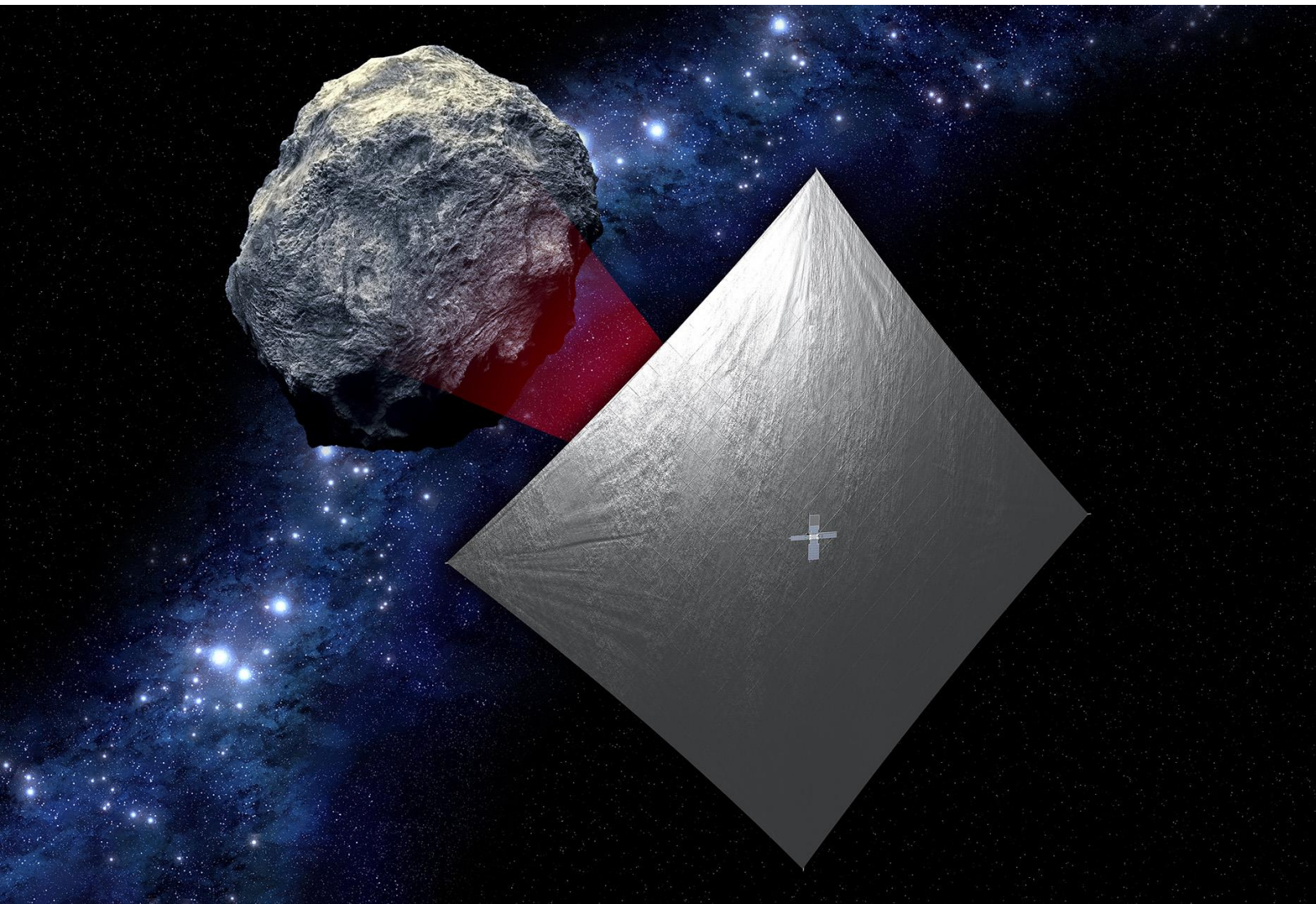


# Near Earth Asteroid (NEA) Scout



Les Johnson, Tiffany Lockett,  
& Alex Few

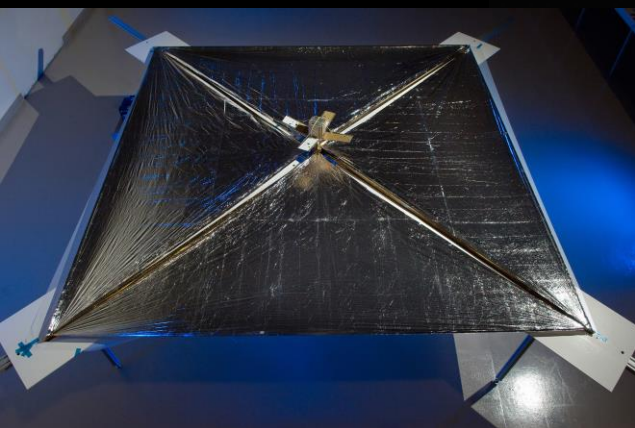
NASA George C. Marshall Space  
Flight Center

Julie Castillo-Rogez

NASA Jet Propulsion Laboratory



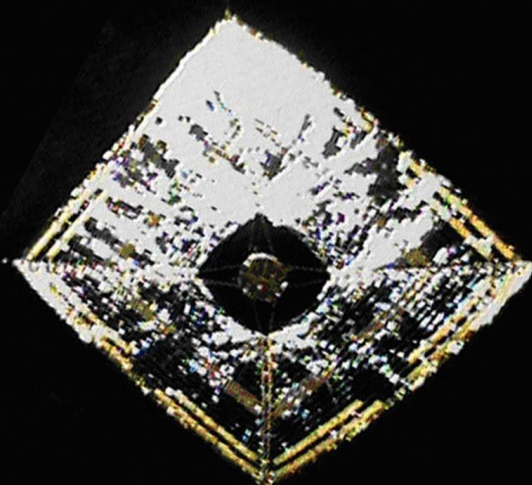
# Solar Sail Missions Flown (as of April 11, 2018)



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

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

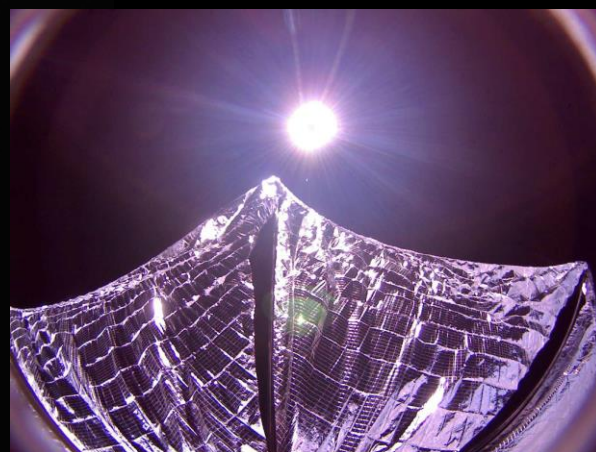
**3U CubeSat**  
**10 m<sup>2</sup>**



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

**Interplanetary**  
**Full Flight**

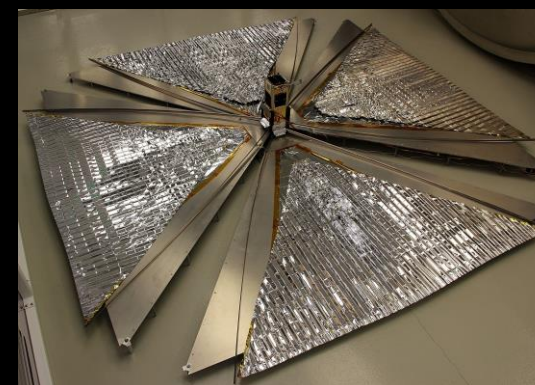
**315 kg Smallsat**  
**196 m<sup>2</sup>**



