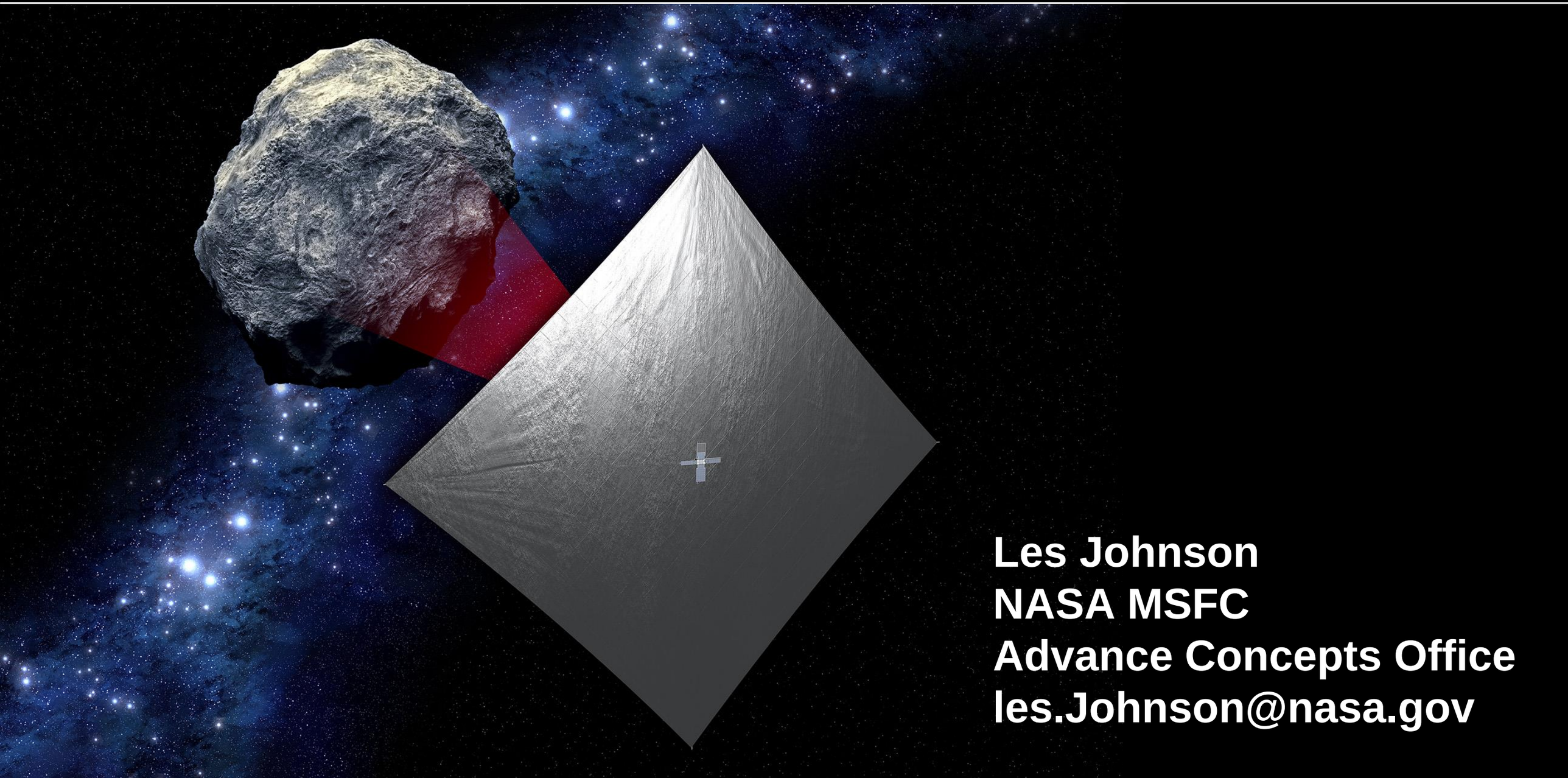
Near Earth Asteroid (NEA) Scout



Les Johnson
NASA MSFC
Advance Concepts Office
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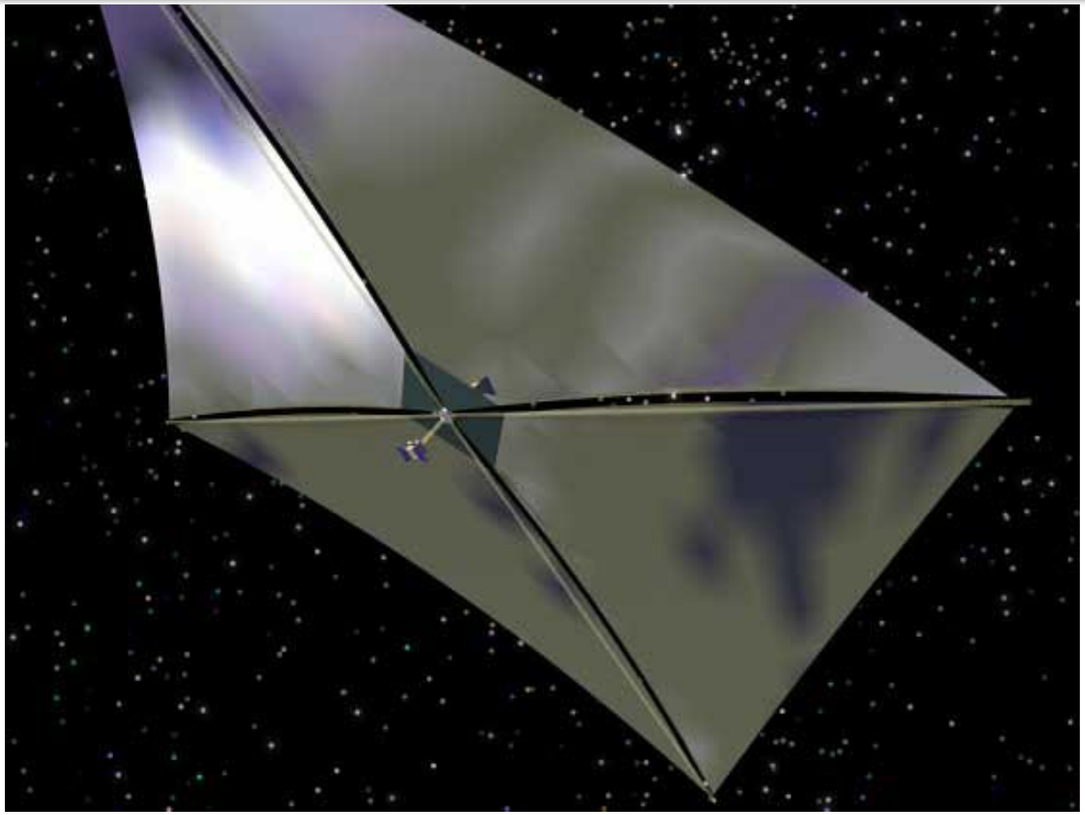
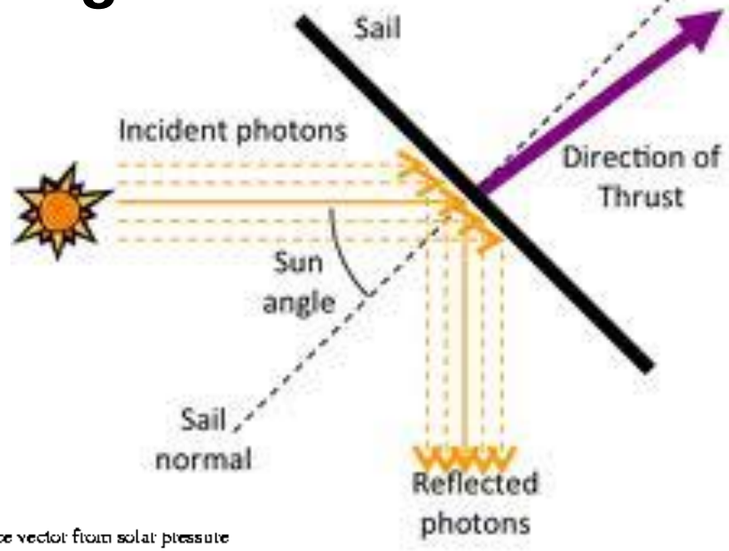
Topics

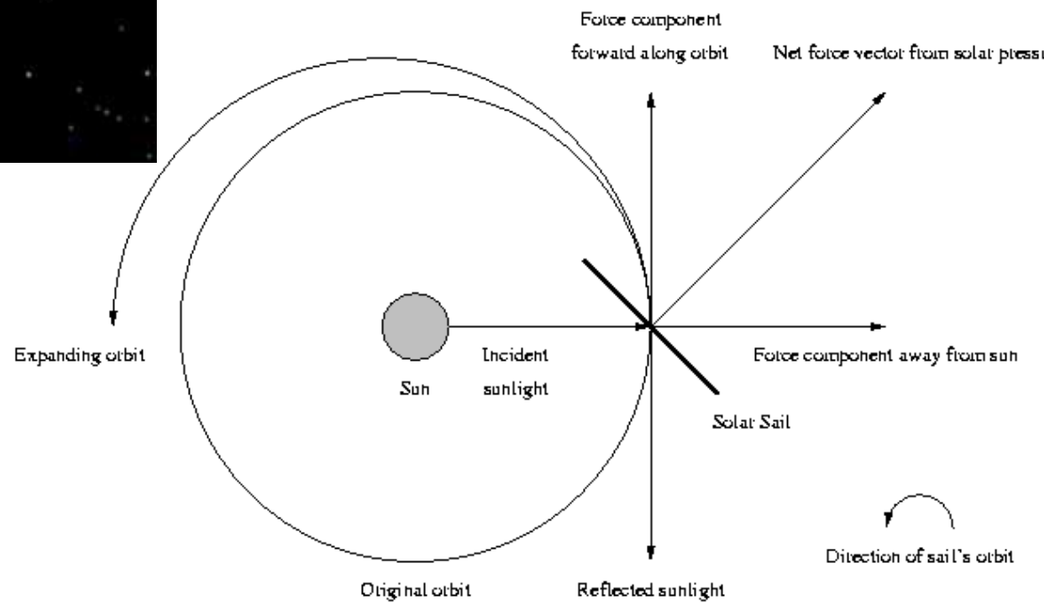
- **What is a solar sail?**
- **A brief history of solar sailing**
- **NASA's Near Earth Asteroid Scout mission**

How does a solar sail work?



