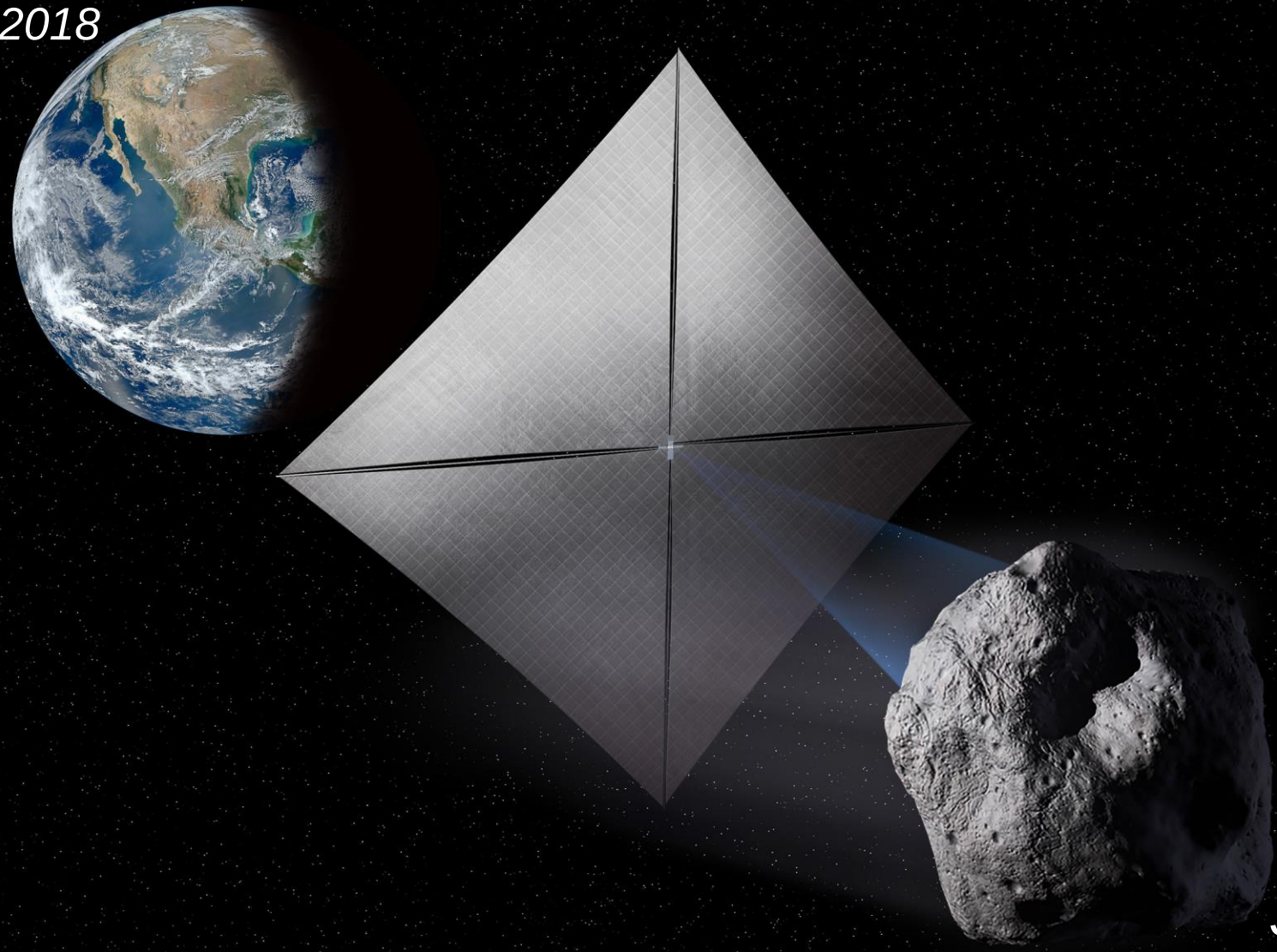
New Moon Explorer (NME) Robotic Mission Concept

2018 AIAA SPACE

EXPL-01, Advanced Power and Propulsion Systems

September 17, 2018



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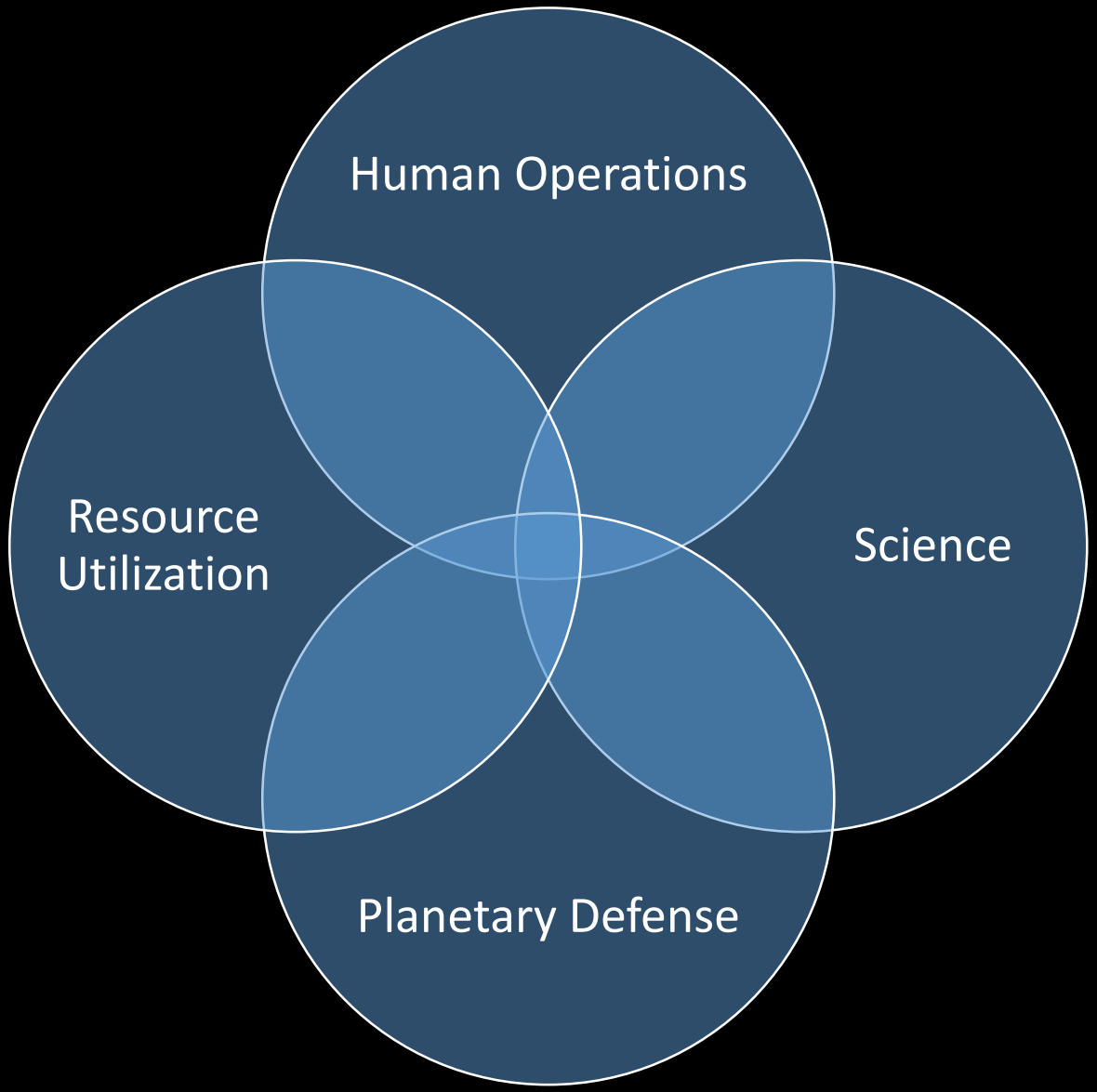
NASA Marshall Space Flight Center

