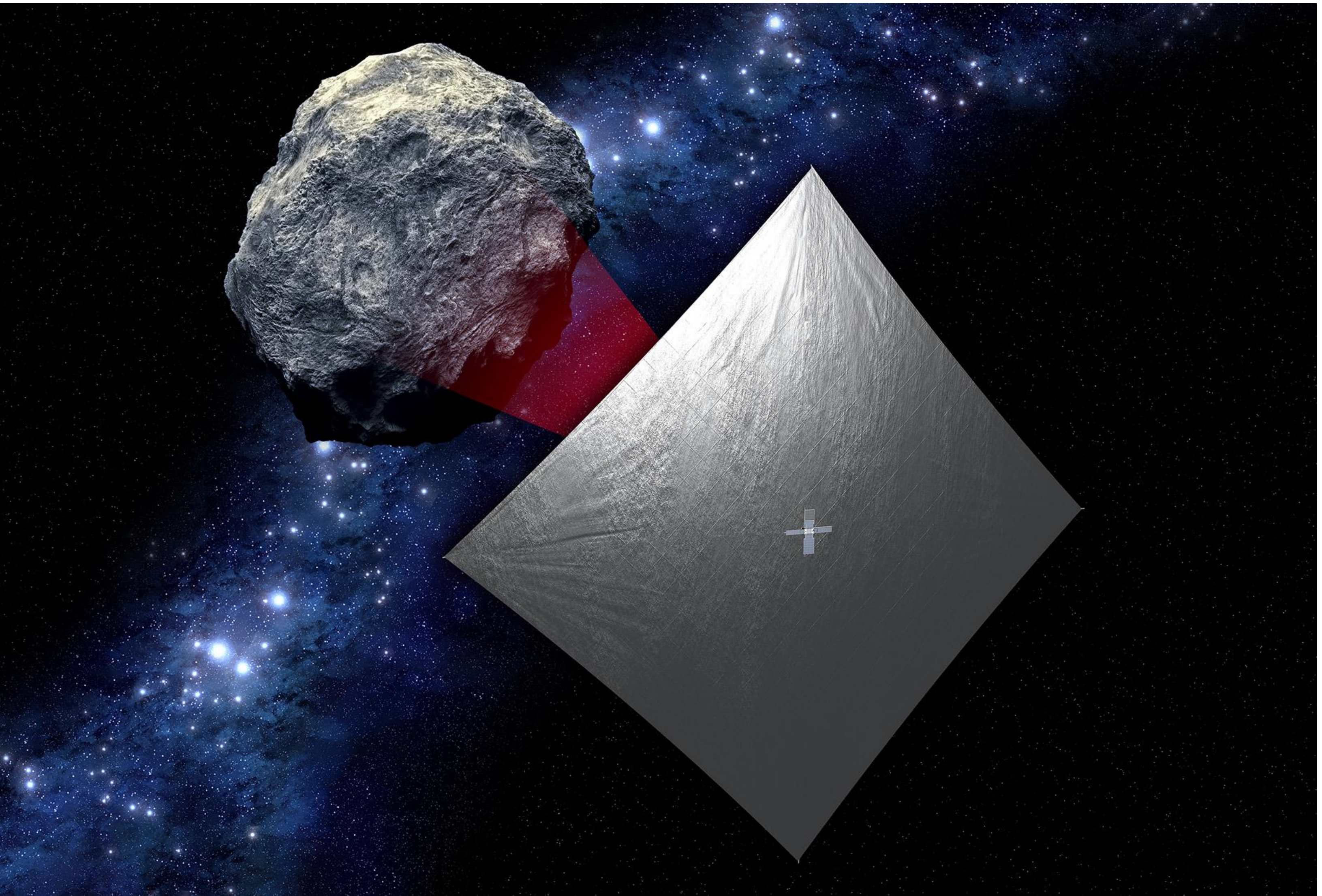
Near Earth Asteroid (NEA) Scout



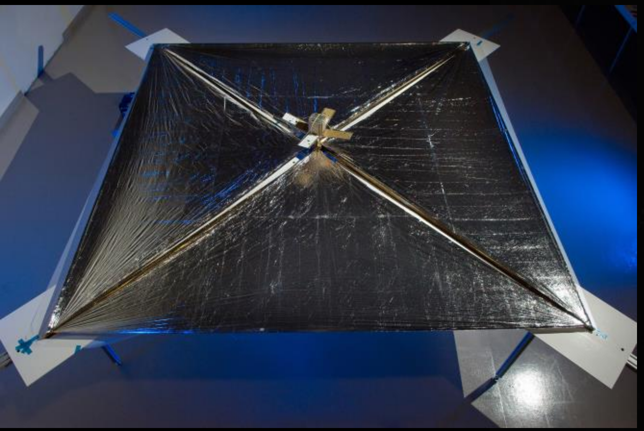
Les Johnson, Tiffany Lockett, & Alex Few

NASA George C. Marshall Space Flight Center

Julie Castillo-Rogez

NASA Jet Propulsion Laboratory

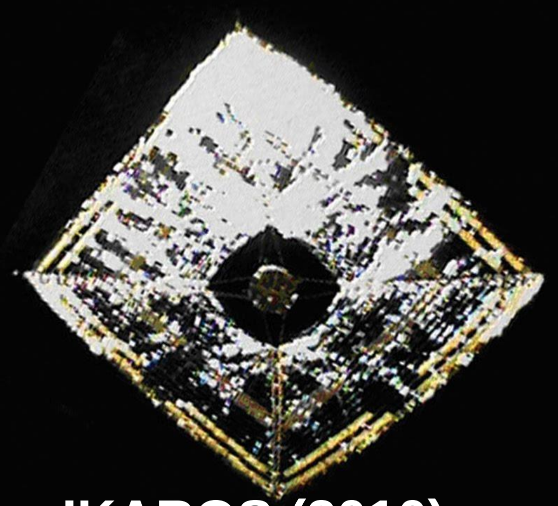
Solar Sail Missions Flown (as of April 11, 2018)