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





Topics

- What is a solar sail?
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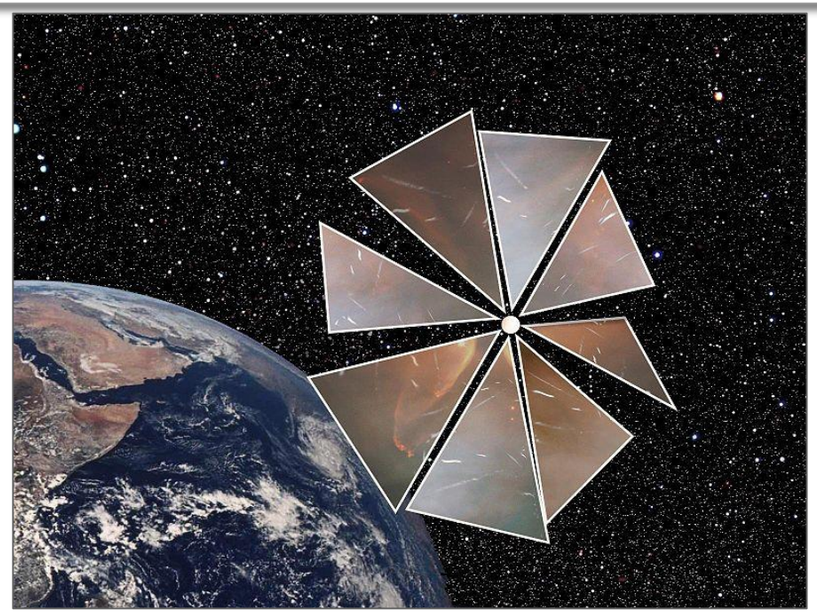
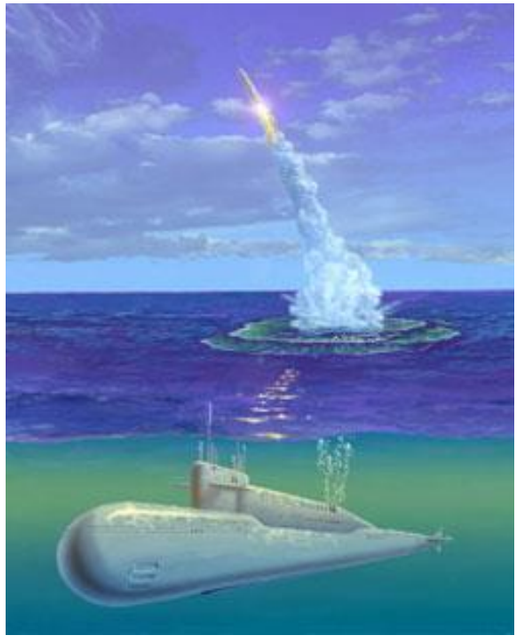
- NASA's Near Earth Asteroid Scout mission

The Planetary Society's Cosmos-1 (2005)

- 100 kg spacecraft
- 8 triangular sail blades deployed from a central hub after launch by the inflating of structural tubes.
  - Sail blades were each 15 m long
  - Total surface area of 600 square meters
- Launched in 2005 from a Russian Volna Rocket from a Russian Delta III submarine in the Barents Sea:





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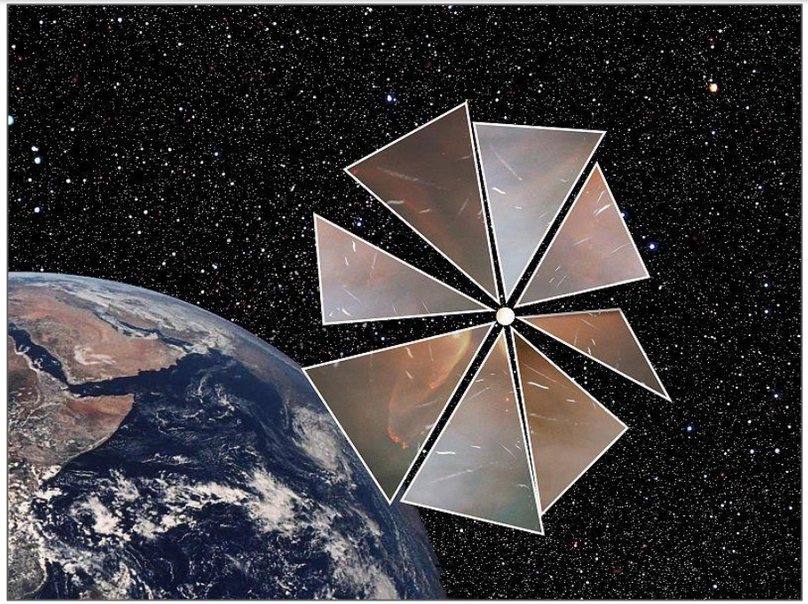
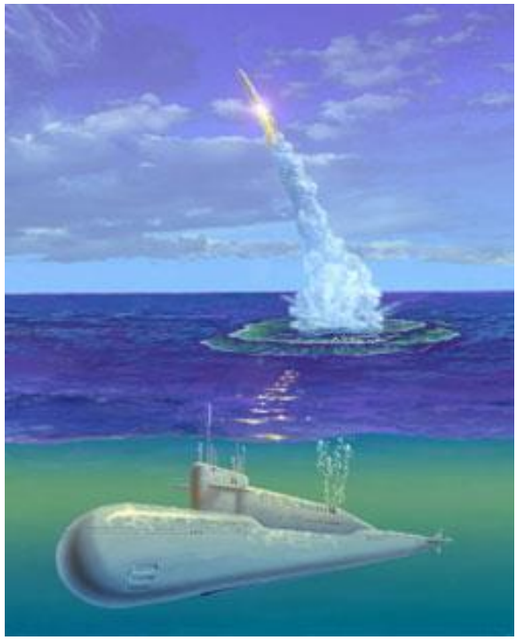
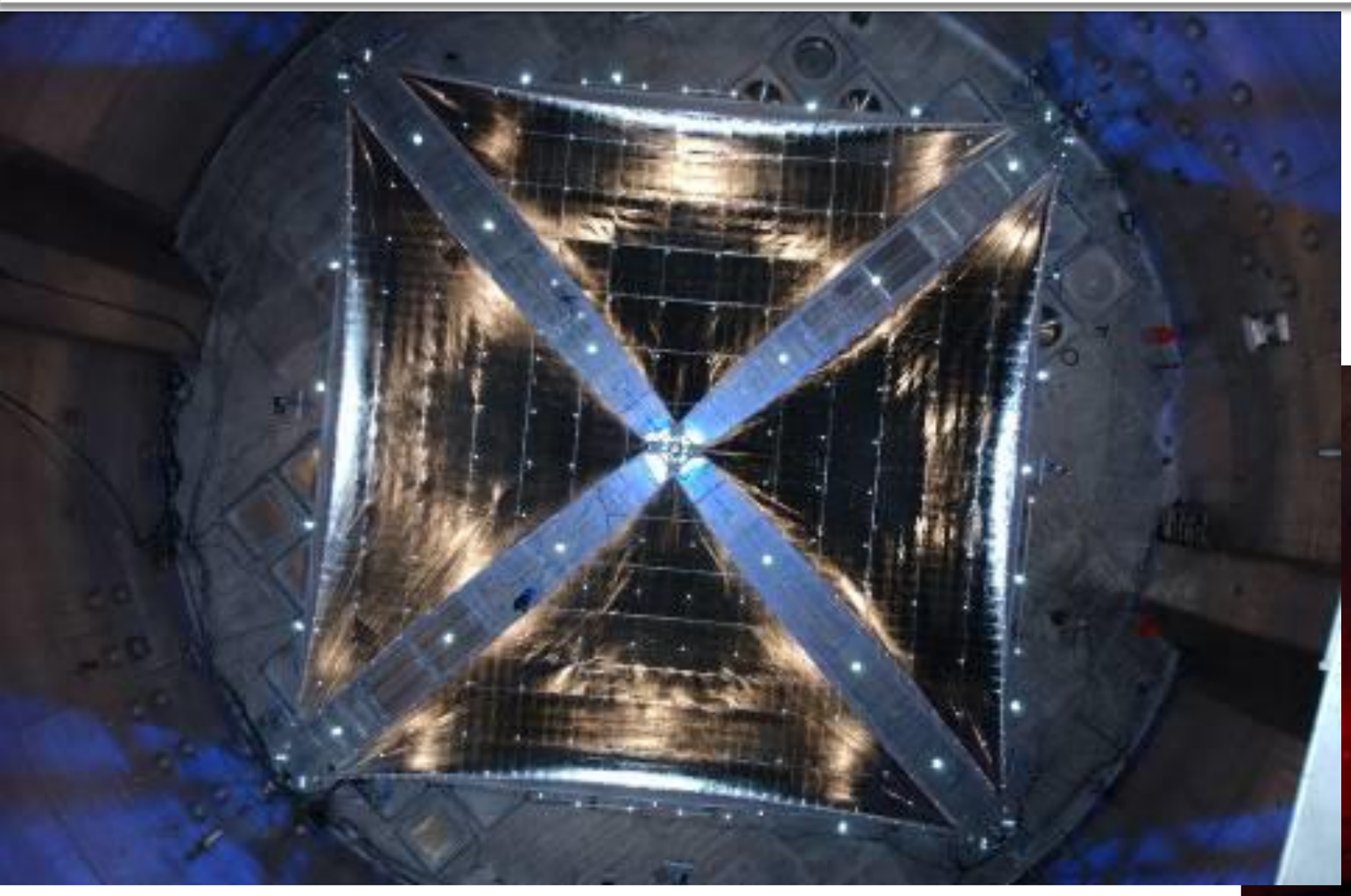