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

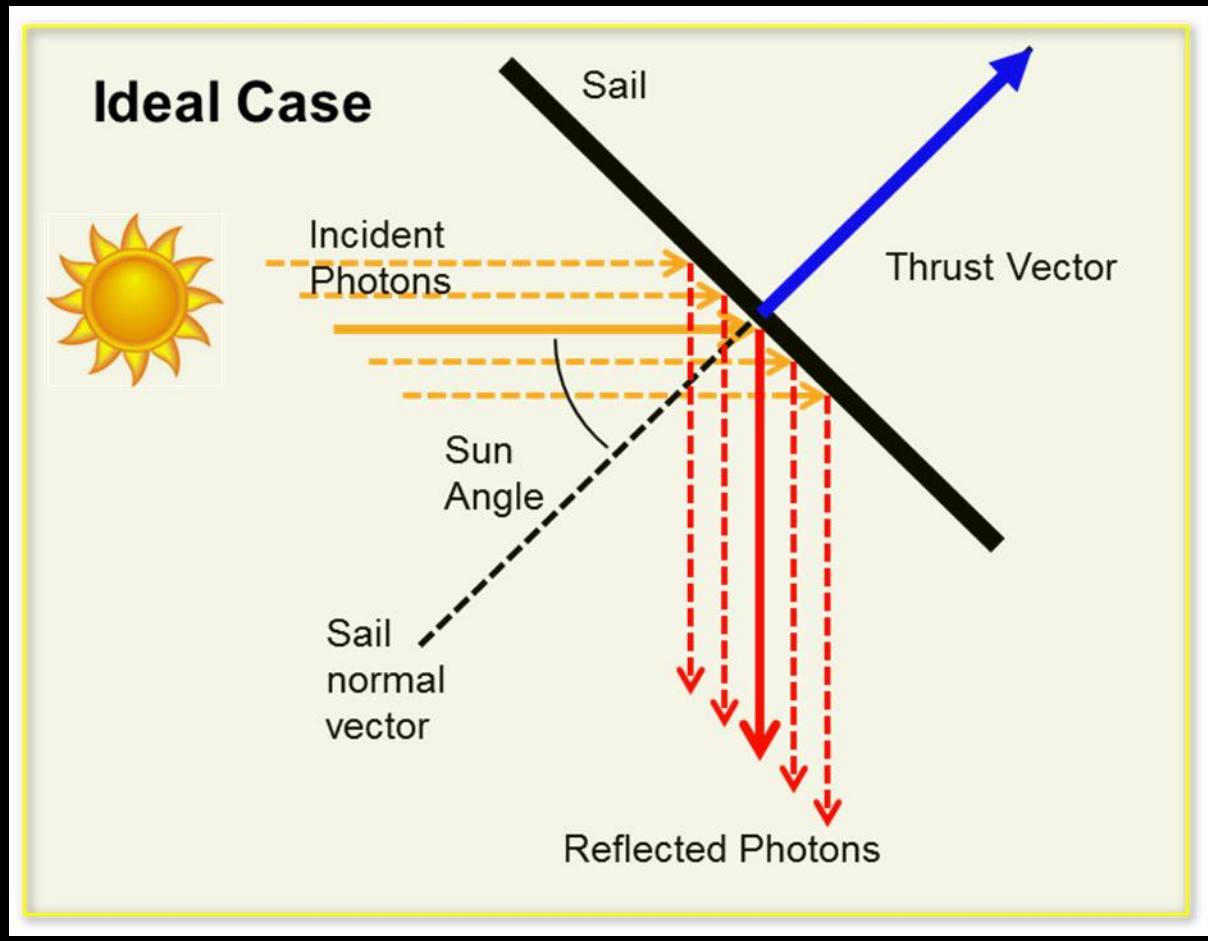


New Moon Explorer sits at the intersection of numerous NASA and commercial objectives

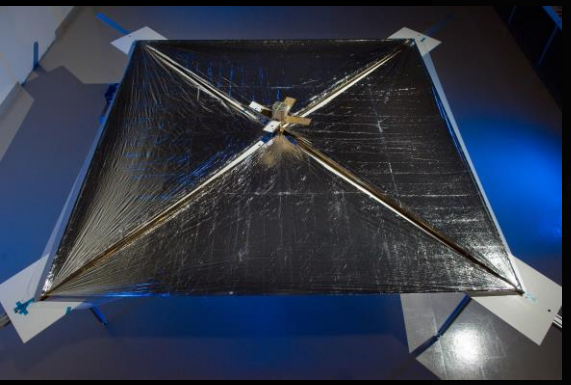
Solar Sails Derive Propulsion By Reflecting Photons

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

NASA Image



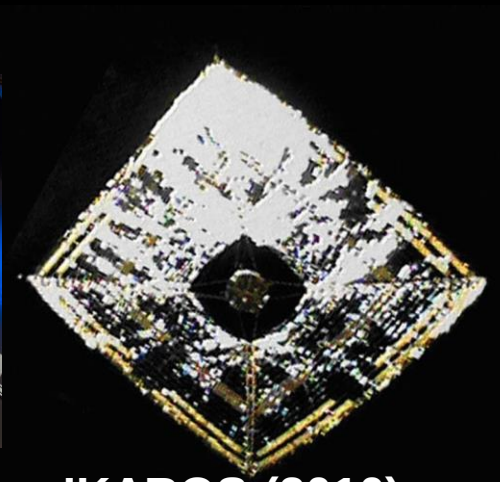
Solar Sail Missions Flown (as of September 7, 2018)



