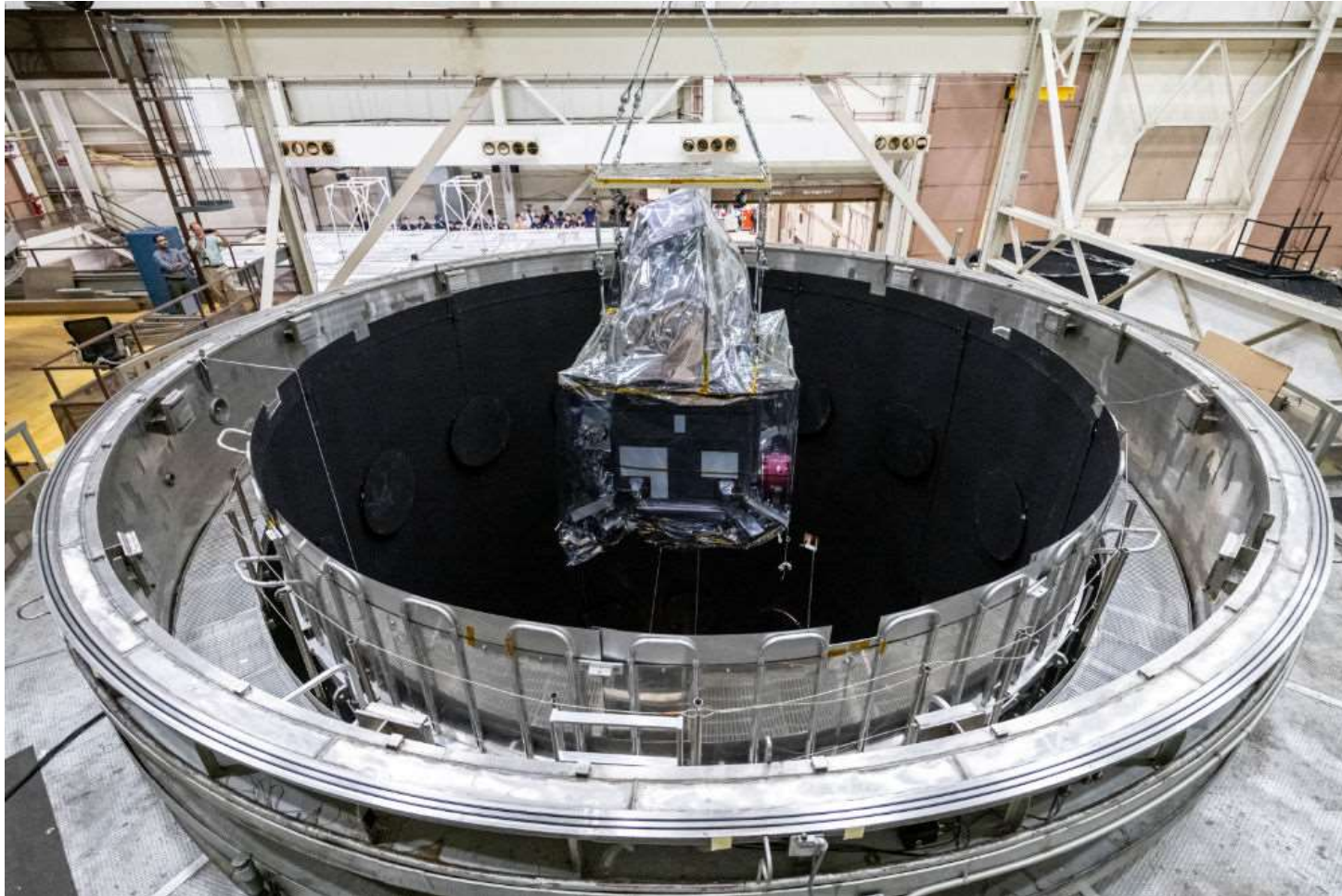
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PACE in Acoustics Chamber



Thermal Balance/Thermal Vacuum





Launch Campaign Overview: Launch!