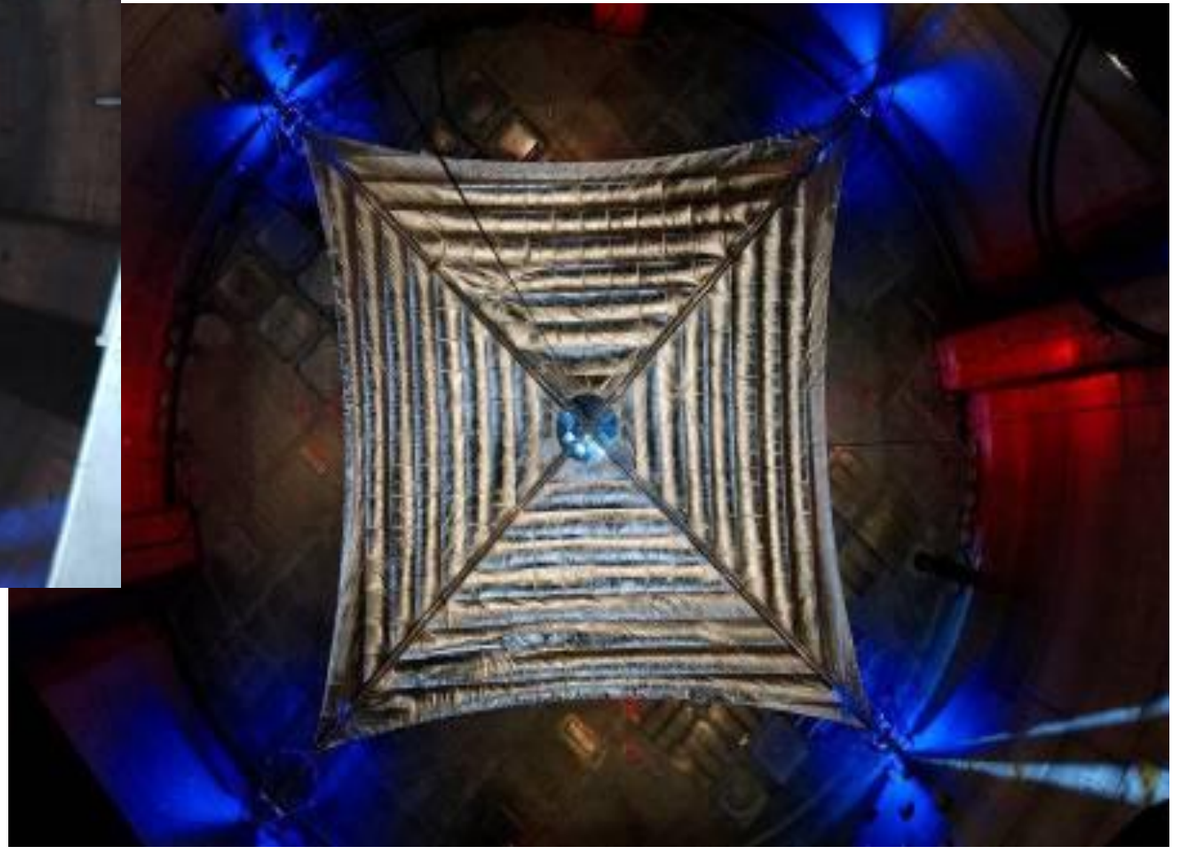


Rocket Failed

NASA Ground Tested Solar Sails in the Mid-2000's



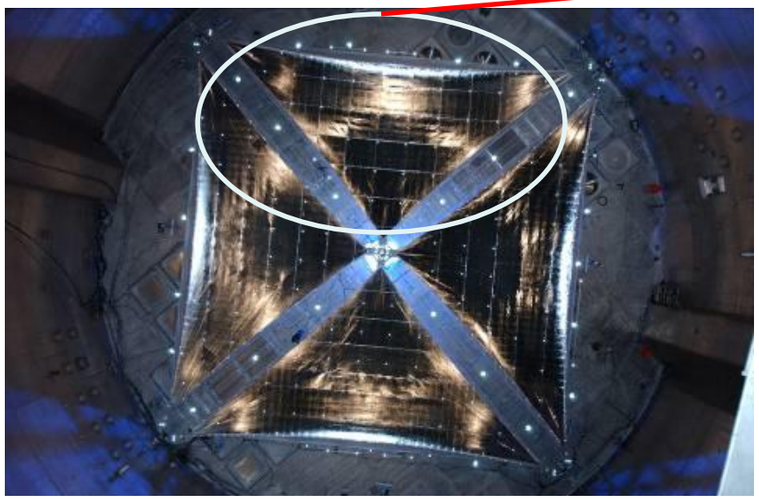
Two 400 square meter sail were autonomously deployed and tested at Plumbrook

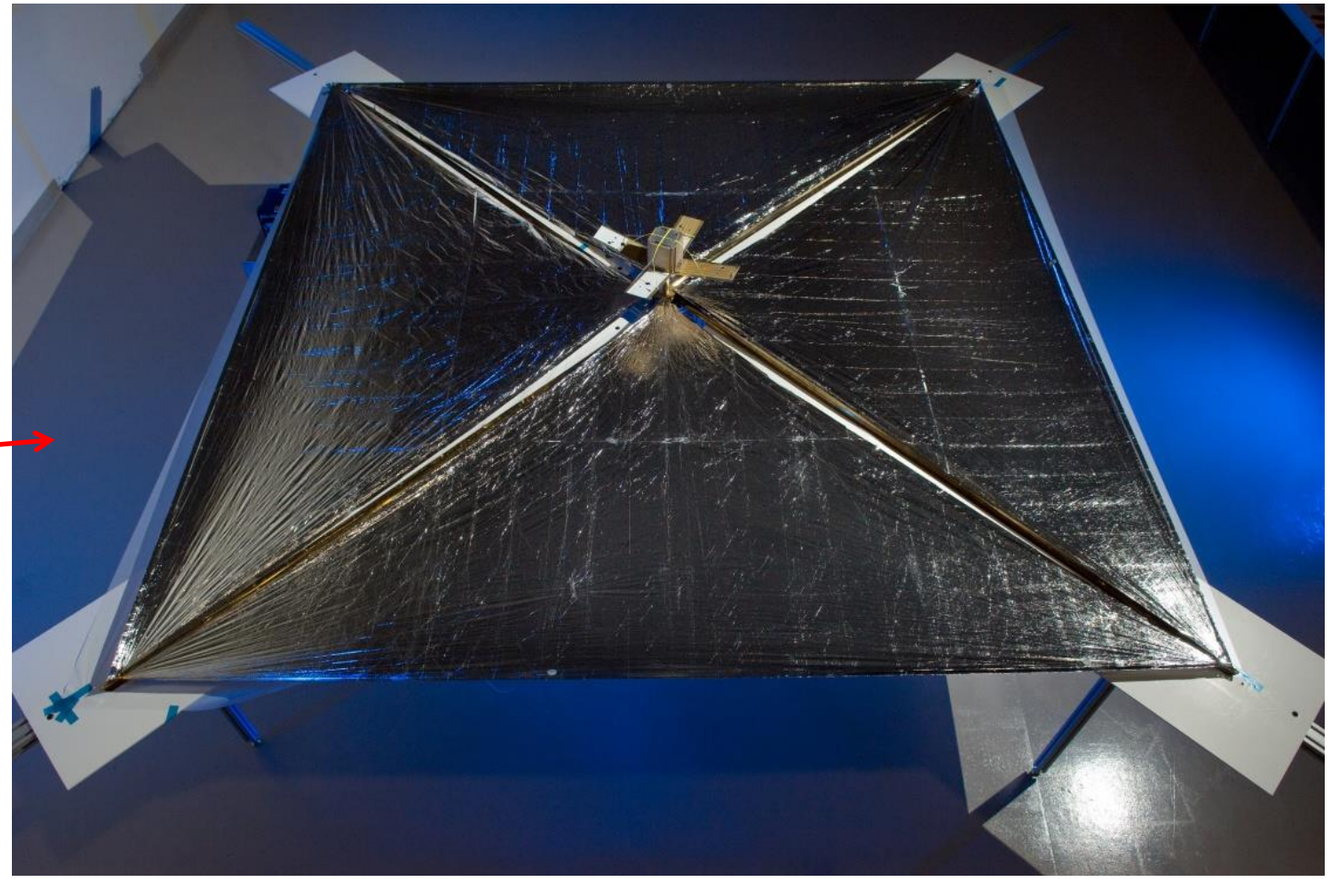


NanoSail-D Demonstration Solar Sail

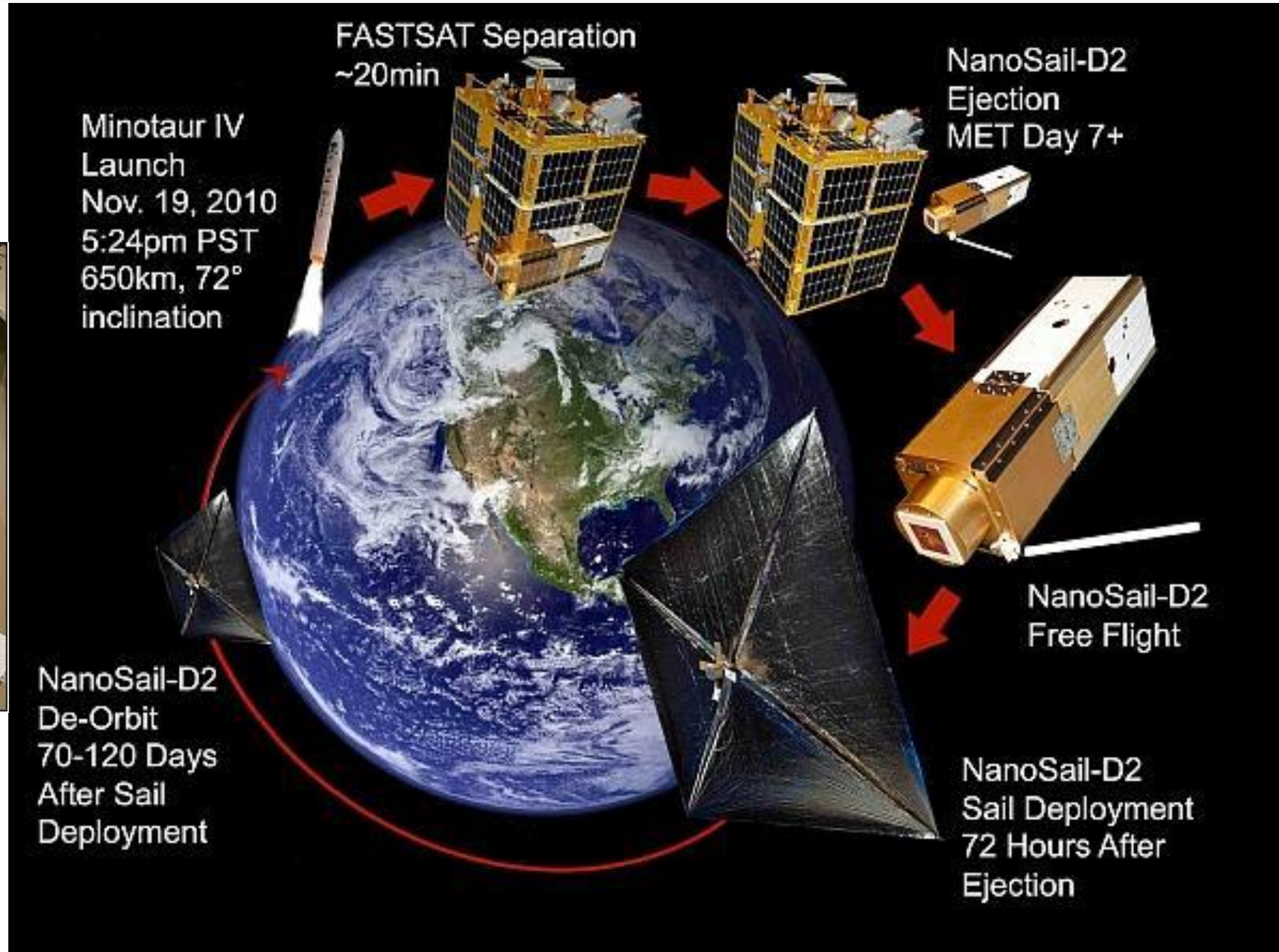
Mission Description:

