

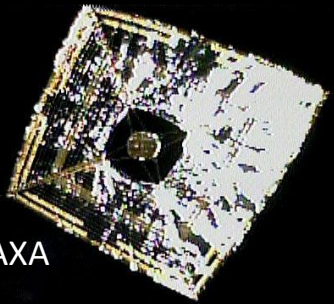
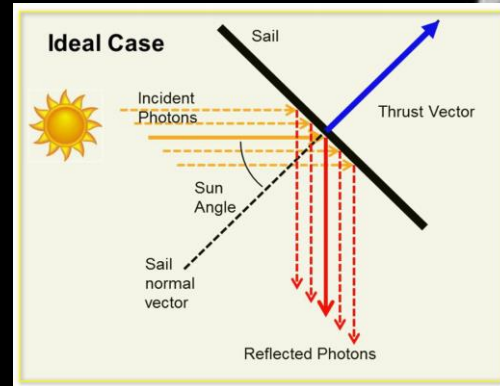
# Solar Sail Propulsion Technology for Planetary Missions

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(NASA MSFC)



# Solar Sail Propulsion

- Produce thrust with sunlight pressure or on thin, lightweight, reflective sheets
- Will never run out of fuel, allowing space missions to new locations
- Low mass & volume, high  $\Delta V$  propulsion



JAXA



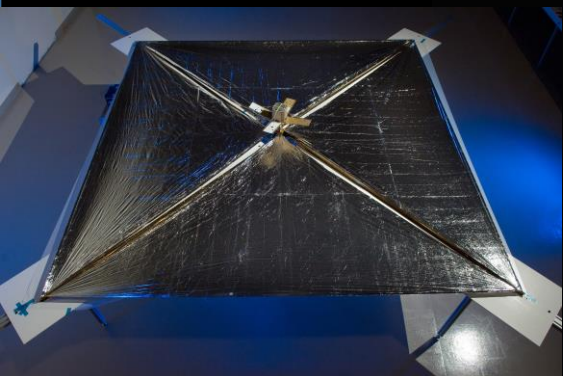
The Planetary Society



Large area, lightweight sail  
2.5 microns thick  
(thinner than a human hair)



