

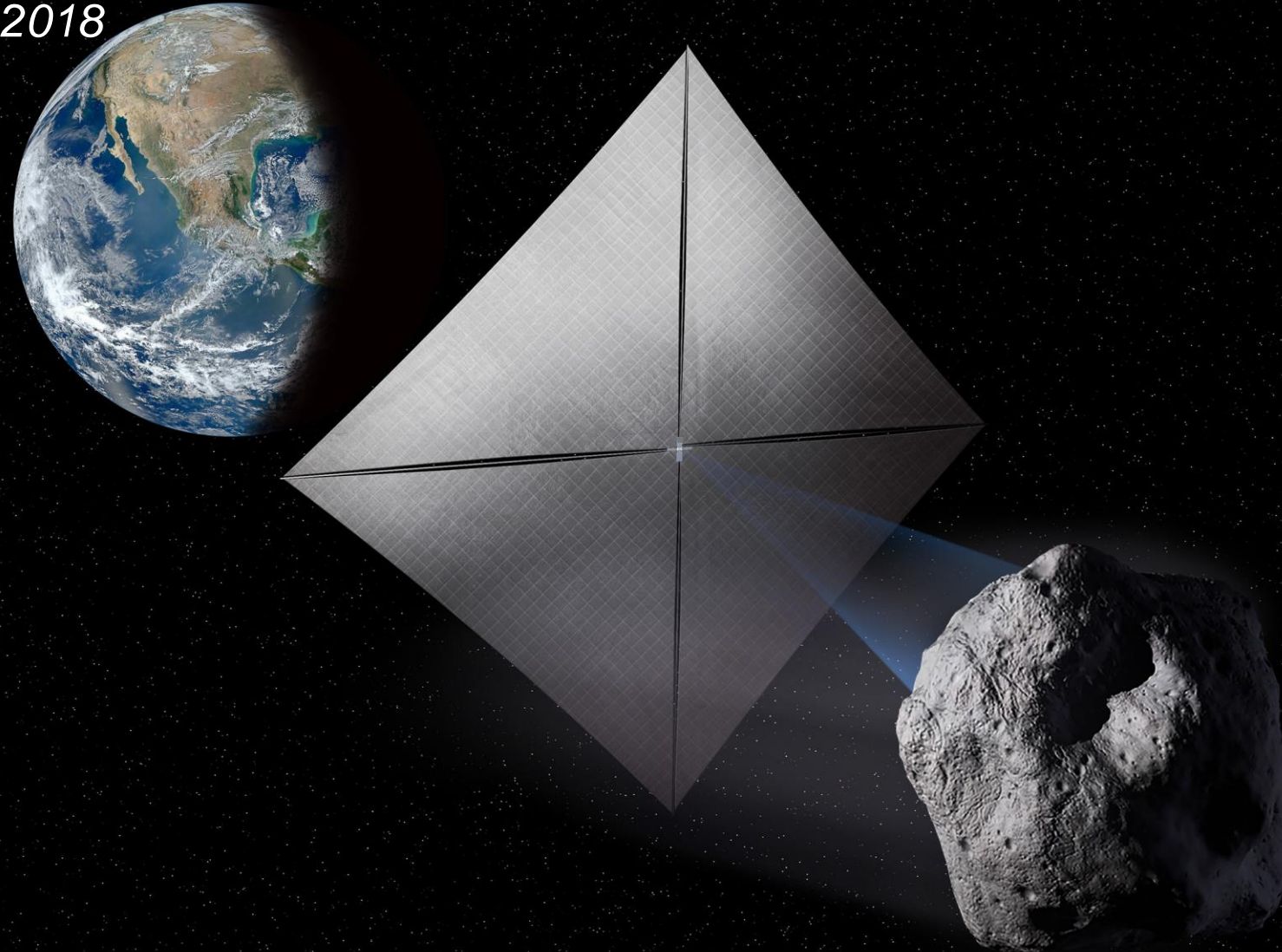


# New Moon Explorer (NME) Robotic Mission Concept

2018 AIAA SPACE

*EXPL-01, Advanced Power and Propulsion Systems*

*September 17, 2018*



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NASA Marshall Space Flight Center

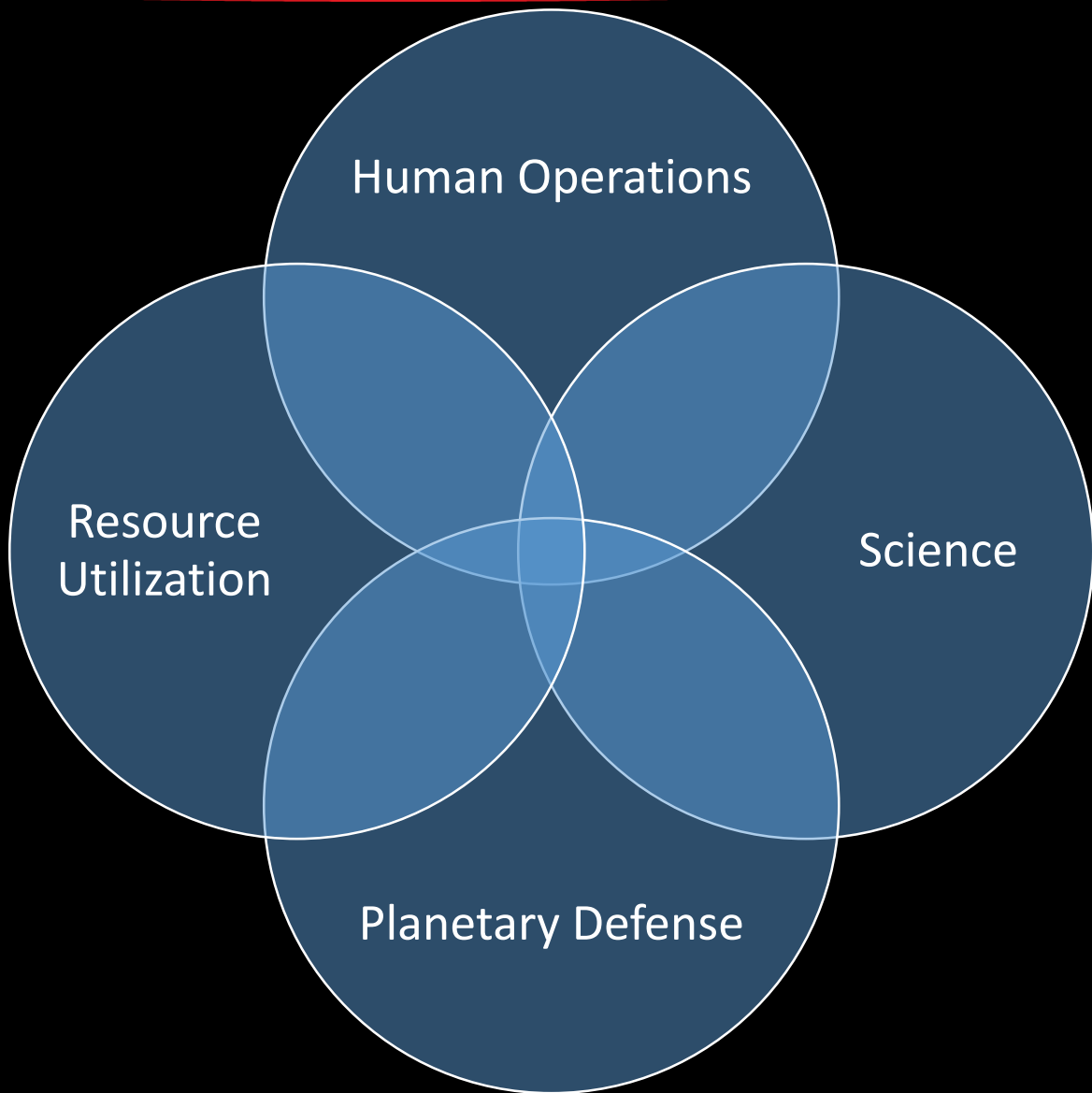


# Mission/Science Objectives

- Science Objectives
  - Observe Earth's 'new moon', the newly discovered near-Earth companion 2016HO3
  - Obtain spin rate, pole position, shape, structure, mass, density, chemical composition, temperature, thermal inertia, regolith characteristics, and spectral type
- Technology Objectives
  - Continue incremental development of solar sail technology
  - Demonstrate use of thin-film power technologies
- Strategic Objectives
  - Address synergies across multiple NASA and industry needs