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

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

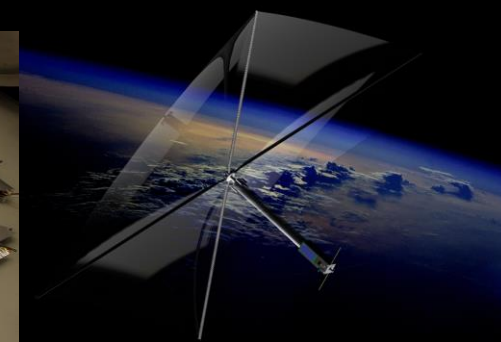
**3U CubeSat**  
**32 m<sup>2</sup>**



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

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

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



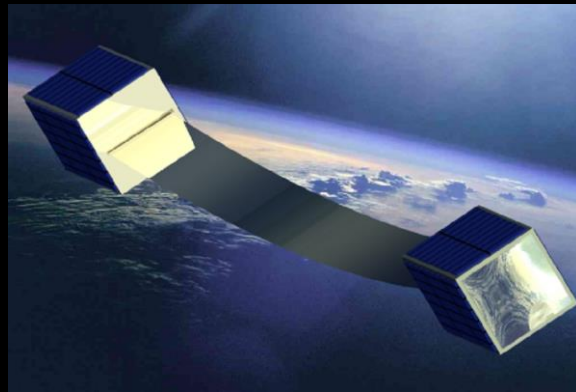
**InflateSail (2017)**  
**EU/Univ. of Surrey**

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

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



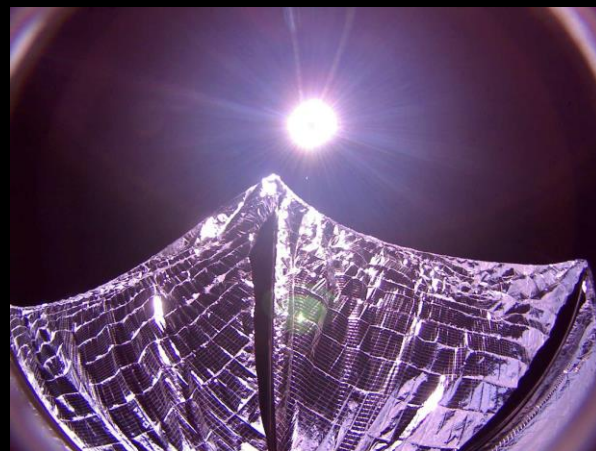
# Planned Solar Sail Missions (as of April 11, 2018)