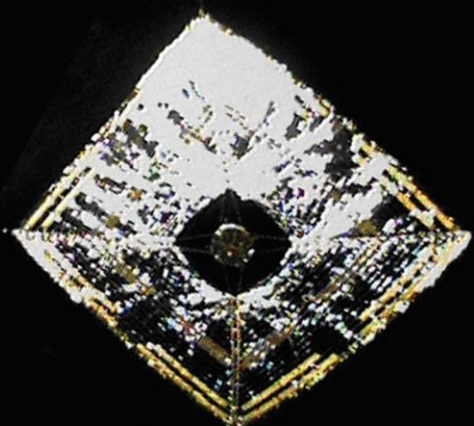
# Solar Sail Missions Flown



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

**Earth Orbit  
Deployment Only**

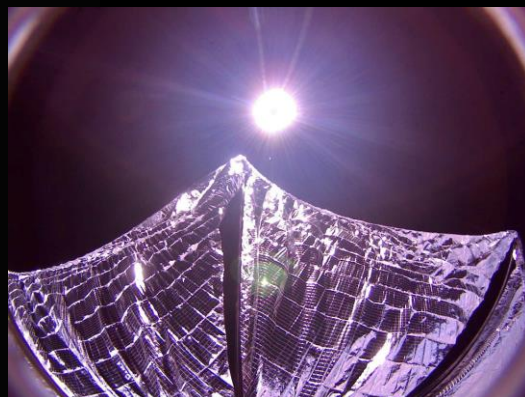
**3U CubeSat  
10 m<sup>2</sup>**



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

**Interplanetary  
Full Flight**

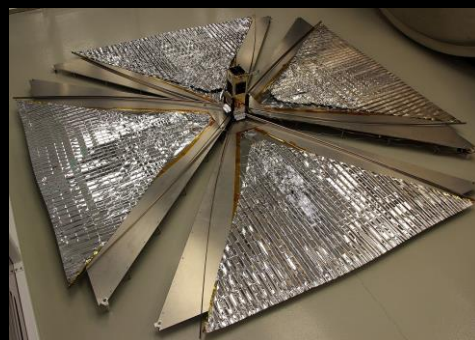
**315 kg Smallsat  
196 m<sup>2</sup>**



**LightSail-1 & 2  
(2015/2019)**  
**The Planetary Society**

**Earth Orbit  
Deployment / Flight**

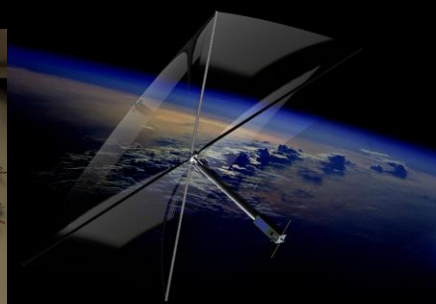
**3U CubeSat  
32 m<sup>2</sup>**



**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>**



# Near Earth Asteroid Scout

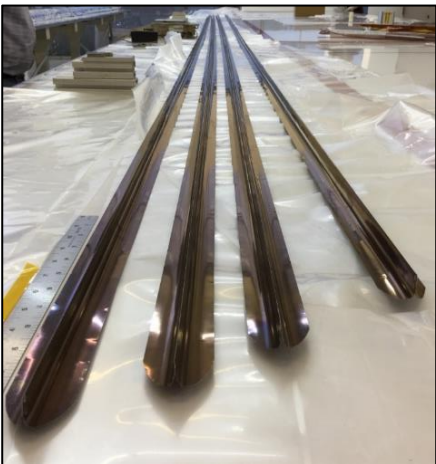
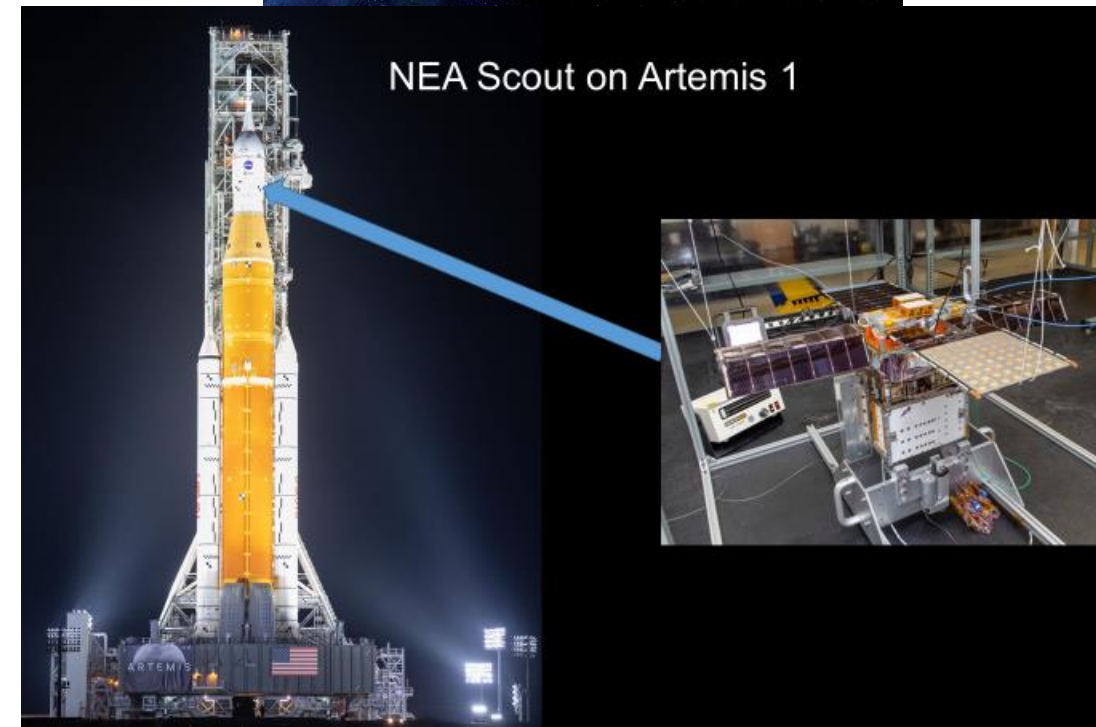
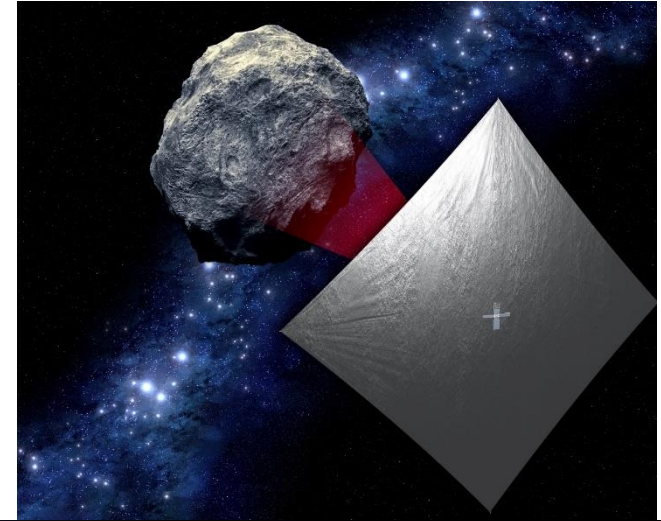
## Launched: Status *Unknown*