NanoSail-D (2010)
NASA

Earth Orbit
Deployment Only

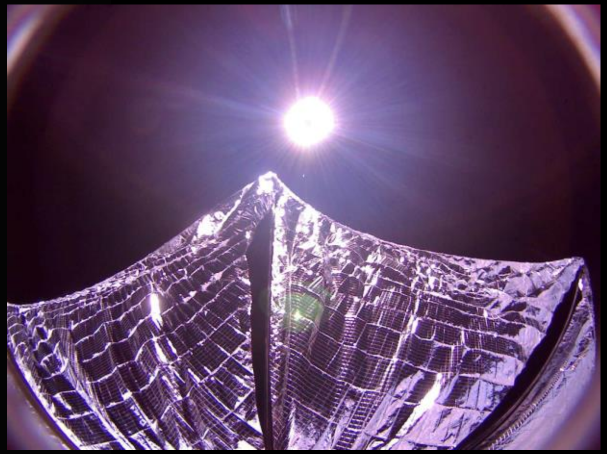
3U CubeSat
10 m^2



IKAROS (2010)
JAXA

Interplanetary
Full Flight

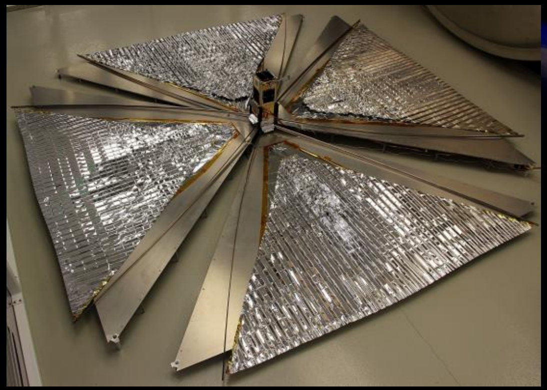
315 kg Smallsat
196 m^2



LightSail-1 (2015)
The Planetary Society

Earth Orbit
Deployment Only

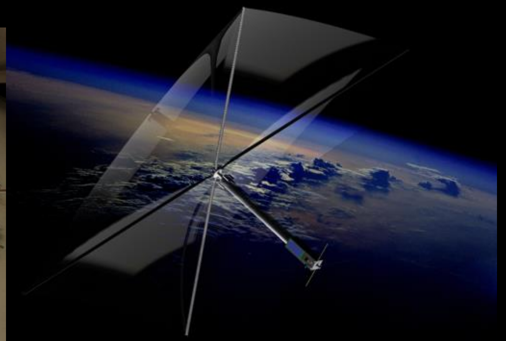
3U CubeSat
32 m^2



CanX-7 (2016)
Canada

Earth Orbit
Deployment Only

3U CubeSat
<10 m^2

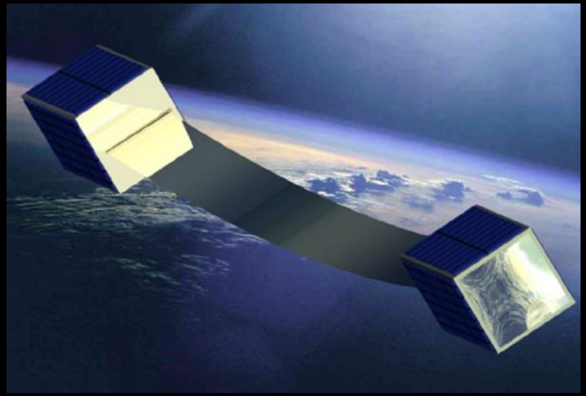


InflateSail (2017)
EU/Univ. of Surrey

Earth Orbit
Deployment Only

3U CubeSat
10 m^2

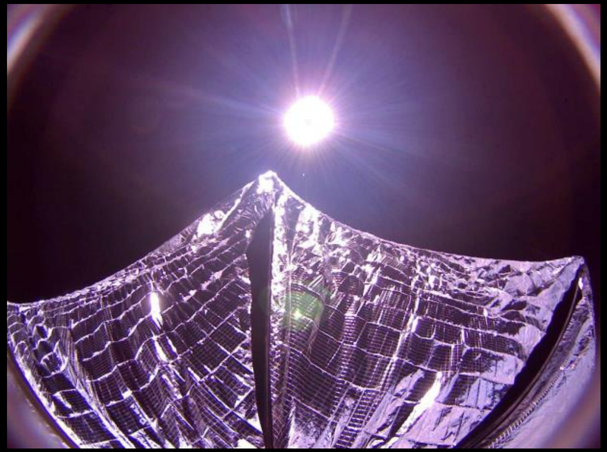
Planned Solar Sail Missions (as of April 11, 2018)



CU Aerospace (2018)
Univ. Illinois / NASA

Earth Orbit
Full Flight

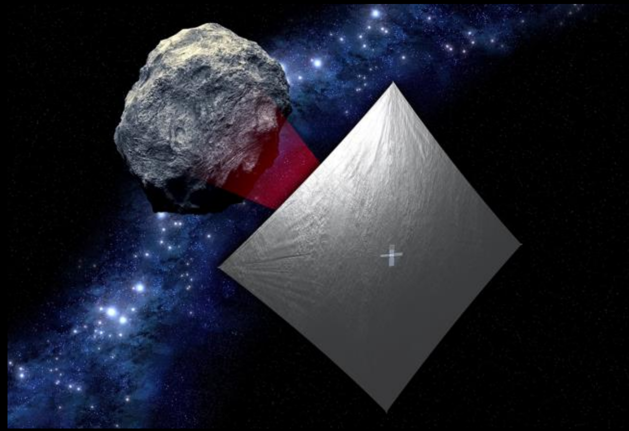
3U CubeSat
20 m^2



LightSail-2 (2018)
The Planetary Society

Earth Orbit
Full Flight

3U CubeSat
32 m^2



Near Earth Asteroid Scout (2019) NASA

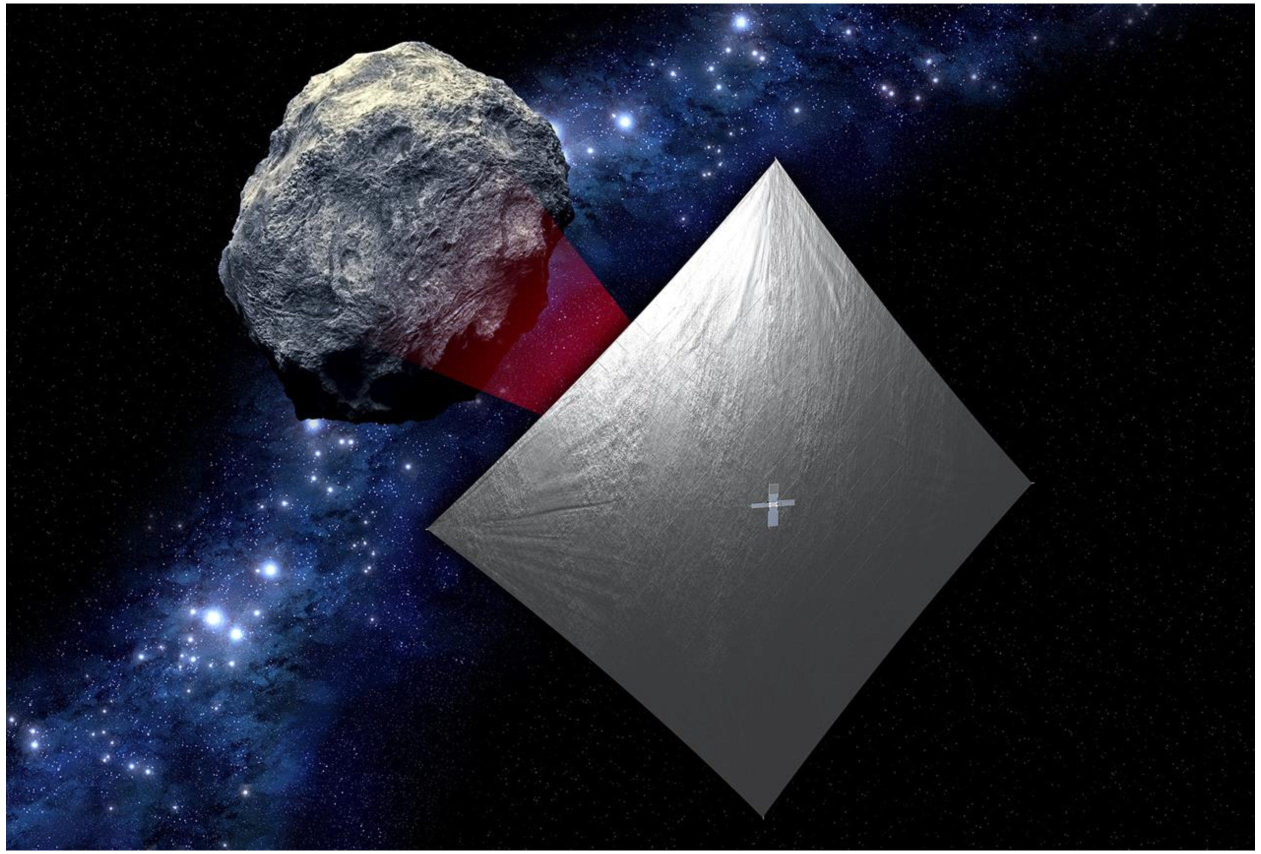
Interplanetary
Full Flight

6U CubeSat
86 m^2

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

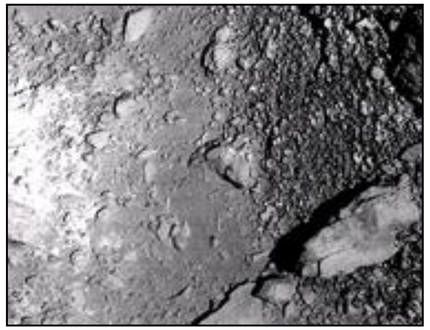


Key Spacecraft & Mission Parameters

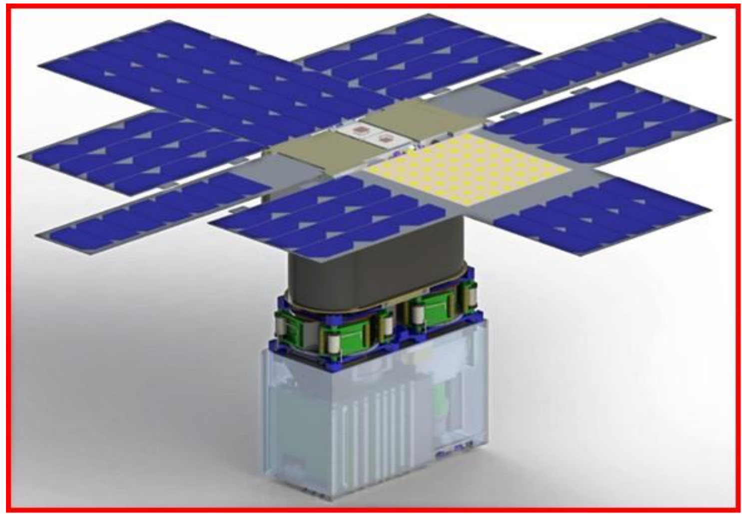
- 6U cubesat (20cm X 10cm X 30 cm)
- ~86 m^2 solar sail propulsion system
- Manifested for launch on the Space Launch System (EM-1/2019)
- 1 AU maximum distance from Earth