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

**Earth Orbit**  
**Full Flight**

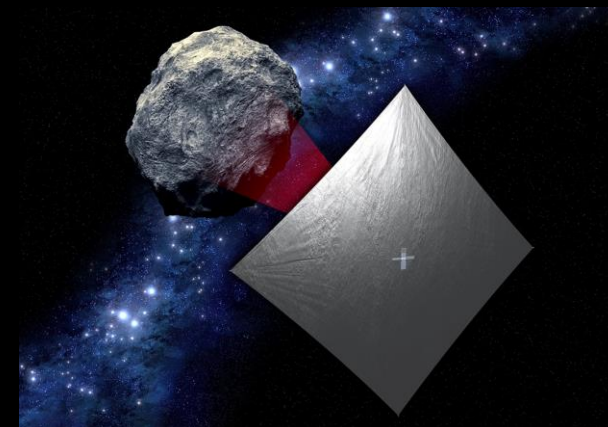
**3U CubeSat**  
**20 m<sup>2</sup>**



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

**Earth Orbit**  
**Full Flight**

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



**Near Earth Asteroid Scout (2019)** NASA

**Interplanetary**  
**Full Flight**

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



# Near Earth Asteroid Scout

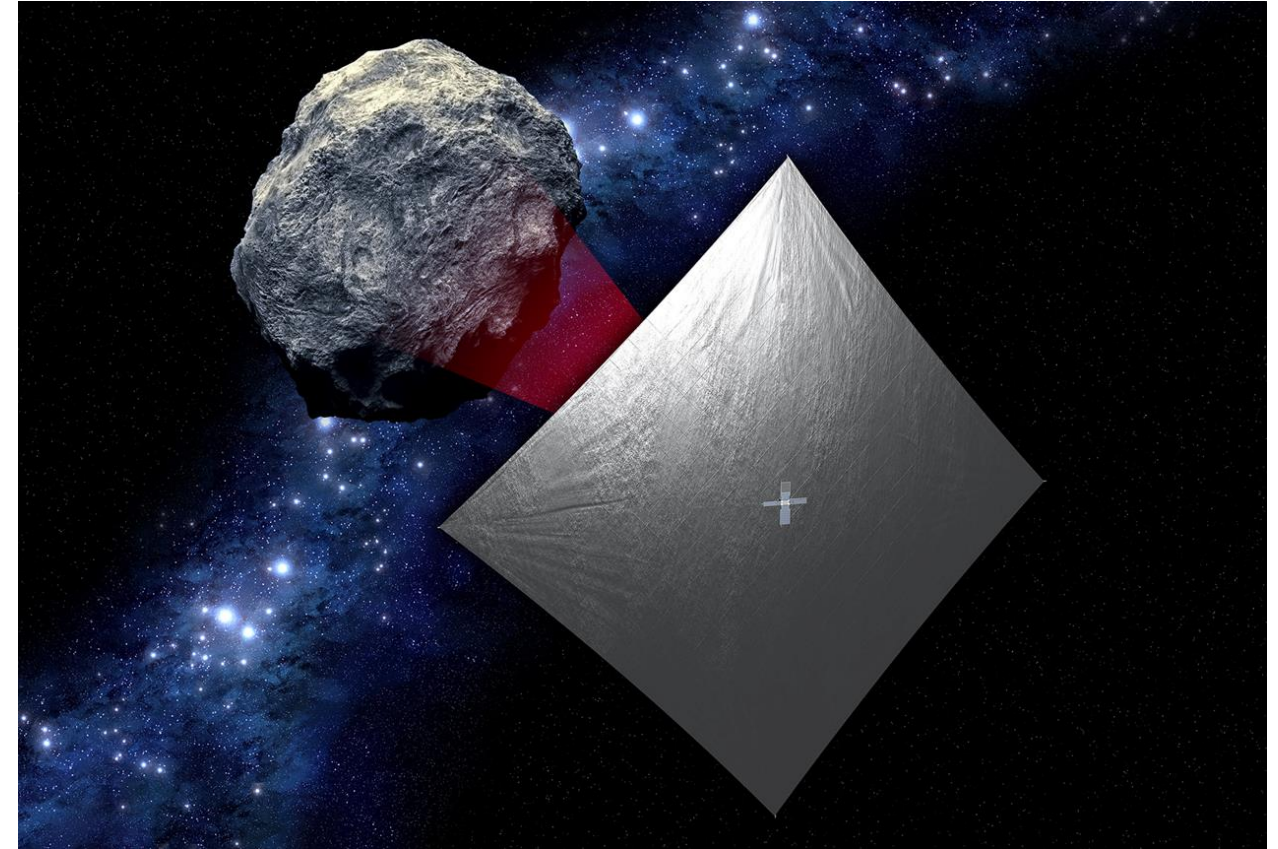


## The Near Earth Asteroid Scout Will

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

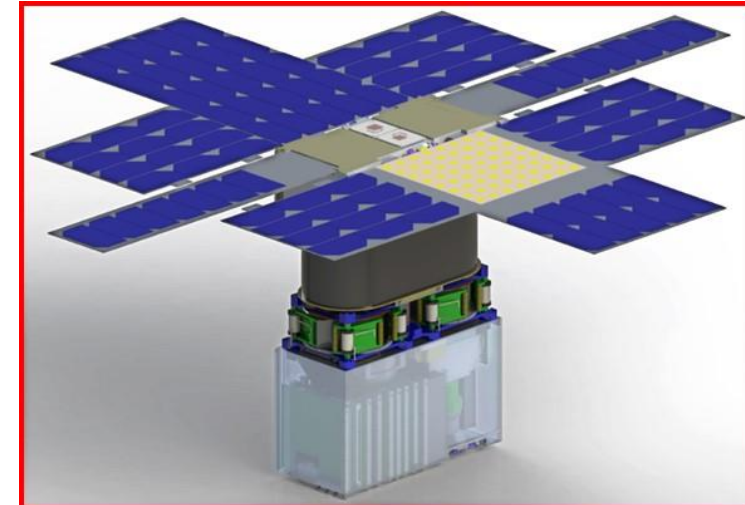
## Key Spacecraft & Mission Parameters

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



**Leverages:** combined experiences of MSFC and JPL with support from GSFC, JSC, & LaRC

**Close Proximity Imaging**  
Local scale morphology, terrain properties, landing site survey



**Target Reconnaissance with medium field imaging**  
Shape, spin, and local environment





# NEA Scout Goals & Objectives



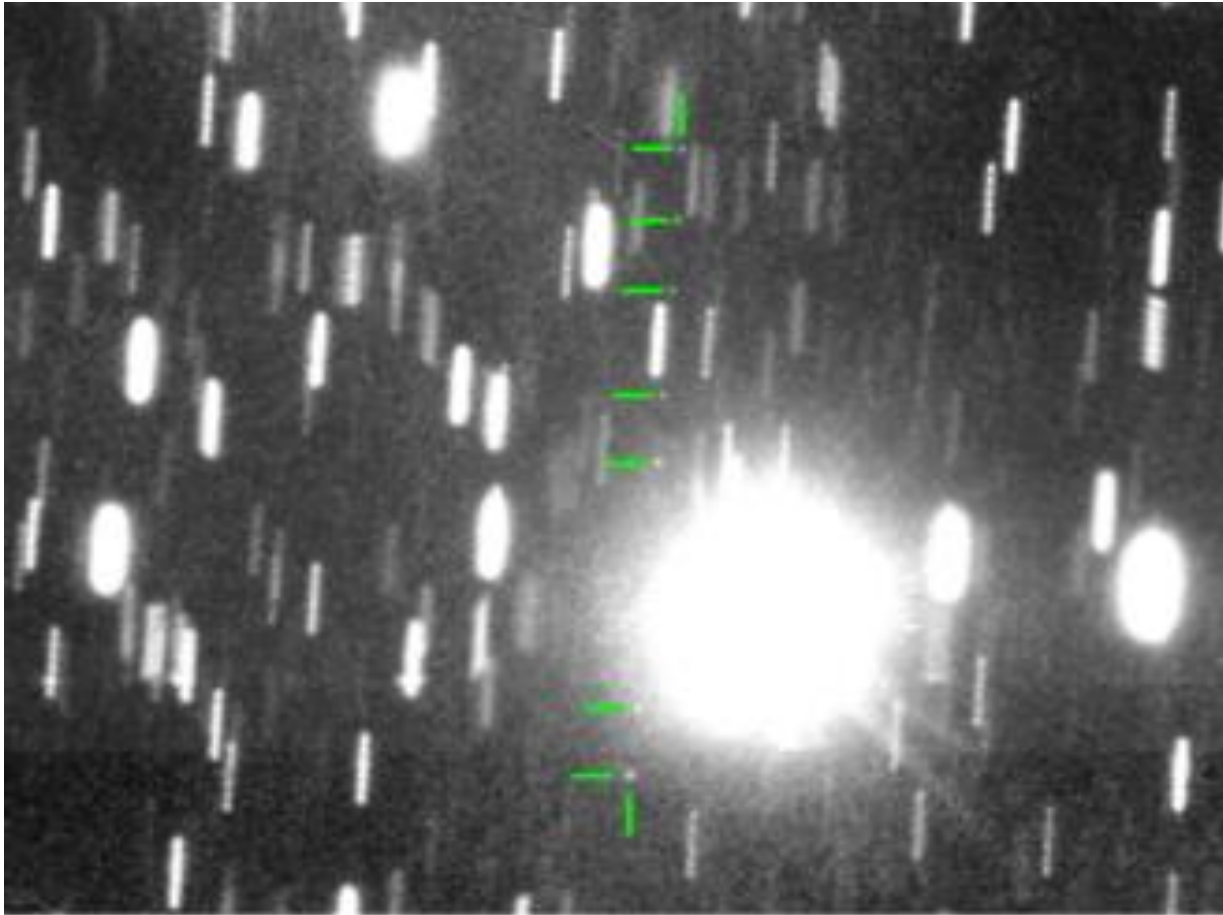
- 1) Design, develop, integrate and operate a spacecraft for the purpose of demonstrating a low cost reconnaissance capability
- 2) Enable asteroids as potential destinations for human exploration
- 3) Characterize a candidate NEA with an imager to address key SKG's

*“Precursor robotics, robotic missions that investigate candidate destinations and provide vital information to prepare for human explorers, will lay the groundwork for humans to achieve new milestones in deep space.”*

**HEOMD/AES Strategic Goals/Objectives  
(Strategic Goal 1, Objective 1.1)**

*“Robotic exploration is the principal method we use to explore the solar system, and is an essential precursor to human exploration of space.”*

**SMD Strategic Goals/Objectives  
(Strategic Goal 1, Objective 1.5)**



Near-Earth Asteroid 1991VG (marked with green lines) on 2017 May 30. This is a composite of several images obtained with the ESO VLT. The images have been combined in 7 stacks tracking the position of the asteroid, resulting in the object appearing as 7 dots as it moves in front of the background stars. The stars appear trailed due to the motion of the asteroid during each series. Credit Hainaut/Micheli/Koschny

- Diameter ~ 5 -12 meters
- Rotation period between a few minutes and less than 1 hour
- Unlikely to have a companion
- Unlikely to retain an exosphere or dust cloud
  - Solar radiation pressure sweeps dust on timescales of hours or day



# Near Earth Asteroid Scout Mission Overview

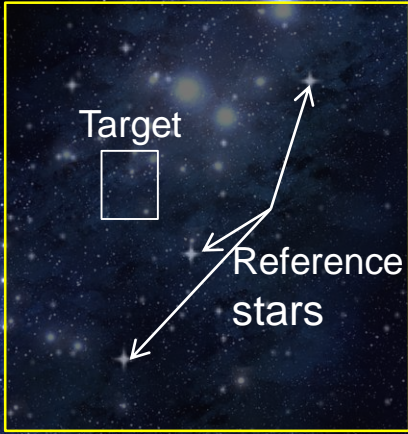


**Close Proximity Science**  
 High-resolution imaging,  
 10 /px over >30% surface  
**SKGs: Local morphology**  
**Regolith properties**

**NEA Reconnaissance**  
 <100 km distance at encounter  
 50 cm/px resolution over 80% surface  
**SKGs: volume, global shape, spin**  
**properties, local environment**

**Target Detection and Approach:**  
 50K km, Light source observation  
**SKGs: Ephemeris determination and**  
**composition assessment**