# Synergies

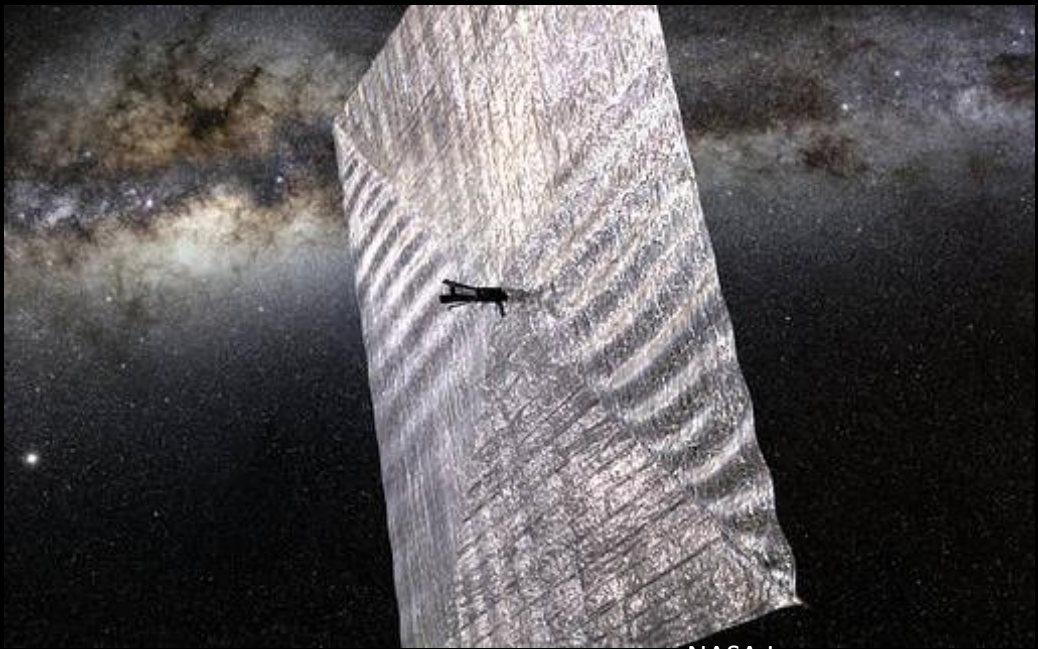


New Moon Explorer sits at the intersection of numerous NASA and commercial objectives

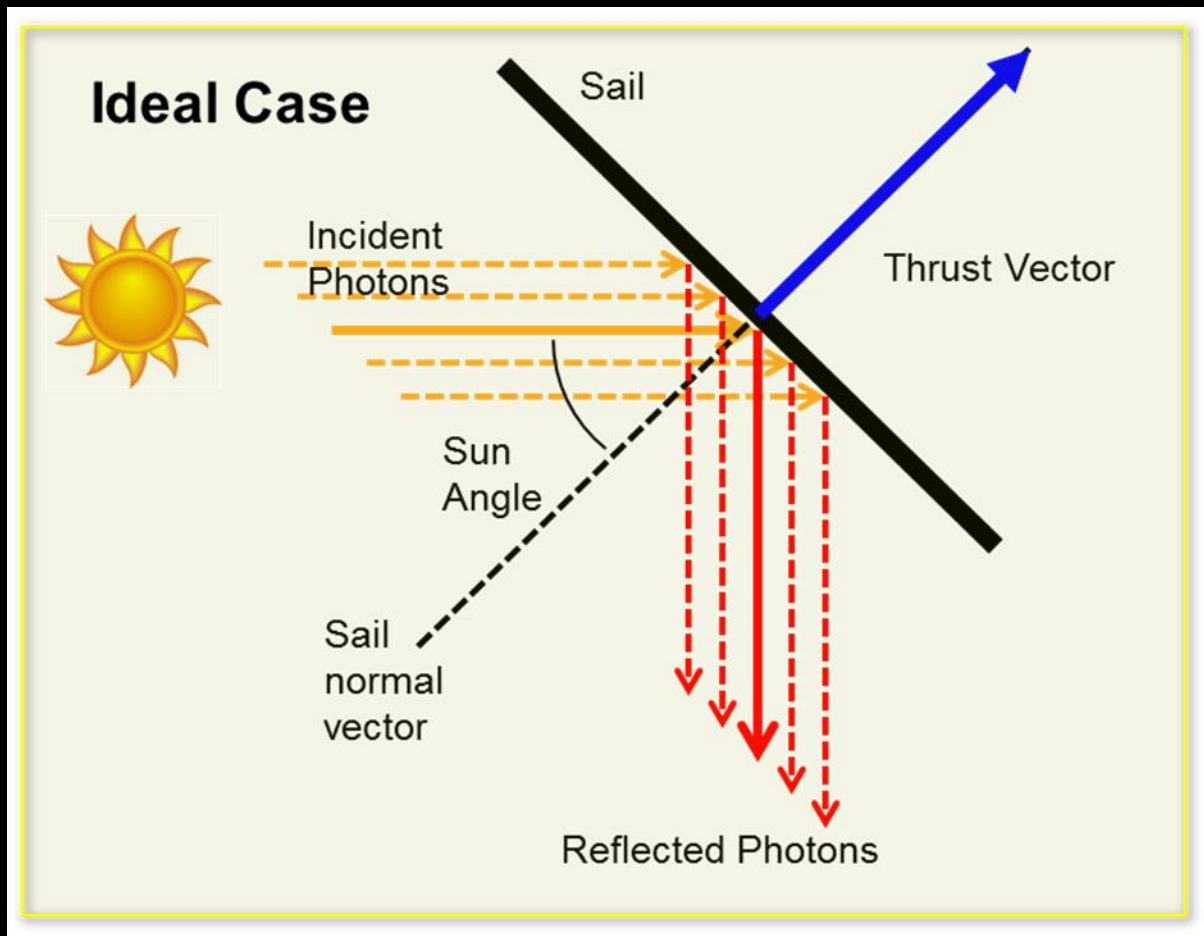


# Solar Sails Derive Propulsion By Reflecting Photons

Solar sails use photon “pressure” or force on thin, lightweight, reflective sheets to produce thrust.



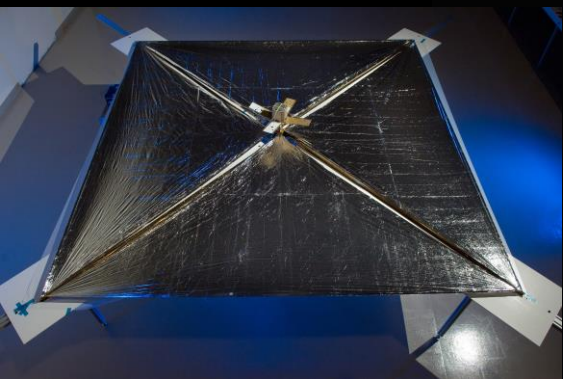
NASA Image







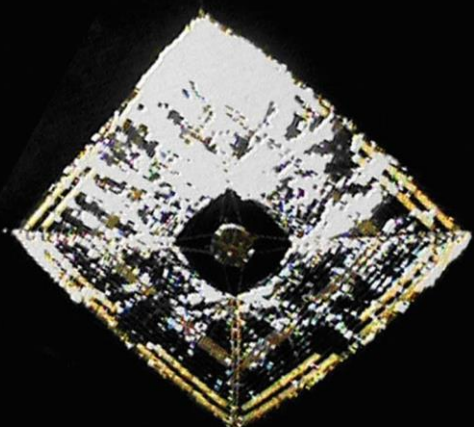
# Solar Sail Missions Flown (as of September 7, 2018)