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

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



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



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**

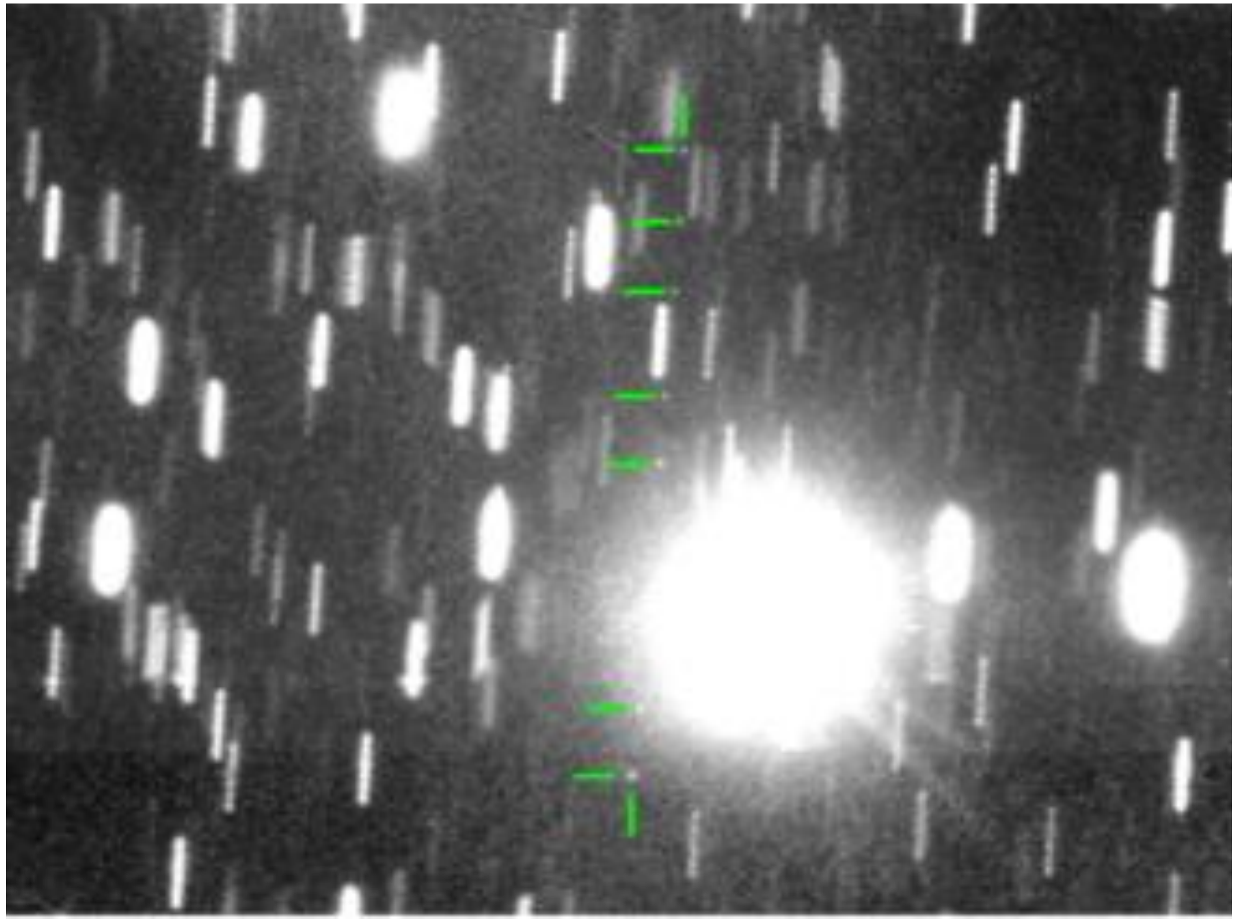
"Precursor robotics, robotic missions that investigate candidate destinations and provide vital information to prepare for human explorers, will lay the groundwork for humans to achieve new milestones in deep space."

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)