JPL

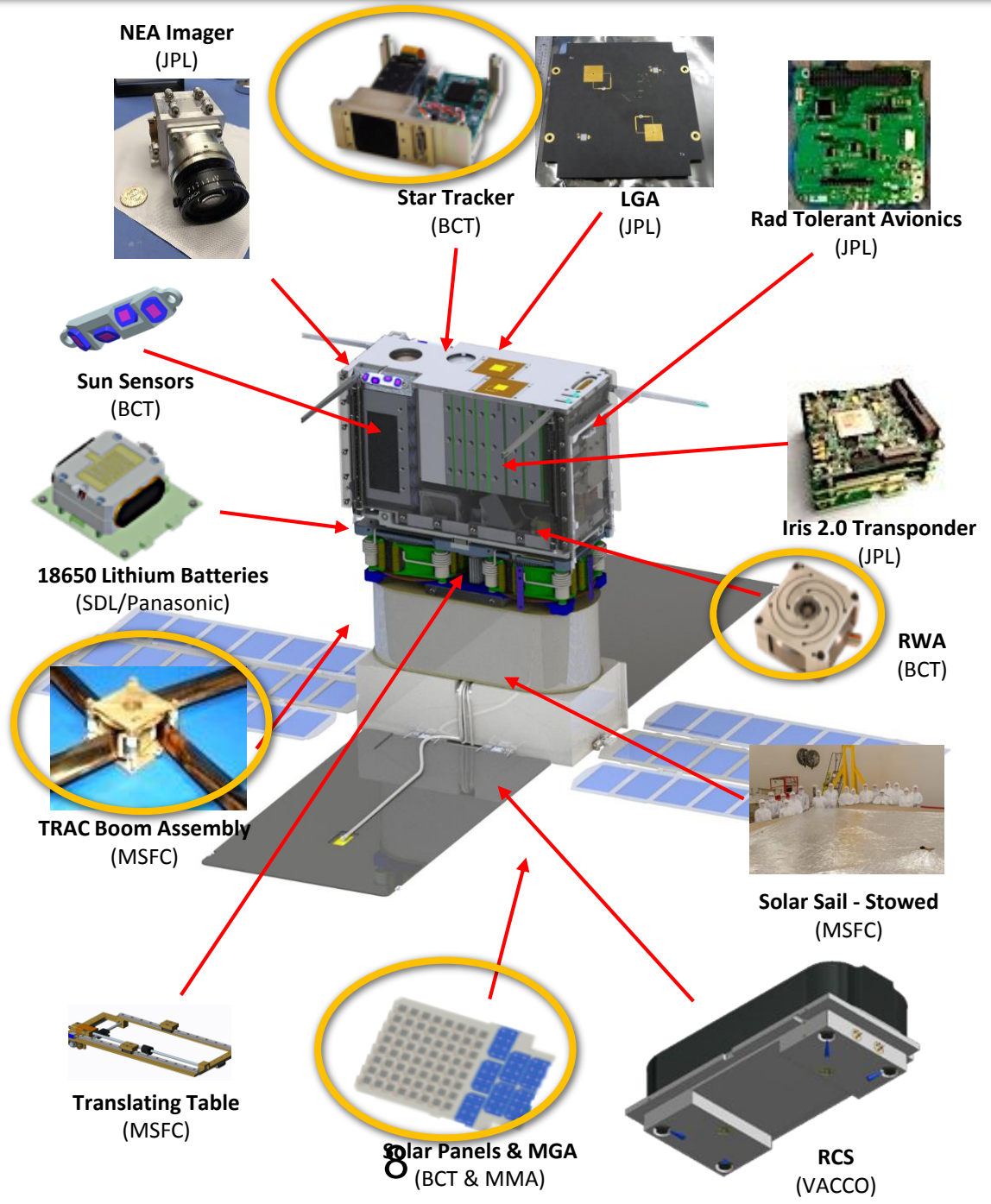




# Flight System Overview



<b>Payload</b>	<ul style="list-style-type: none"> <li>Context Camera</li> </ul>
<b>Mechanical &amp; Structure</b>	<ul style="list-style-type: none"> <li>"6U" CubeSat form factor</li> <li>&lt;14 kg total launch mass</li> <li>Modular flight system concept</li> </ul>
<b>Propulsion</b>	<ul style="list-style-type: none"> <li>~86 m<sup>2</sup> aluminized CP-1 solar sail (based on NanoSail-D2)</li> </ul>
<b>Avionics</b>	<ul style="list-style-type: none"> <li>Radiation tolerant architecture</li> </ul>
<b>Electrical Power System</b>	<ul style="list-style-type: none"> <li>Trifold deployable solar arrays with GaAs cells (~51.2 W EOL at 1 AU solar distance)</li> <li>6.2 Ah Battery</li> <li>10 -12.3 V unregulated, 5 V/3.5 V regulated</li> </ul>
<b>Telecom</b>	<ul style="list-style-type: none"> <li>JPL Iris 2.0 X-Band Transponder; 4 W RF output power supports doppler, ranging, and D-DOR</li> <li>2 pairs of INSPIRE-heritage LGAs (RX/TX)</li> <li>8x8 element microstrip array MGA (TX); ~1 kbps to 34m DSN at 0.8 AU</li> </ul>
<b>Attitude Control System</b>	<ul style="list-style-type: none"> <li>15 mNm-s (x3) &amp; 100 mNm-s RWAs</li> <li>Active mass translation system</li> <li>VACCO R-236fa (refrigerant gas) 'warm gas' RCS system</li> <li>Nano StarTracker, Coarse Sun Sensors &amp; MEMS IMU for attitude determination</li> </ul>