### Goals

- First long duration (> 2 years) interplanetary science mission using solar sail propulsion

### Key Spacecraft & Mission Parameters

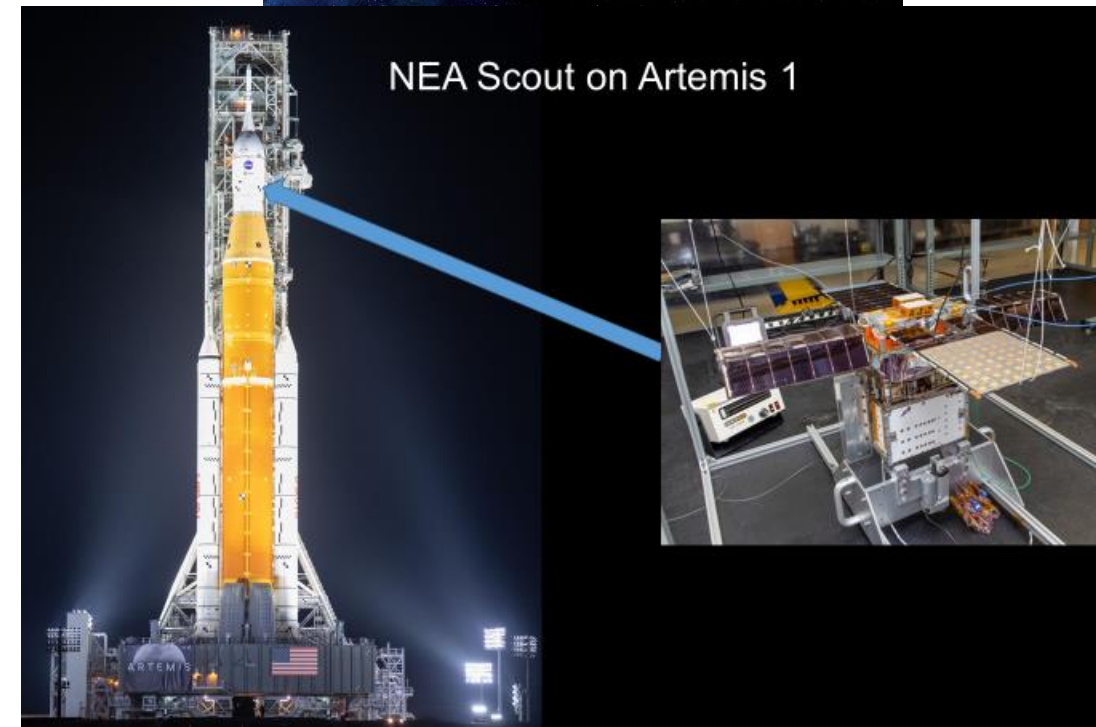
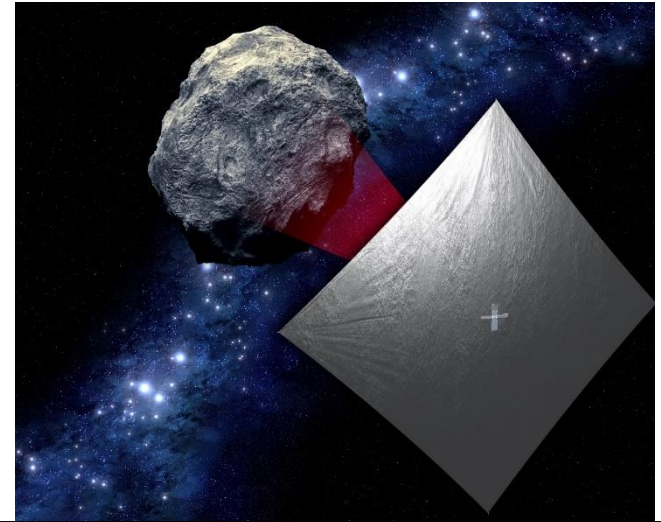
- 6U cubesat (8" X 4" X 12")
- 86 m<sup>2</sup> (925 ft<sup>2</sup>) solar sail propulsion system
- Launched November 16 with Artemis 1
- Unable to make radio contact (as of this time)





