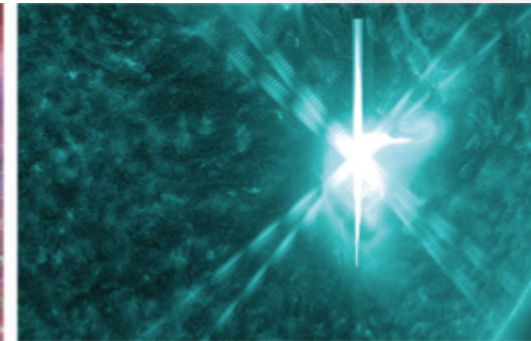
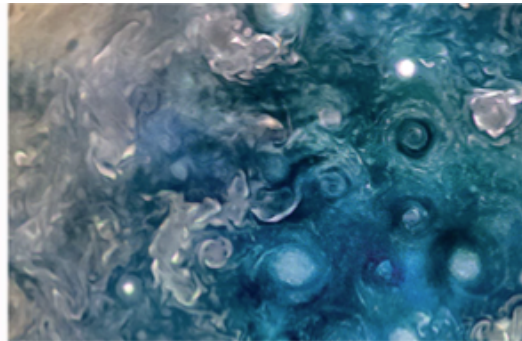


# SCIENCE

National Aeronautics and  
Space Administration



Next-Gen Suborbital Researchers Conference

## Expanding Opportunities for SMD Research

**Thomas H. Zurbuchen**  
Associate Administrator  
Science Mission Directorate  
@Dr\_ThomasZ

DECEMBER 18, 2017

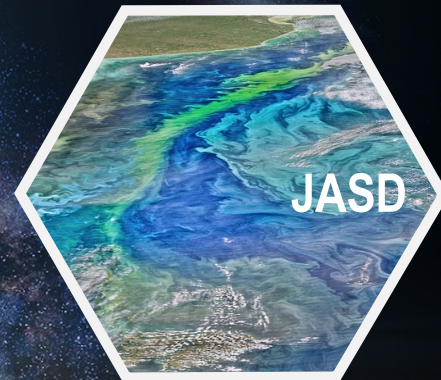
# Suborbital Programs for Science

- Enable science leadership by sustaining program balance
- Enhance science/dollars through partnerships and broader objectives
- Enrich commercial collaborations with tailored management approaches