NanoSail-D (2010)
NASA

Earth Orbit
Deployment Only

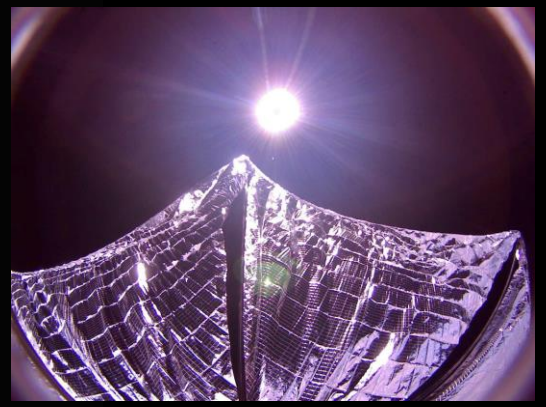
3U CubeSat
10 m^2



IKAROS (2010)
JAXA

Interplanetary
Full Flight

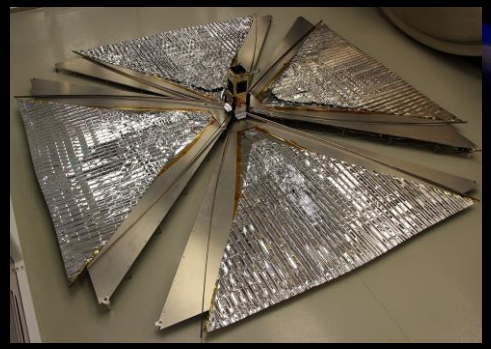
315 kg Smallsat
196 m^2



LightSail-1 (2015)
The Planetary Society

Earth Orbit
Deployment Only

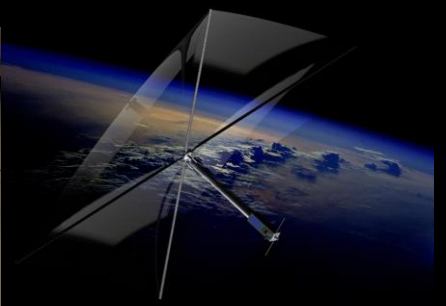
3U CubeSat
32 m^2



CanX-7 (2016)
Canada

Earth Orbit
Deployment Only

3U CubeSat
<10 m^2

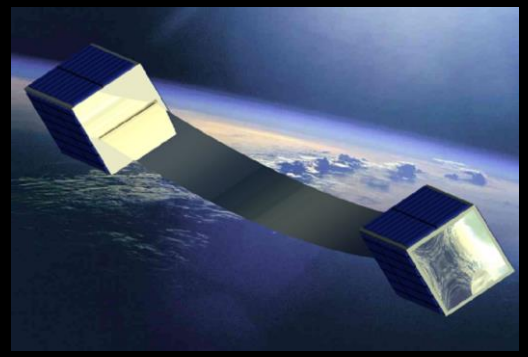


InflateSail (2017)
EU/Univ. of Surrey

Earth Orbit
Deployment Only

3U CubeSat
10 m^2

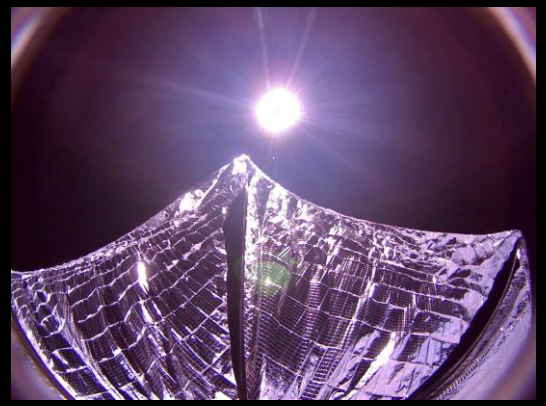
Planned Solar Sail Missions (as of September 7, 2018)