- PACE arrives at launch site: 14 Nov 2023
- Launch site CPT, Propellant loading, TDRS tests, and many other activities....
- Launch Vehicle Readiness Review, Flight Readiness Review, Launch Readiness Review, many other reviews...
- Red-tag/Green-tag item closeouts completed
- Two launch SCRUBS on 6 & 7 Feb 2024 due to high winds, then a picture-perfect launch & ascent on a SpaceX Falcon 9
- **Launch: February 8, 2024**





PACE in space!!!

for the first time in ~2 decades
PACE will bring new and **unprecedented** science

- ✓ Spectral information from OCI – new data products on global scales
- ✓ Advanced aerosol & cloud characterization from SPEXone & HARP2
- ✓ Opportunities for advanced ocean color atmospheric correction
- ✓ Potential to derive new ocean products from multi-angle polarimetry

Thank **You** to EVERYONE on the PACE Team!



PACE

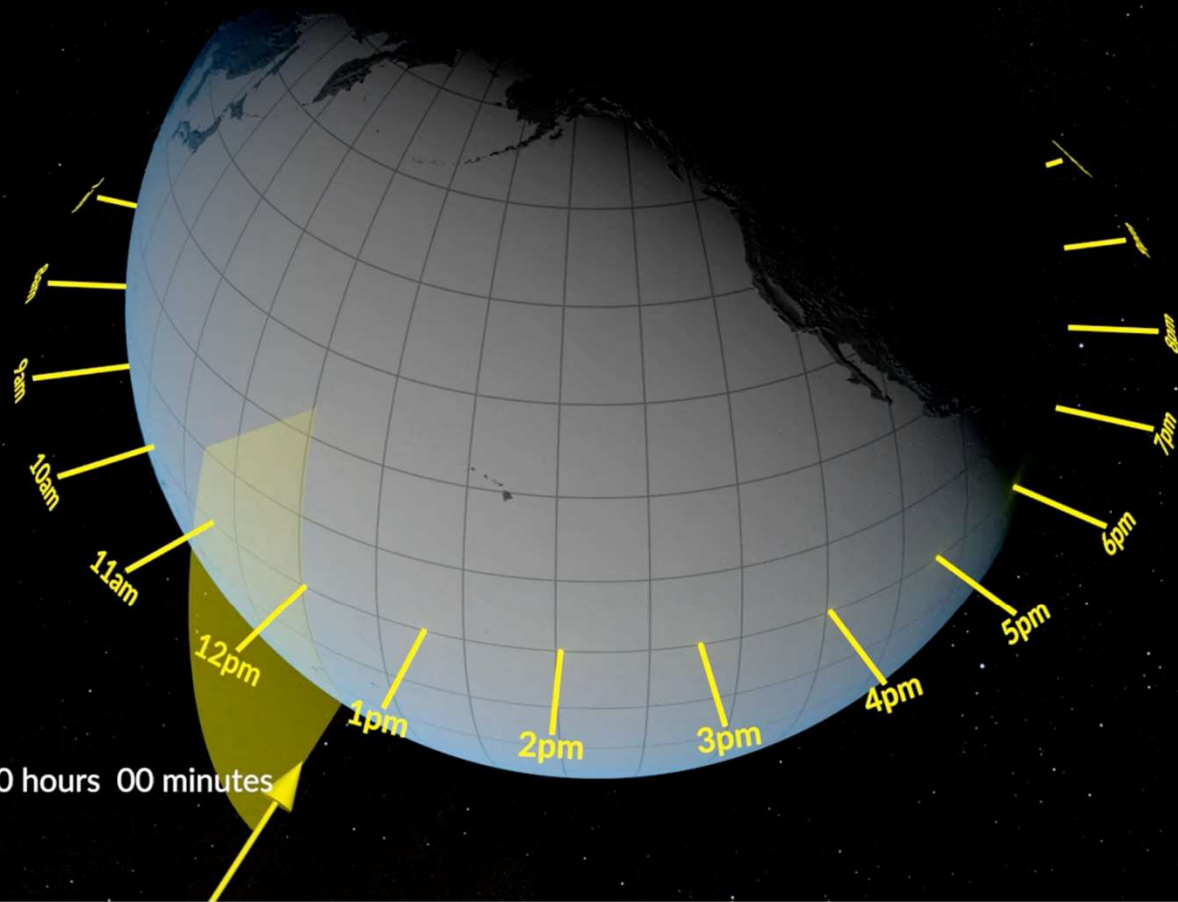


Questions?

PACE

Plankton, Aerosol, Cloud, ocean Ecosystem

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