# NASA Science Mission Directorate

An Integrated Program  
Enabling Great Science



# Science by the NUMBERS



**TECHNOLOGY  
INNOVATION**  
~\$400M Invested Annually



**RESEARCH**  
~10,000 U.S. Scientists Funded  
~3,000 Competitively Selected Awards  
~\$600M Awarded Annually



**SPACECRAFT**  
105 Missions  
88 Spacecraft



**CUBESATS**  
17 Science Missions  
11 Technology Demos



**SOUNDING ROCKETS**  
16 Science Missions  
3 Tech/Student Missions

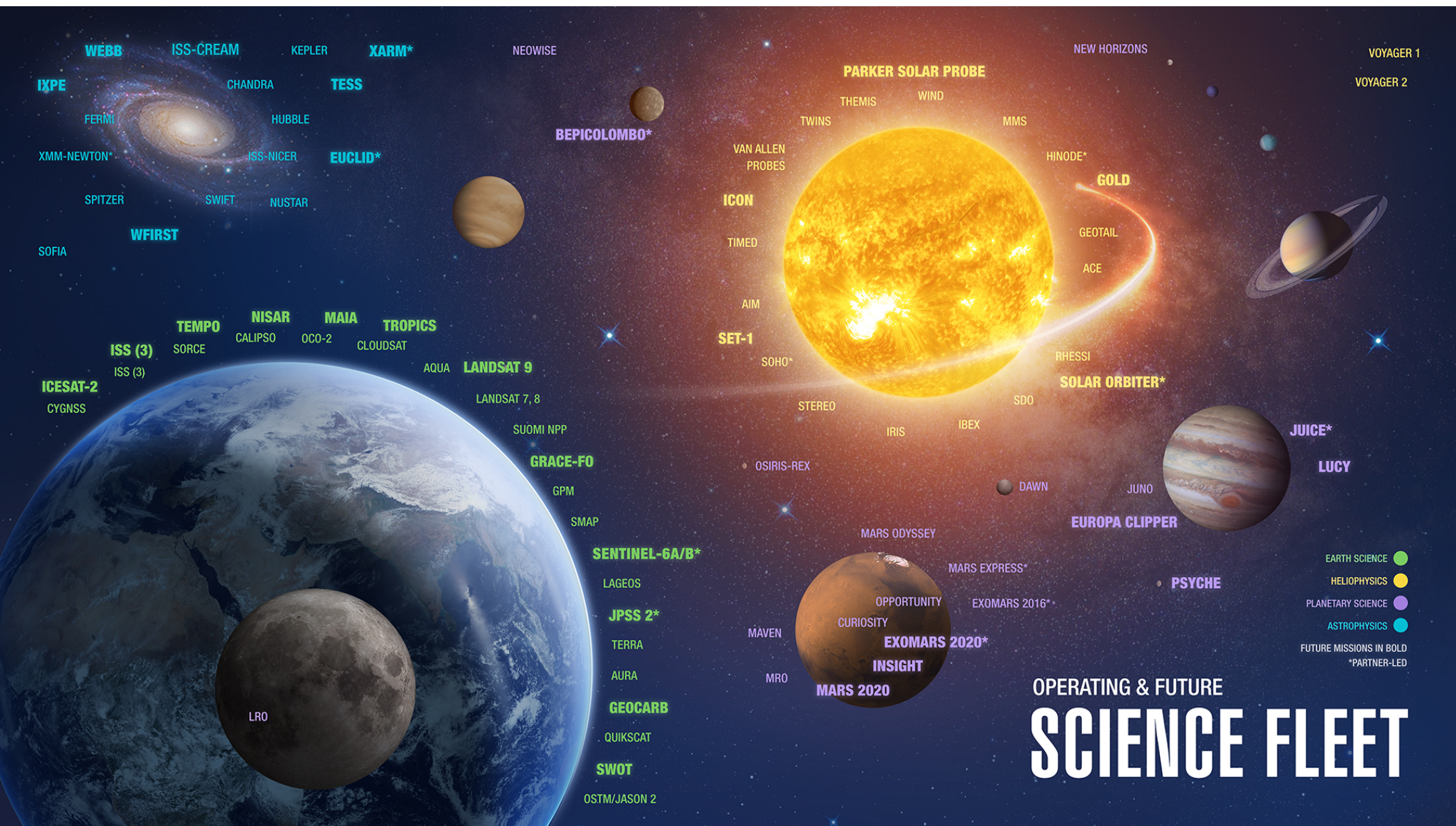


**EARTH-BASED  
INVESTIGATIONS**  
25 Major Airborne Missions  
8 Global Networks



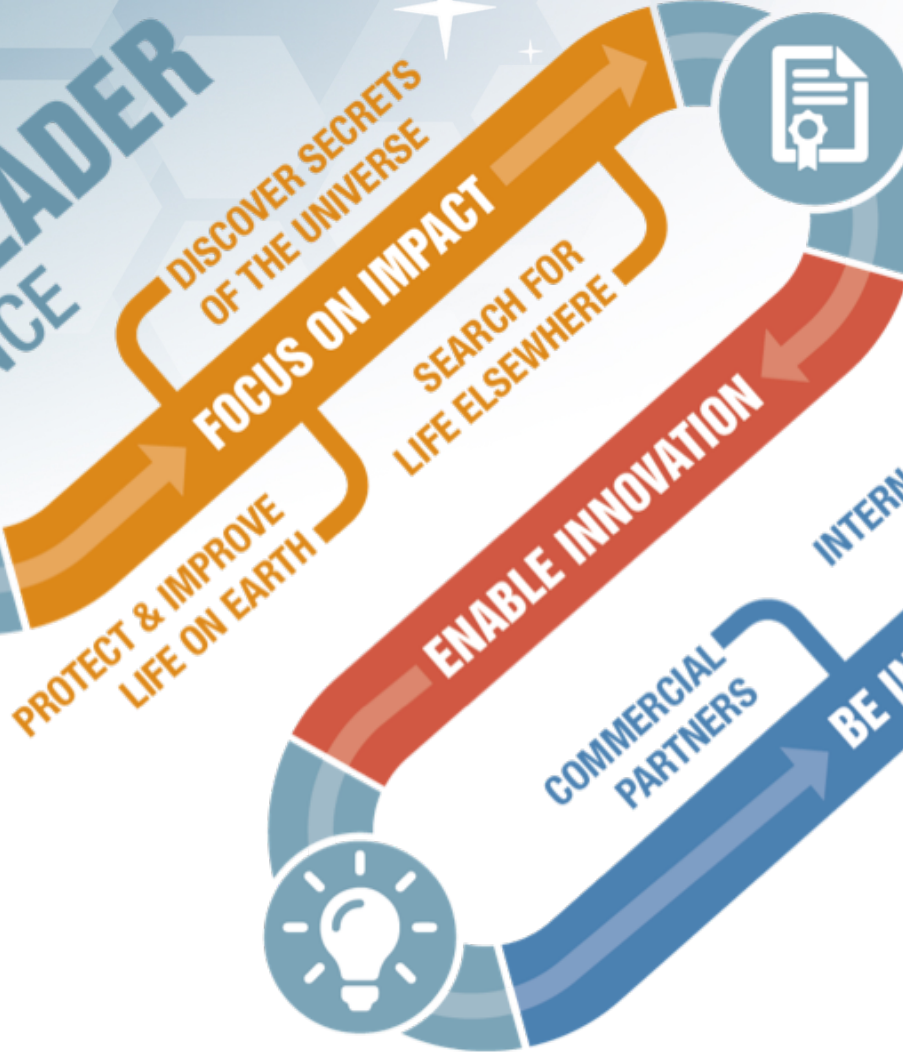
**BALLOONS**  
13 Science Payloads  
1 HASP with up to  
12 student experiments