CU Aerospace (2018)
Univ. Illinois / NASA

Earth Orbit
Full Flight

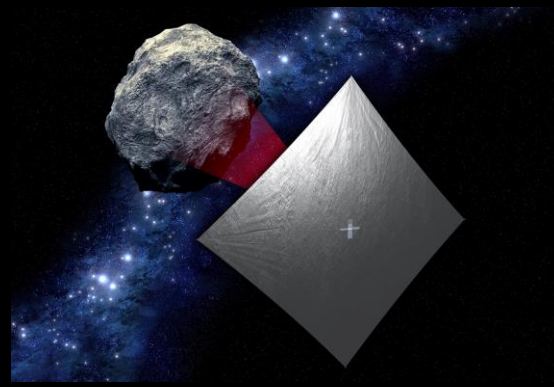
3U CubeSat
20 m^2



LightSail-2 (2018)
The Planetary Society

Earth Orbit
Full Flight

3U CubeSat
32 m^2

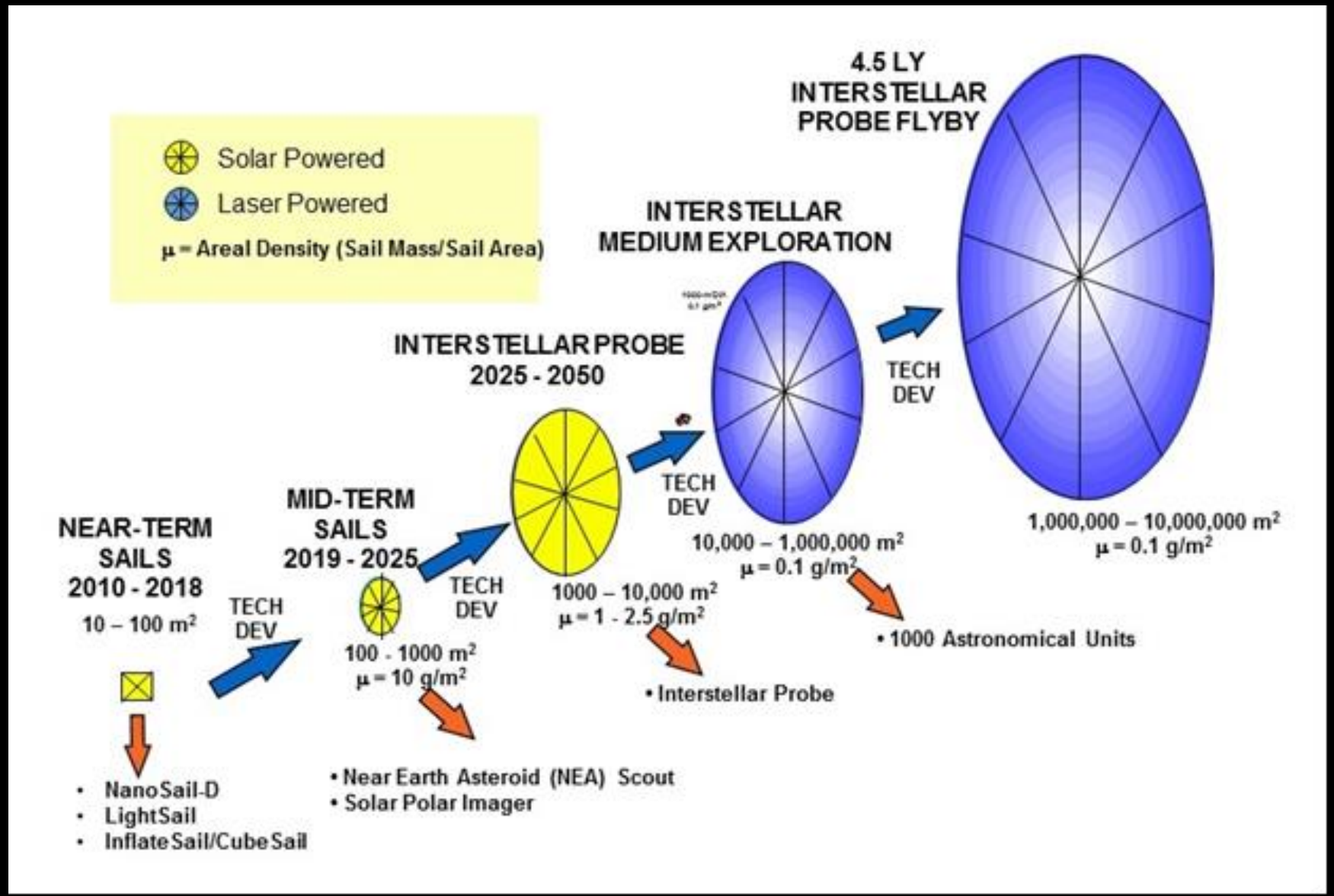


Near Earth Asteroid Scout (2020) NASA

Interplanetary
Full Flight

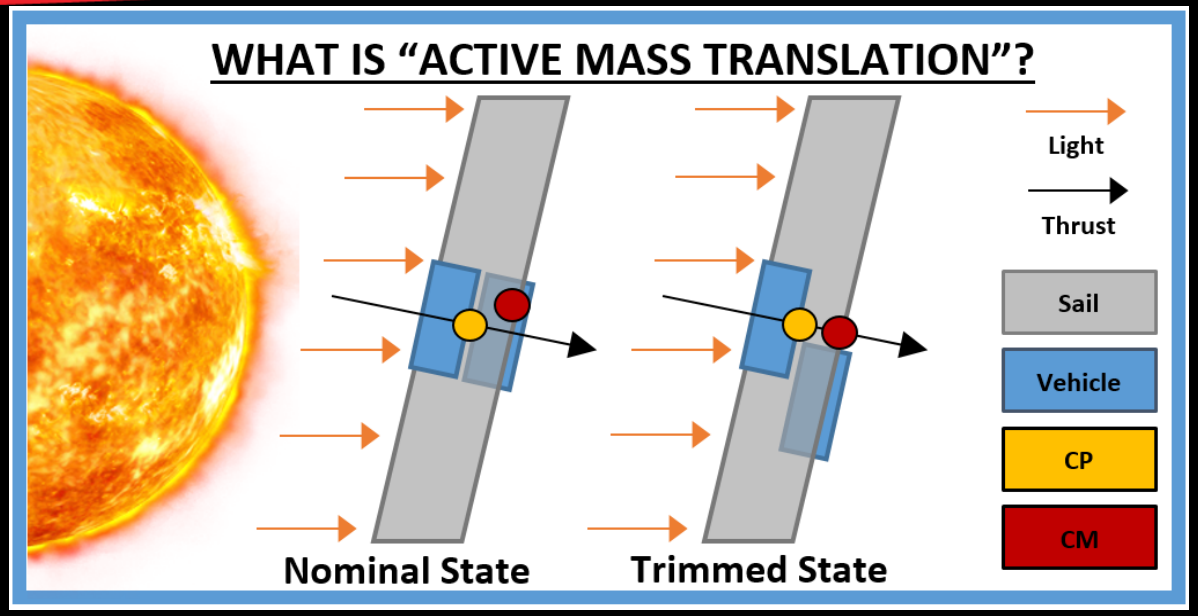
6U CubeSat
86 m^2

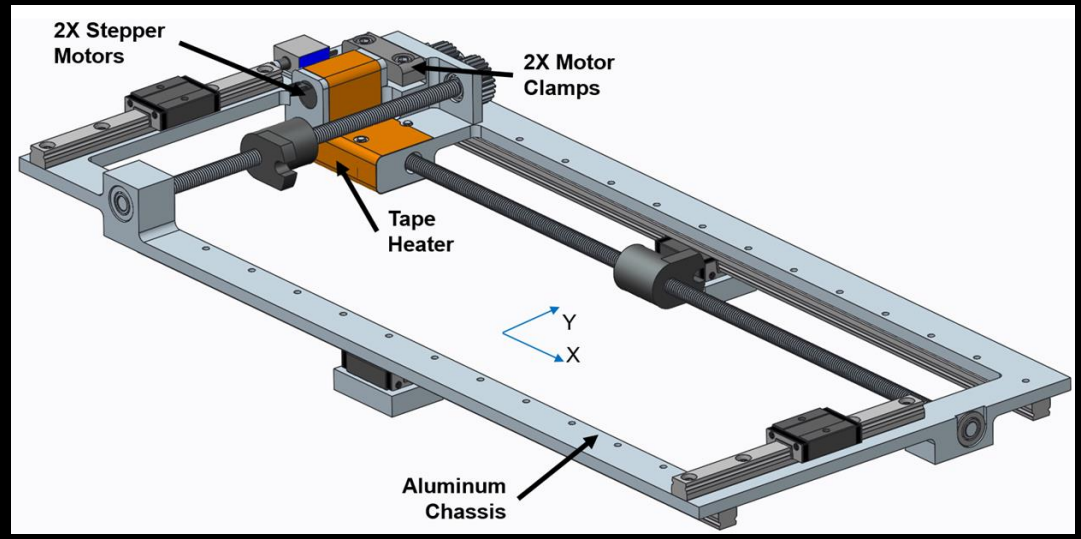
Notional Roadmap To The Future of Solar Sails