**NanoSail-D (2010)**  
**NASA**

**Earth Orbit**  
**Deployment Only**

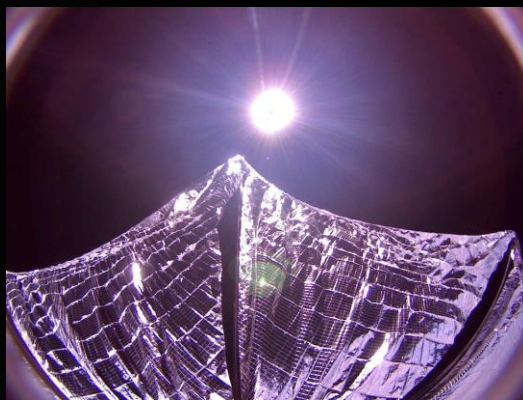
**3U CubeSat**  
**10 m<sup>2</sup>**



**IKAROS (2010)**  
**JAXA**

**Interplanetary**  
**Full Flight**

**315 kg Smallsat**  
**196 m<sup>2</sup>**



**LightSail-1 (2015)**  
**The Planetary Society**

**Earth Orbit**  
**Deployment Only**

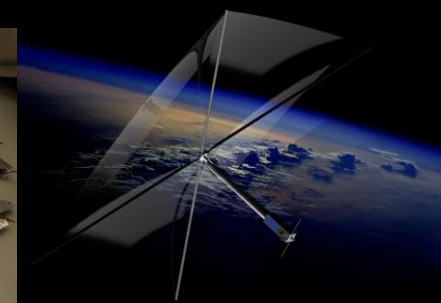
**3U CubeSat**  
**32 m<sup>2</sup>**



**CanX-7 (2016)**  
**Canada**

**Earth Orbit**  
**Deployment Only**

**3U CubeSat**  
**<10 m<sup>2</sup>**



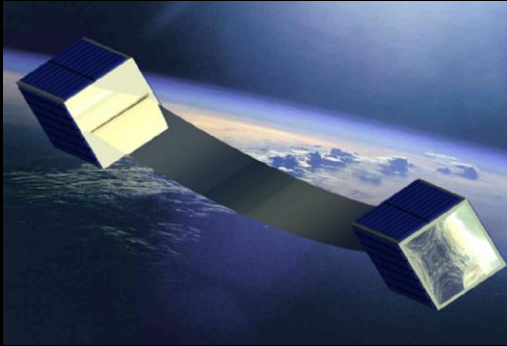
**InflateSail (2017)**  
**EU/Univ. of Surrey**

**Earth Orbit**  
**Deployment Only**

**3U CubeSat**  
**10 m<sup>2</sup>**



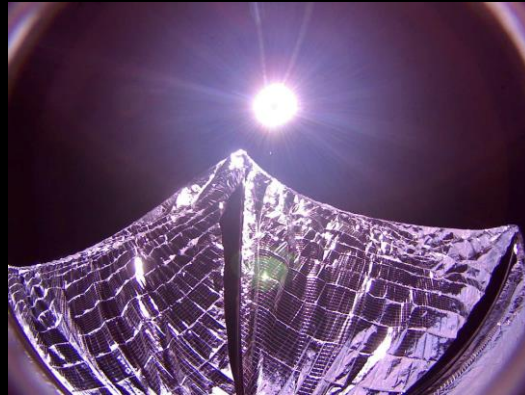
# Planned Solar Sail Missions (as of September 7, 2018)



**CU Aerospace (2018)  
Univ. Illinois / NASA**

**Earth Orbit  
Full Flight**

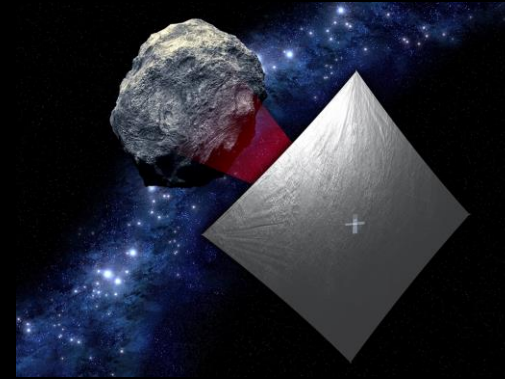
**3U CubeSat  
20 m<sup>2</sup>**



**LightSail-2 (2018)  
The Planetary Society**

**Earth Orbit  
Full Flight**

**3U CubeSat  
32 m<sup>2</sup>**



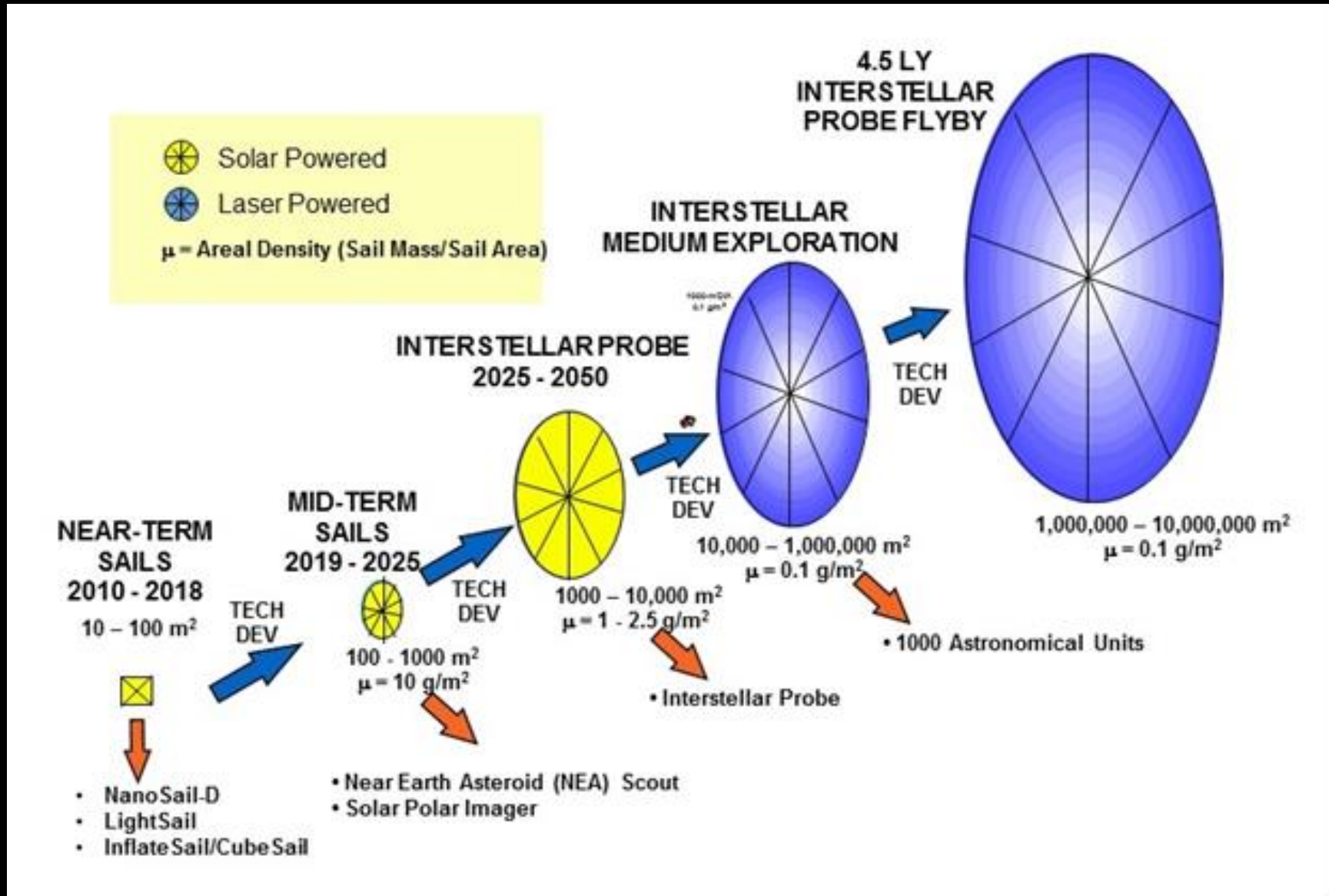
**Near Earth Asteroid  
Scout (2020) NASA**