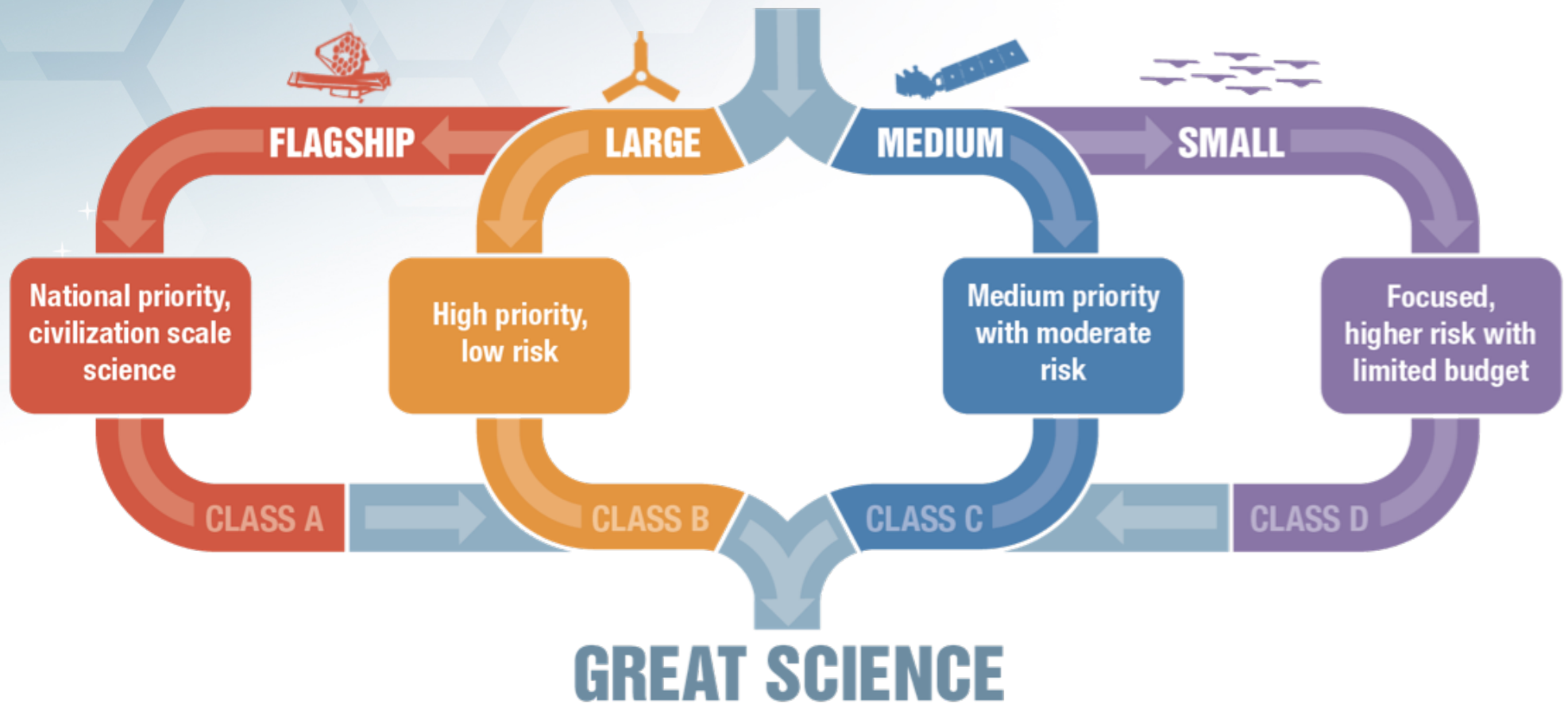


# BE A LEADER IN SCIENCE

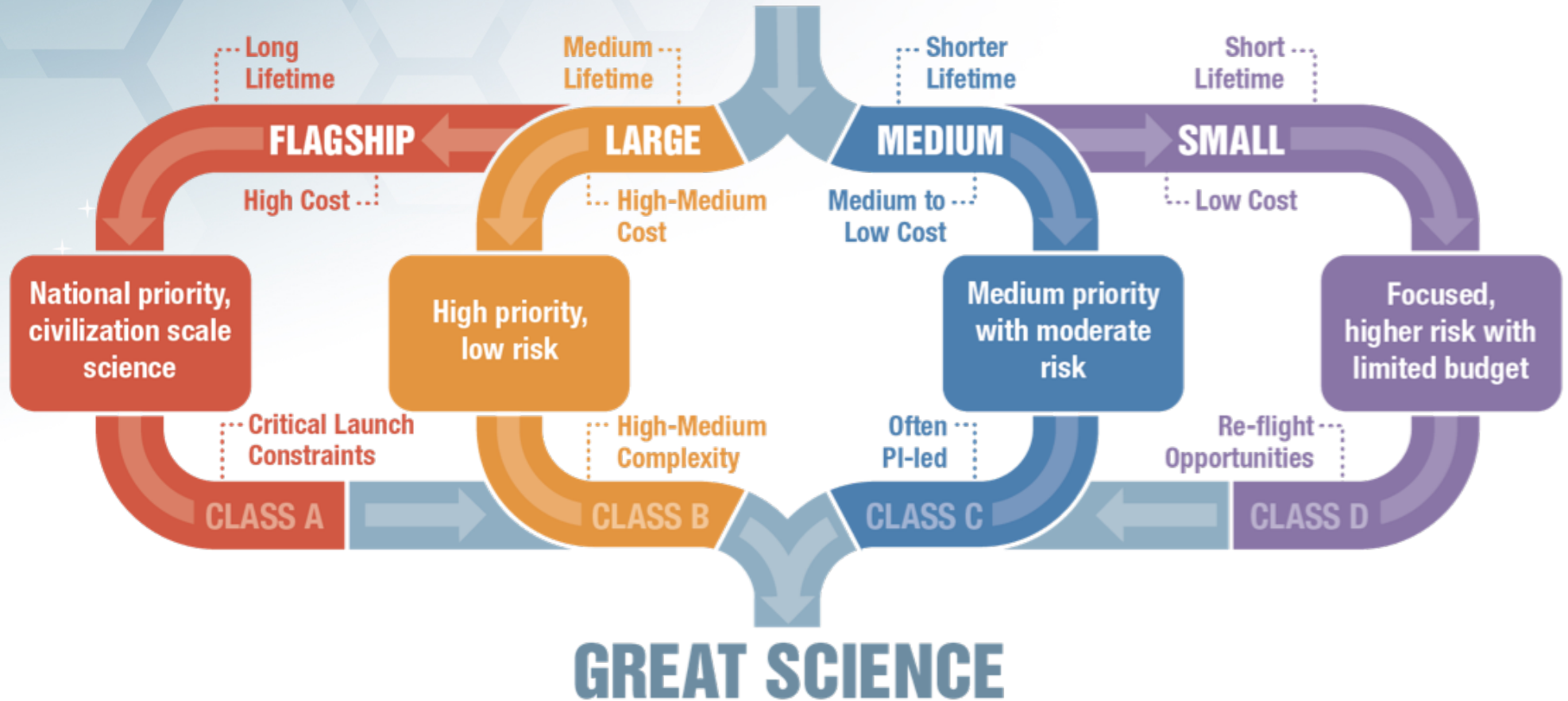


# INSPIRE LEARNERS OF ALL AGES

# BALANCED MISSION PORTFOLIO



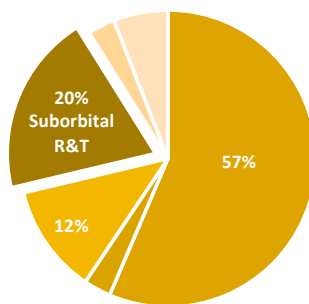
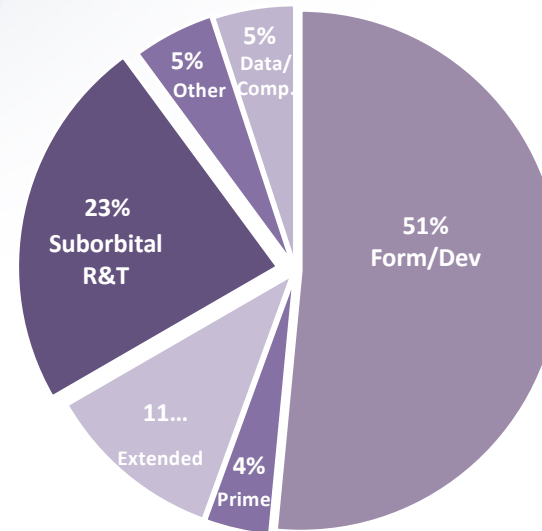
# BALANCED MISSION PORTFOLIO



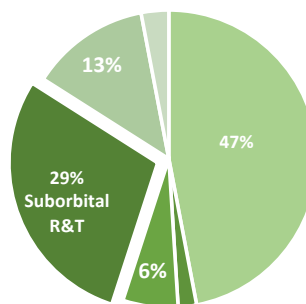


# SMD Balances New and Existing Missions\*

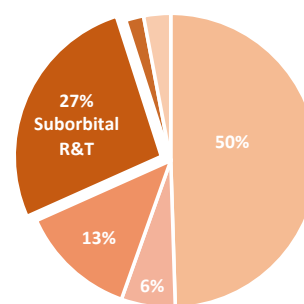
- Development of large missions (>\$1B through launch) typically account for ~50% of SMD's budget
- Nearly 25% of SMD's budget goes to Suborbital and Research & Tech programs



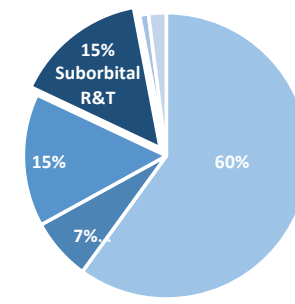
HELIOPHYSICS



EARTH SCIENCE



PLANETARY SCIENCE



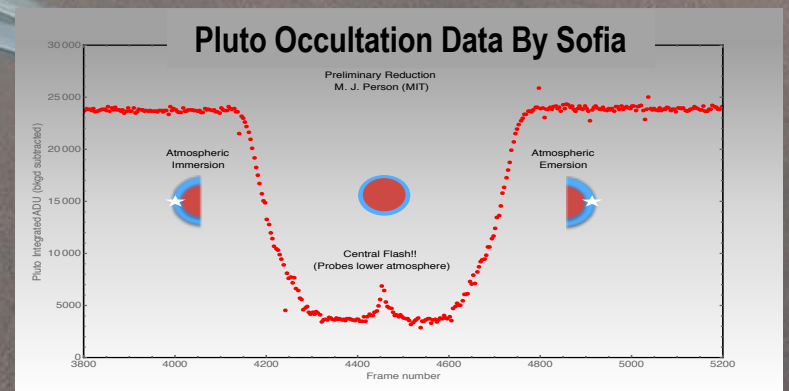
ASTROPHYSICS

\*FY17 \$



# SOFIA

Intercepting Pluto's Shadow, 2011





# BARREL

Balloon Campaigns Above Antarctica, Sweden  
Observing Electrons Interacting with Atmosphere





# Hi-C

High Resolution Images of Solar Corona  
and Previously Unseen Magnetic Activity



# First Balloon-based Astrophysics Mission

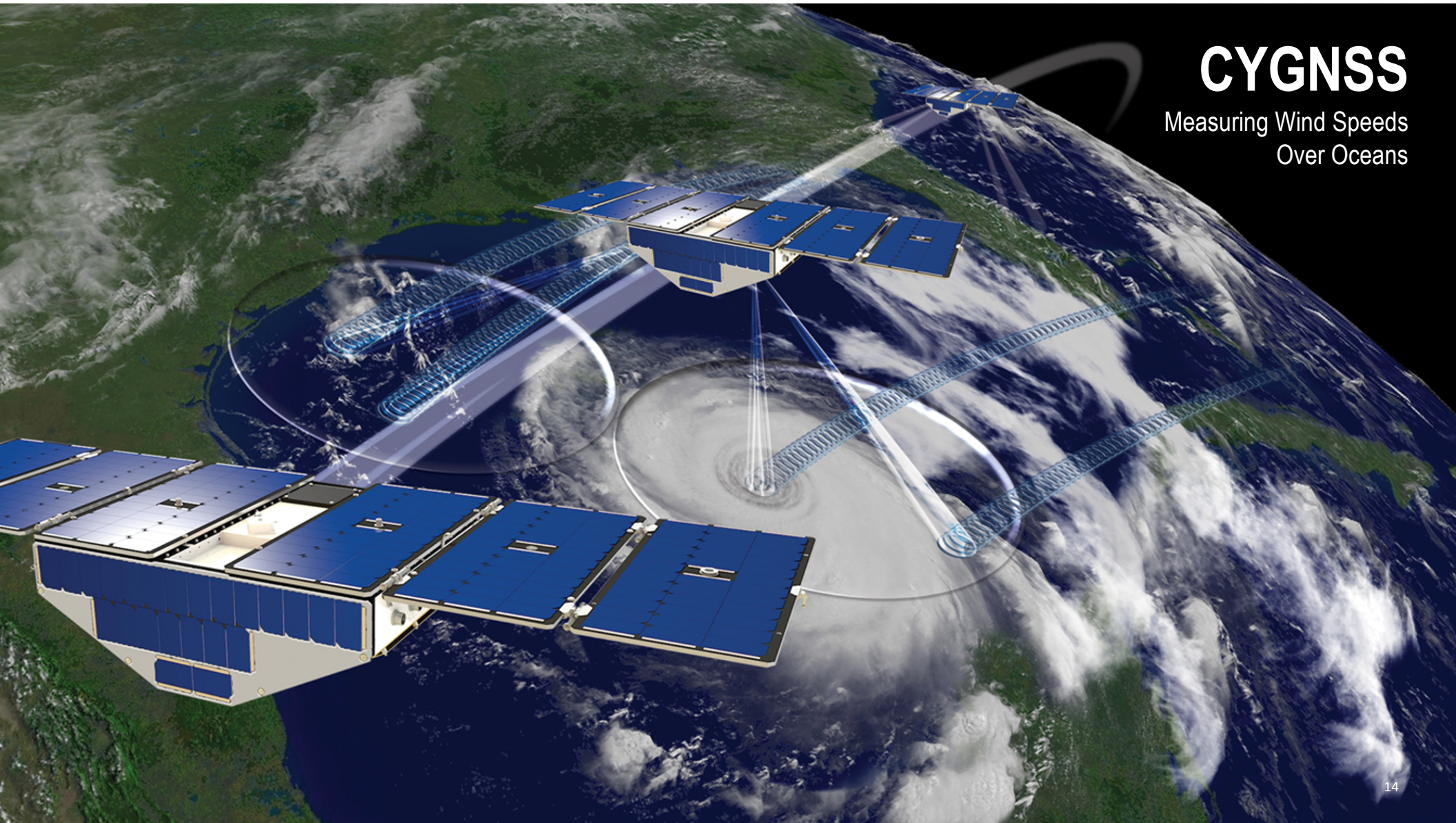
- Galactic/Extragalactic ULDB\* Spectroscopic Terahertz Observatory (GUSTO)
- Astrophysics Explorers Mission of Opportunity, selected March, 2017
- Mission large-scale surveys & spectral diagnostics of the Interstellar Medium (ISM)
- Answers key questions on lifecycle of ISM and massive star formation