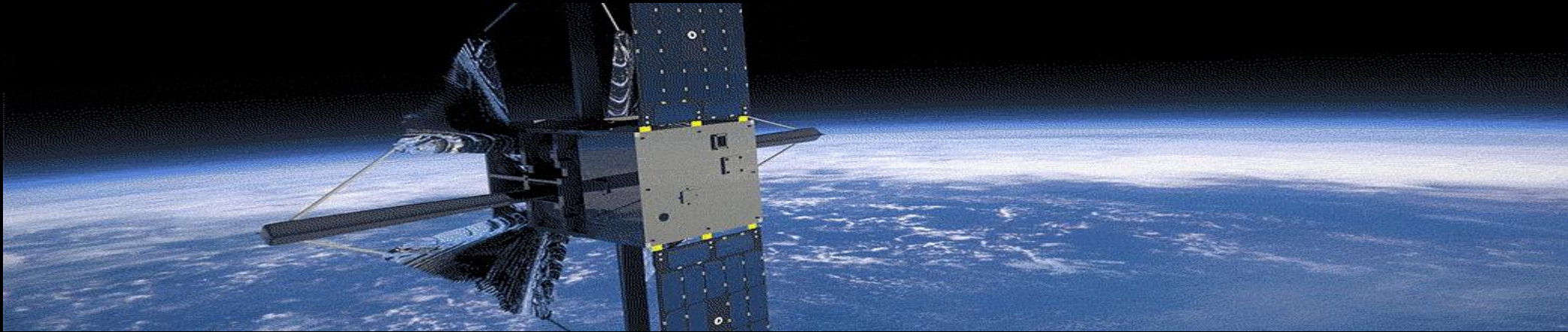
# Near Earth Asteroid Scout Launched: Status *Unknown*

Still attempting to make radio contact





# Advanced Composite Solar Sail System (ACS3)



## Objectives:

- Demonstrate successful deployment of the composite boom as well as sail packing and deployment systems in low-Earth orbit
- Evaluate the efficacy of the shape and design of the solar sail
- Characterize the thrust functionality of the sail as the spacecraft gradually changes orbit
- Appx. 81 m<sup>2</sup>



Images Courtesy of NASA's Langley Research Center



# Solar Cruiser Technology Demonstration Mission (as currently defined)

## Mission Technology Goals

Demonstrate solar sail propulsion technology to enable near- and mid-term science missions up to and including high solar inclination orbits, sub-L1 halo orbits, non-Keplerian solar and other planetary orbits

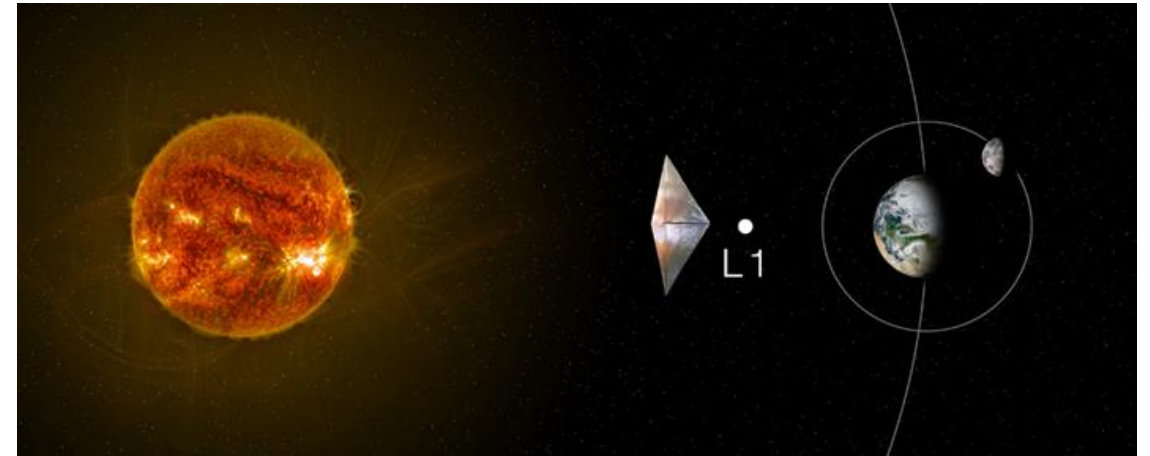
- Mercury, Venus and other inner solar system missions
- Mission destinations of interest to the nation in cis-lunar space
- Increased Space Weather warning times (Sub L1 station keeping)
- Sustained in-situ measurements within the Earth's magnetotail
- High inclination solar orbital observations

## The Team

- NASA MSFC: Project Management, ADCS Software, MDNav, Mission Operations
- Ball Aerospace: Sailcraft Bus & Sailcraft I&T
- Redwire: Solar Sail System

## Status

- Completed Phase B and successful technical PDR
- Not confirmed for 2025 launch (by NASA SMD) due to schedule
- Offered rideshare to L1 by NOAA in 2028
- Secured \$10M to mature sail technology to TRL-6 in FY23
- Secured additional funding from NOAA to fabricate the flight sail



## Technical Details

### Solar Sail

- Deployed Area:  $\sim 17,800 \text{ ft}^2$  ( $1653 \text{ m}^2$ )
- Fabric: 2.5 micron thick Colorless Polyimide-1
- Composite Boom Lengths (X4): 97 ft (29.5 m) each