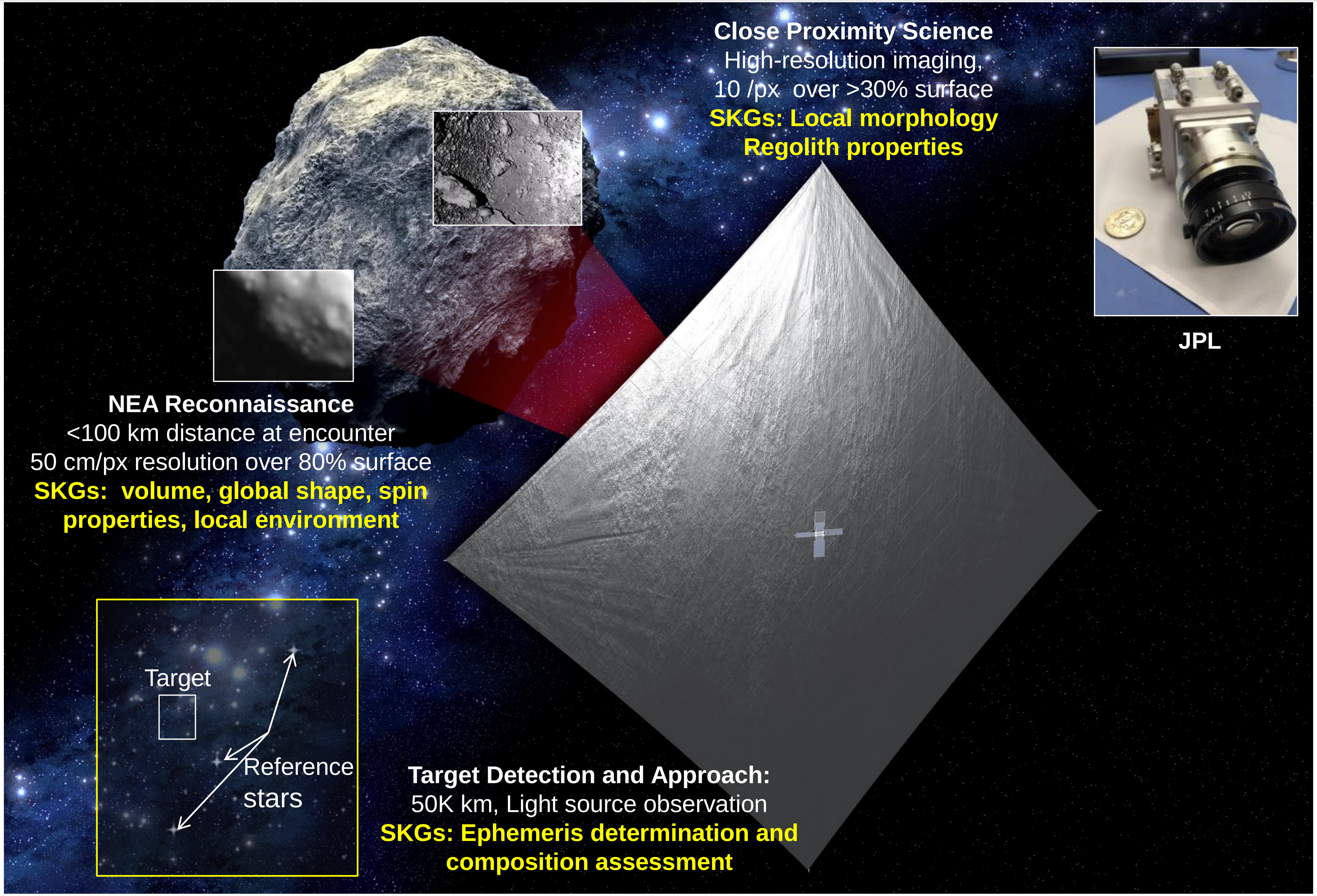
Baseline Target Asteroid: 1991 VG



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

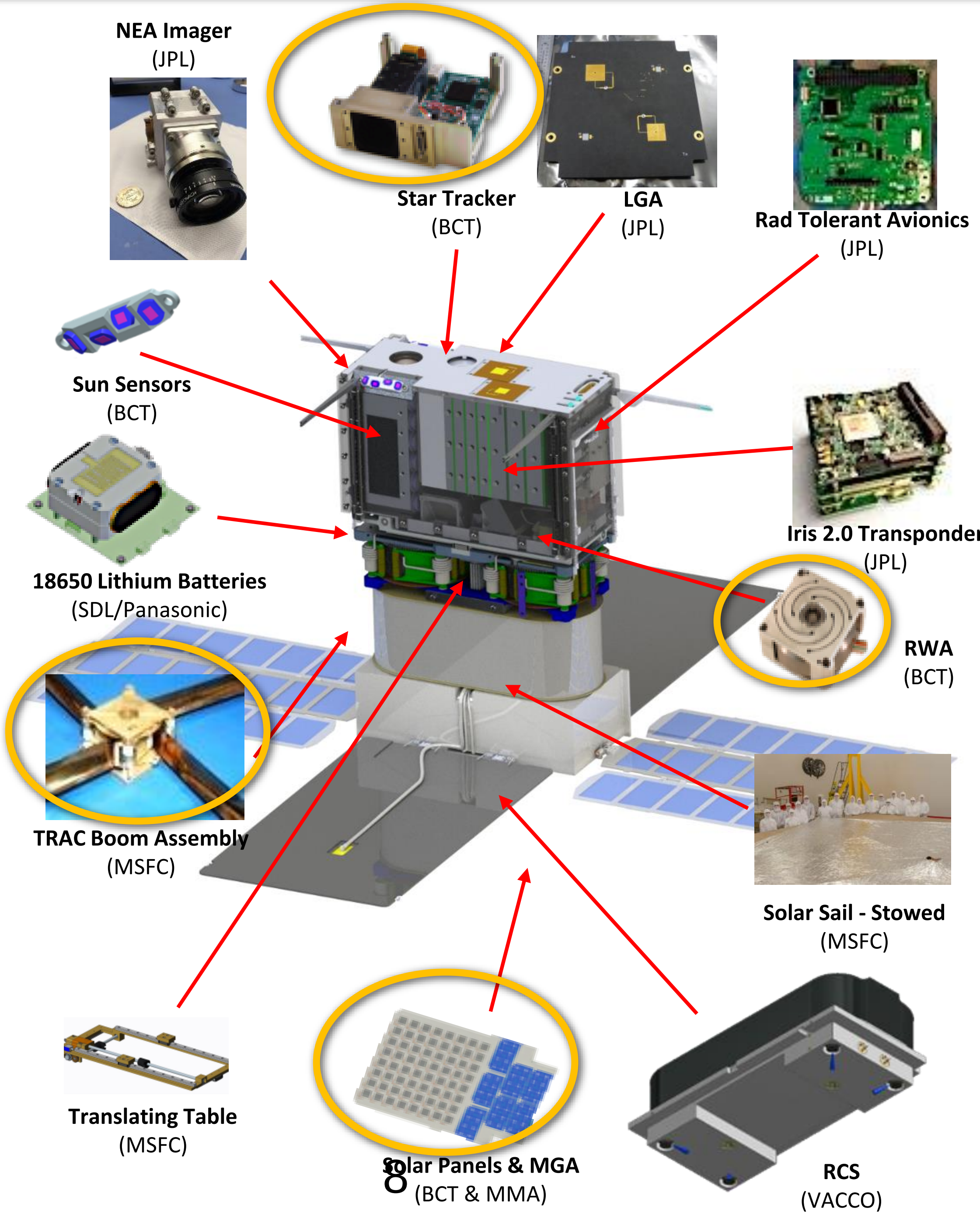
Near Earth Asteroid Scout Mission Overview



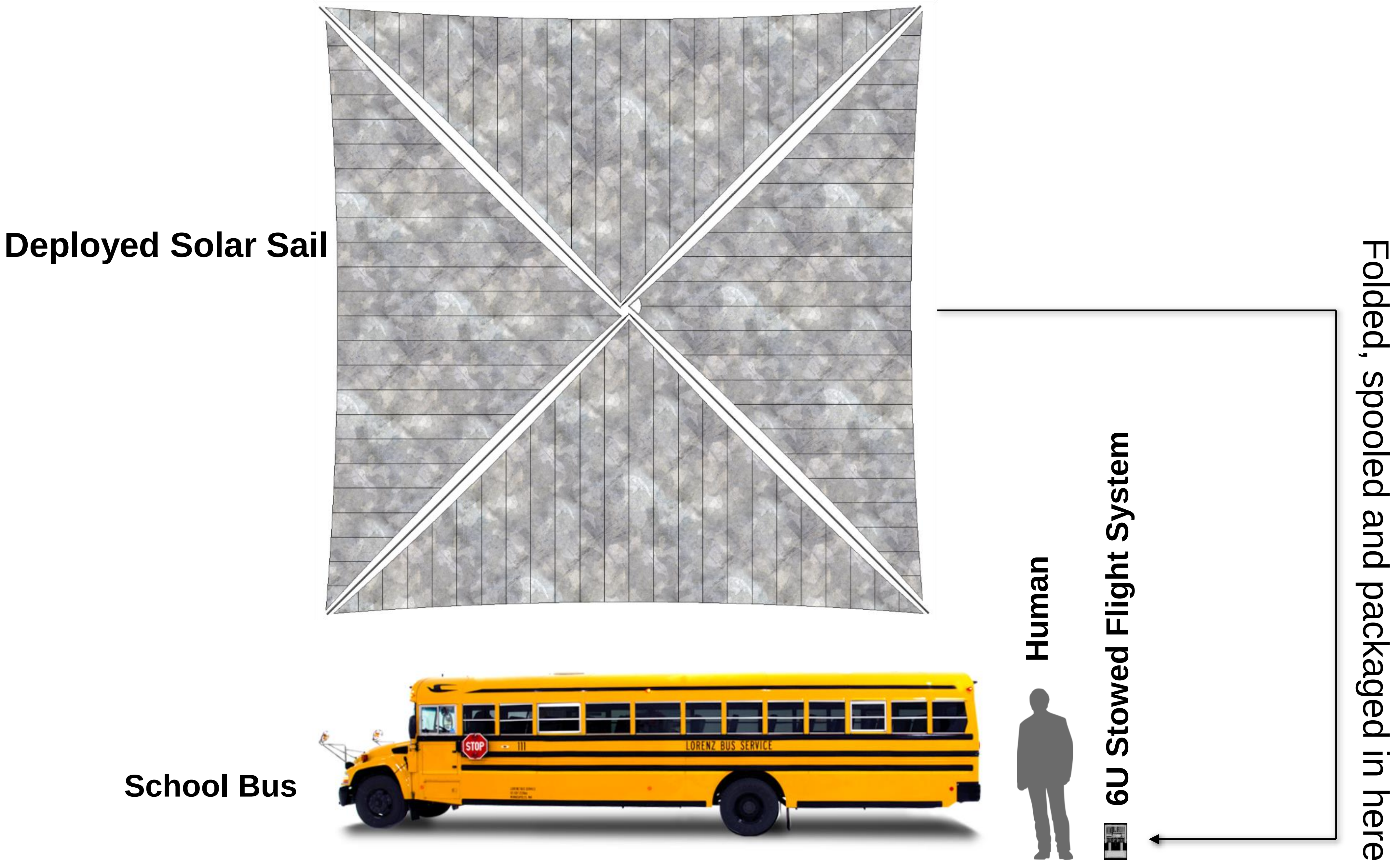
Flight System Overview

Payload	• Context Camera
Mechanical & Structure	• "6U" CubeSat form factor • <14 kg total launch mass • Modular flight system concept
Propulsion	• ~86 m^2 aluminized CP-1 solar sail (based on NanoSail-D2)
Avionics	• Radiation tolerant architecture
Electrical Power System	• Trifold deployable solar arrays with GaAs cells (~51.2 W EOL at 1 AU solar distance) • 6.2 Ah Battery • 10 -12.3 V unregulated, 5 V/3.5 V regulated
Telecom	• JPL Iris 2.0 X-Band Transponder; 4 W RF output power supports doppler, ranging, and D-DOR • 2 pairs of INSPIRE-heritage LGAs (RX/TX) • 8x8 element microstrip array MGA (TX); ~1 kbps to 34m DSN at 0.8 AU
Attitude Control System	• 15 mNm-s (x3) & 100 mNm-s RWAs • Active mass translation system • VACCO R-236fa (refrigerant gas) 'warm gas' RCS system • Nano StarTracker, Coarse Sun Sensors & MEMS IMU for attitude determination