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



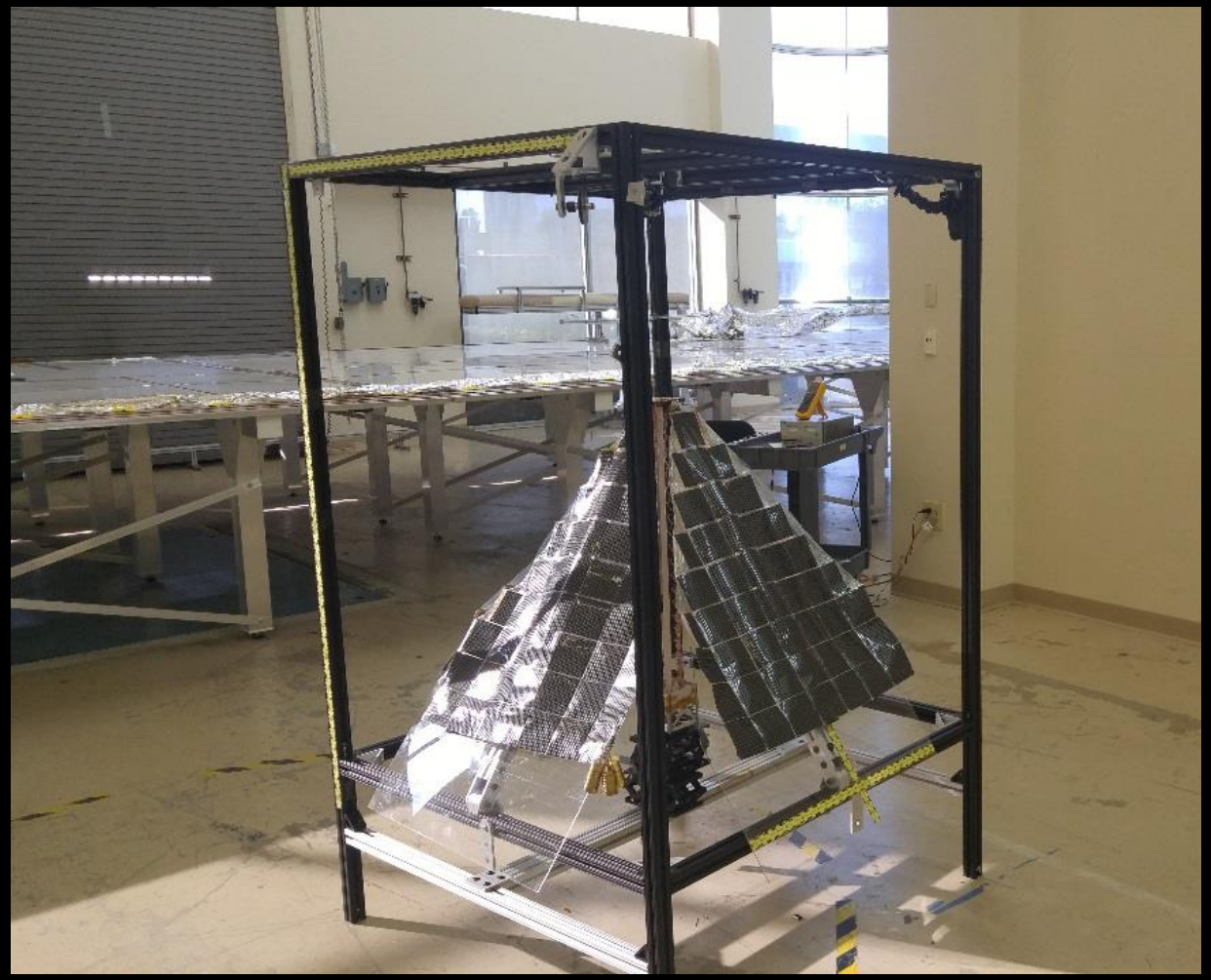


Thin-Film Power Generation

- 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

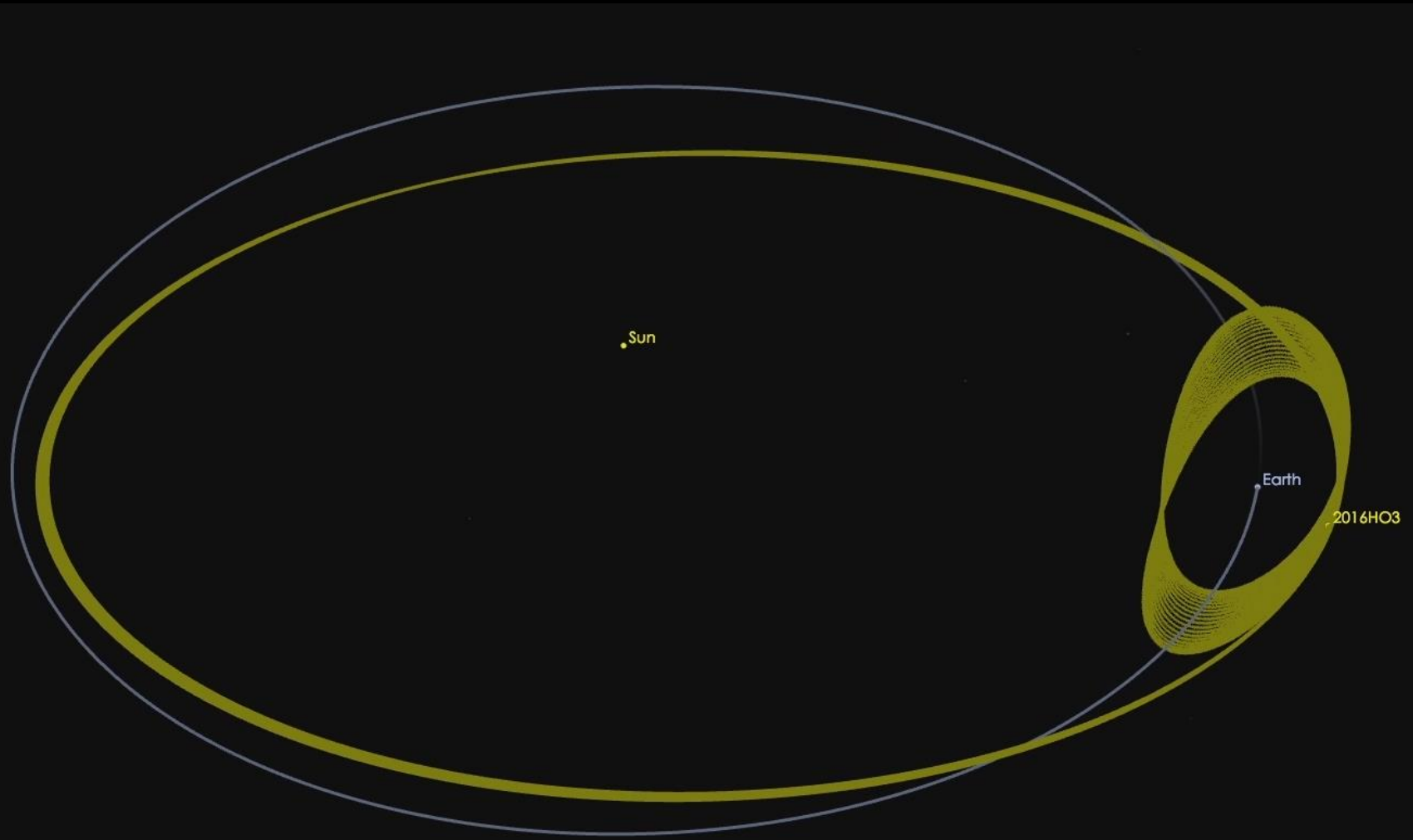
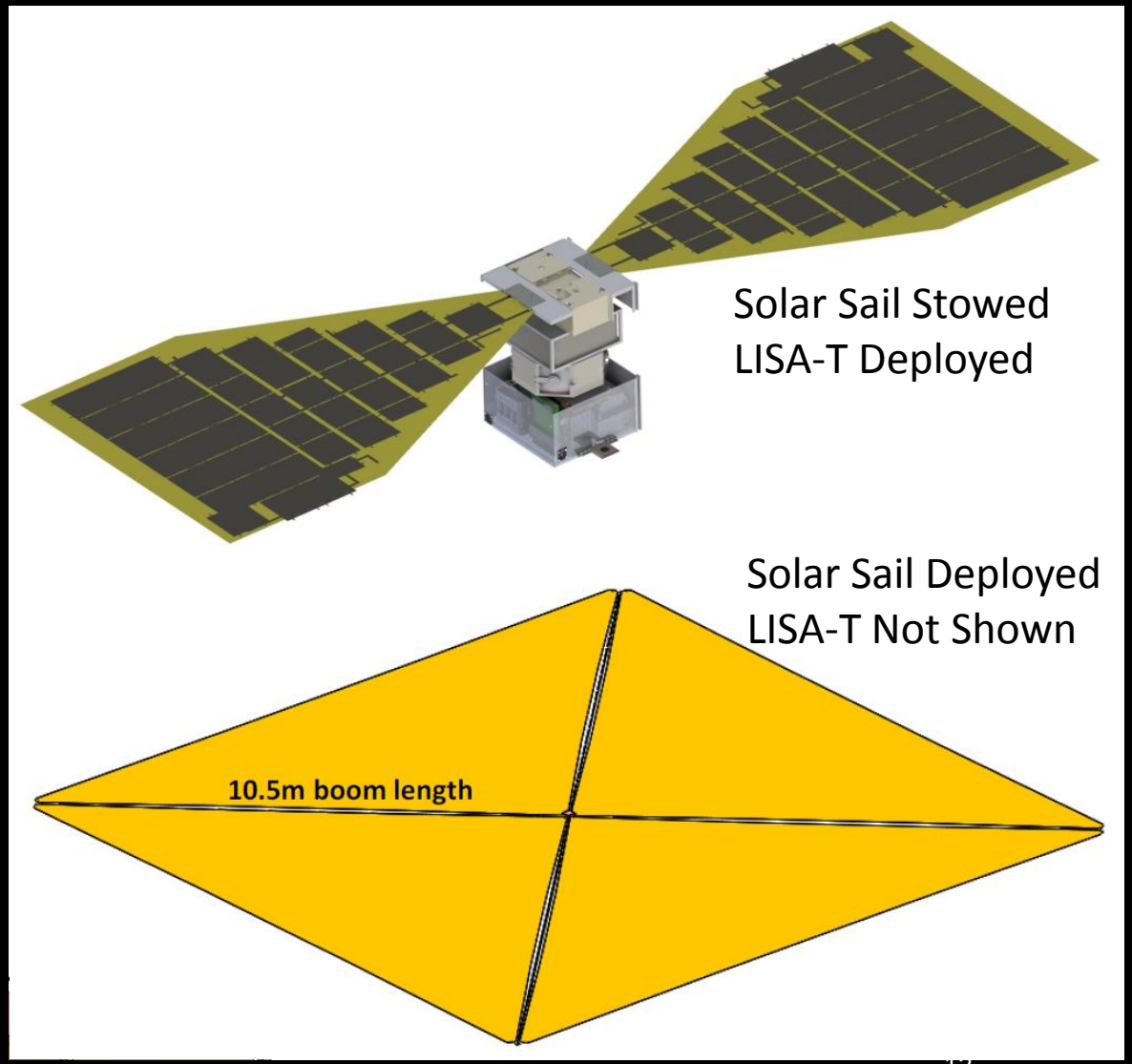