\* *Ultra-long Duration Balloon*



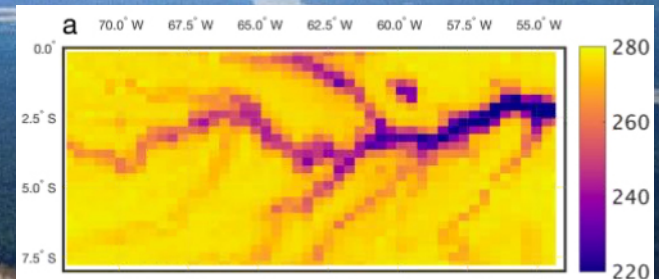
# CYGNSS

Measuring Wind Speeds  
Over Oceans

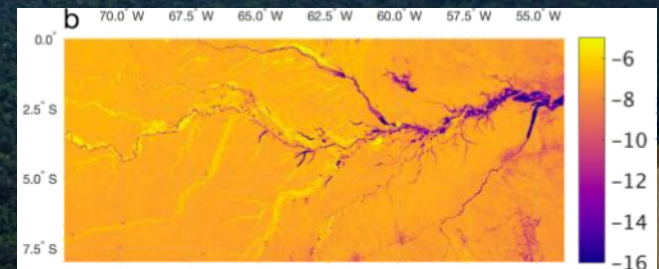




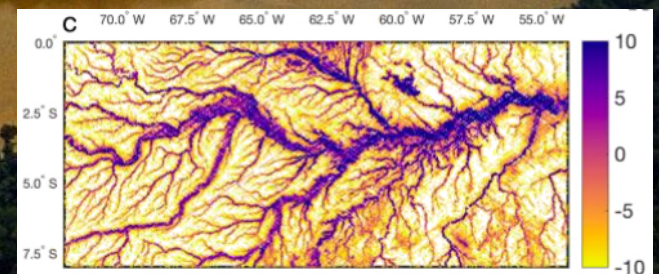
# CYGNSS Innovation



*SMAP passive microwave*



*SMAP active radar*



*CYGNSS SNR*

*Courtesy: Clara Chew, NASA/JPL*

# Suborbital Programs for Science

- Enable science leadership by sustaining program balance
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# Science + Technology Programs Across Disciplines

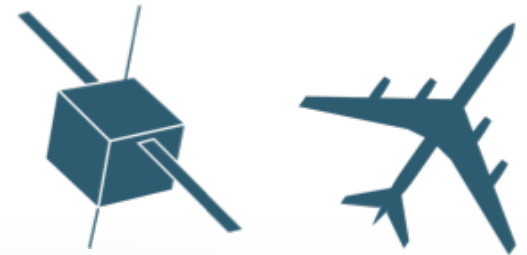
## Technology Programs



## Ground, Suborbital & In-Space Validation



## Flight Opportunities



*Commercial Engagement Opportunities Across The Portfolio*



# Science + Technology Programs Across Disciplines

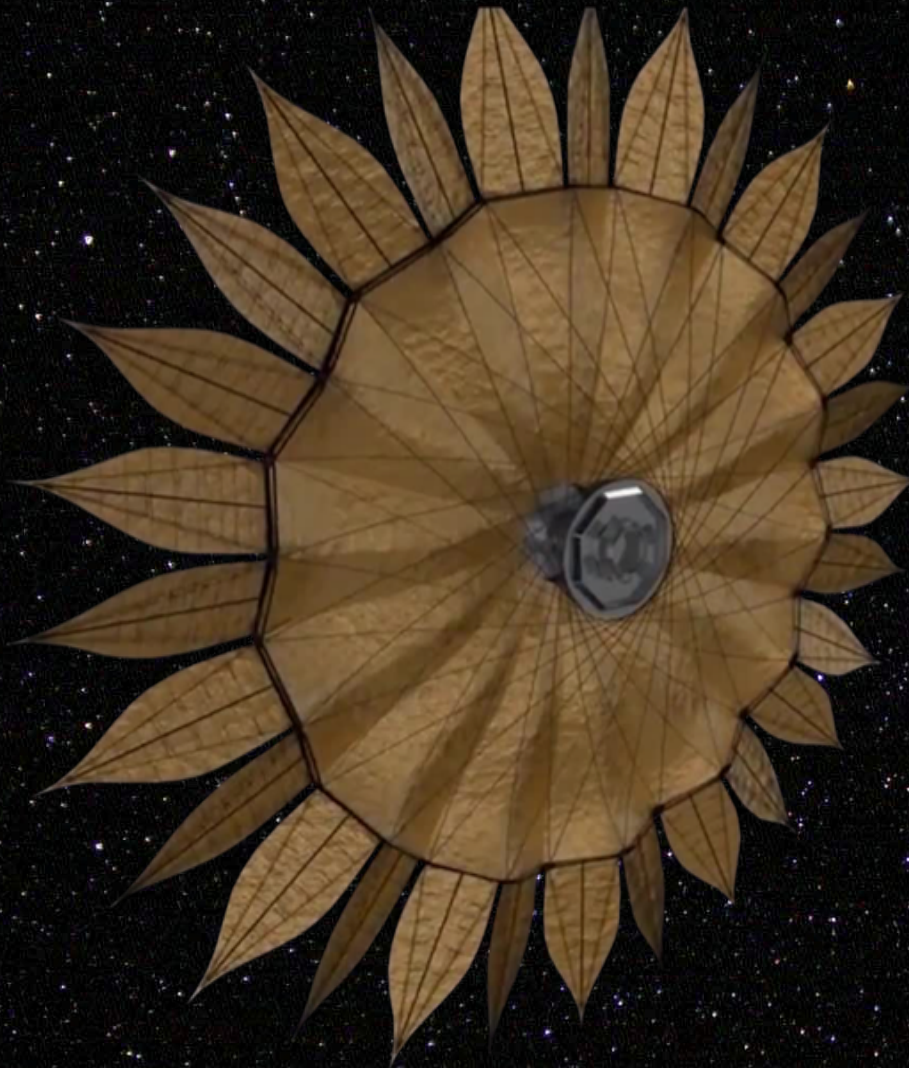
## Technology Programs

12 technology programs, including:

- INVEST - In-Space Validation of Earth Science Technology
- APRA - Astrophysics Research and Analysis
- HTIDeS - Heliophysics Technology and Instrument Development for Science
- ISST - Icy Satellites Surface Technology
- MARS - Mars Technology Program
- PICASSO - Planetary Instrument Concepts for the Advancement of Solar System Observations