A fully functional planetary spacecraft in a shoebox



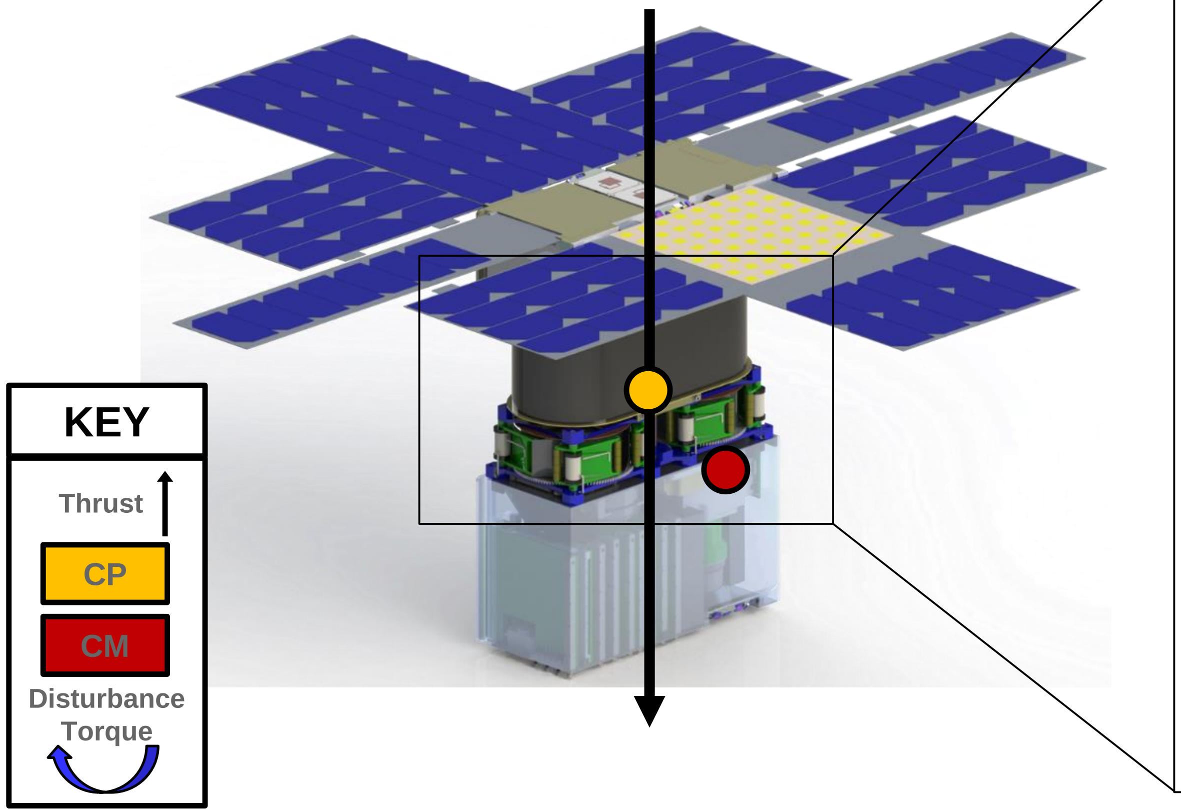
NEA Scout Approximate Scale

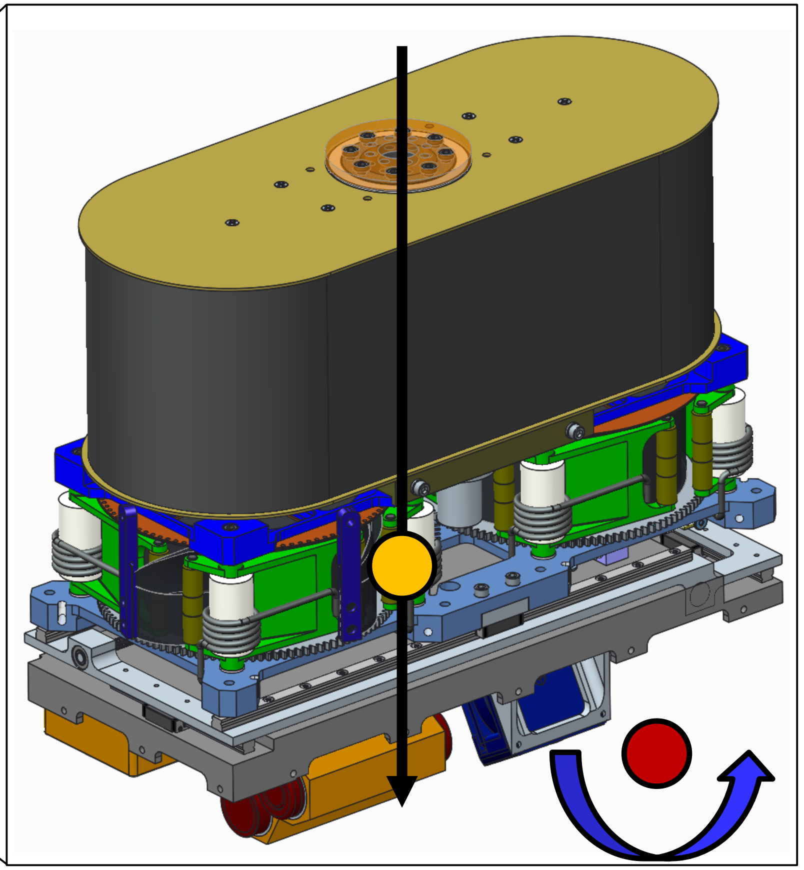


Active Mass Translation (AMT) Overview

Problems and Challenges

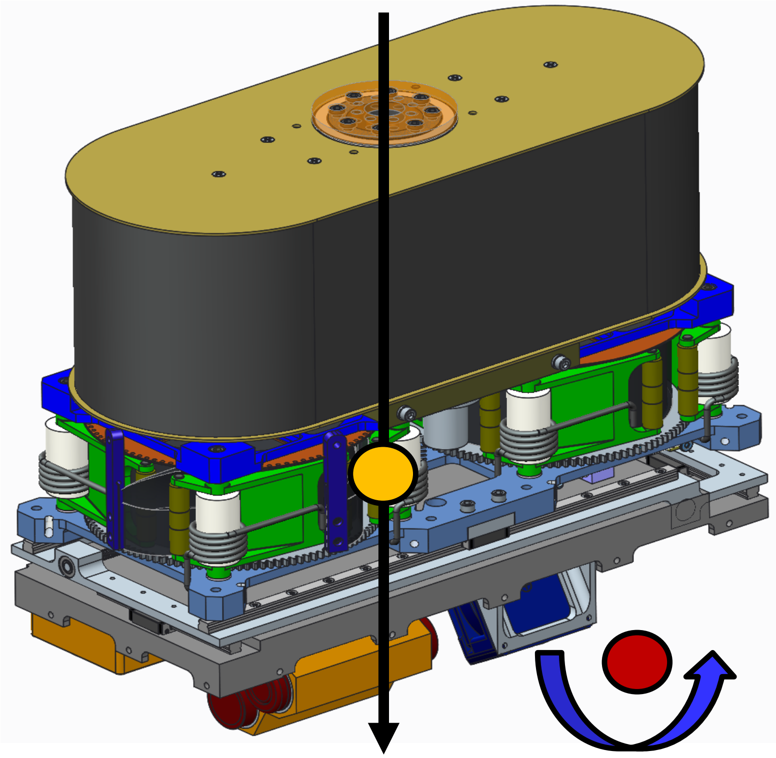
- NEA Scout's center of mass (CM) and center of pressure (CP) are not collinear with the estimated thrust vector. This creates a ***disturbance torque***. Furthermore, the CP is fore of the CM, creating a naturally unstable vehicle and necessitating an active control mechanism.
- Little mass and volume 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***.