### Payload

- 2.5 kg context camera
- Can accommodate 5 – 10 kg without significant changes

### Destination

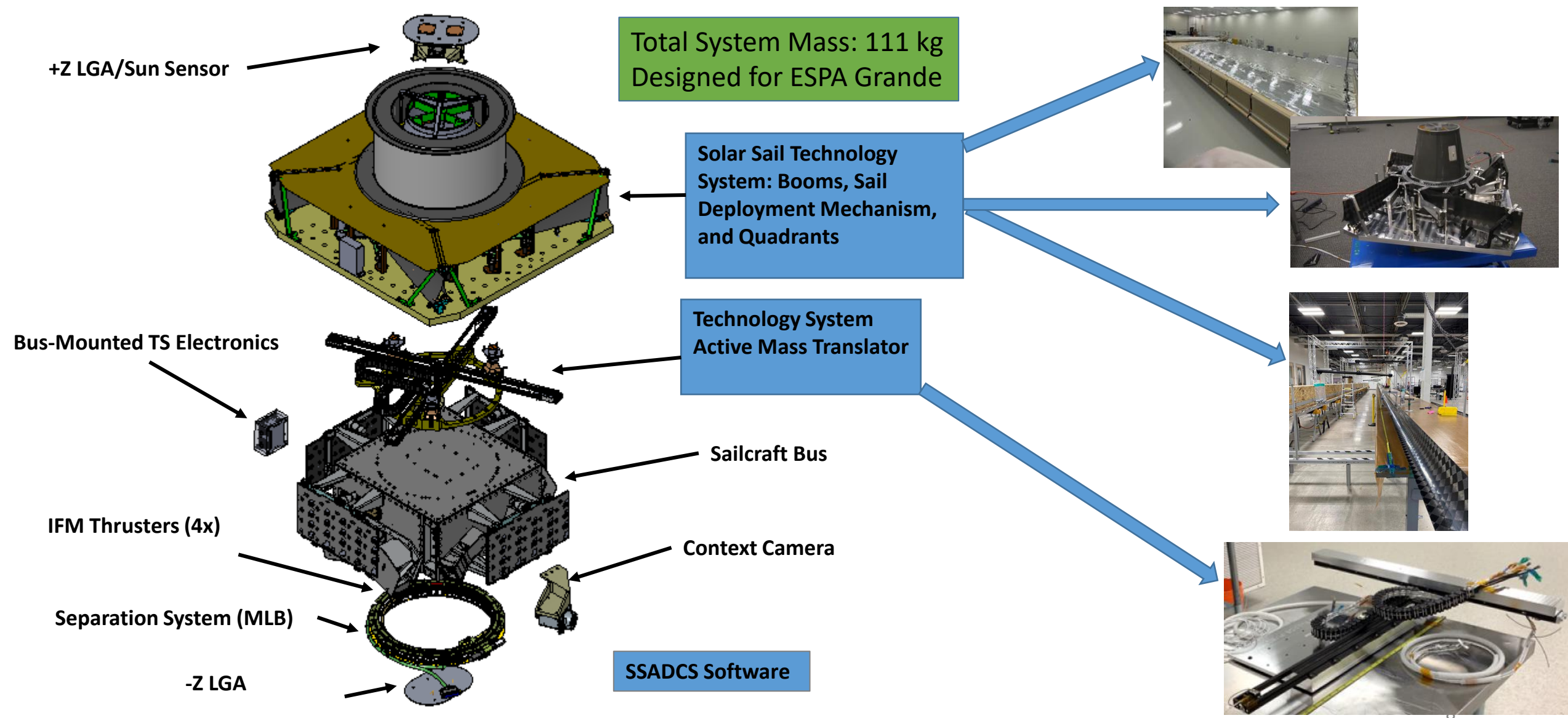
- Non-Keplerian sub-L1 halo orbit

### Launch

- Secondary payload on ESPA Grande on Falcon 9 with IMAP mission



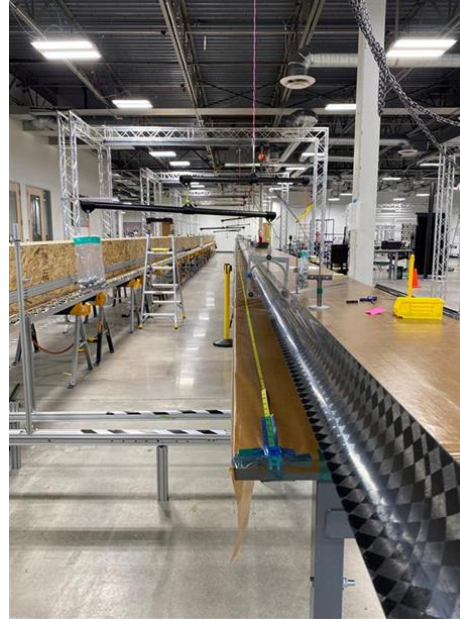
# Solar Cruiser Flight and Technology Systems