# Starshade

Exoplanet Exploration Program  
to Block Star's Light



# Science + Technology Programs Across Disciplines

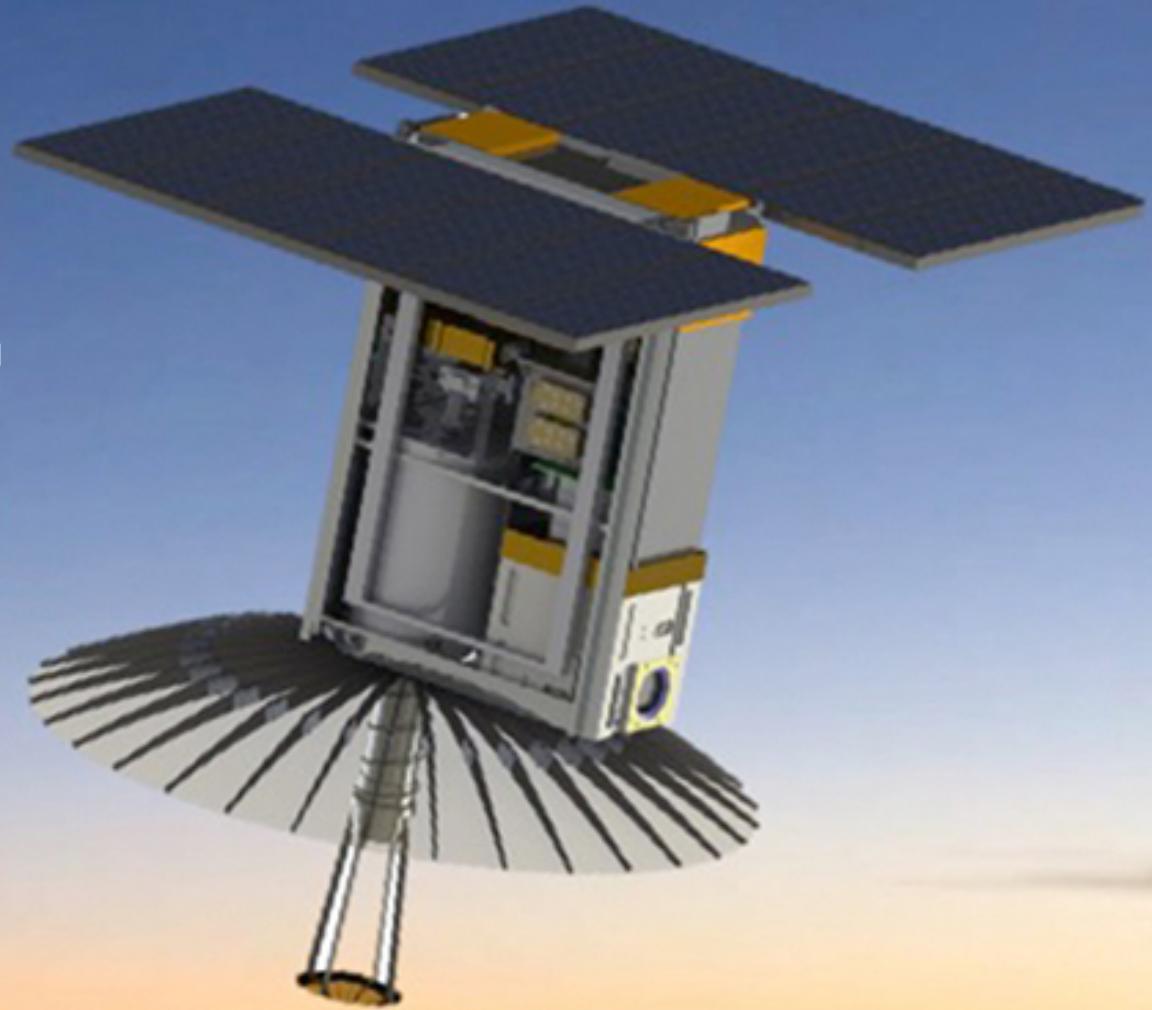
## Ground, Suborbital & In-Space Validation

- IIP - Aircraft for Validation
- INVEST - CubeSats
- FOP - Flight Opportunities Program - Commercial Balloons, Technology Validation Platforms
- APRA - Rockets, Balloons
- HTIDeS - Rockets, Balloons, CubeSats



# RainCube

InVEST Program CubeSat Platform  
for Precipitation Observations



# Science + Technology Programs Across Disciplines

## Flight Opportunities

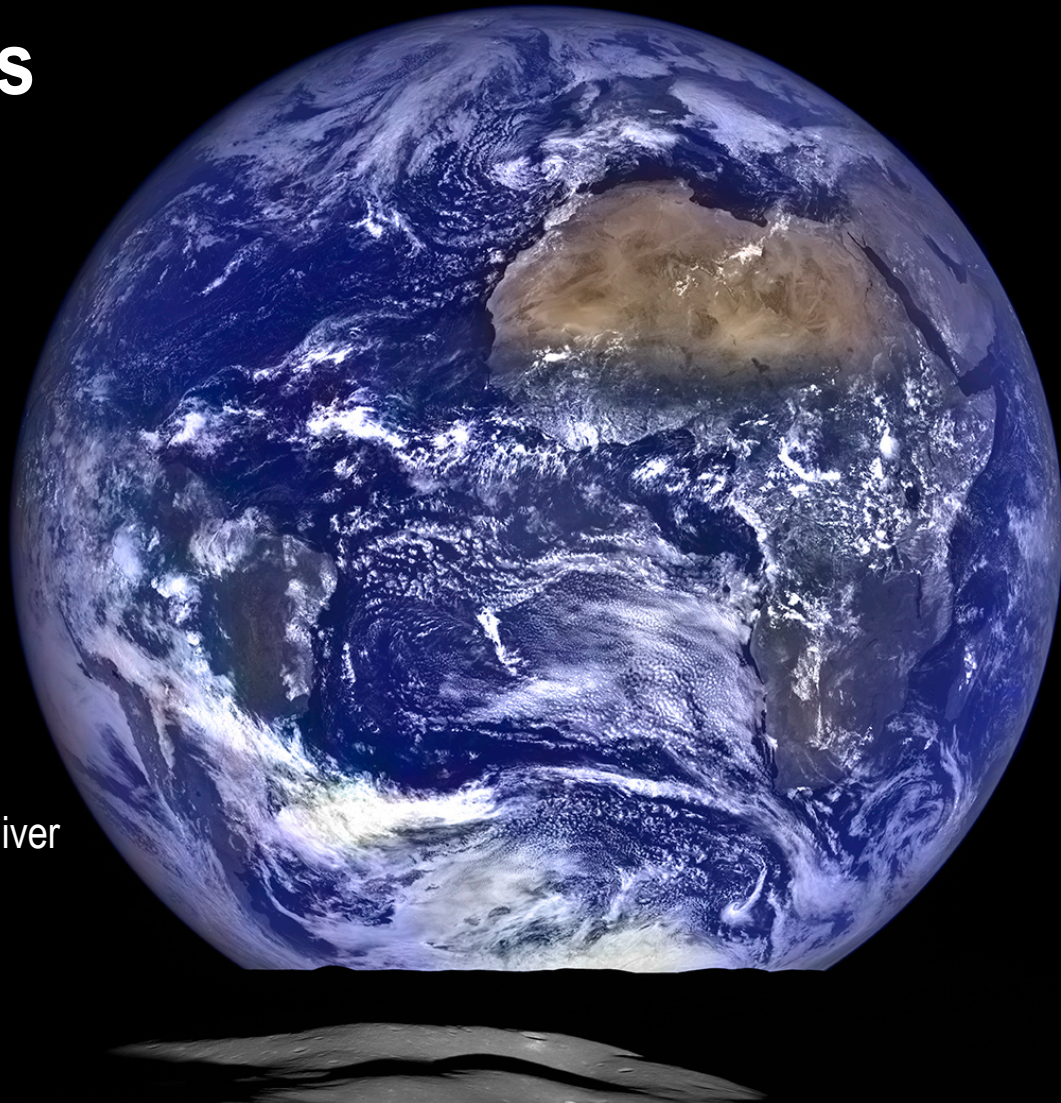
- Planetary – SIMPLEx
- Earth – Earth Venture, Airborne, Investment, Missions of Opportunity
- Heliophysics – Explorers, Missions of Opportunity
- Astrophysics – Explorers, Missions of Opportunity