- 10 m^2 sail
- Made from tested ground demonstrator hardware

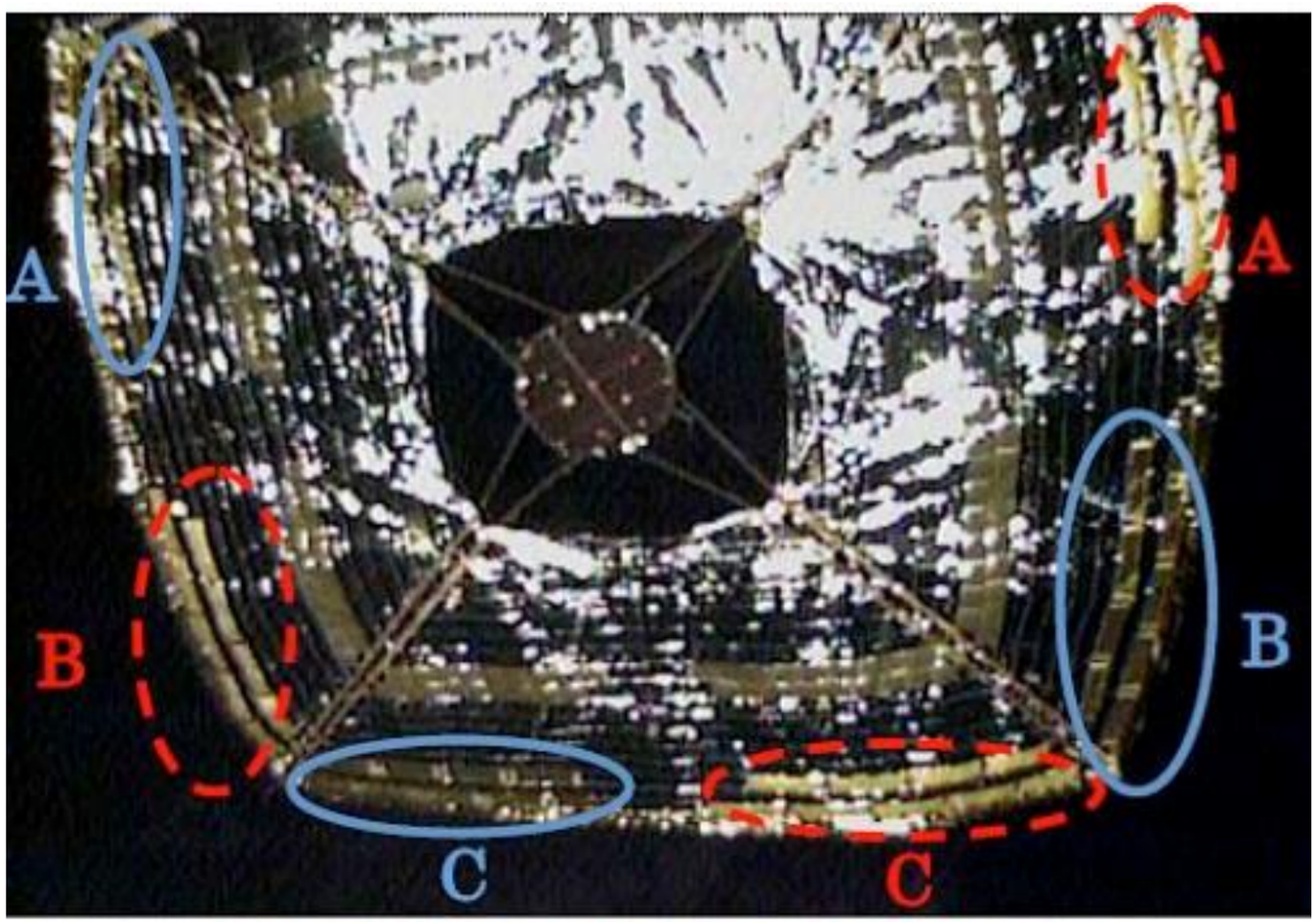




NanoSail-D2 Mission (2010)



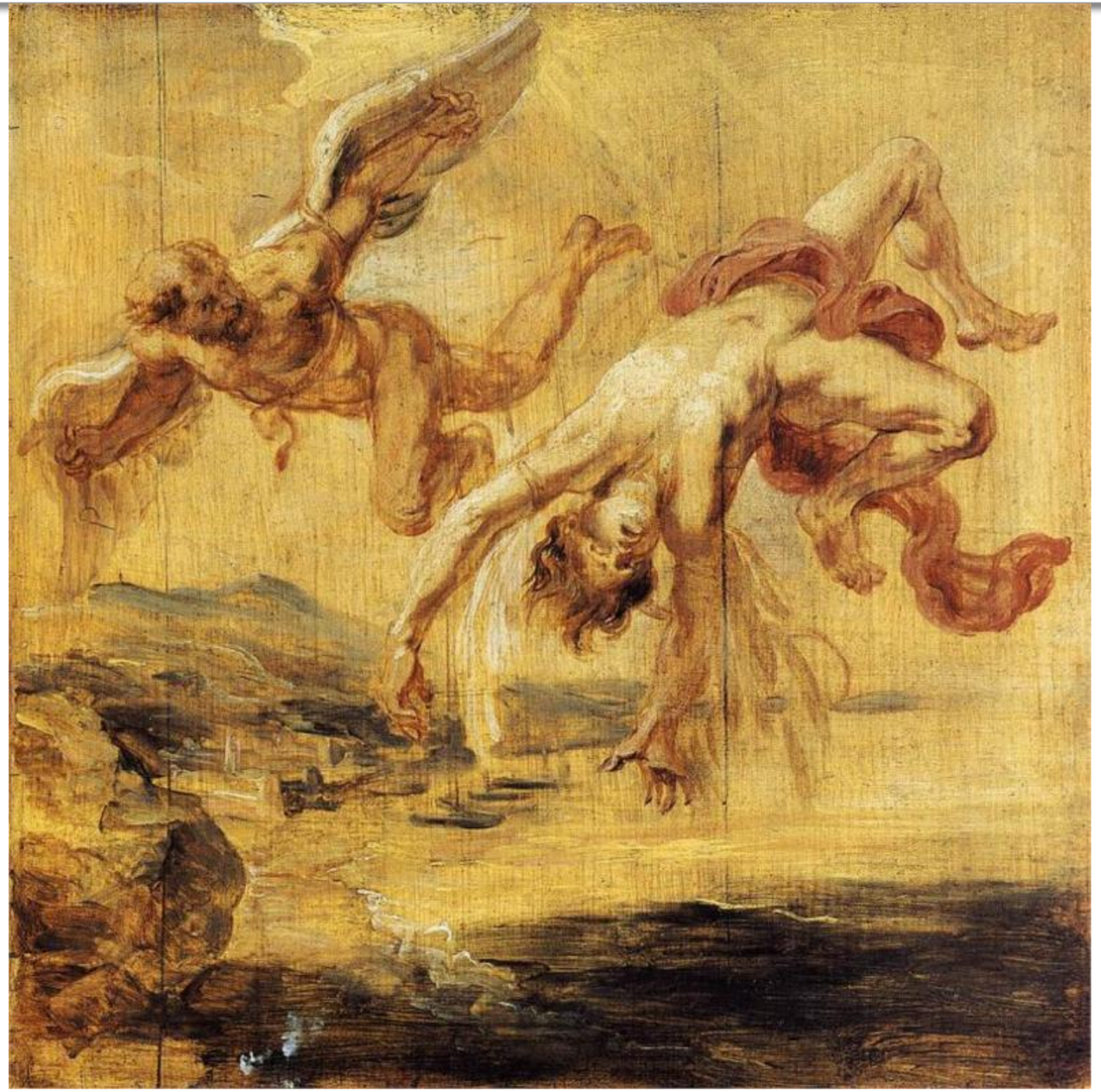
Interplanetary Kite-craft Accelerated by Radiation of the Sun (IKAROS)



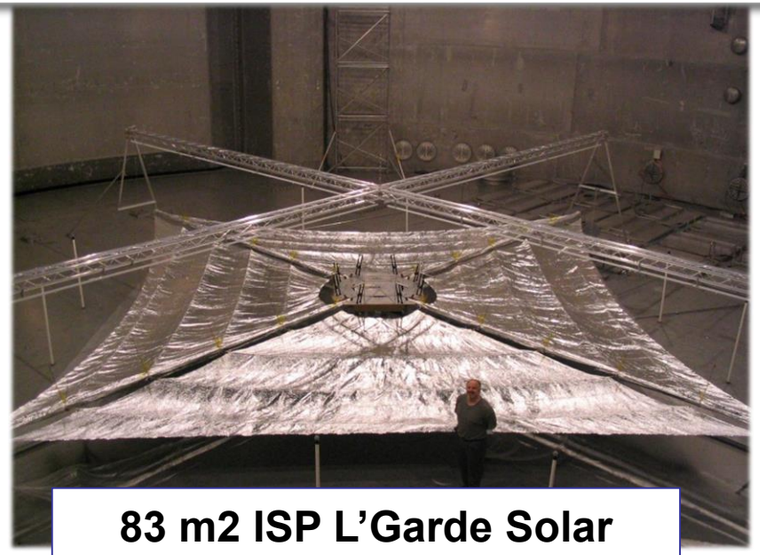
Liquid crystal device power was off.