# Prototype Quadrant Deployed and Tested

- Full-scale quadrant Prototype deployment testing complete

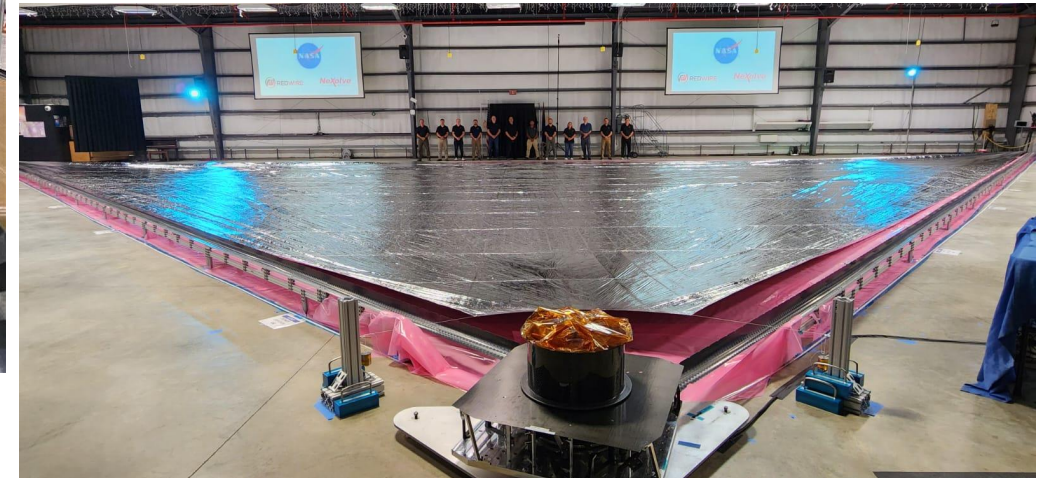


Prototype Sail Quadrant (SQ) Manufacturing



## SQ Deployment

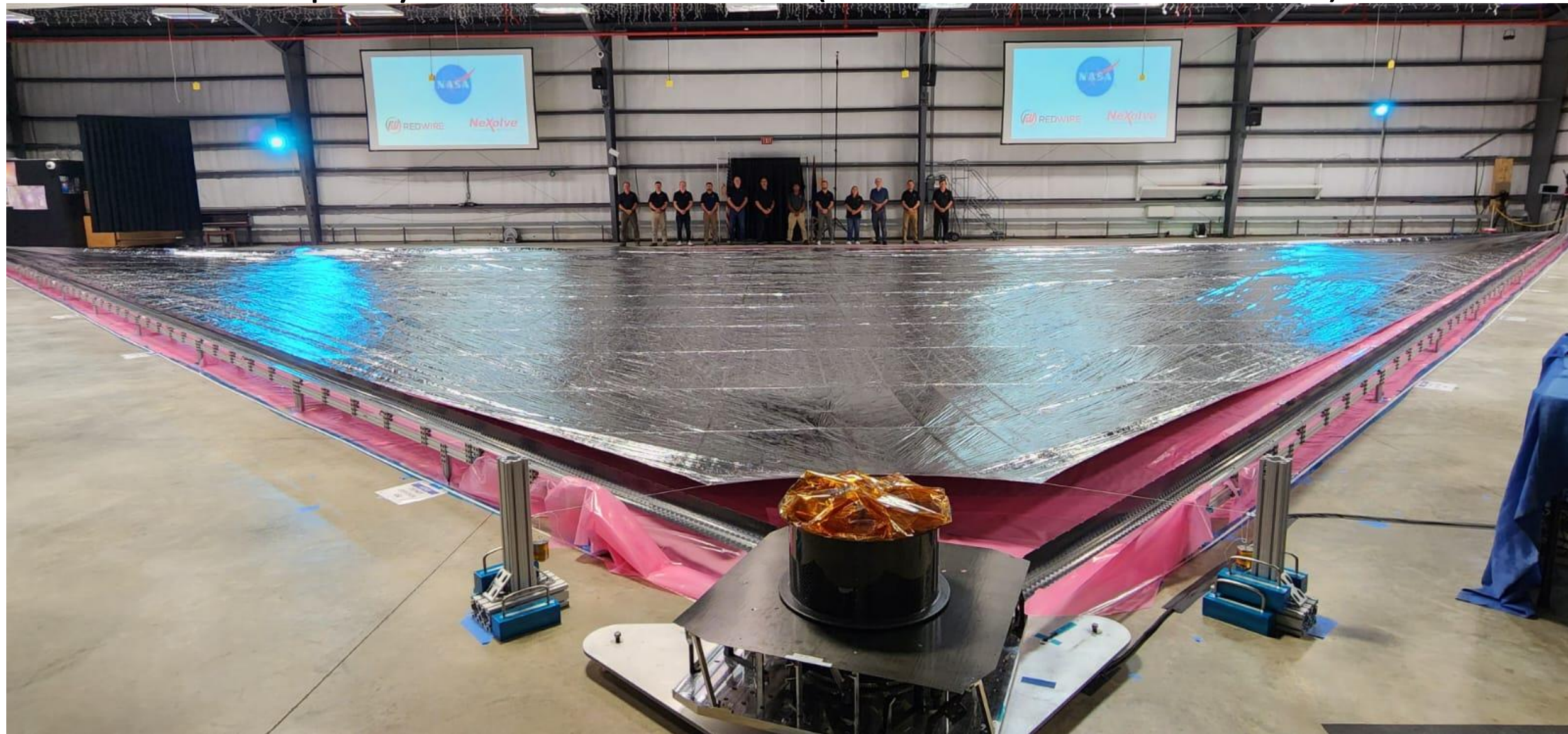
Test Design layout in MSFC Activities Center