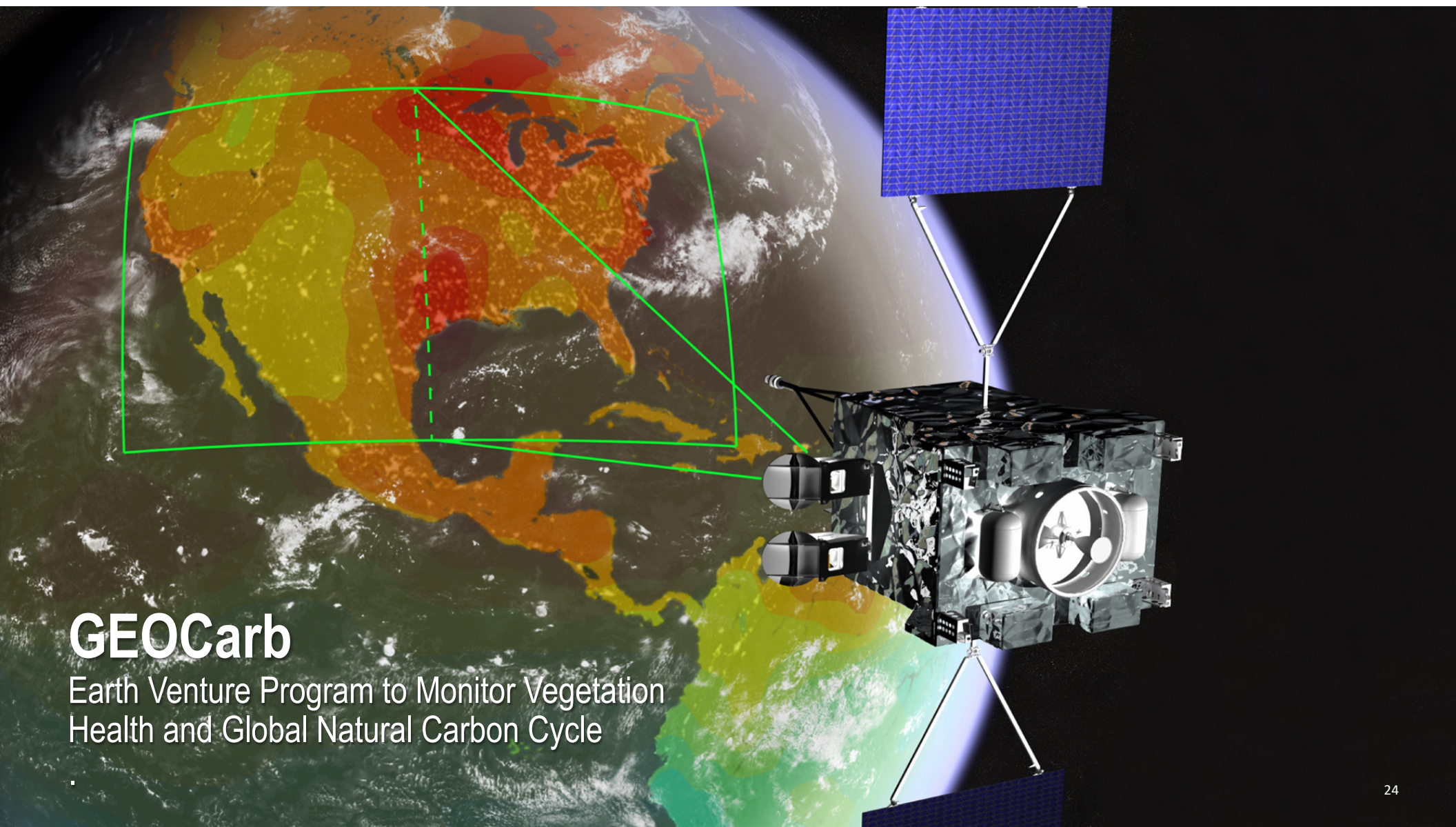
# Lunar Opportunities

**Summer 2017**

RFI for Commercial Lunar Landers to Deliver  
NASA Science Investigations to Moon







# GEOCarb

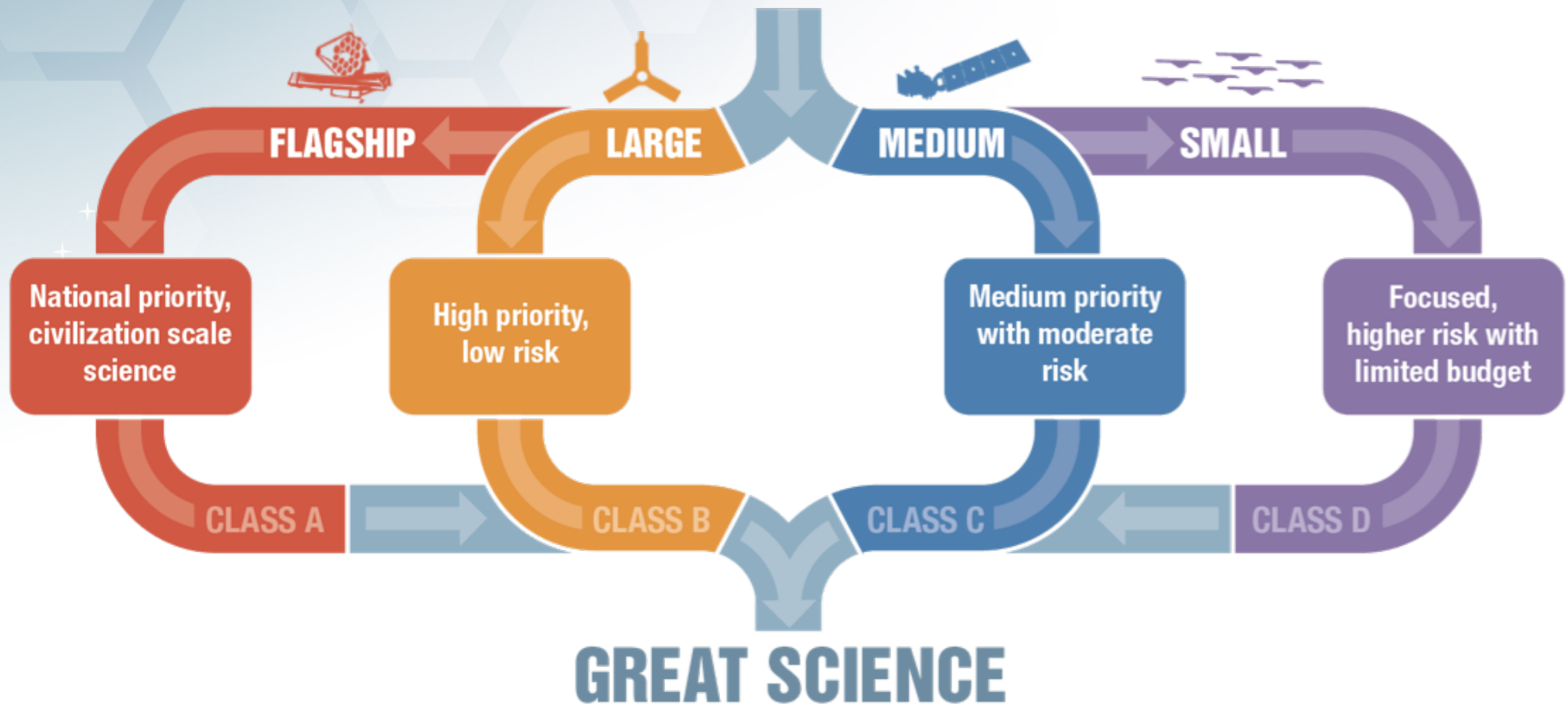
Earth Venture Program to Monitor Vegetation  
Health and Global Natural Carbon Cycle



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# BALANCED MISSION PORTFOLIO





# Importance of Small, Innovative Missions

- **Expand** science programs to take advantage of small satellite rapid innovation to achieve breakthrough science
- **Enable** fast access to space with focused science measurements fill a critical gap between large flight projects
- **Leverage** technology investments to further improve potential of science instruments
- **Partner** with commercial entities to acquire new capabilities of small satellite platforms

# Small Missions Strategy Implementation

*Accepting higher risk for scientific gain by implementing a tailored, streamlined classification approach*





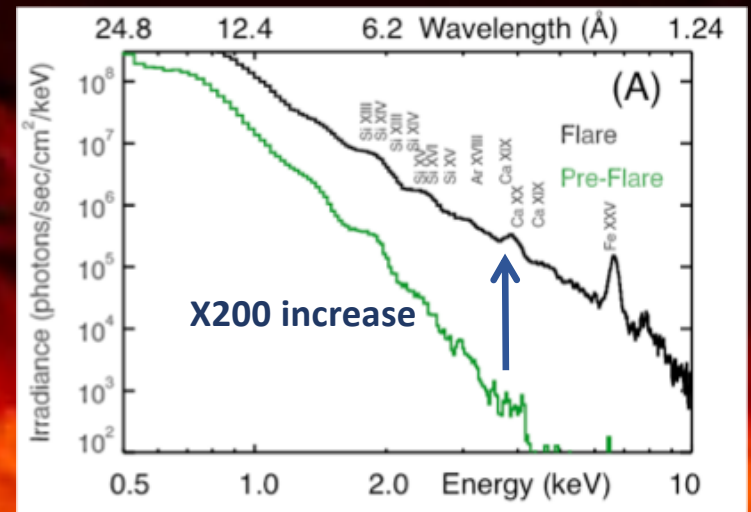
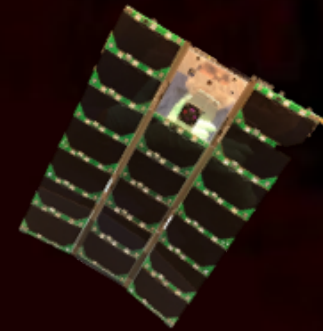
# CubeSats/SmallSats for Science