Liquid crystal device power was on.

Fortunately, IKAROS accomplished with Icarus could not…



Sunjammer Solar Sail Demonstration Mission



83 m2 ISP L'Garde Solar Sail 2004

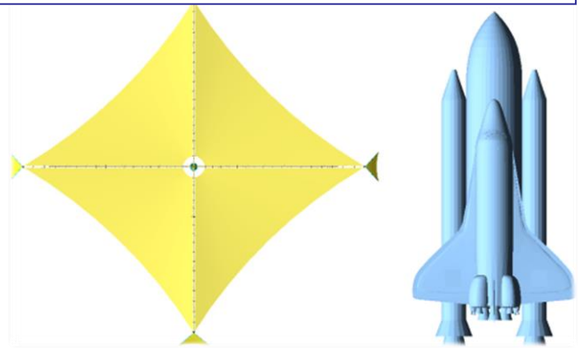
318 m2 ISP L'Garde Solar Sail 2005

Based on one of the 400 m² NASA Demonstrators:

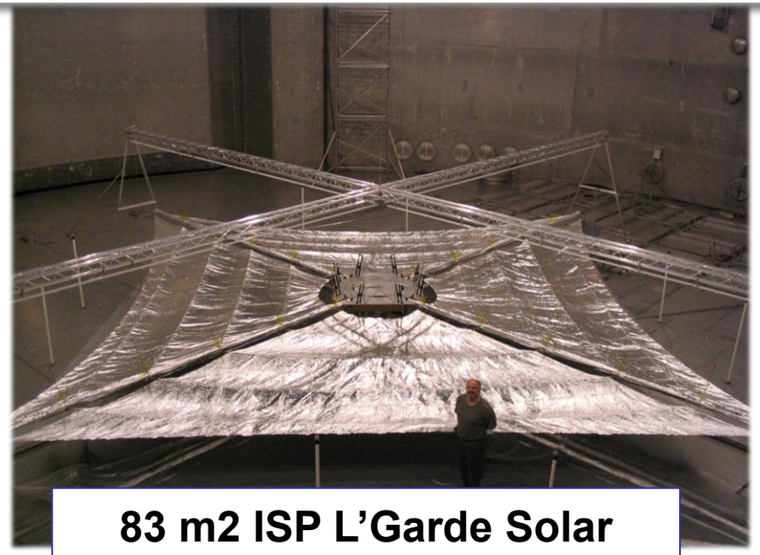
- Cold Rigidization Boom Technology
- Aluminized Sun Side
- High Emissivity Eclipse Surface
- Beam Tip Vane Control

1200 m² L'Garde Sunjammer was to launch in 2015

STMD Technology Demonstration Mission (TDM)



Sunjammer Solar Sail Demonstration Mission



83 m2 ISP L'Garde Solar Sail 2004

Canceled

Based on one of the 400 m^2 NASA Demonstrators:

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- Aluminized Sun Side
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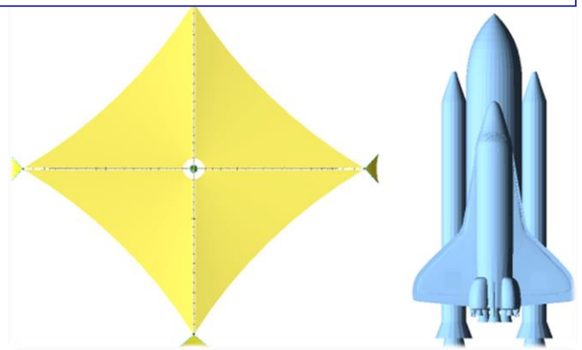

STMD Technology Demonstration Mission (TDM)

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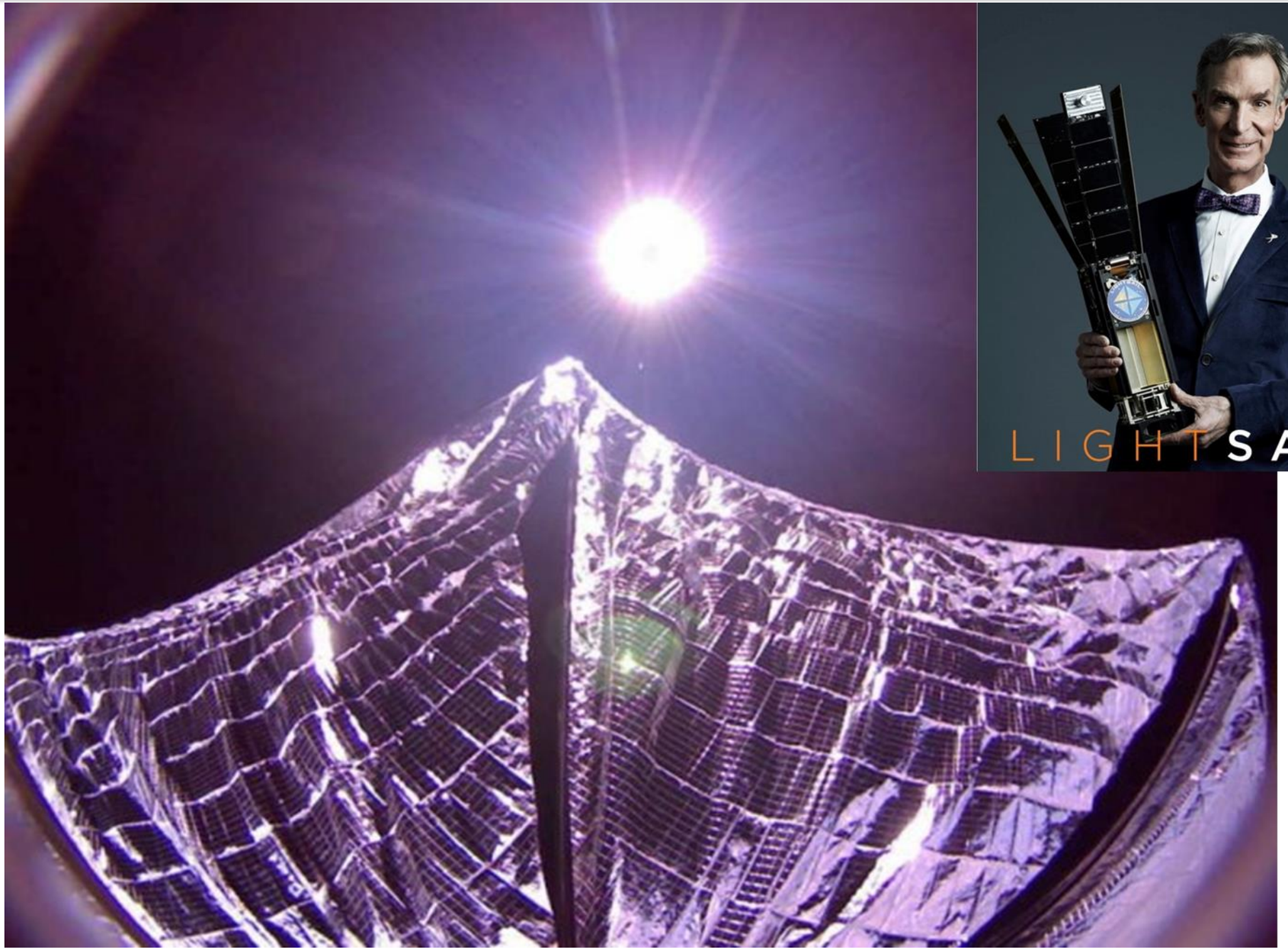
2015's LightSail-A (The Planetary Society)



32 m^2
No active 'sailing'
3U cubesat

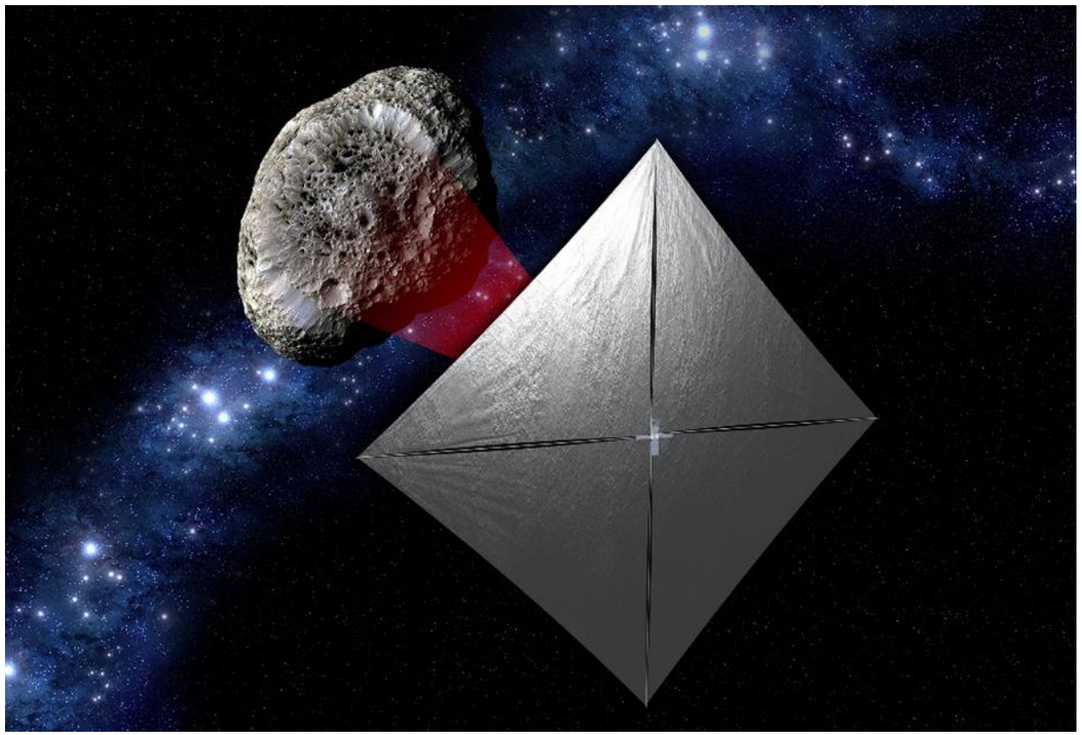
Topics

- What is a solar sail?
- A brief history of solar sailing
- NASA's Near Earth Asteroid Scout mission