Image: JPL

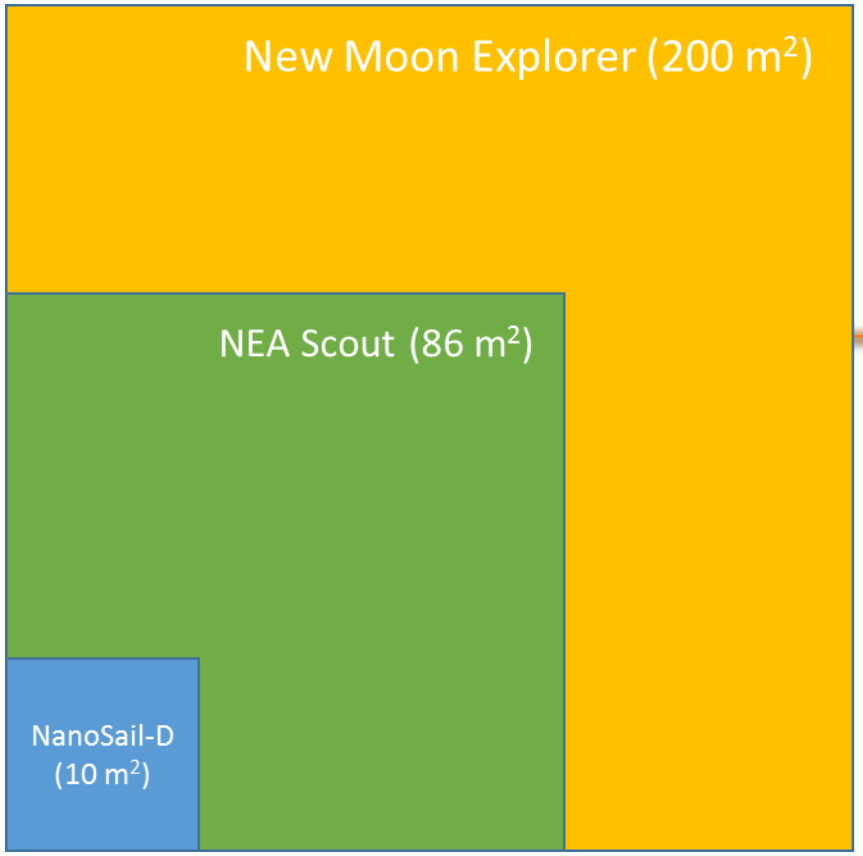
Spacecraft Features

- Low-cost 12U form factor
- Solar Sail propelled
  - 200 m^2 toughened CP1 quadrant configuration
  - 4x 10.5-m Slit-tube composite booms laminate designed using Roccor 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

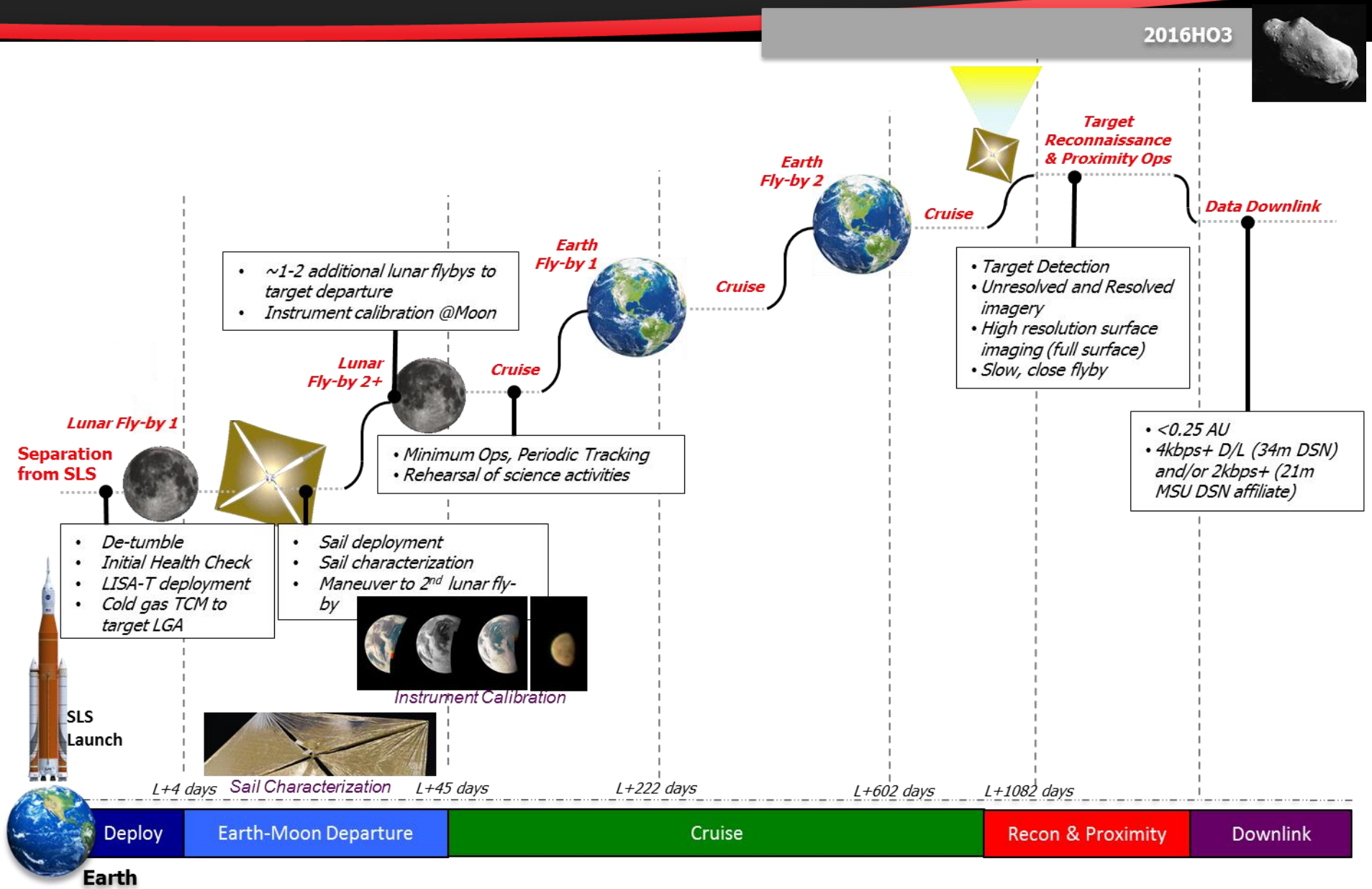


School Bus

12U Stowed Flight System

Folded, spooled and packaged

Concept of Operations



Co-Author Acknowledgements

- Les Johnson (Marshall Space Flight Center)
- Leslie McNutt (Marshall Space Flight Center)
- Alexander Few (Marshall Space Flight Center)
- Andrew Heaton (Marshall Space Flight Center)
- John Carr (Marshall Space Flight Center)
- Darren Boyd (Marshall Space Flight Center)
- Joseph Nuth (Goddard Space Flight Center)
- Dana Turse (Roccor)
- Aaron Zucherman (Morehead State University)
- Bejamin Malphrus (Morehead State University)
- Michael Combs (Morehead State University)