- Significant increase in capabilities of CubeSats/SmallSats over past 5 years
- Industry and academia exploited trends to craft highly capable, low cost-missions
- Budget includes new SMD-wide initiative to use CubeSats/SmallSats to advance selected high-priority science objectives in cost-effective manner

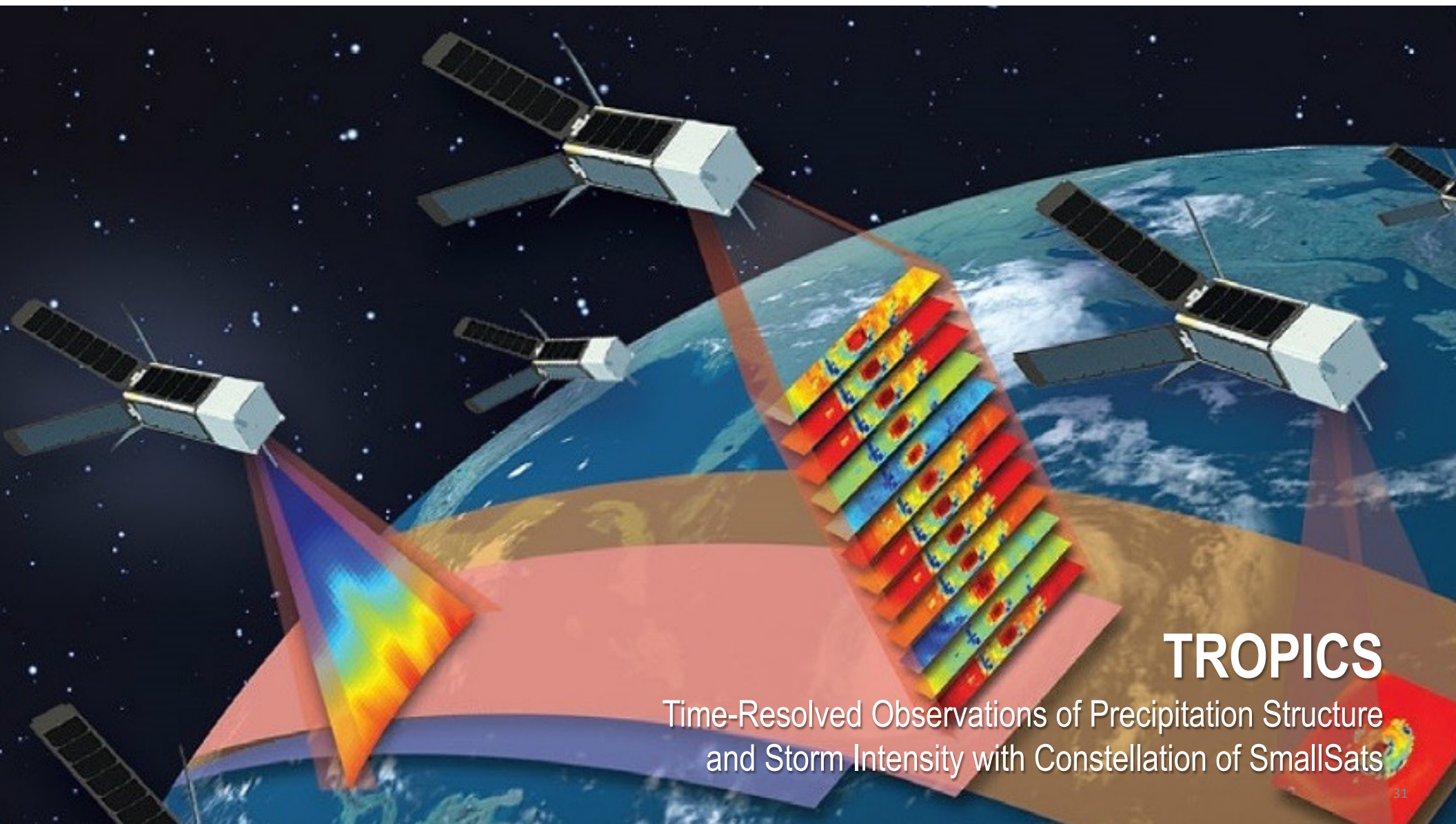


# MinXSS

Miniature X-ray  
Solar Spectrometer







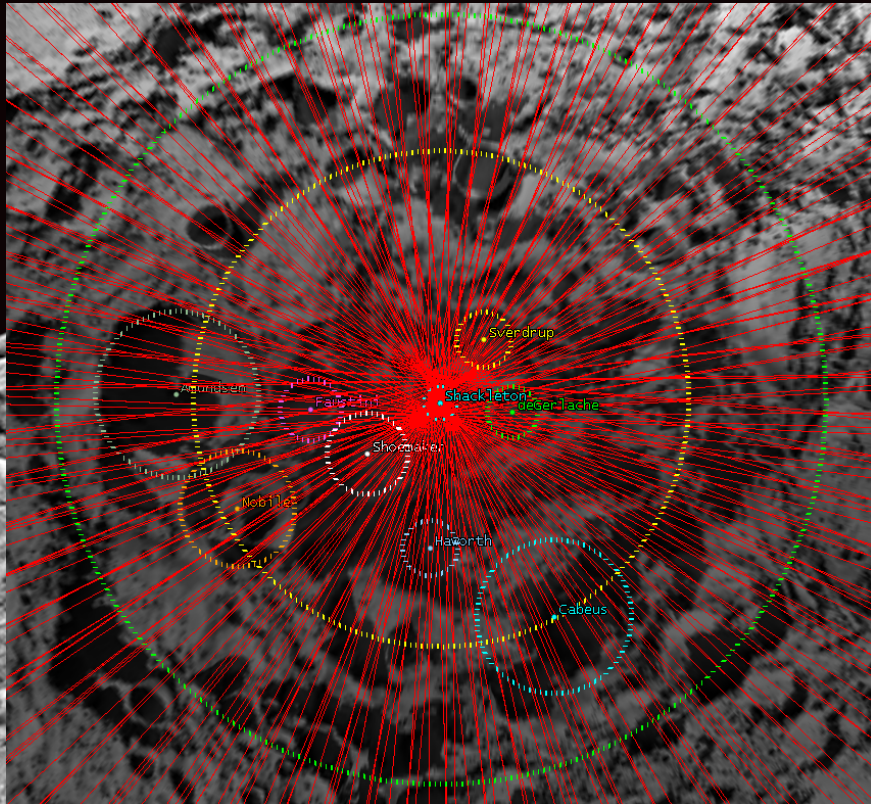
# TROPICS

Time-Resolved Observations of Precipitation Structure  
and Storm Intensity with Constellation of SmallSats