**Interplanetary  
Full Flight**

**6U CubeSat  
86 m<sup>2</sup>**



# Notional Roadmap To The Future of Solar Sails

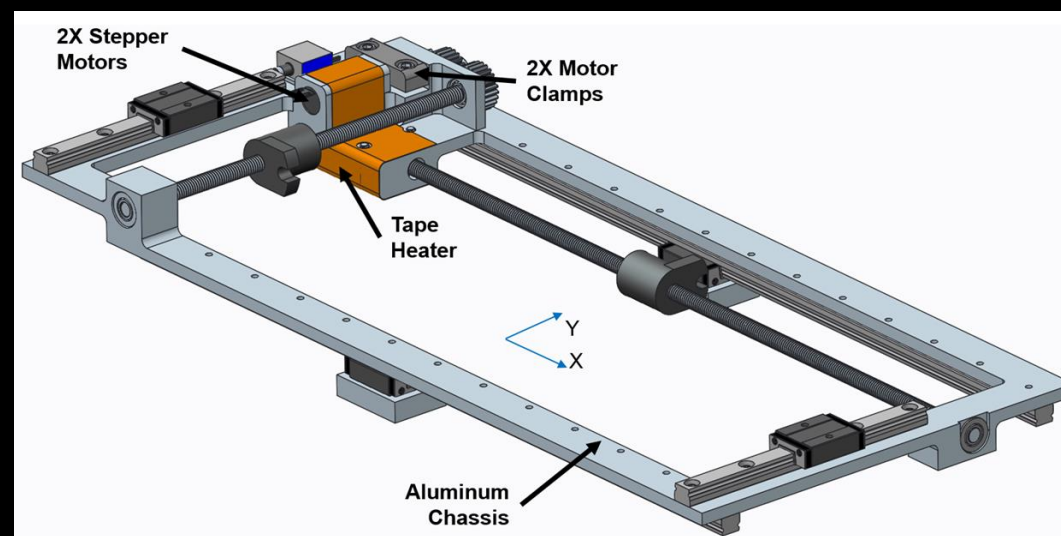
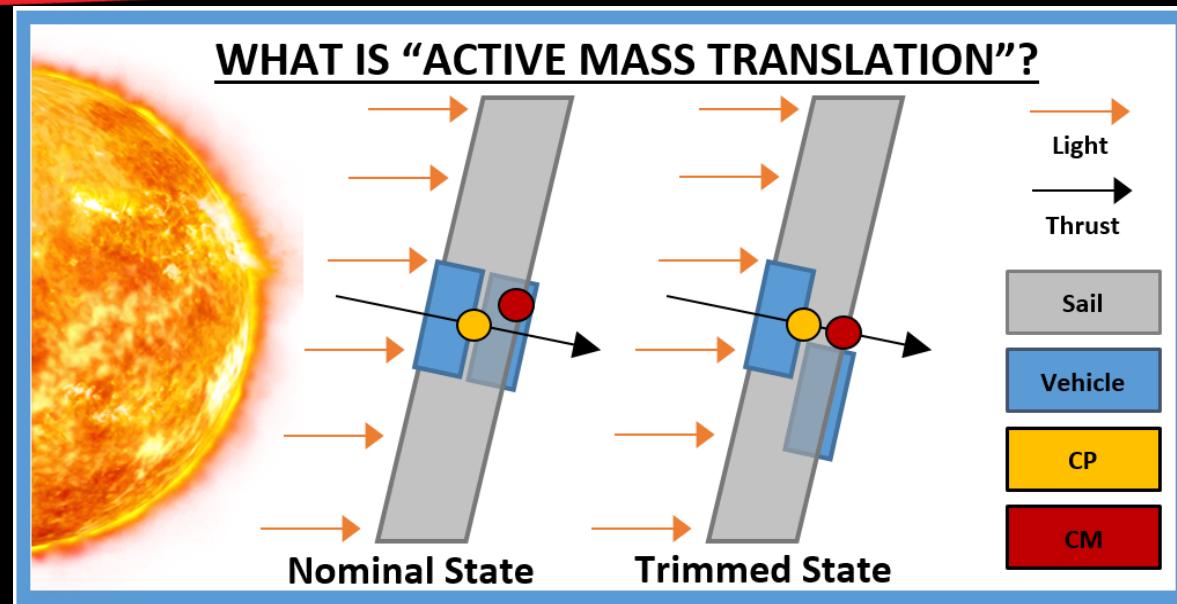






# Momentum Management System

- Solar Radiation Pressure imparts a persistent torque on the spacecraft for the duration of the mission
- Use of expendable propellant to maintain desired Solar Sail attitude and/or desaturate reaction wheels would be mission limiting, particularly in small form factors
- A momentum management system is needed to accompany a solar sail concept
- NEA Scout utilizes Active Mass Translation (right) while IKAROS utilized Liquid Crystal Devices







# Thin-Film Power Generation

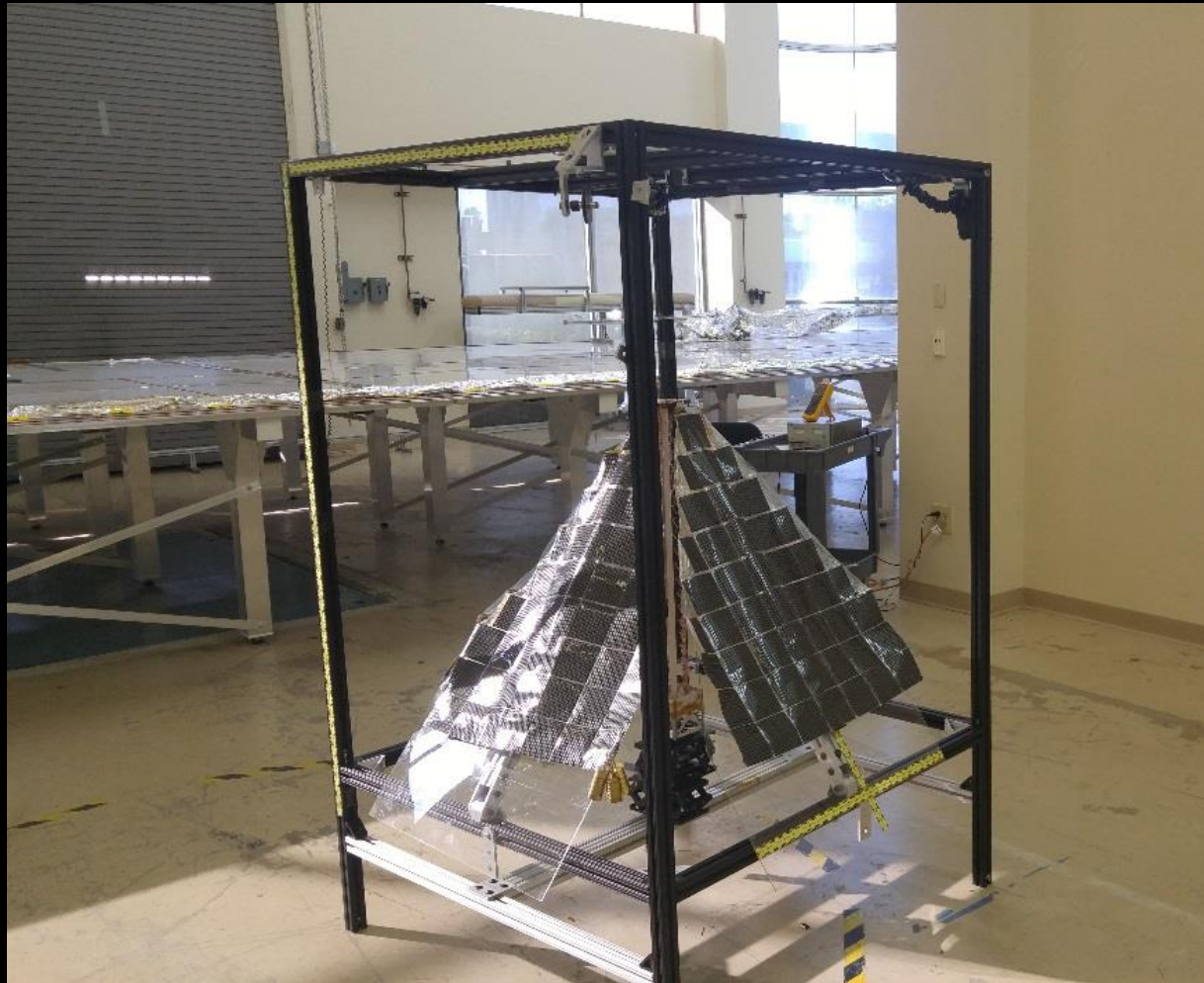
- Leverages technology development from Lightweight Solar Array and anTenna (LISA-T)
- Thin-film photovoltaics coated with polyimide and solvent bonded on Toughened CP1
- Cells electrically interconnected via micro-welded ribbons and embedded traces
- Placed on independent substrate and deployed (can be integral to Solar Sail)
- Phased array antenna can be similarly embedded resulting in integrated propellantless propulsion, power generation, and telecommunications capability