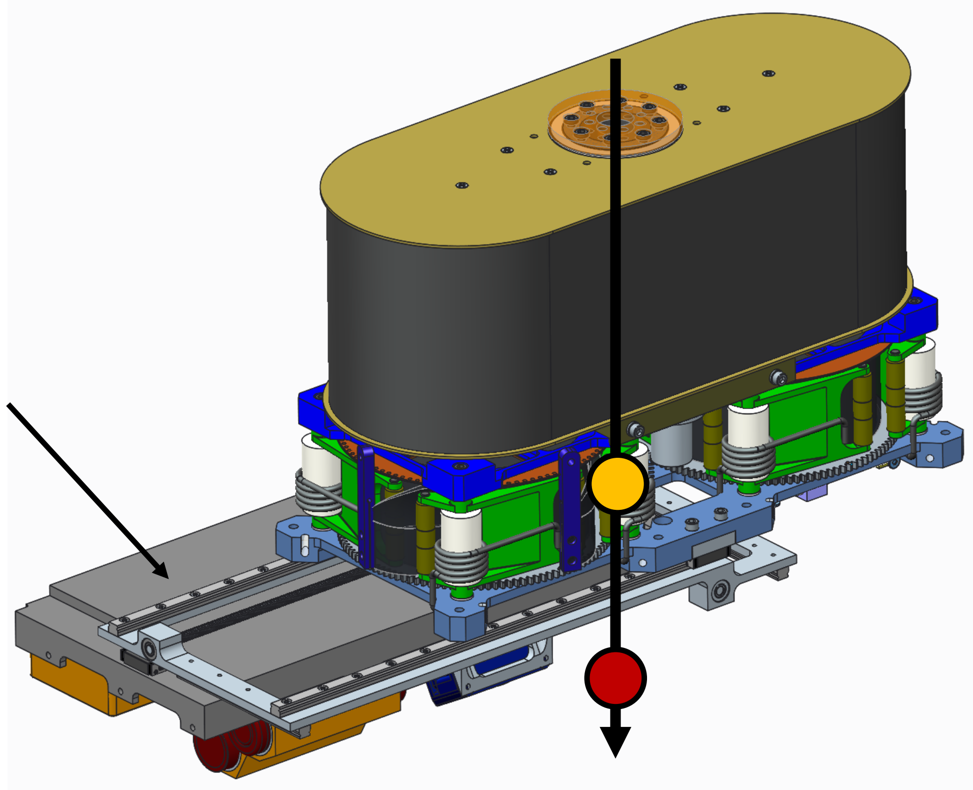
AMT Overview

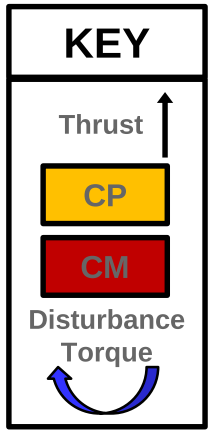
Nominal State

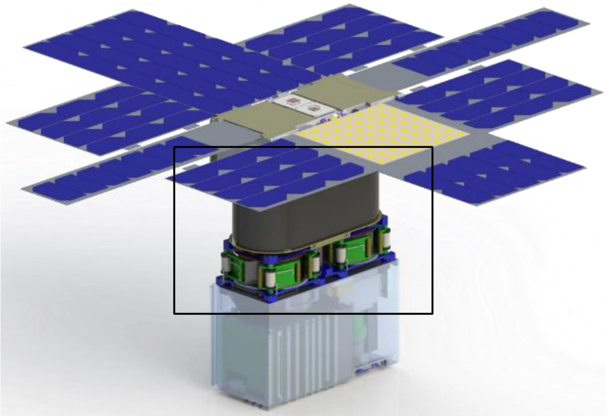


AMT

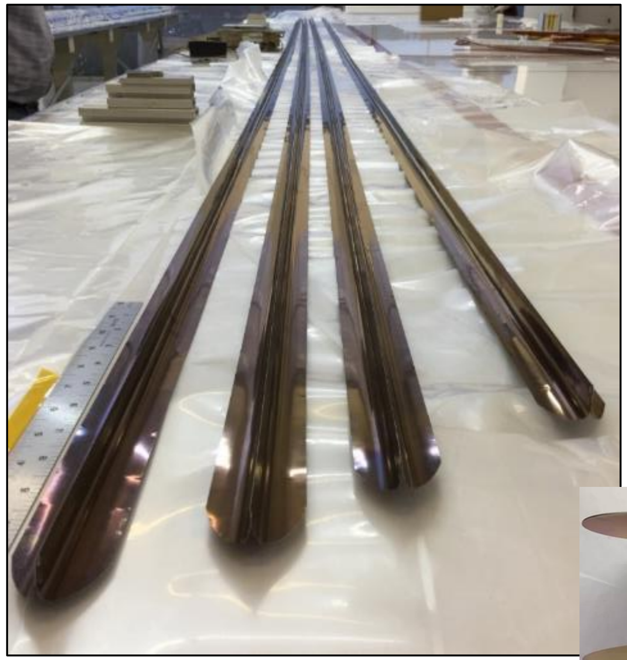
Trimmed State

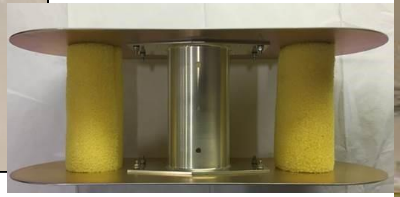