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

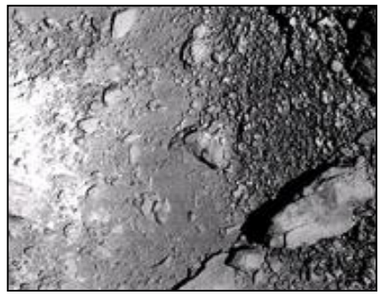


Key Spacecraft & Mission Parameters

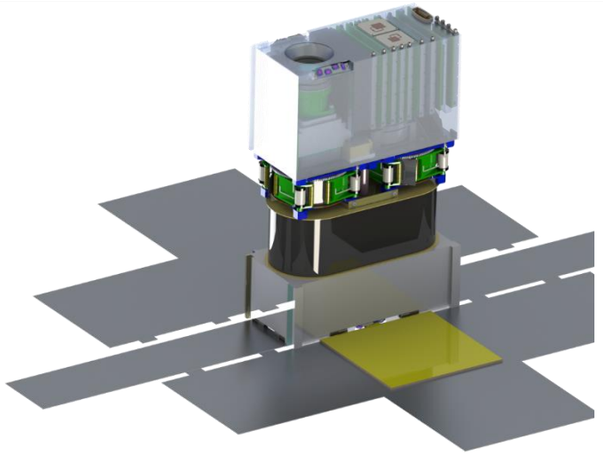
- 6U cubesat (20cm X 10cm X 30 cm)
- ~86 m^2 solar sail propulsion system
- Manifested for launch on the Space Launch System (EM-1/2018)
- 1 AU maximum distance from Earth

Leverages: combined experiences of MSFC (PM, SE and Solar Sail) and JPL (flight system bus, instrument and science) with support from GSFC, JSC, & LaRC

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

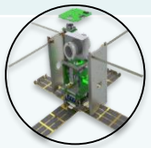
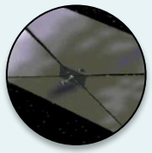


Close Proximity Imaging
Local scale morphology, terrain properties, landing site survey

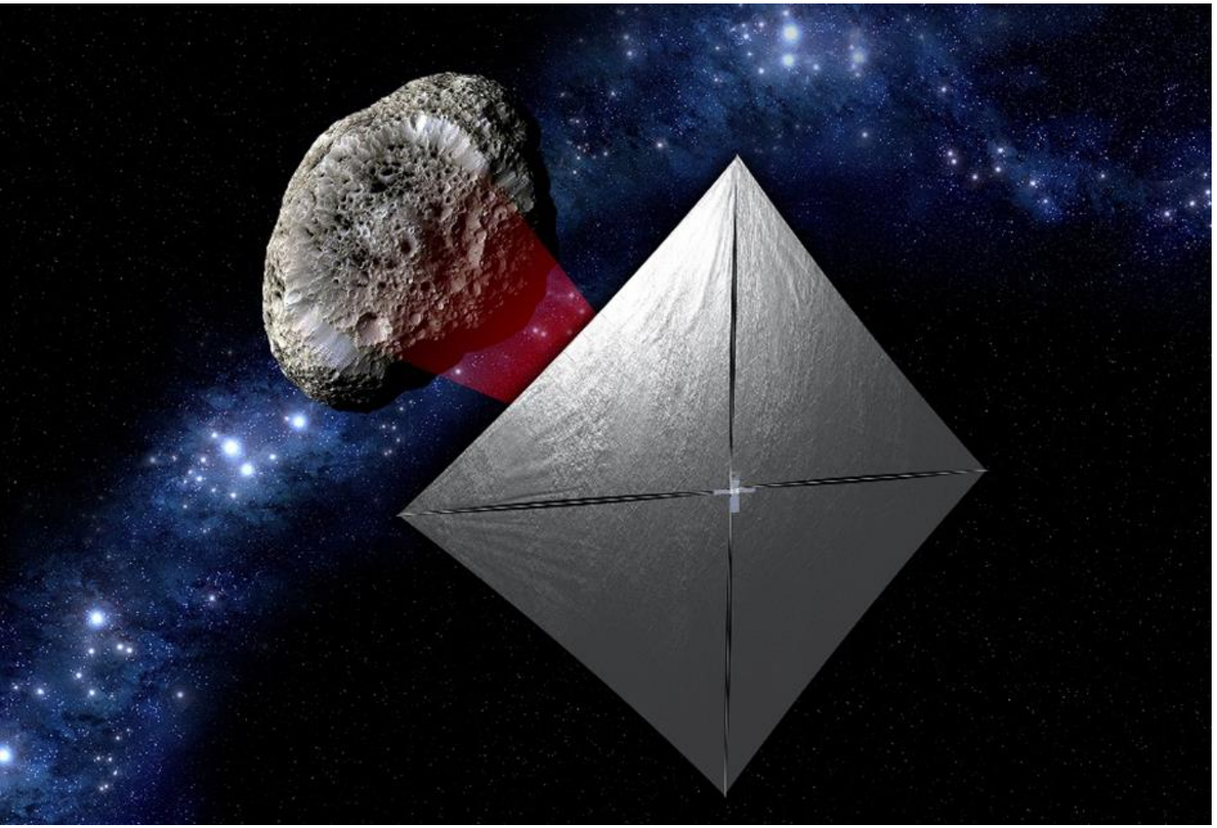


NEA Scout Sponsored by HEOMD AES

- **HEOMD's Advanced Exploration Systems (AES) selected 3 cubesats for flight on SLS EM1**
- **Primary selection criteria:**
  - Relevance to Space Exploration Strategic Knowledge Gaps (SKGs)
  - Life cycle cost
  - Synergistic use of previously demonstrated technologies
  - Optimal use of available civil servant workforce

Payload *NASA Centers*	**Strategic Knowledge Gaps Addressed**	**Mission Concept**
BioSentinel ***ARC**/JSC* 	**Human health/performance in high-radiation space environments** • Fundamental effects on biological systems of ionizing radiation in space environments	Study radiation-induced DNA damage of live organisms in cis-lunar space; correlate with measurements on ISS and Earth
Lunar Flashlight ***JPL**/MSFC* 	**Lunar resource potential** • Quantity and distribution of water and other volatiles in lunar cold traps	Locate ice deposits in the Moon's permanently shadowed craters
Near Earth Asteroid (NEA) Scout ***MSFC**/JPL* 	**Human NEA mission target identification** • NEA size, rotation state (rate/pole position) **How to work on and interact with NEA surface** • NEA surface mechanical properties	Flyby and characterize one NEA that is candidate for a human mission

NEA Scout Roles and Responsibilities



Near Earth Asteroid Scout

- Project Manager: Leslie McNutt (MSFC)
- Science PI: Julie Castillo-Rogez (JPL)
- Solar Sail PI: Les Johnson (MSFC)
- Spacecraft System: JPL
- Solar Sail System: MSFC

L1 Science Requirements

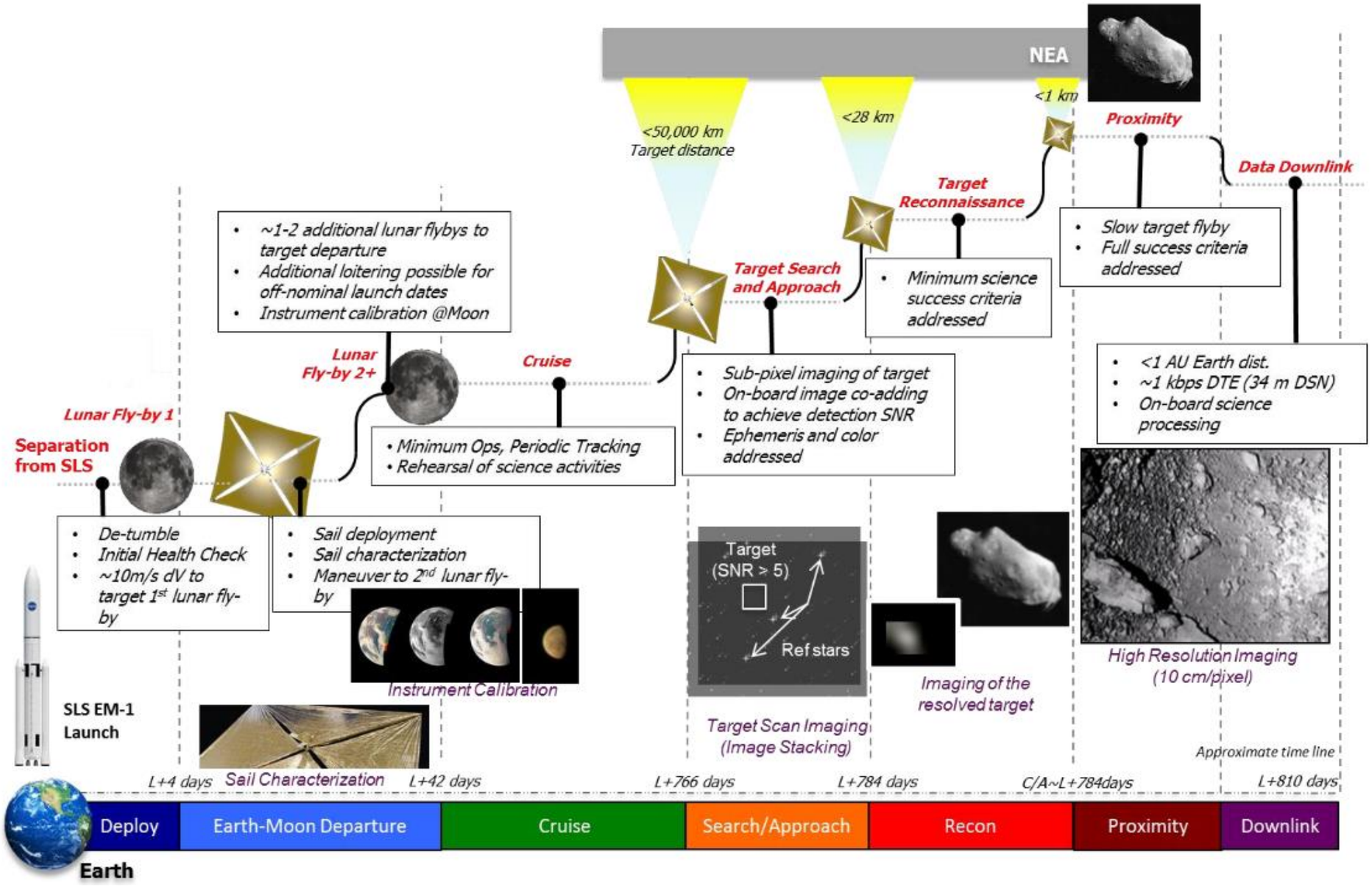
- **NEA SCOUT SHALL HAVE THE CAPABILITY TO ADDRESS KEY STRATEGIC KNOWLEDGE GAPS AT A NEAR EARTH ASTEROID**