# Thin-Film Power Generation (contd.)

**Omni – GN&C simplicity and non-pointed**



**Planar – pointed, high performance**







# Target Overview

- 2016HO3 is a Near-Earth companion representing the closest, most stable quasi-satellite to Earth
- Discovered by Pan-STARRS on April 27, 2016
- 40-100 meters in diameter
- Earth MOID 0.0348 AU (13.6 LD)
- Fast rotator with an estimated rotational period of 0.467 hours

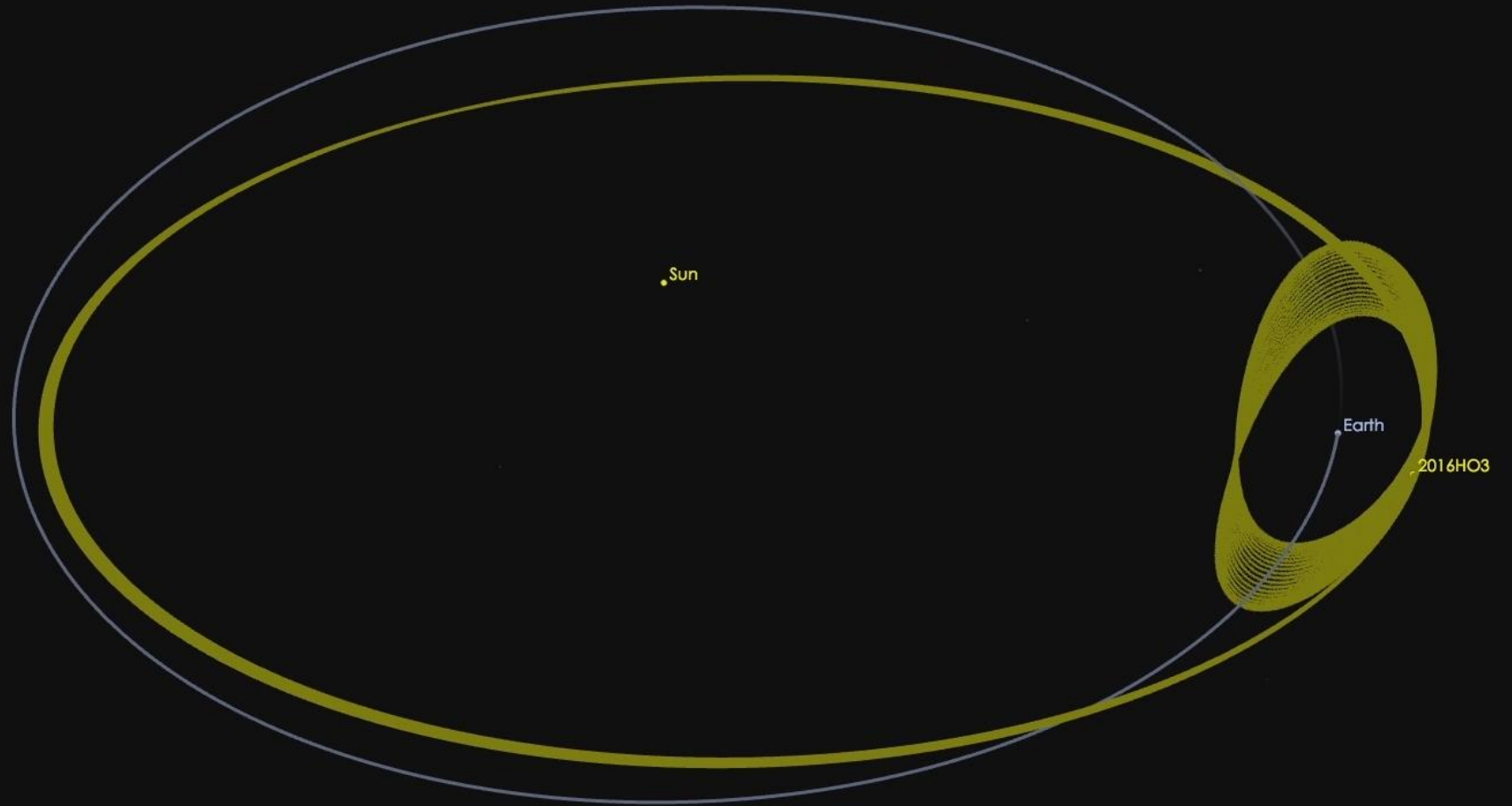


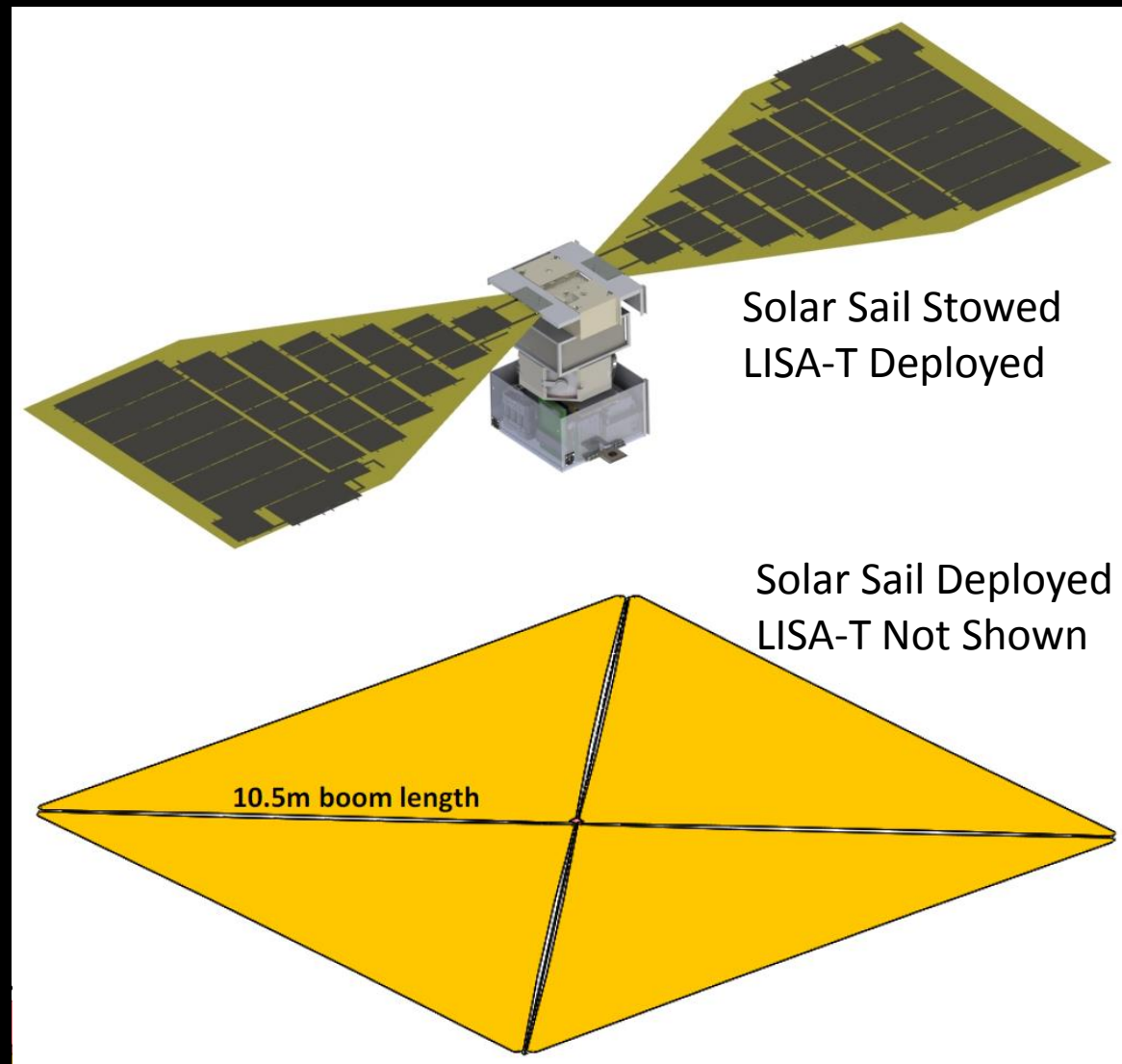
Image: JPL





# Spacecraft Features

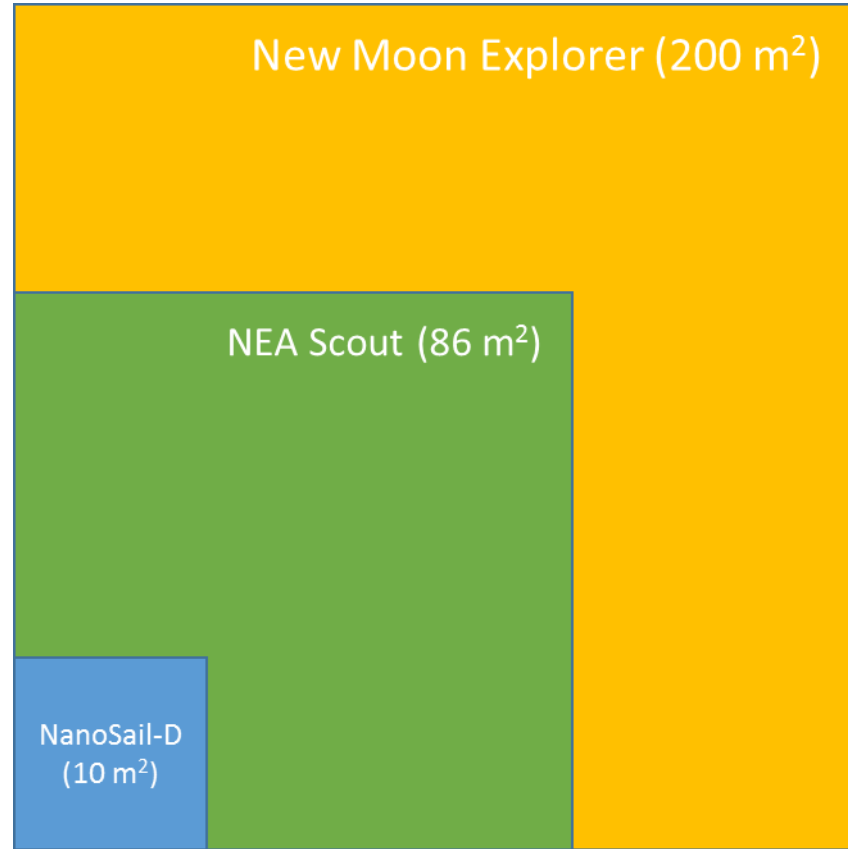
- Low-cost 12U form factor
- Solar Sail propelled
  - 200 m<sup>2</sup> toughened CP1 quadrant configuration
  - 4x 10.5-m Slit-tube composite booms laminate designed using Rocco Solar Sail Tool (SST)