BACKUP

NASA's Near Earth Asteroid Scout

The Near Earth Asteroid Scout Will:

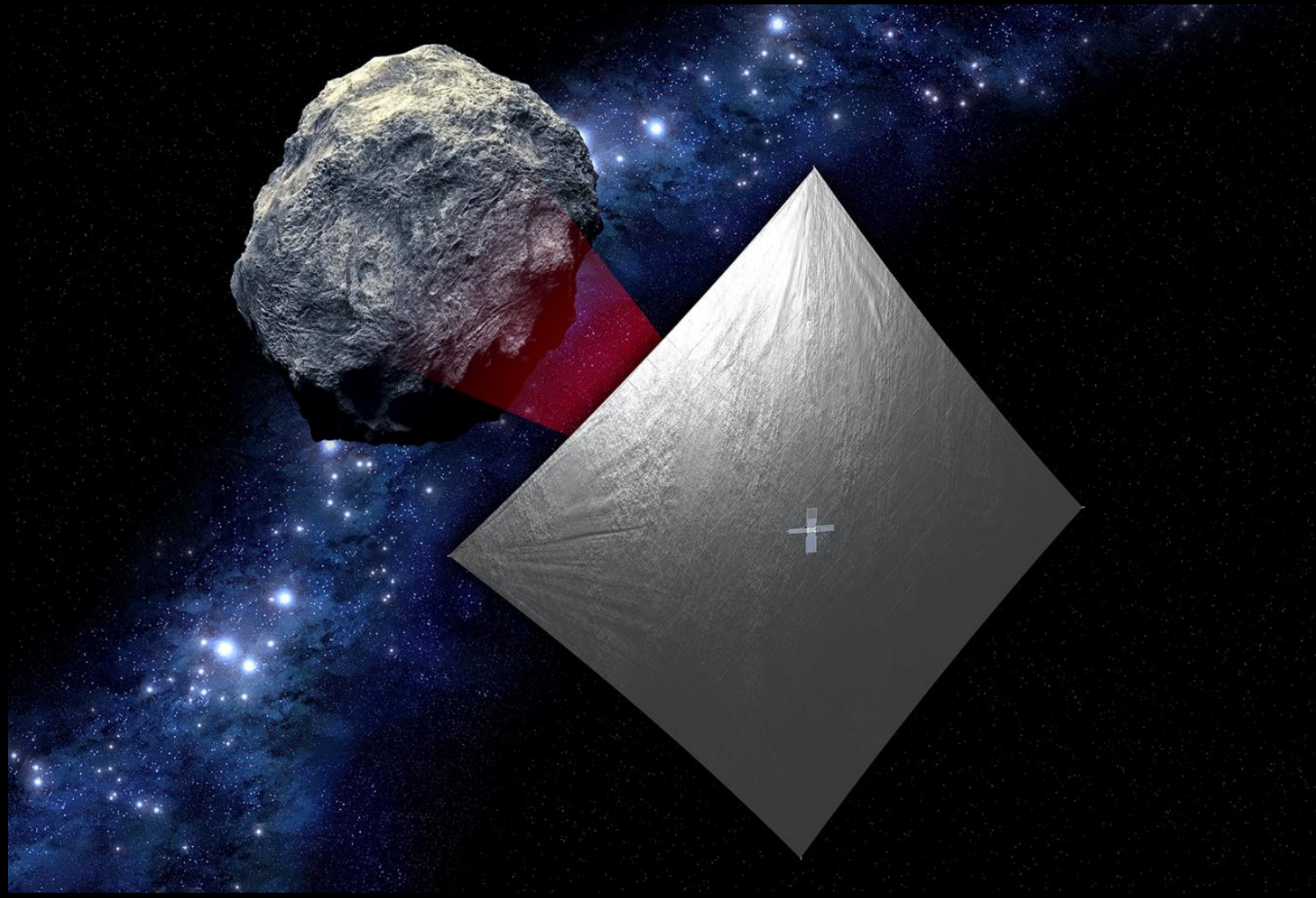
- Image/characterize a NEA during a slow flyby
- Demonstrate a low cost asteroid reconnaissance capability

Key Spacecraft & Mission Parameters

- 6U cubesat (20 cm X 10 cm X 30 cm)
- ~86 m^2 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

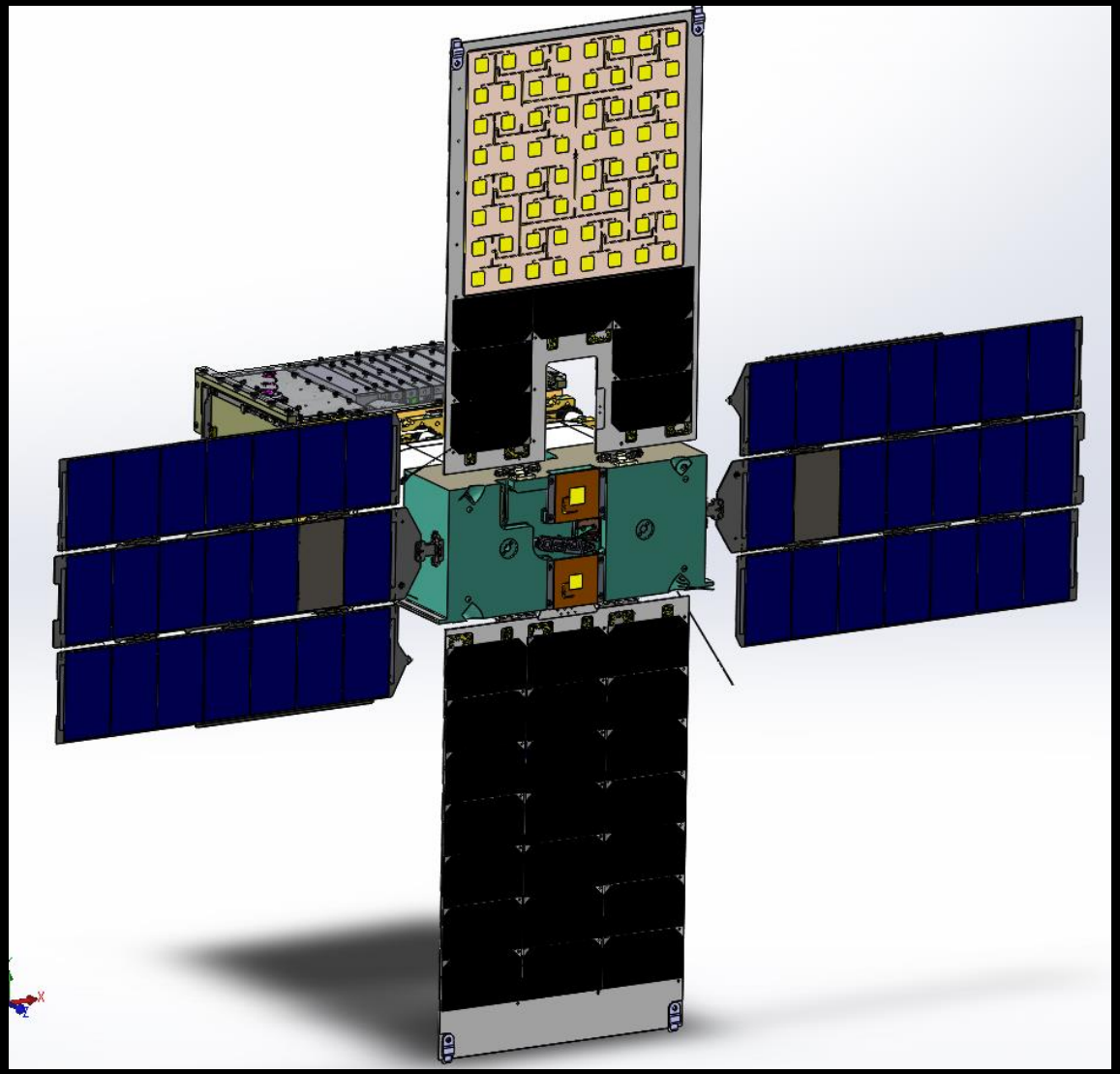
Solar Sail Propulsion System Characteristics