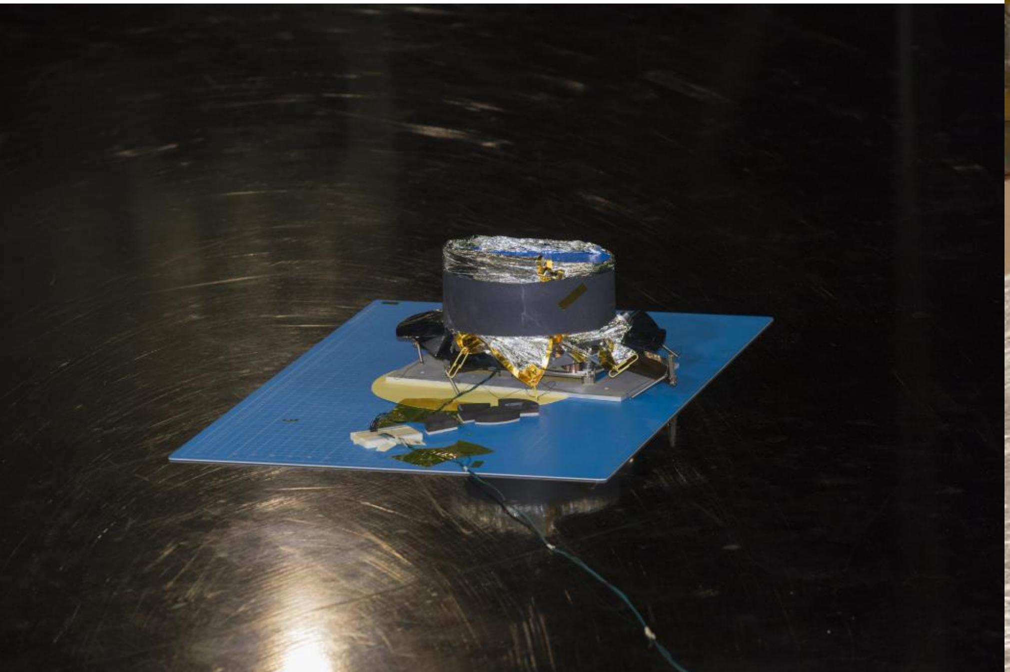




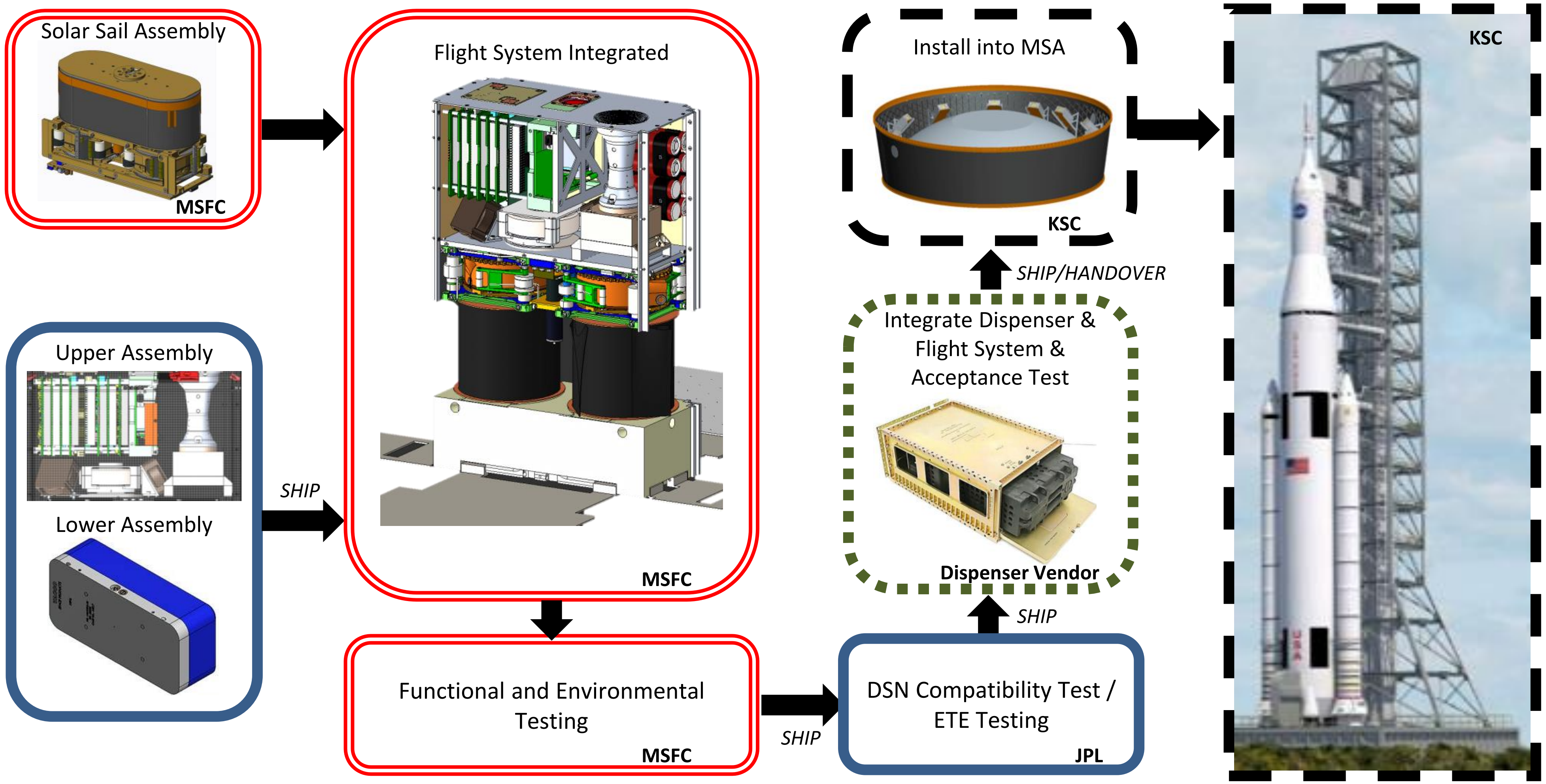
On Schedule to Deliver Spacecraft



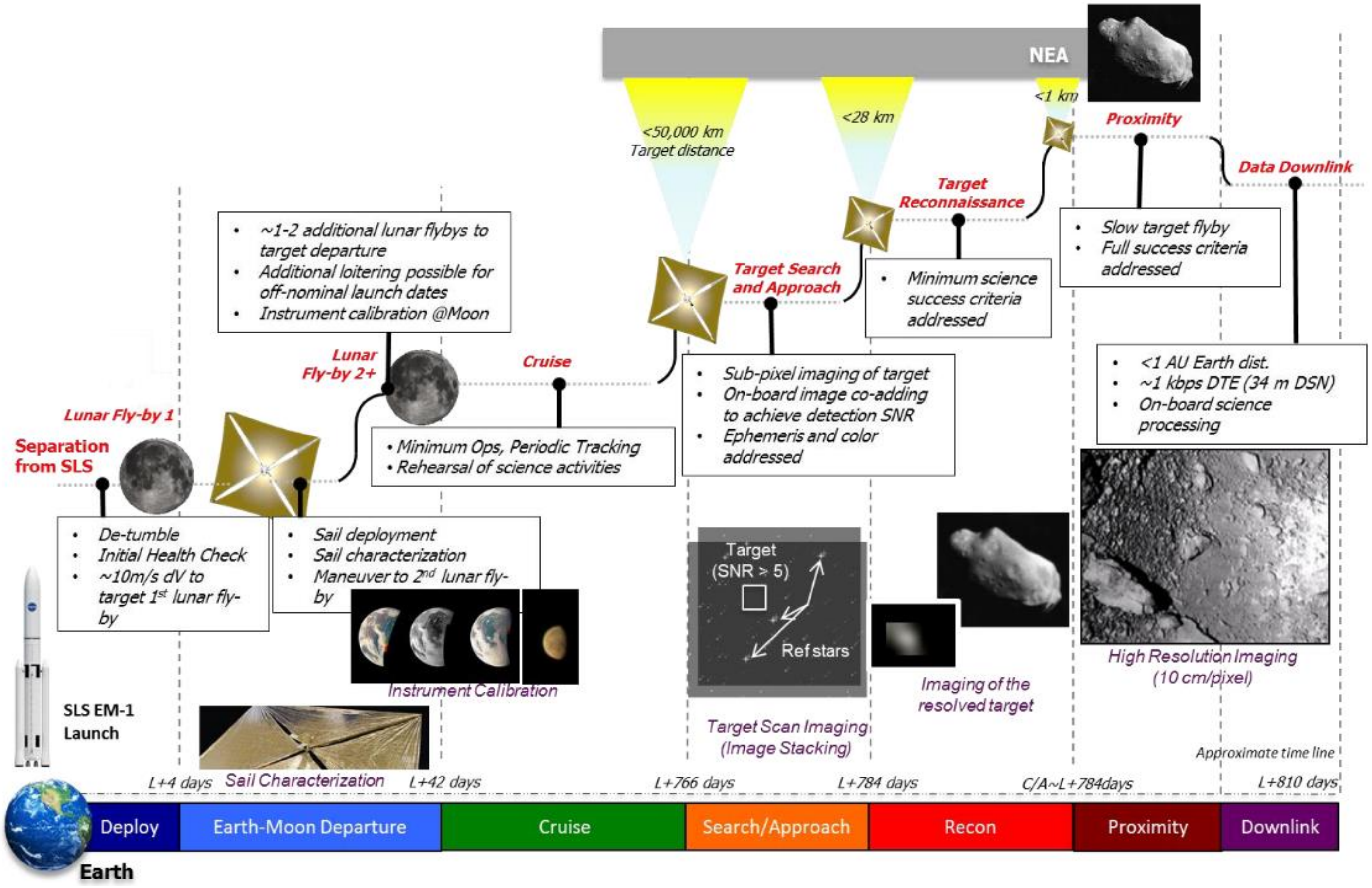




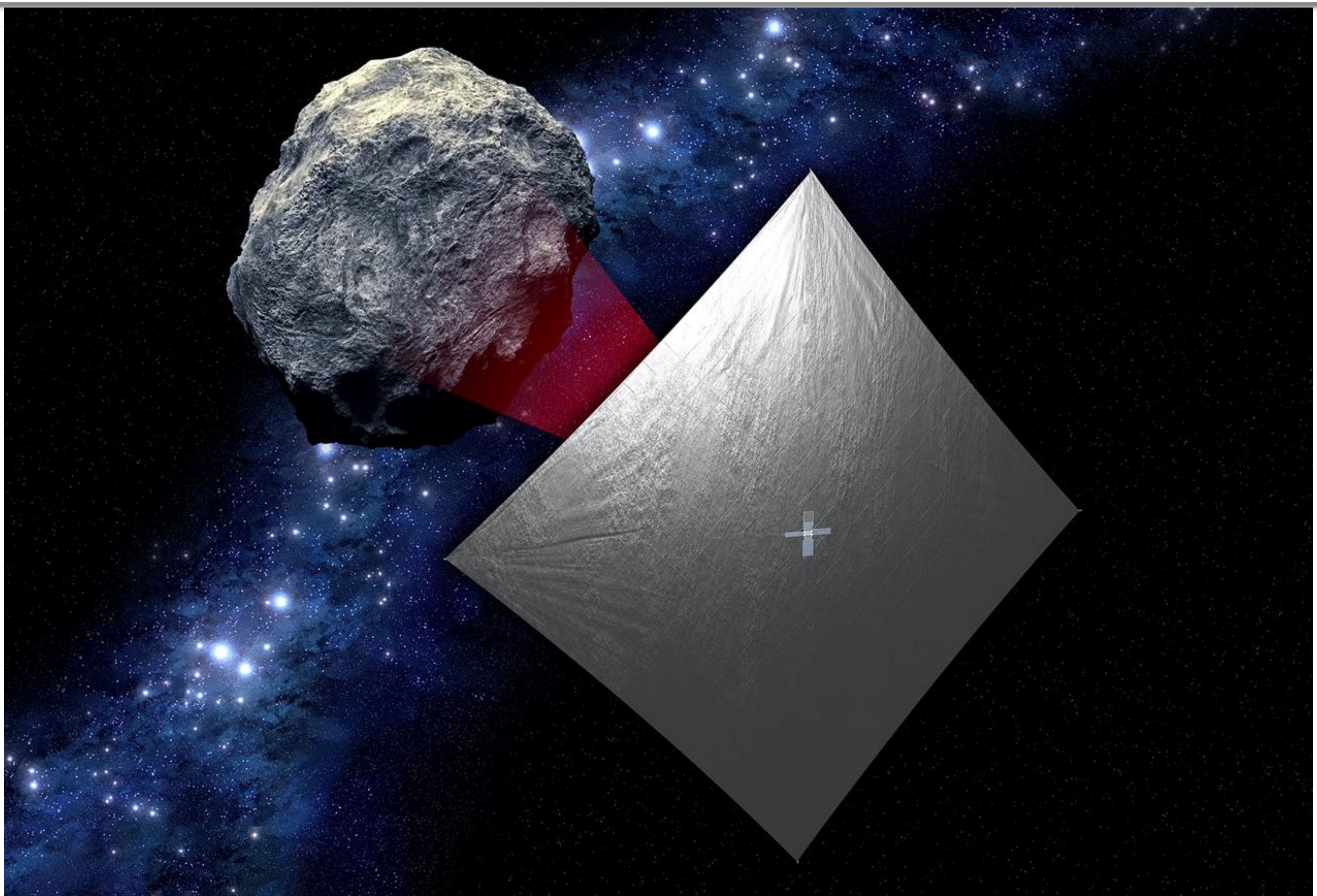
Assembly, Integration, and Test (AI&T) Overview