  - Active Mass Translator MMS
- Planar, bi-pedal 'LISA-T' for power generation and telecommunications
- Deep space CubeSat avionics as utilized on MarCO (launched 2018) and NEA Scout and IceCube missions (launch 2020)
- Cold gas for momentum desaturations and impulsive events
- Leverages developmental lessons learned from the NEA Scout mission





# Deployed Solar Sail Approximate Scale

Deployed Solar Sail



School Bus

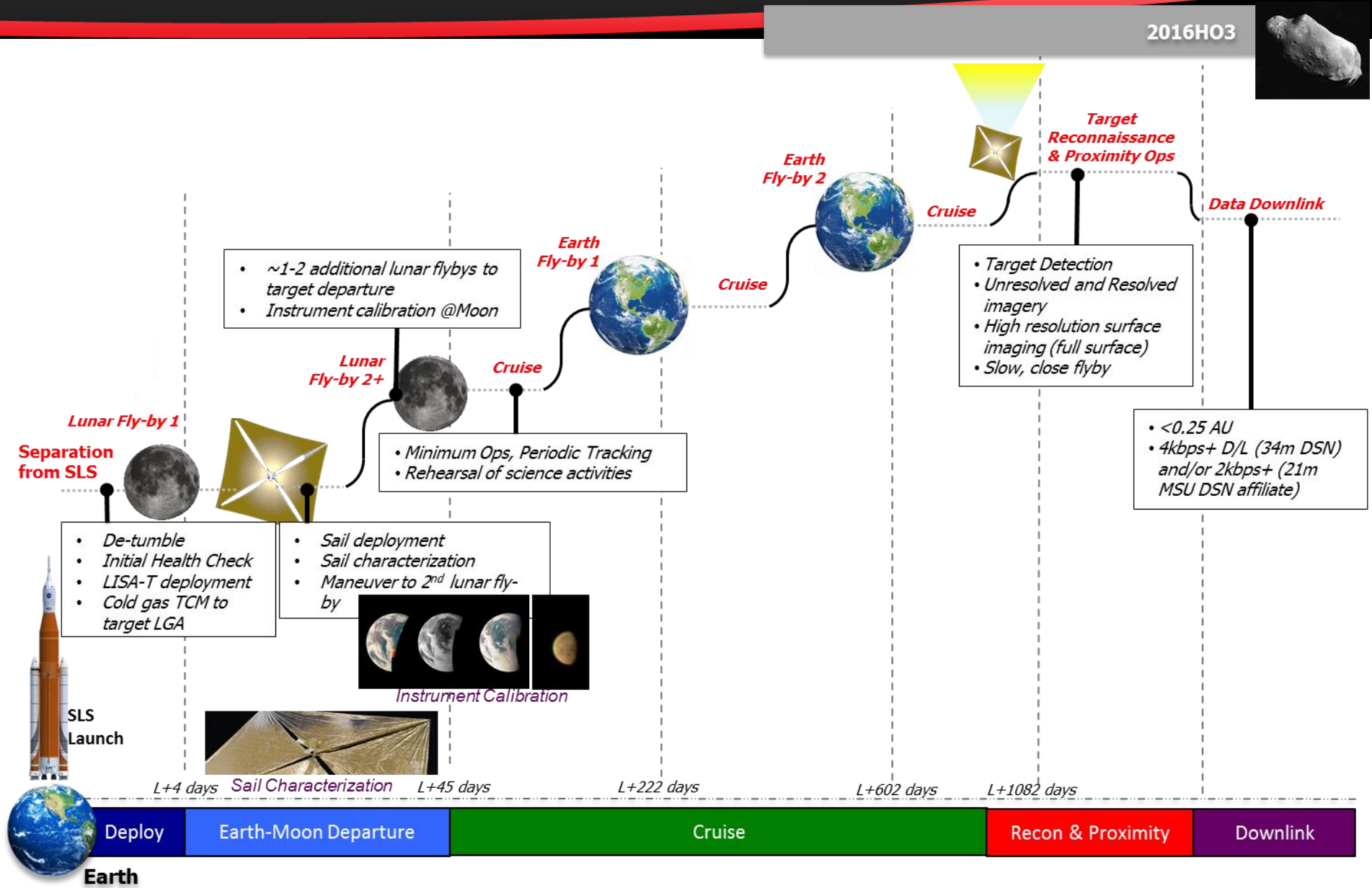


12U Stowed Flight System

Folded, spooled and packaged



# Concept of Operations







# Co-Author Acknowledgements

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- Benjamin Malphrus (Morehead State University)
- Michael Combs (Morehead State University)