**A fully functional planetary spacecraft in a shoebox**

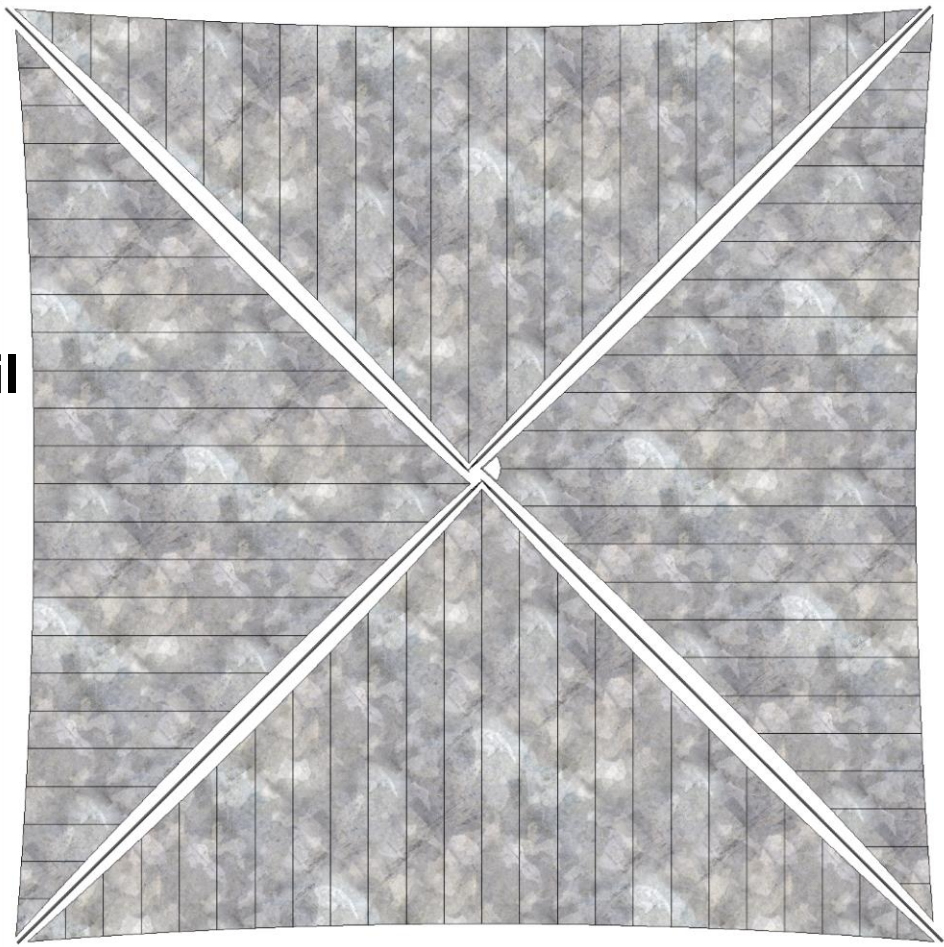




# NEA Scout Approximate Scale



Deployed Solar Sail



School Bus



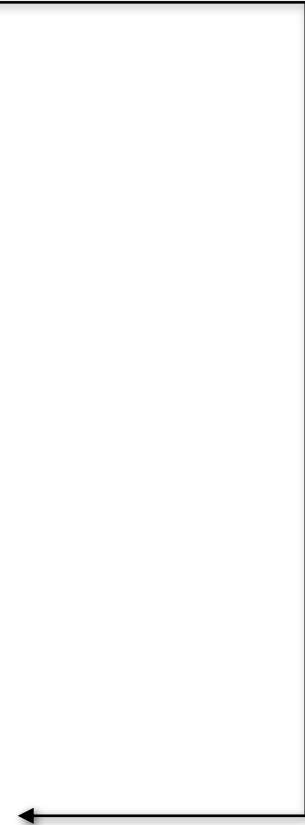
Human



6U Stowed Flight System

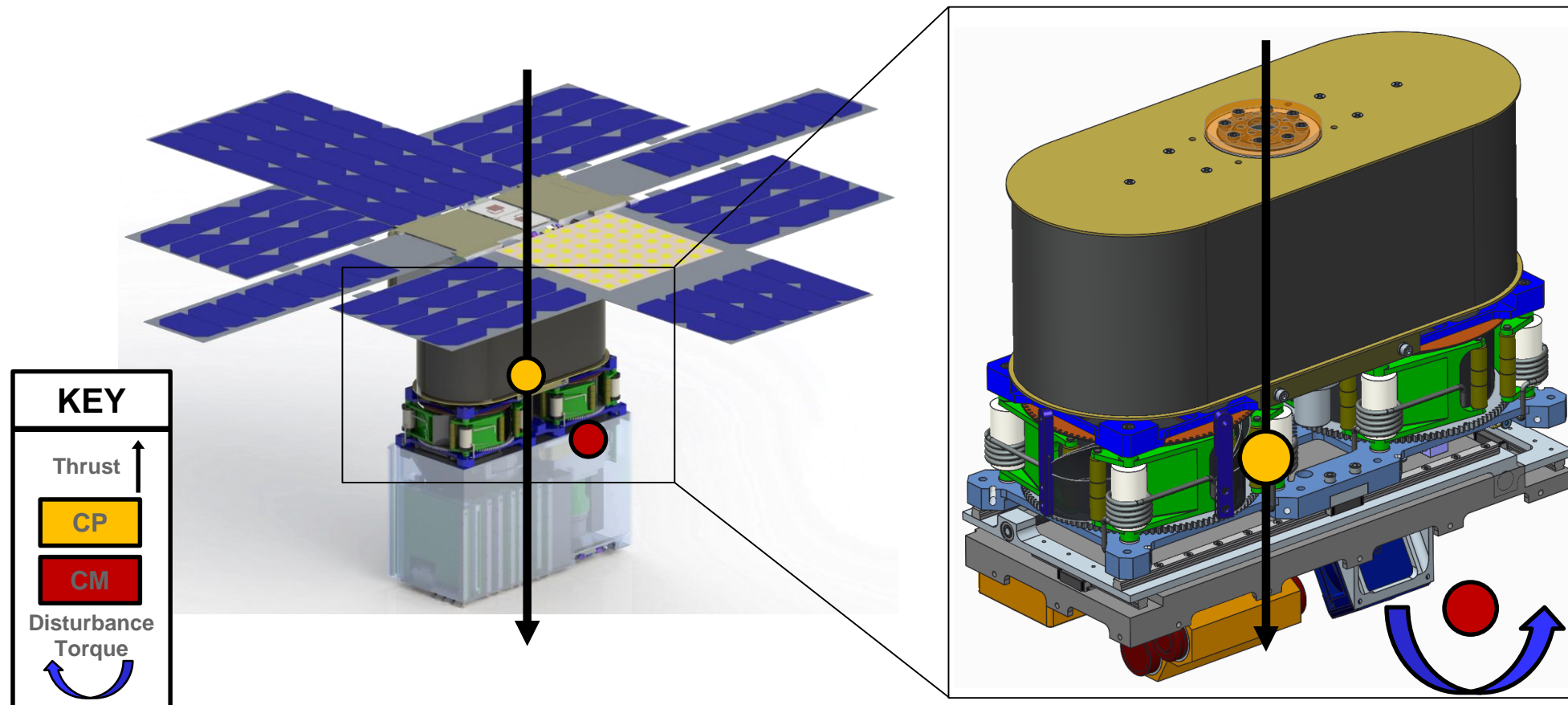


Folded, spooled and packaged in here

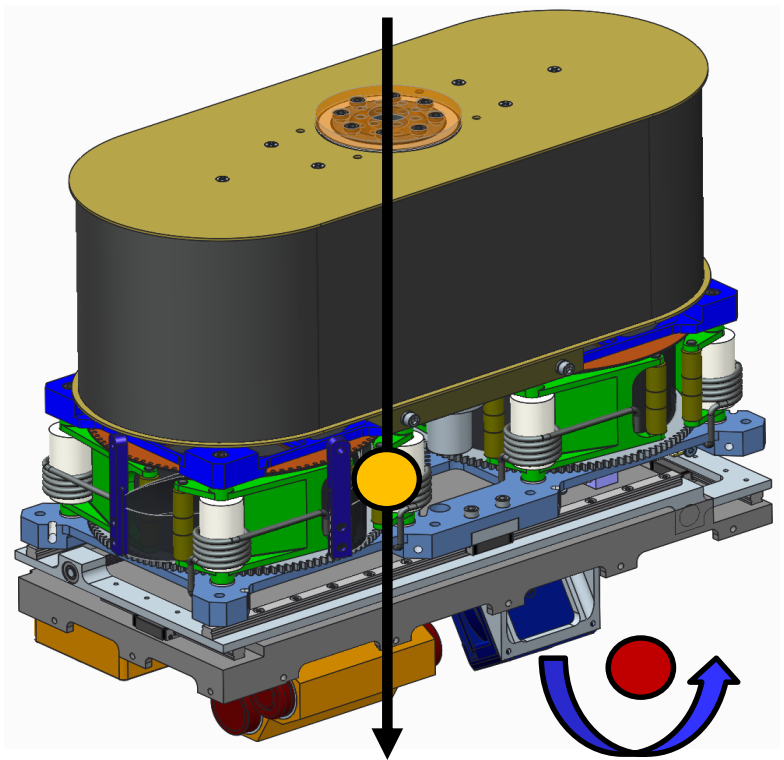


## Problems and Challenges

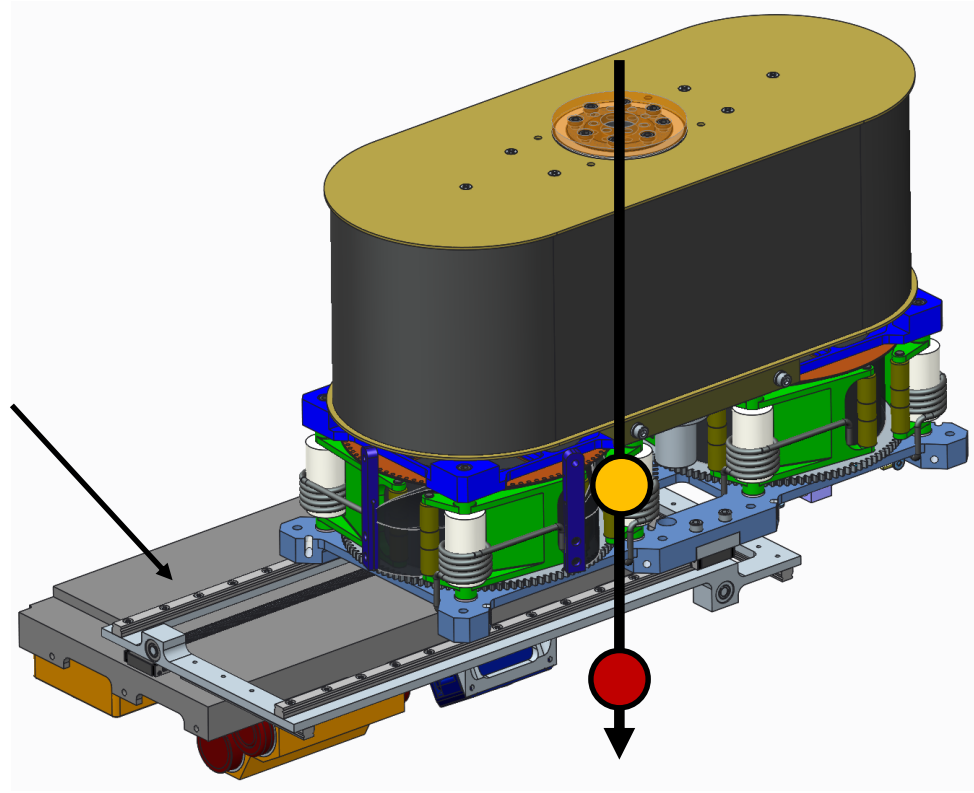
- NEA Scout's center of mass (CM) and center of pressure (CP) are not collinear with the estimated thrust vector. This creates a *disturbance torque*. Furthermore, the CP is fore of the CM, creating a naturally unstable vehicle and necessitating an active control mechanism.
- Little mass and volume available. This challenge is compounded by the vehicle's total mass (14 kg) and volume (6 Liters) requirement. The AMT was originally given 250 grams and a volume of 226 x 105 x 17 mm (400 cc). This *volume* and *mass* will include: an X-Y translation stage, thermal controls, limit switches, and a wire harness. The *wire harness* must pass through the AMT and survive exposure to *deep space environments*.