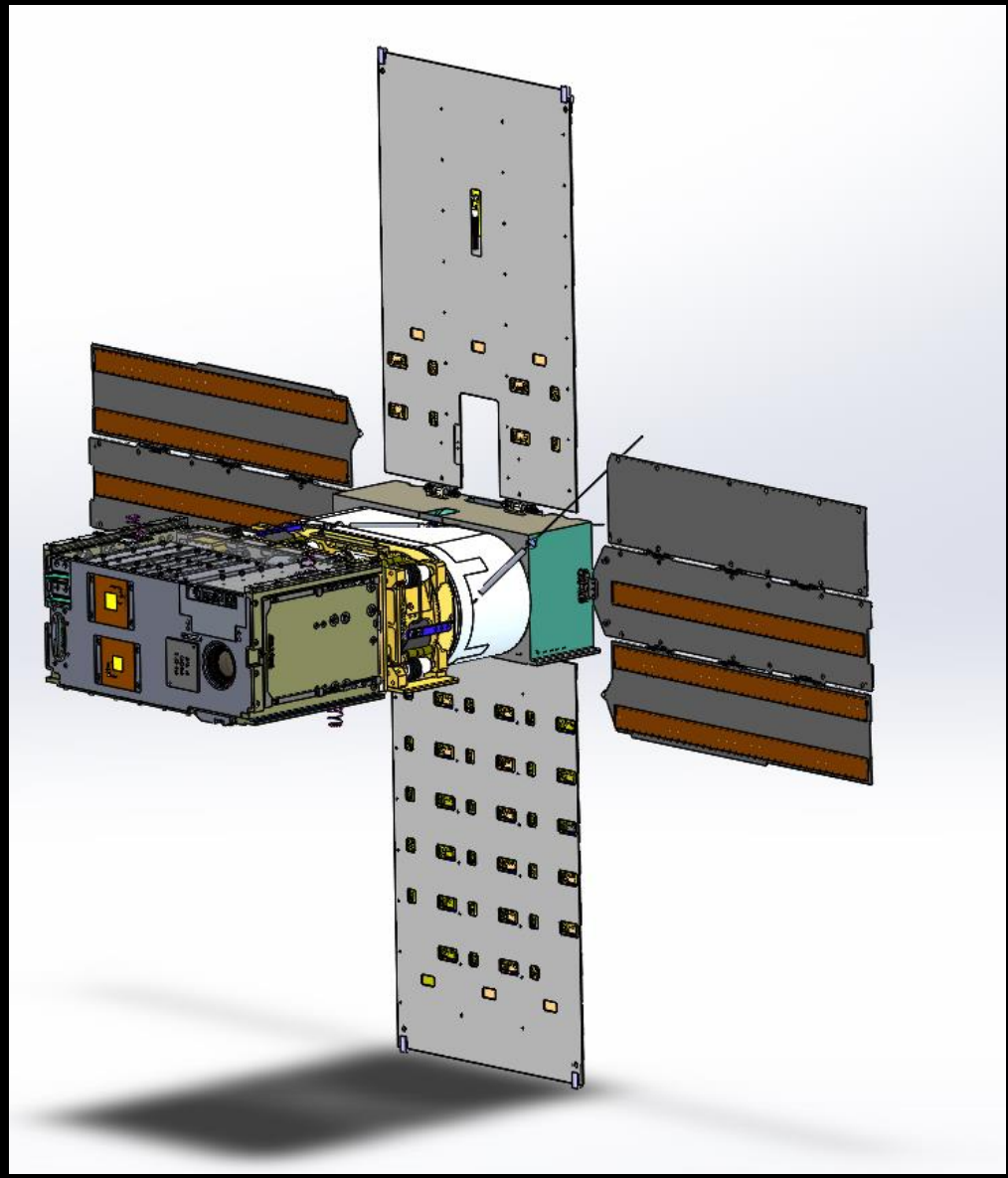
- ~ 7.3 m Trac booms
- 2.5μ aluminized CP-1 substrate
- > 90% reflectivity



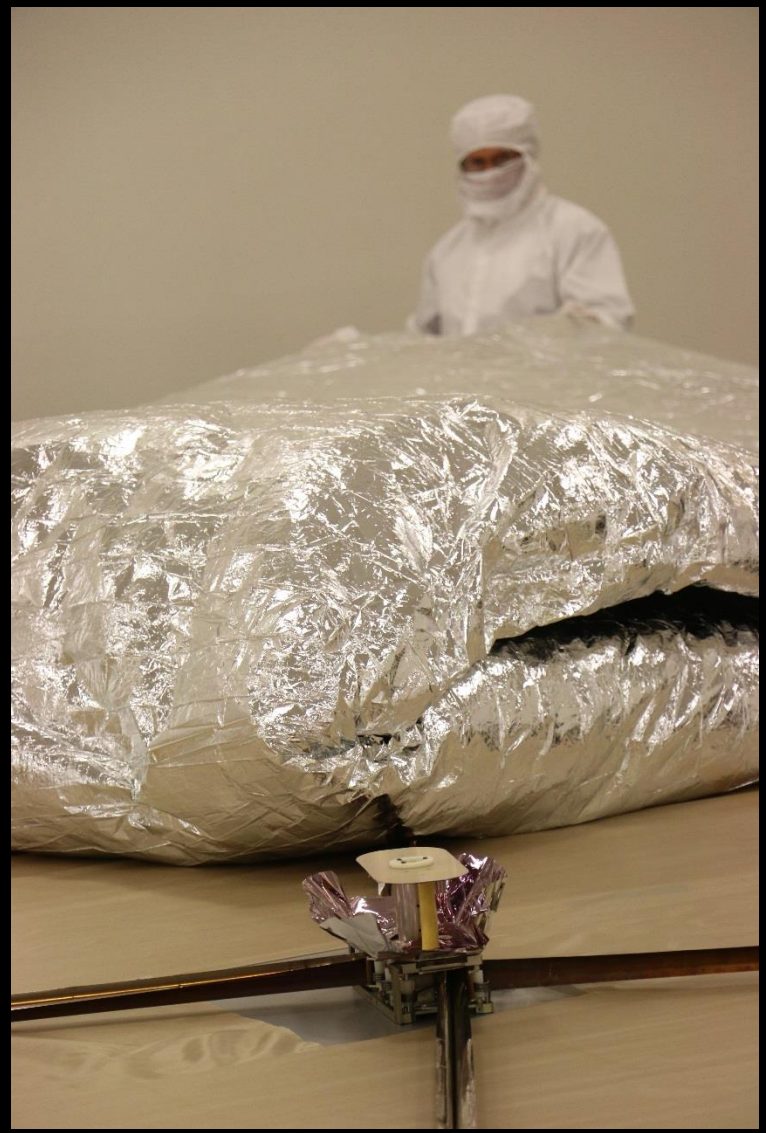
NASA Image

NEA Scout Flight System





NEA Scout Hardware Overview



NEA Scout Full Scale Successful Deployment

NASA Image