BACKUP



# NASA's Near Earth Asteroid Scout

## The Near Earth Asteroid Scout Will:

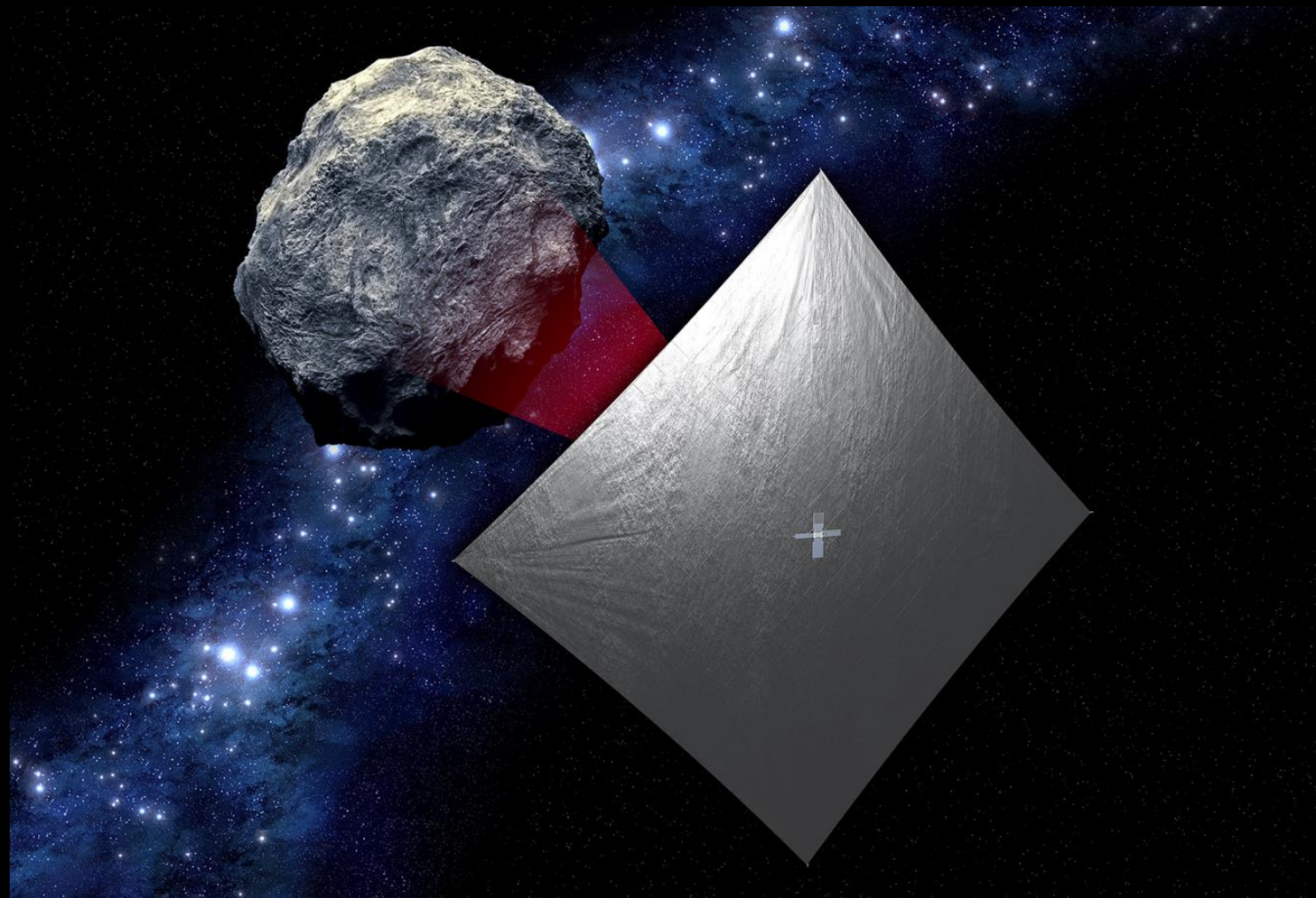
- Image/characterize a NEA during a slow flyby
- Demonstrate a low cost asteroid reconnaissance capability

## Key Spacecraft & Mission Parameters

- 6U cubesat (20 cm X 10 cm X 30 cm)
- ~86 m<sup>2</sup> solar sail propulsion system
- Manifested for launch on the Space Launch System (EM-1/2019)
- Up to 2.5 year mission duration
- 1 AU maximum distance from Earth