Concept of Operations Overview

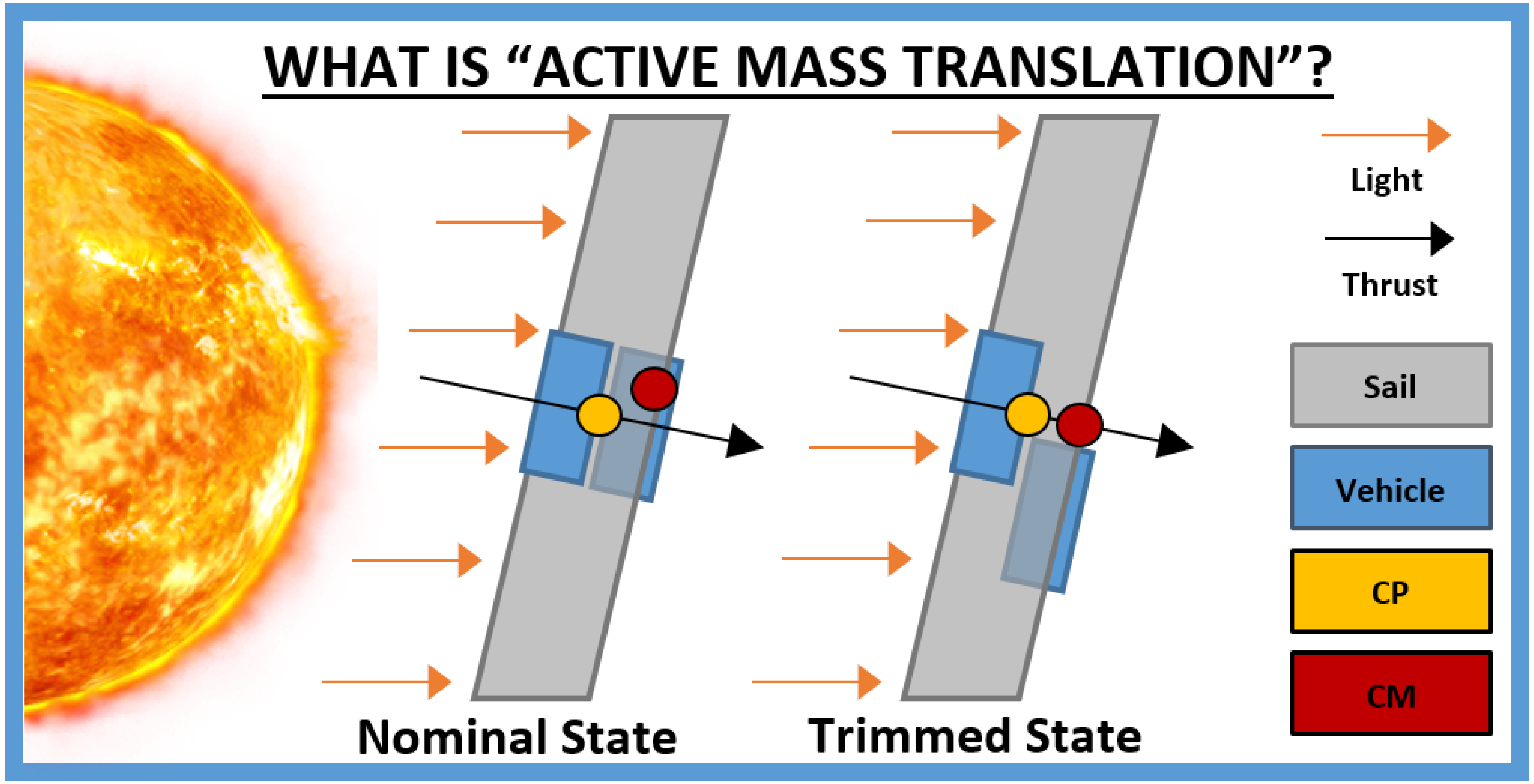


Questions?



Backup Information

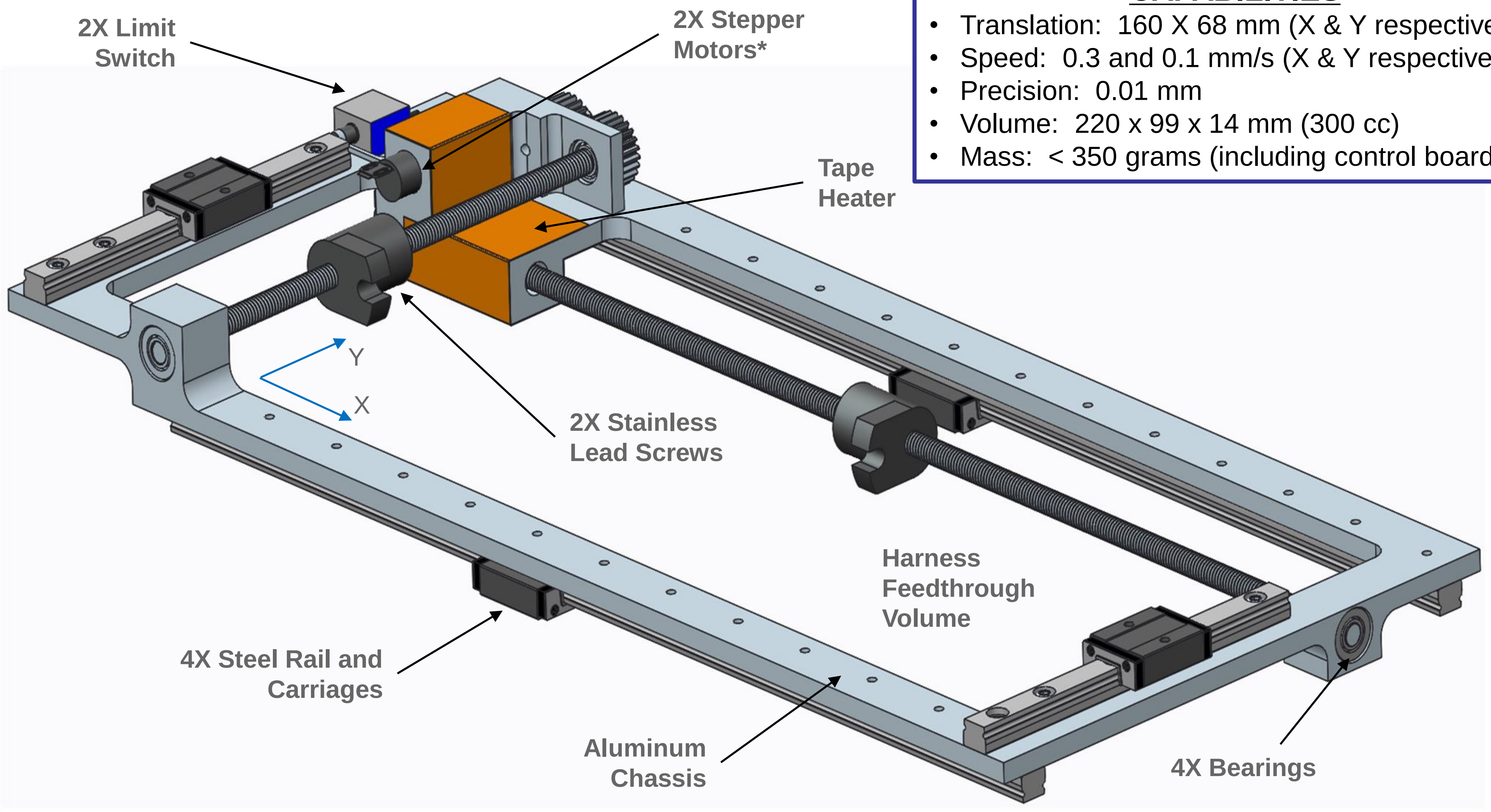
The Need for CM/CP Adjustment



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

AMT Overview

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