- Full Success Criteria: Fly by a near Earth asteroid and acquire images sufficient to determine the target volume, shape model, asteroid spectral type and meteorite analogs, rotational properties (pole position, rotation period), orbit, debris/dust field in local environment, and regolith characteristics.

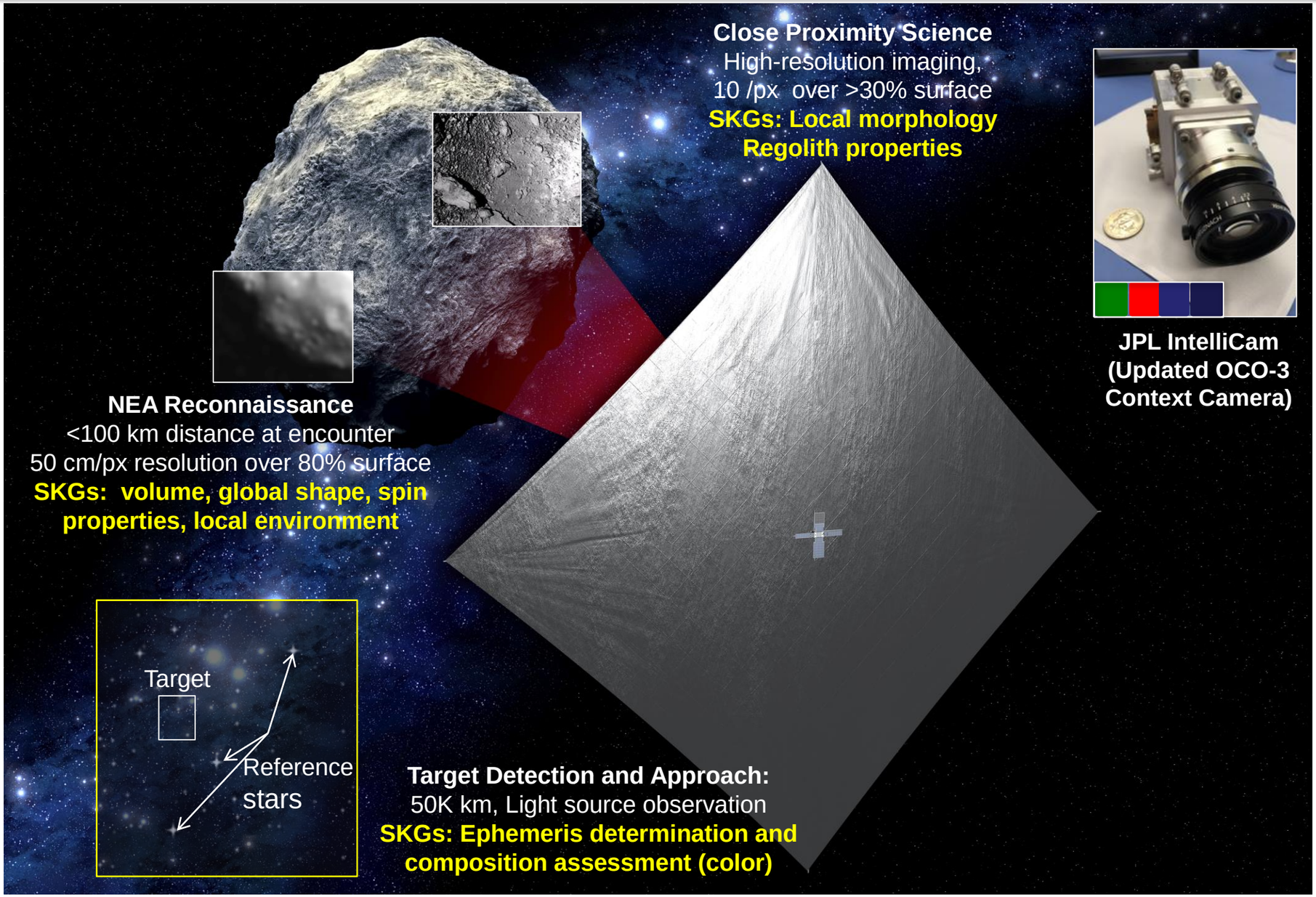
- Minimum Success Criteria: Fly by a near Earth asteroid and acquire images sufficient to estimate the target volume, the asteroid spectral type, determine rotational properties (pole position, rotation period), and orbit.

- Rationale: This requirement addresses the need to fill Strategic Knowledge Gaps related to asteroids as a precursor to subsequent safe and successful human missions. The data obtained will also support the advancement of science interests in asteroids.

Concept of Operations Overview



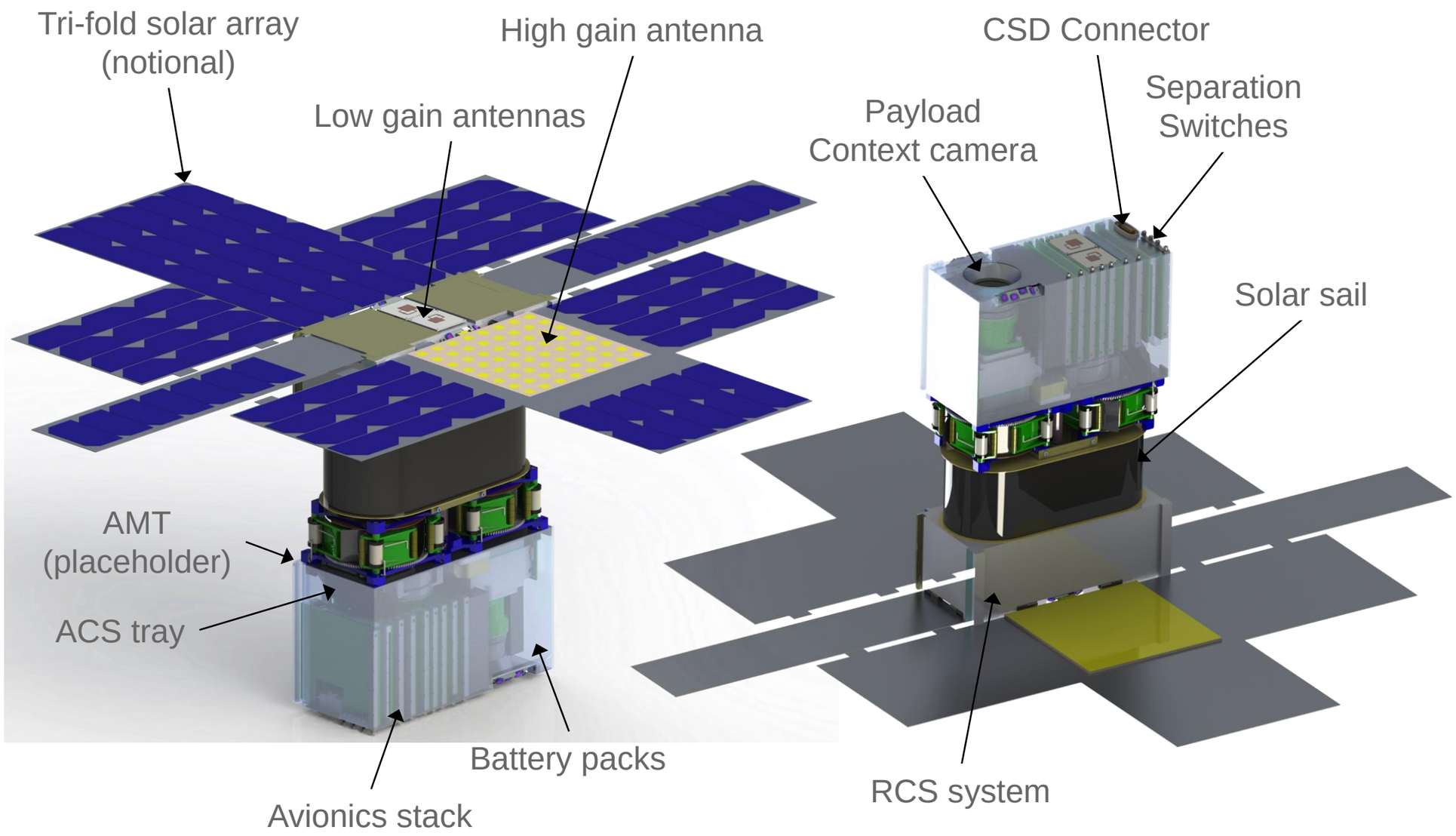
Near Earth Asteroid Scout Asteroid Flyby