### Nominal State

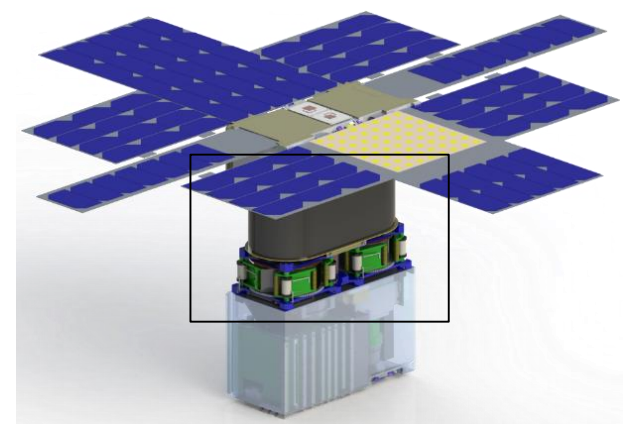


### Trimmed State



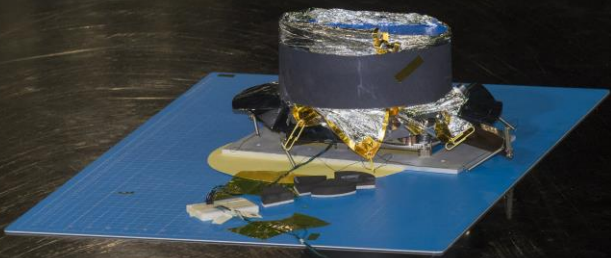
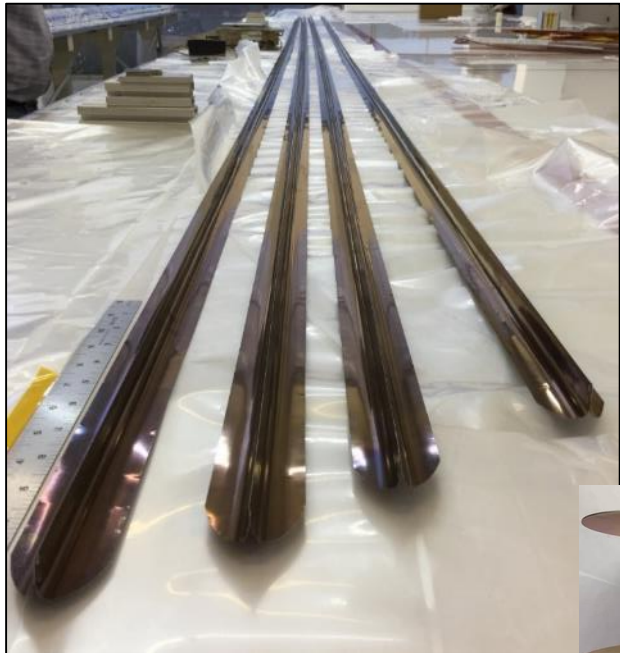
AMT