Prototype single quadrant hardware:  
1 full-scale SQ  
2 full-scale TRAC booms  
1 full-scale Sail Deployment Mechanism



# Prototype Solar Sail Quadrant Deployed and Tested ( $\sim 4700 \text{ ft}^2$ / $440 \text{ m}^2$ )





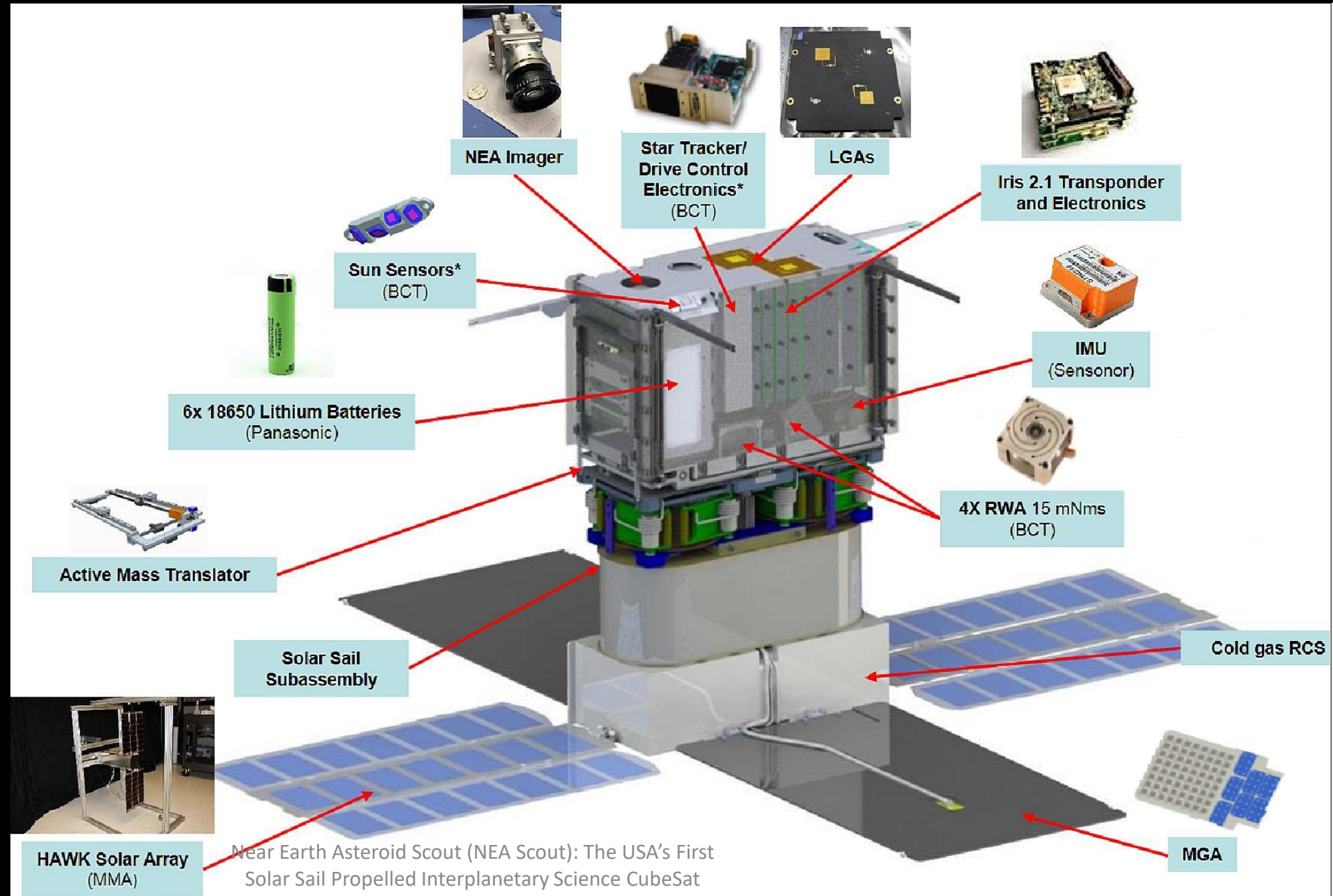
For more information, contact

Les Johnson

[les.johnson@nasa.gov](mailto:les.johnson@nasa.gov)