# LunaH-Map

Lunar Polar Hydrogen Mapper





# NICER

Revealing Structure, Dynamics  
and Energetics of Neutron Stars

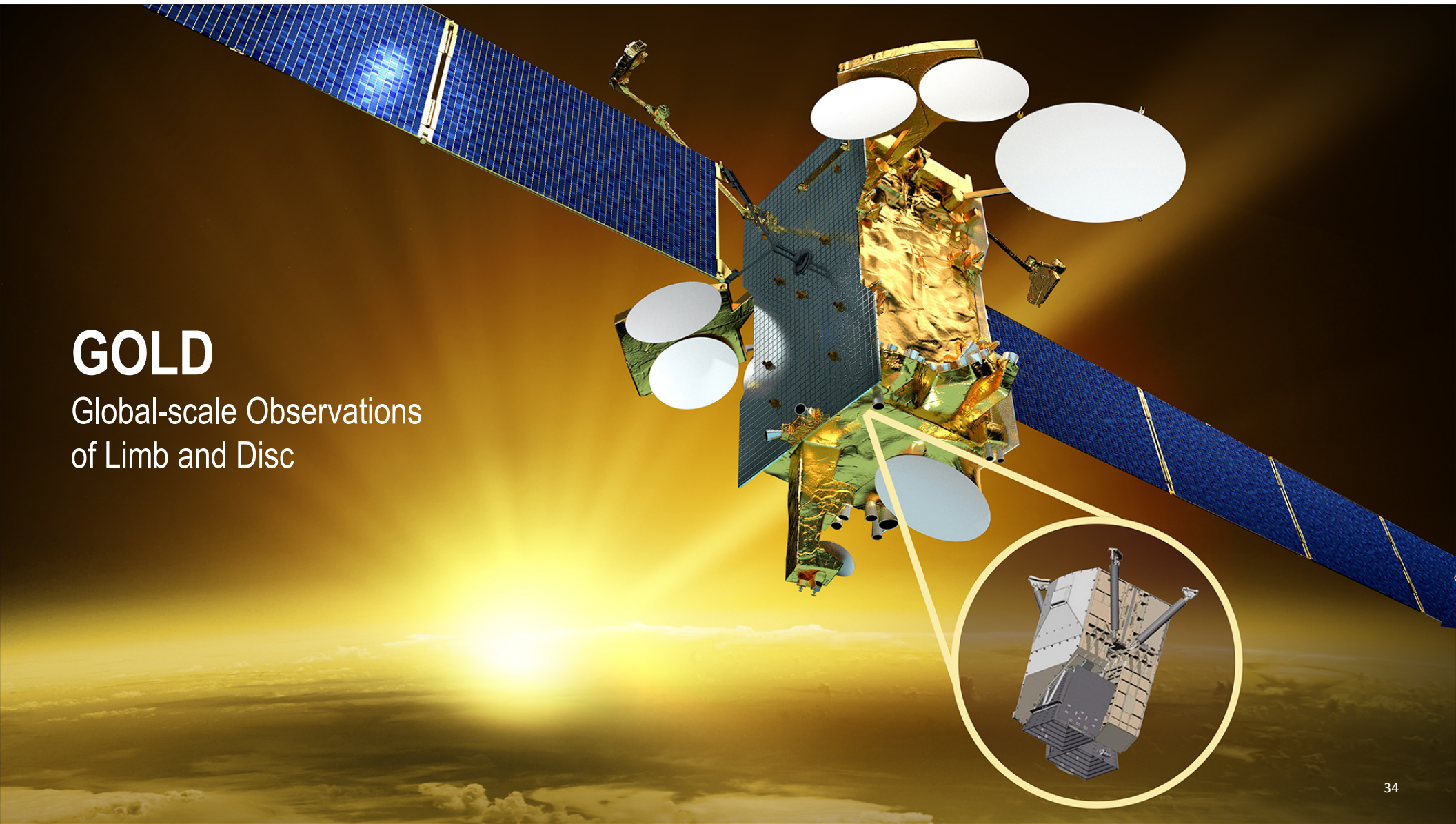


*Artistic Rendering*

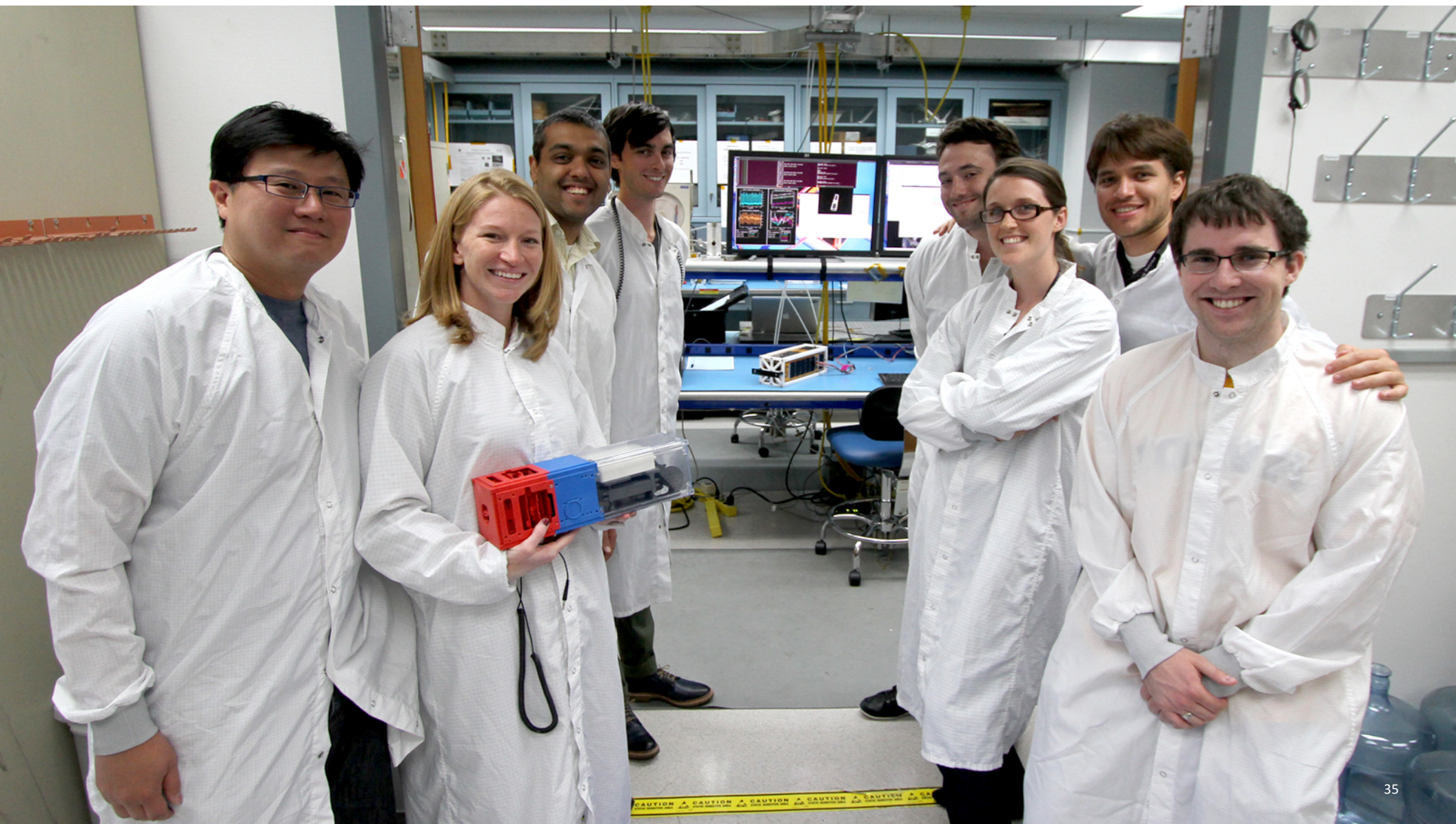


# GOLD

Global-scale Observations  
of Limb and Disc









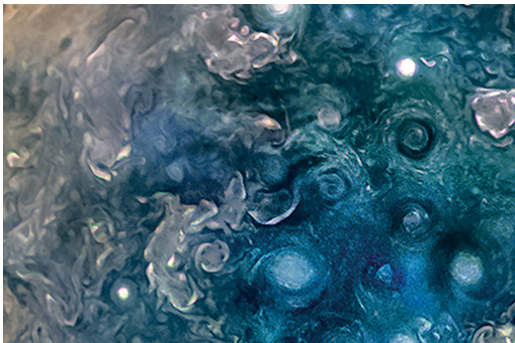
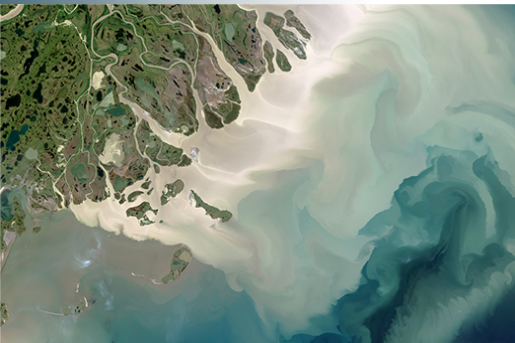
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