KEY	
Thrust ↑	
CP	
CM	
Disturbance Torque	



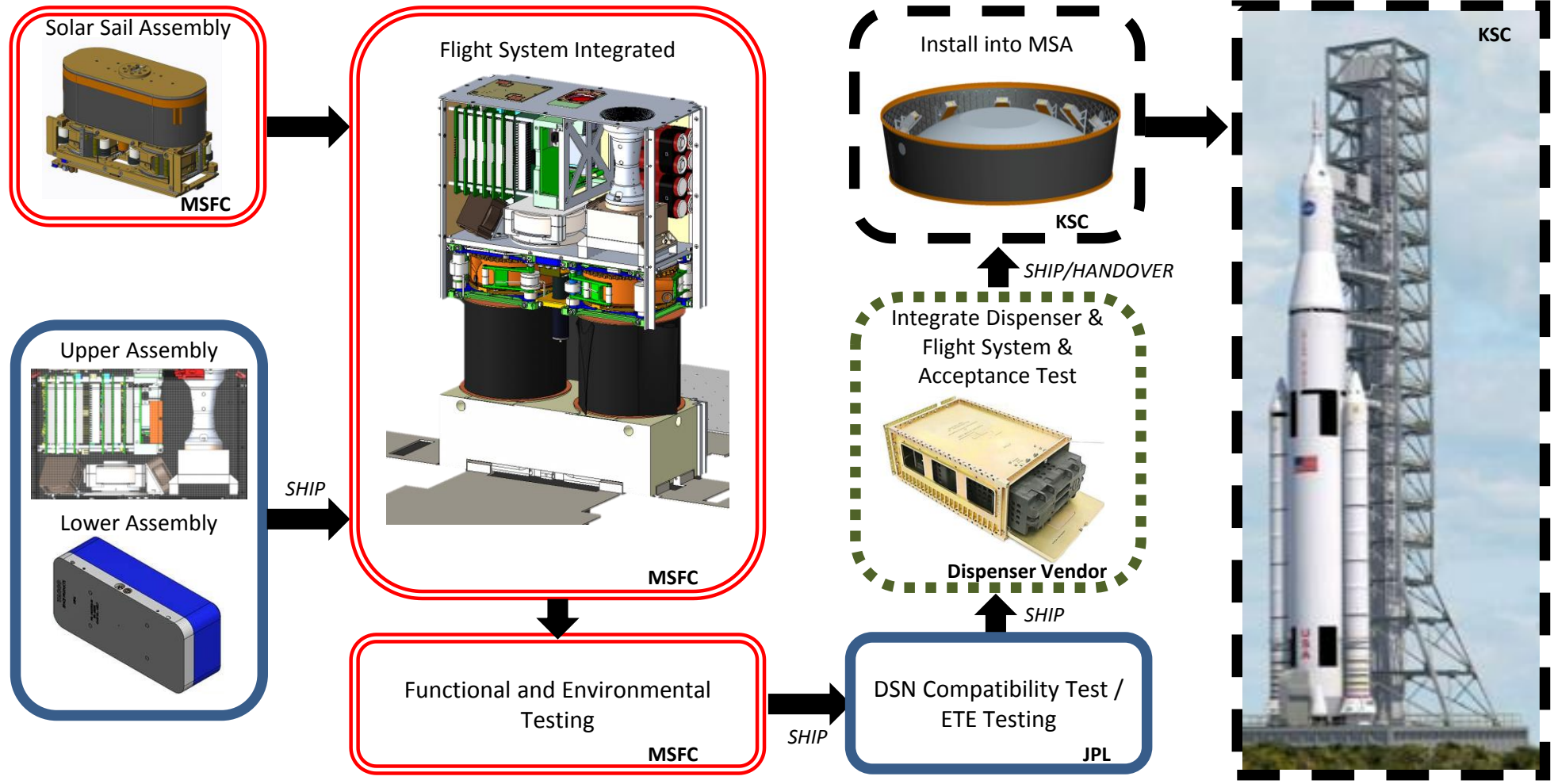


# On Schedule to Deliver Spacecraft



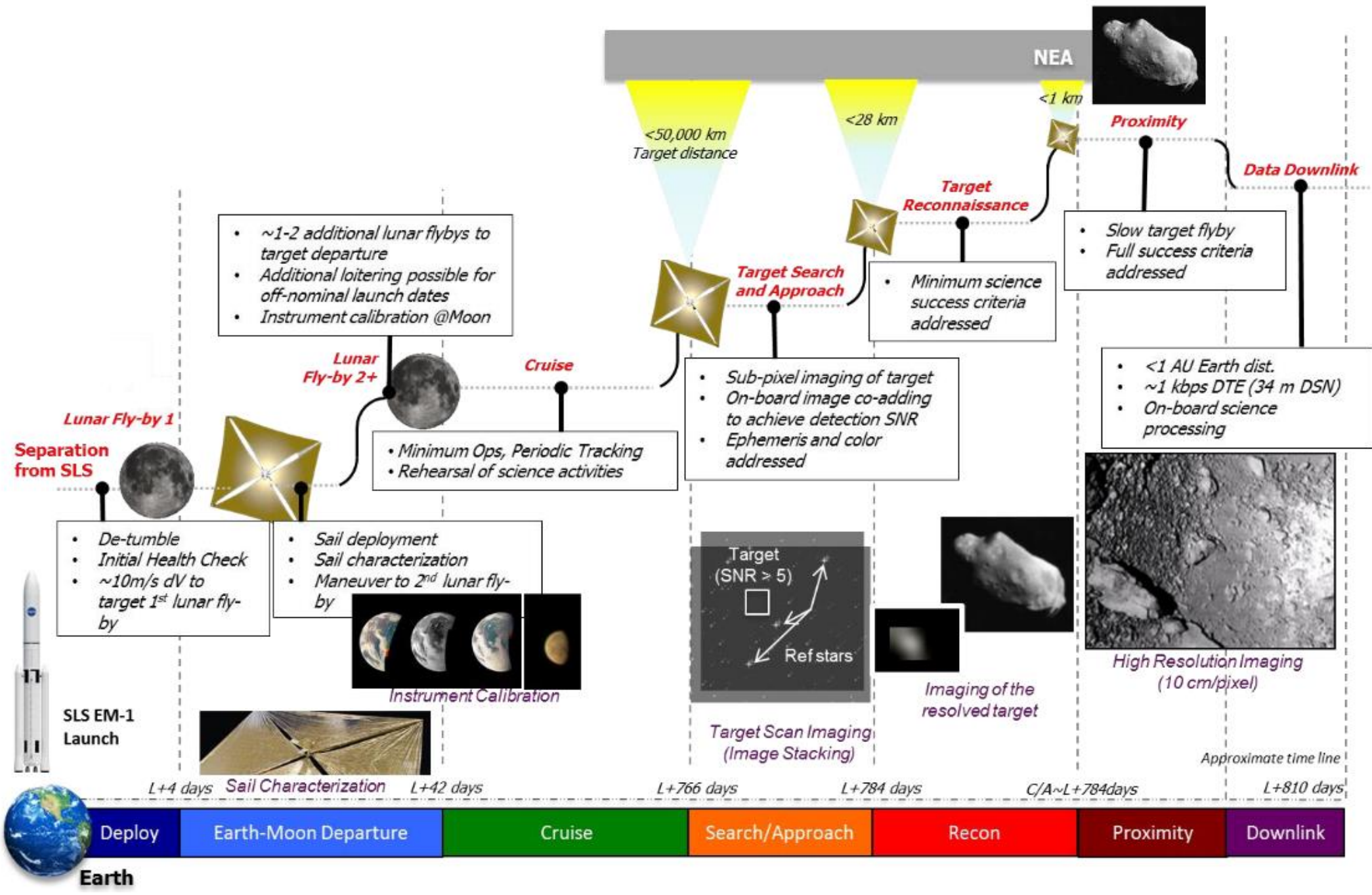
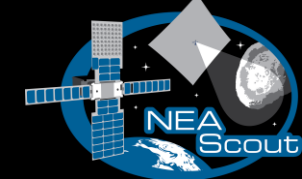