Baseline Target: 1991 VG

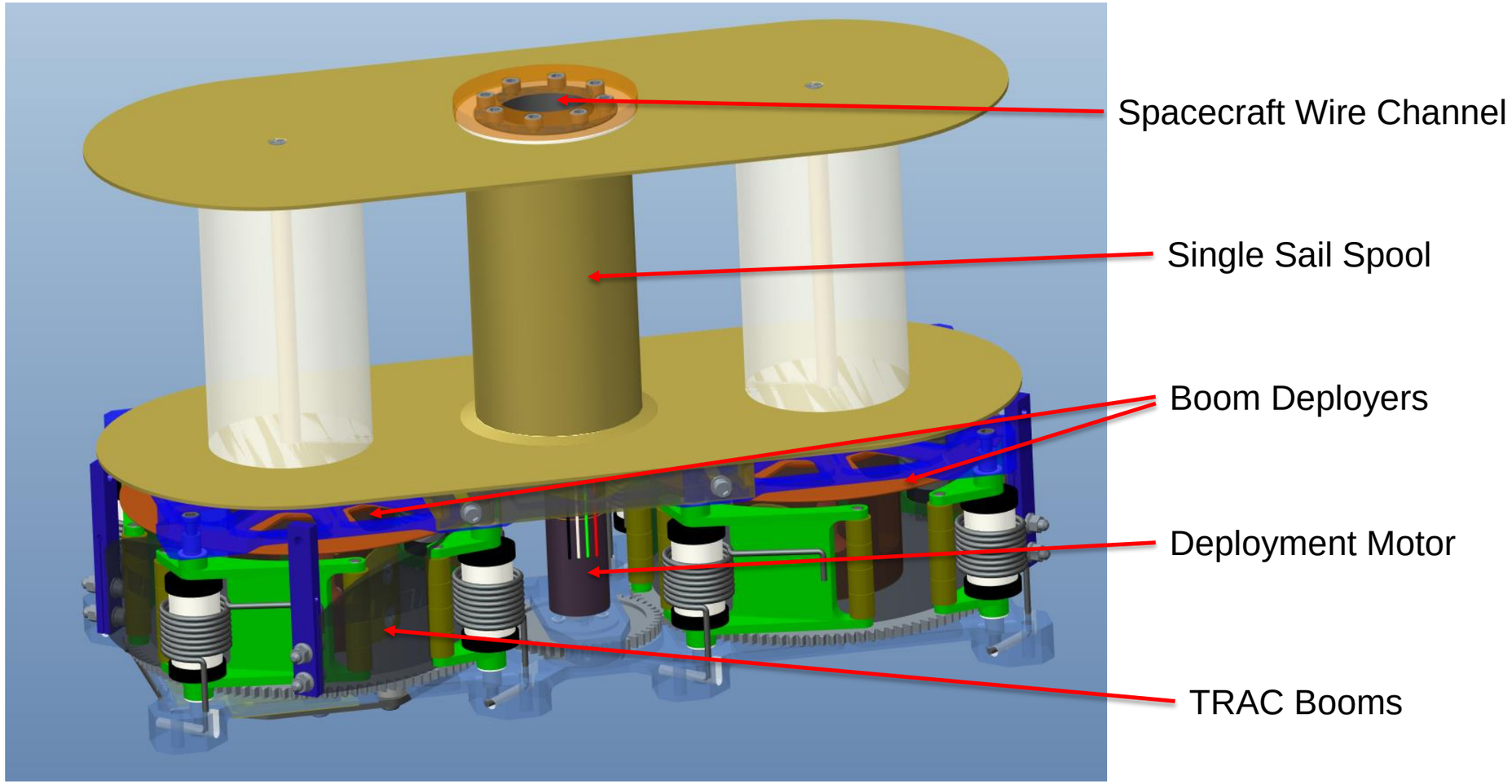
- Diameter ~ 5-12 meters
- Albedo is unknown
- Position is known within 2700 km (1-σ) but optical observation opportunity in July ‘17 will decrease uncertainty to a few 100s km
- Rotation period between a few minutes and less than 1 hour
- Unlikely to have a companion
- Unlikely to retain an exosphere or dust cloud
  - Solar radiation pressure sweeps dust on timescales of hours or day

NEA Scout Flight System Configuration



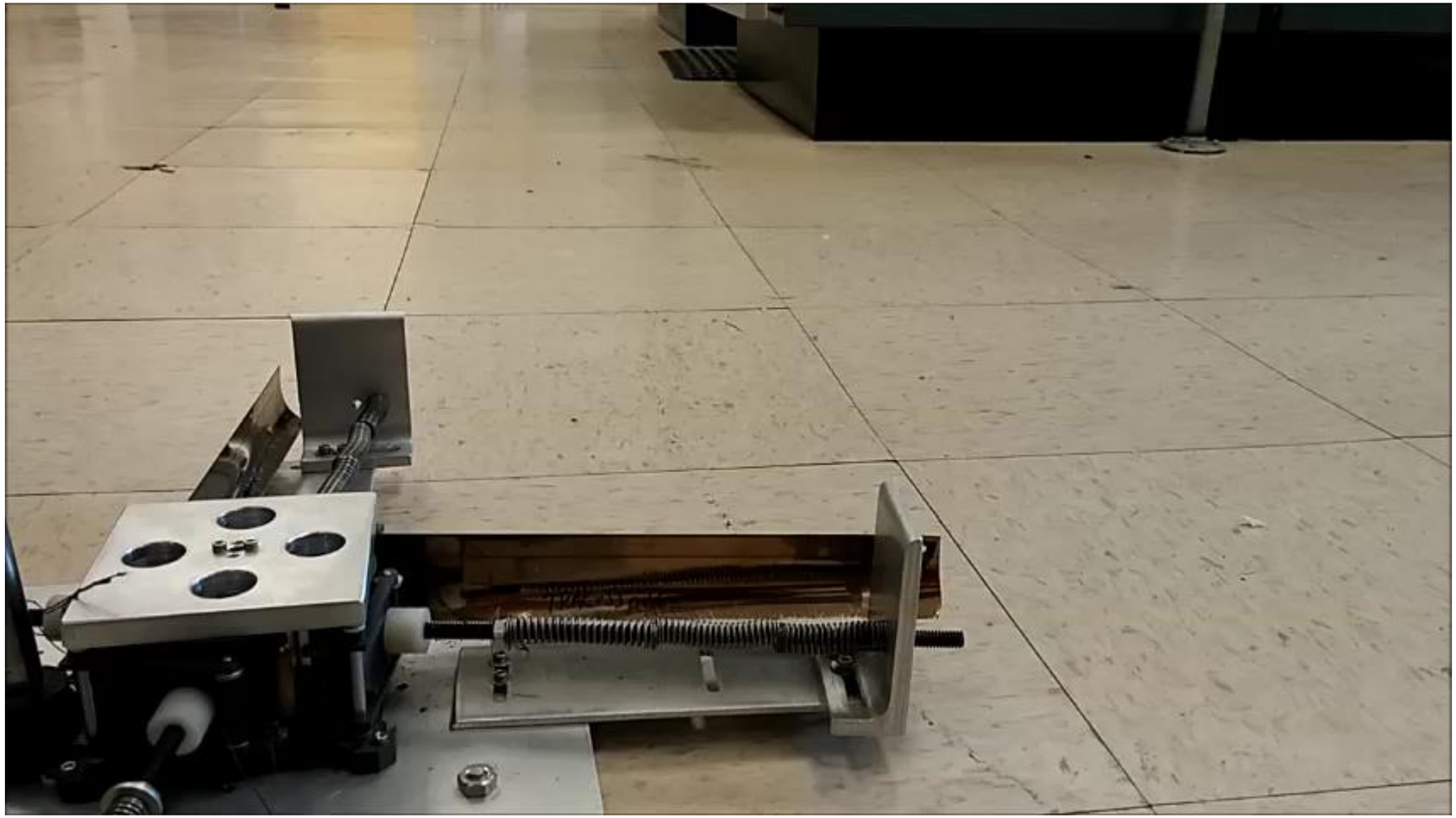
Integrated flight system, stowed sail; Credit: JPL

Solar Sail Subsystem Overview



Solar Sail Subsystem without sail, Credit: NASA

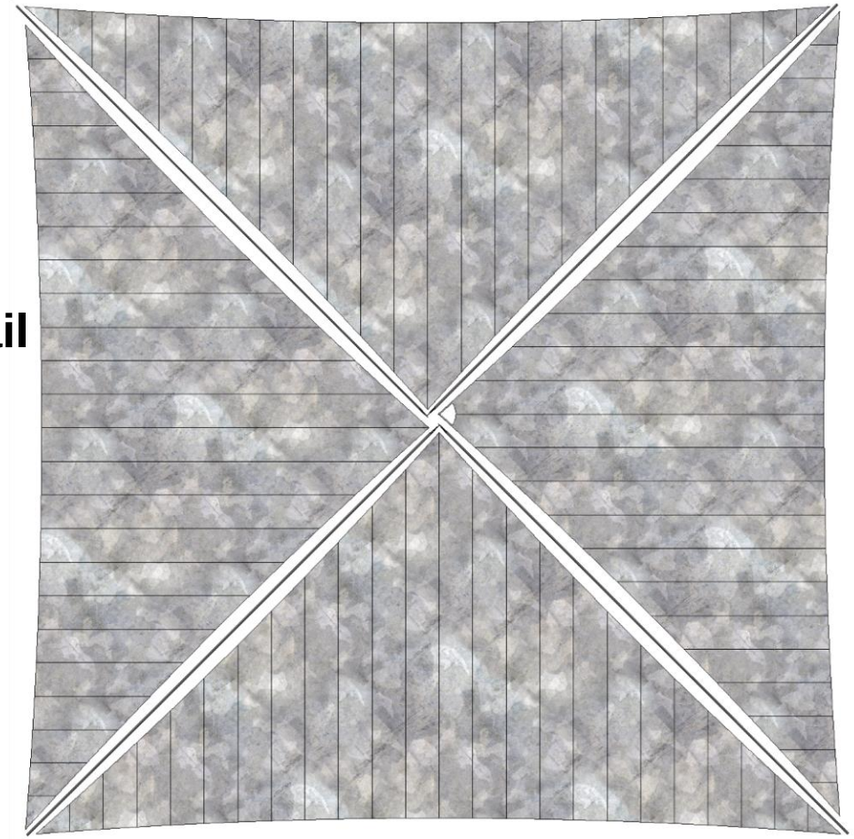
Test Deployment with Linear Springs



Early prototype, Credit: NASA

NEA Scout Approximate Scale

Deployed Solar Sail



School Bus

Human

6U Stowed Flight System

Folded, spooled and packaged in here

QUESTIONS?