## Solar Sail Propulsion System Characteristics

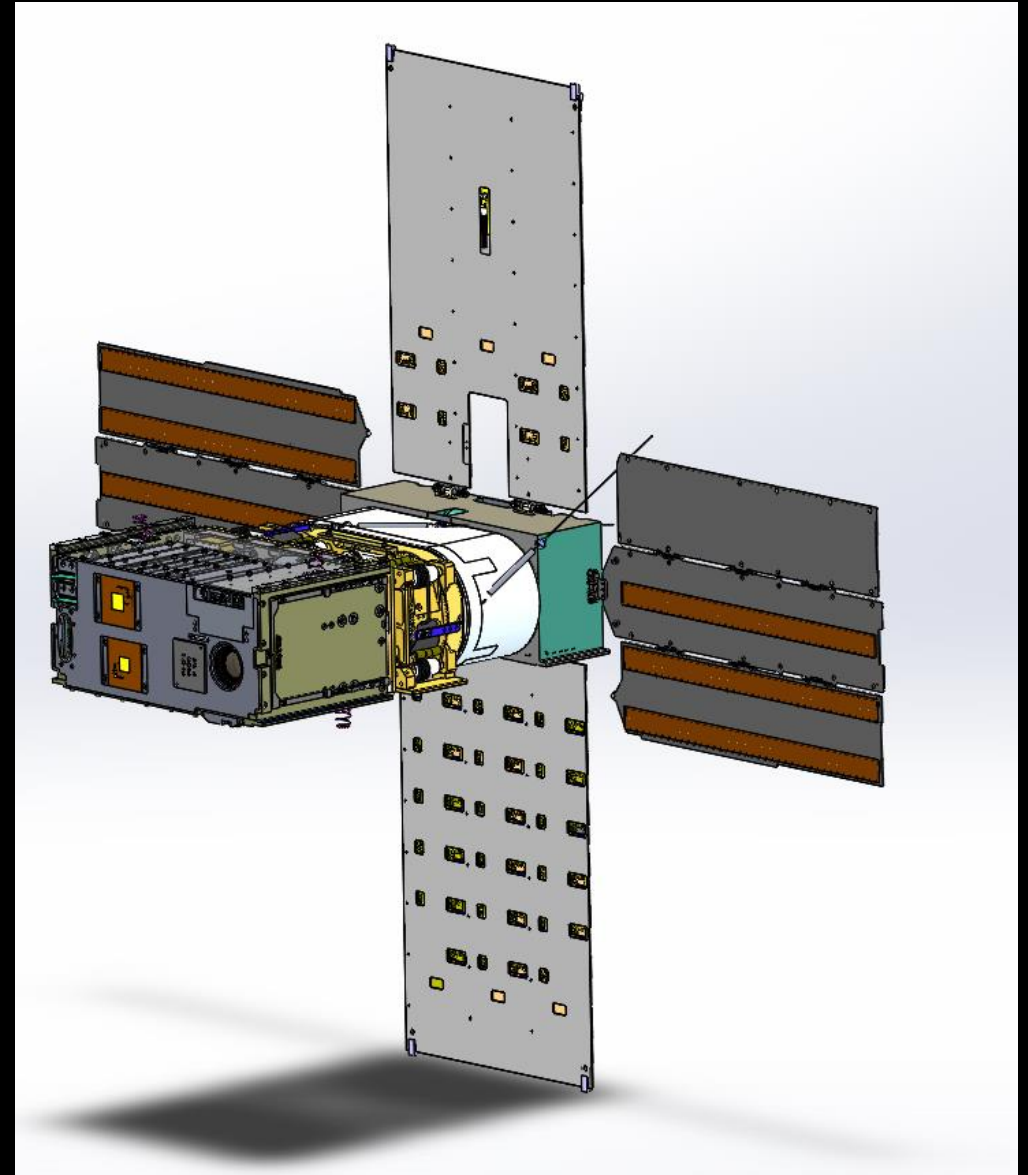
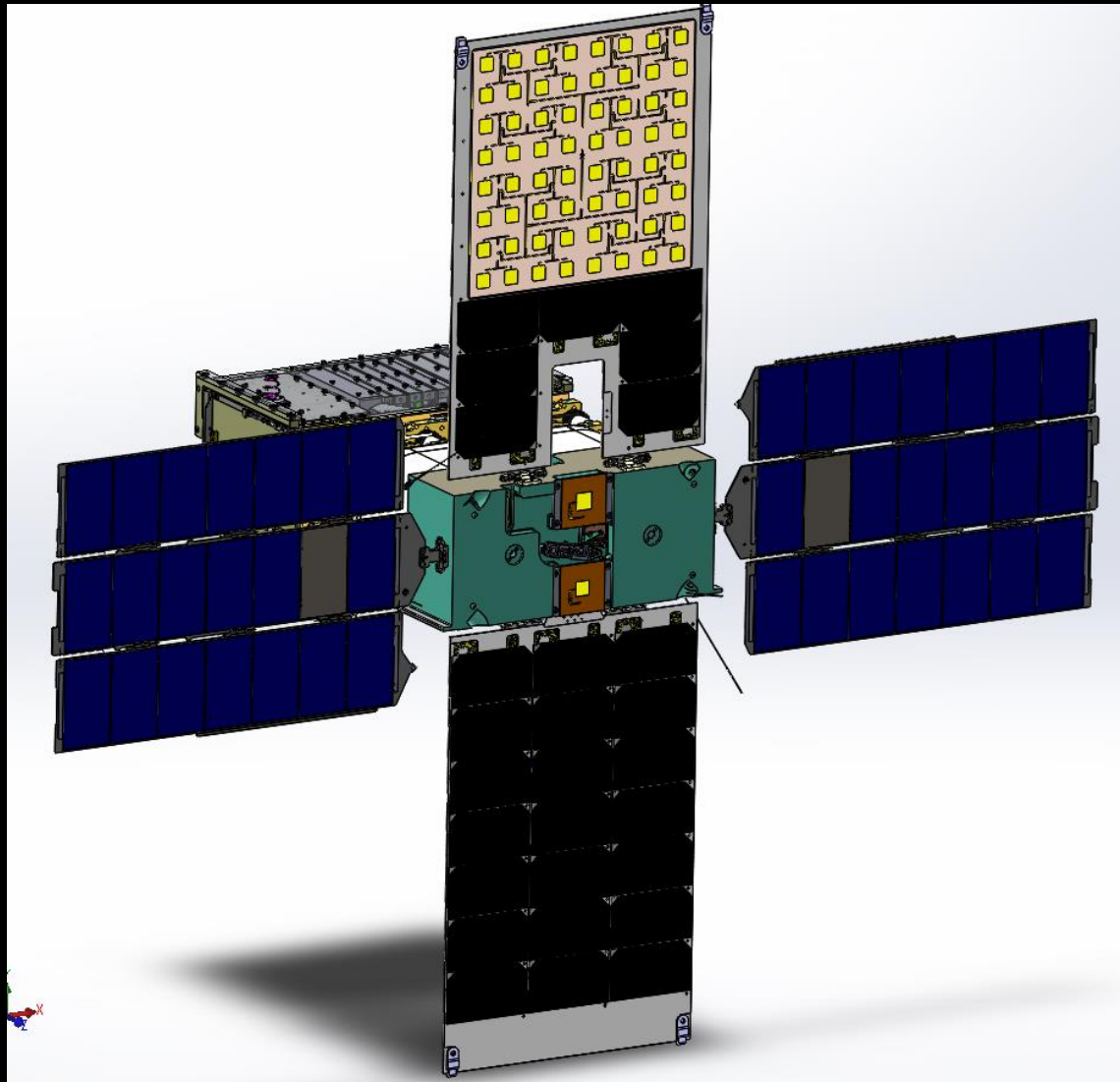
- ~ 7.3 m Trac booms
- 2.5 $\mu$  aluminized CP-1 substrate
- > 90% reflectivity





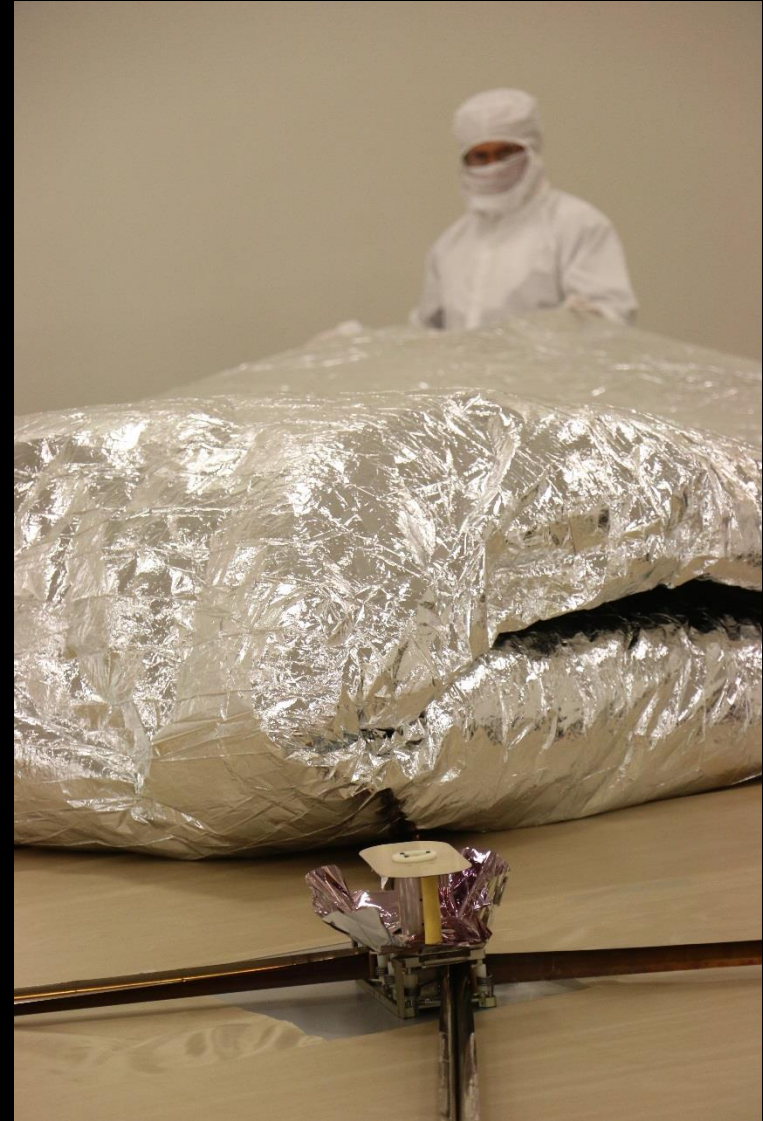
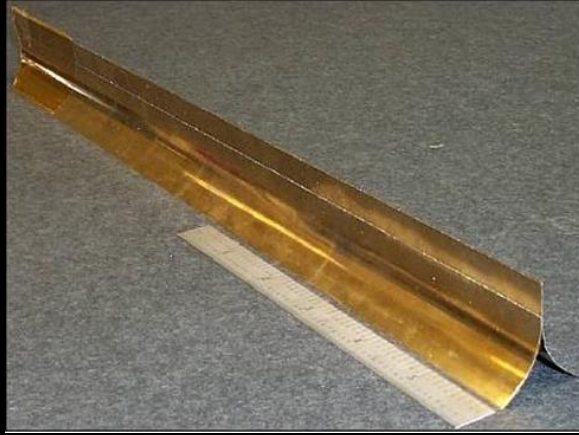


# NEA Scout Flight System





# NEA Scout Hardware Overview







# NEA Scout Full Scale Successful Deployment