# Assembly, Integration, and Test (AI&T) Overview

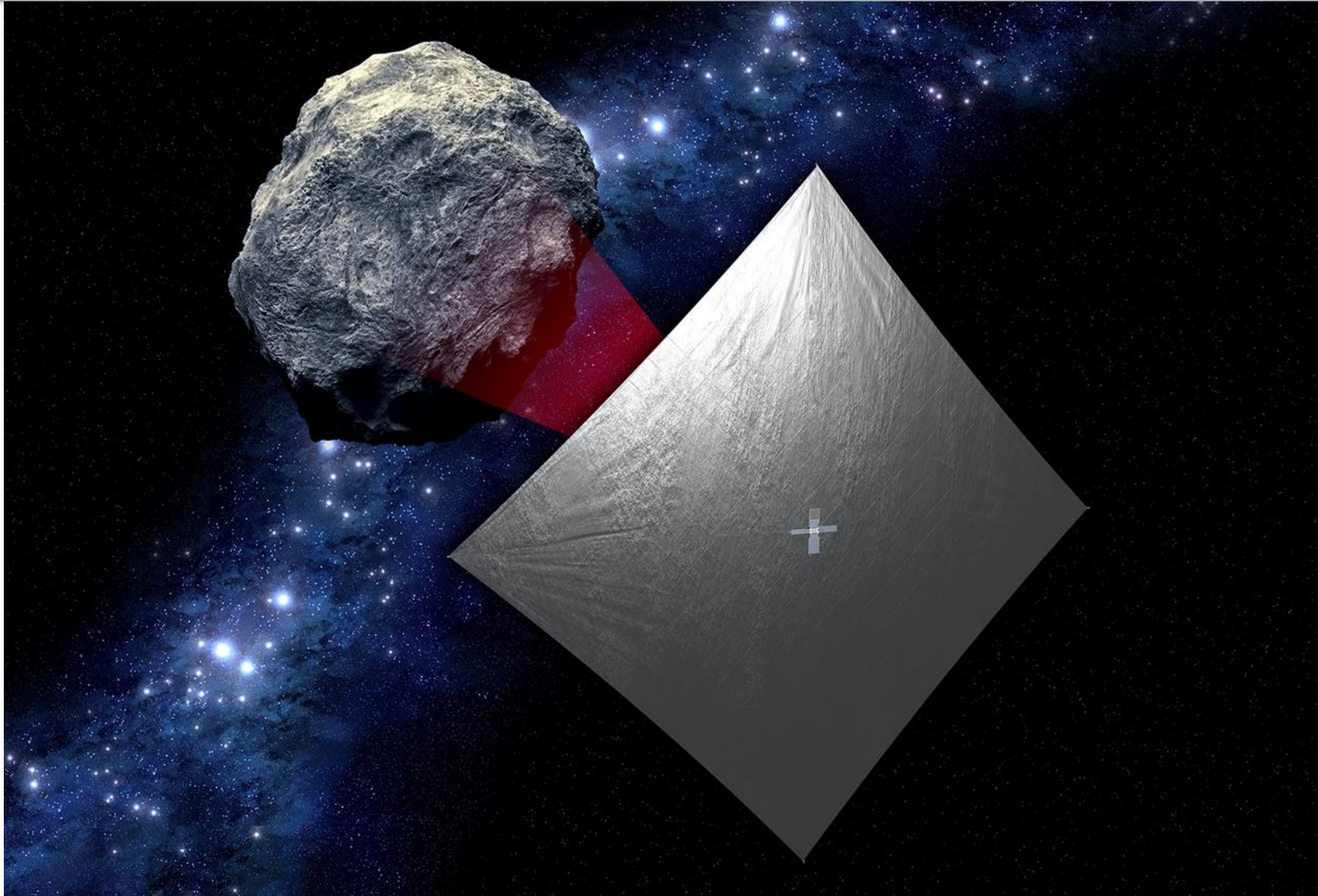




# Concept of Operations Overview



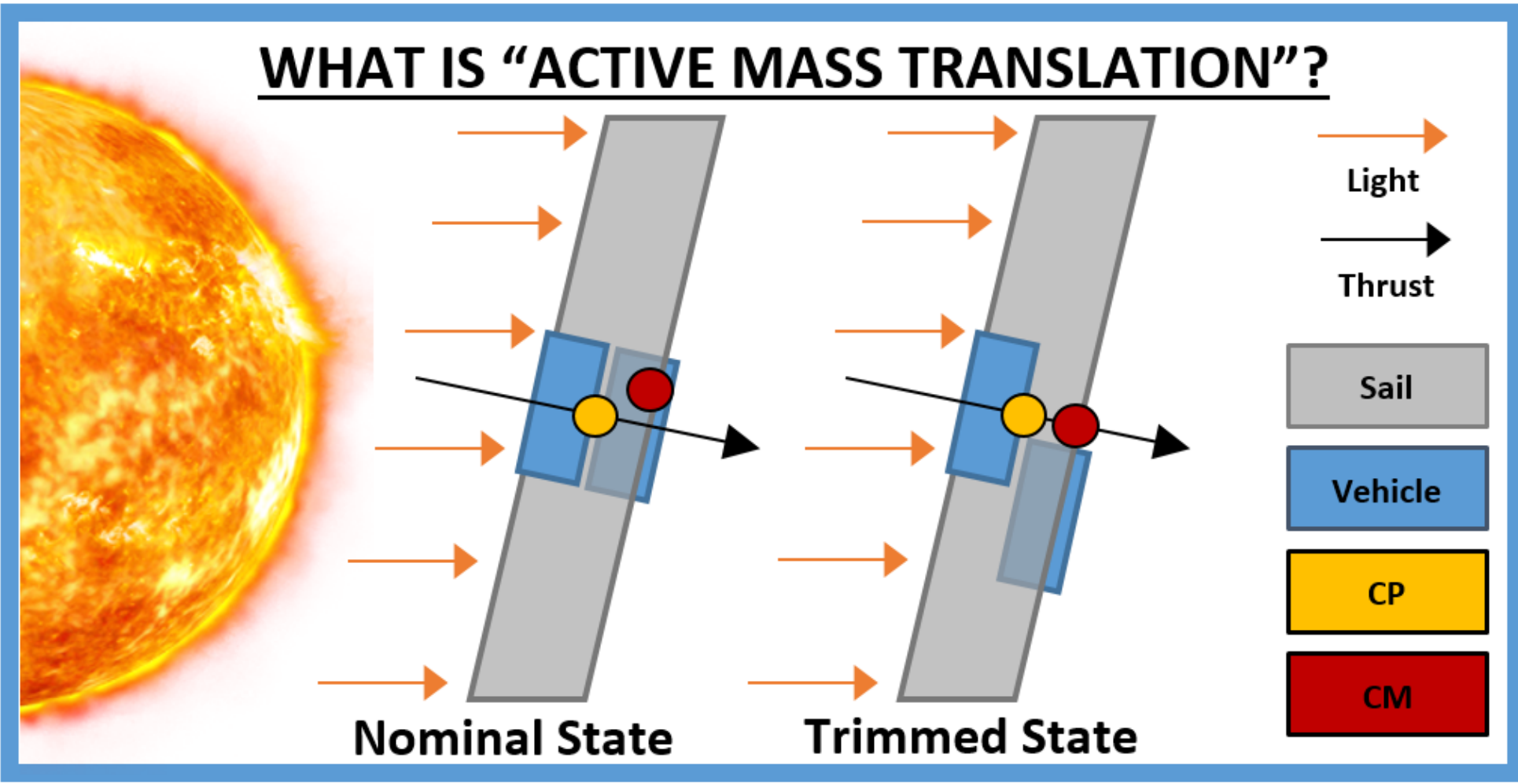
# Questions?





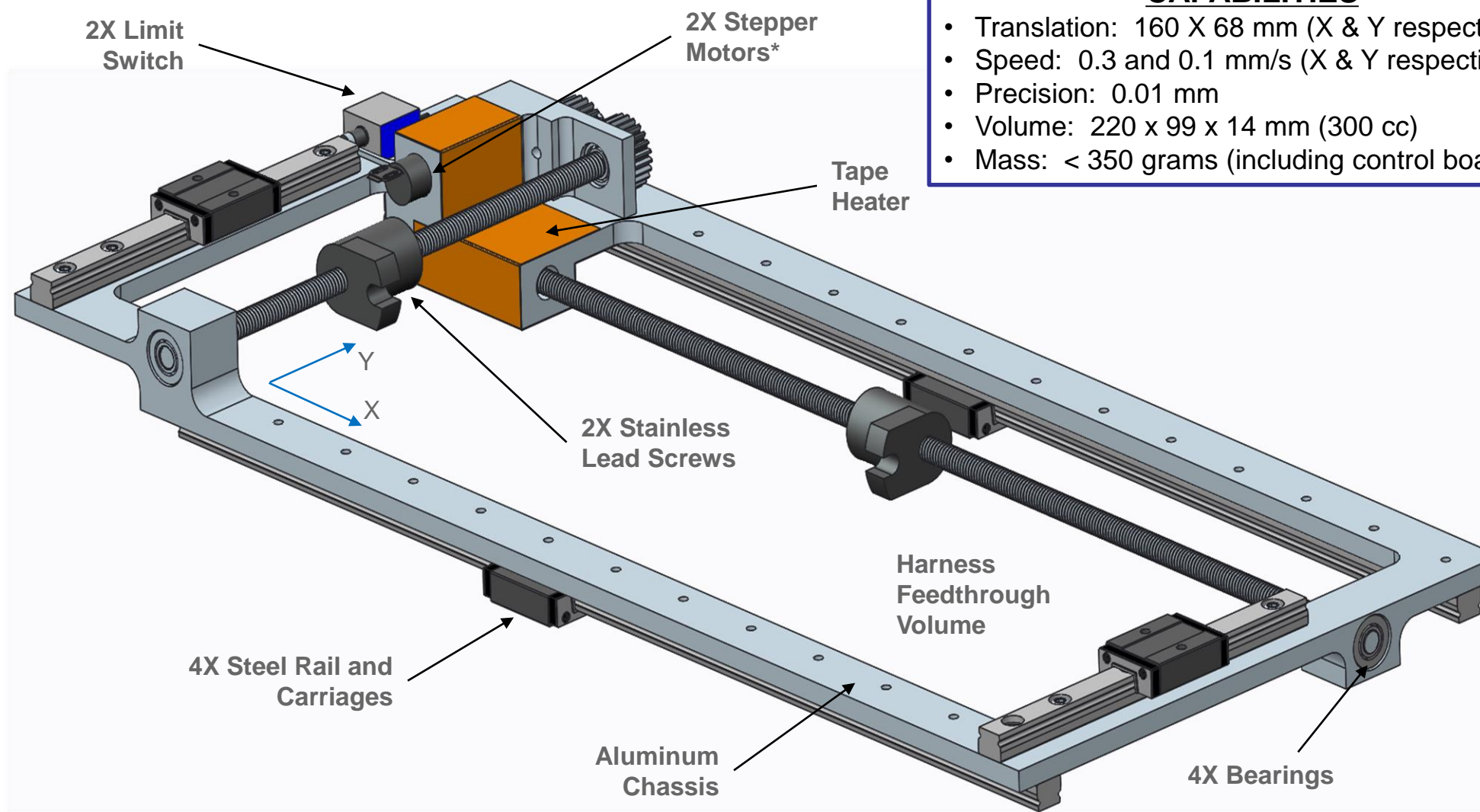
# Backup Information





The AMT will move one portion of the NEA Scout relative to the other. This translation of mass will alter the inertial properties of the vehicle and align the CP and CM

## Current Design State



- CAPABILITIES**
- Translation: 160 X 68 mm (X & Y respectively)
  - Speed: 0.3 and 0.1 mm/s (X & Y respectively)
  - Precision: 0.01 mm
  - Volume: 220 x 99 x 14 mm (300 cc)
  - Mass: < 350 grams (including control board)

\* Stepper Motors are housed inside of the aluminum block and are not readily visible