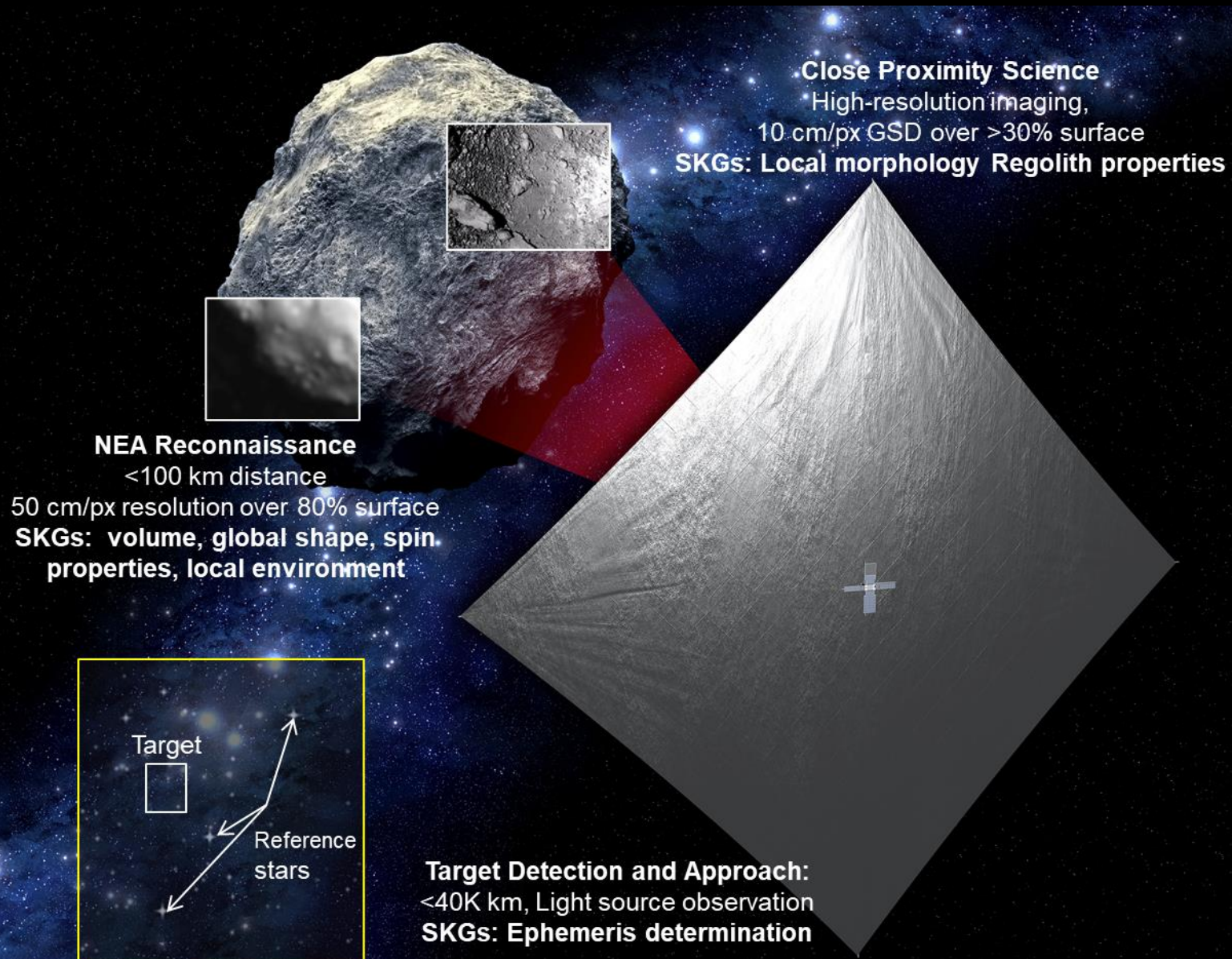


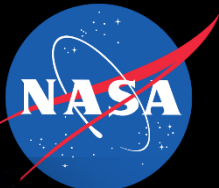
# NEA Scout Spacecraft (Exploded View)





# NEA Scout Science





# NASA Has Two Decades of Solar Sail Development

## Experience Increasing Solar Sail Capabilities

