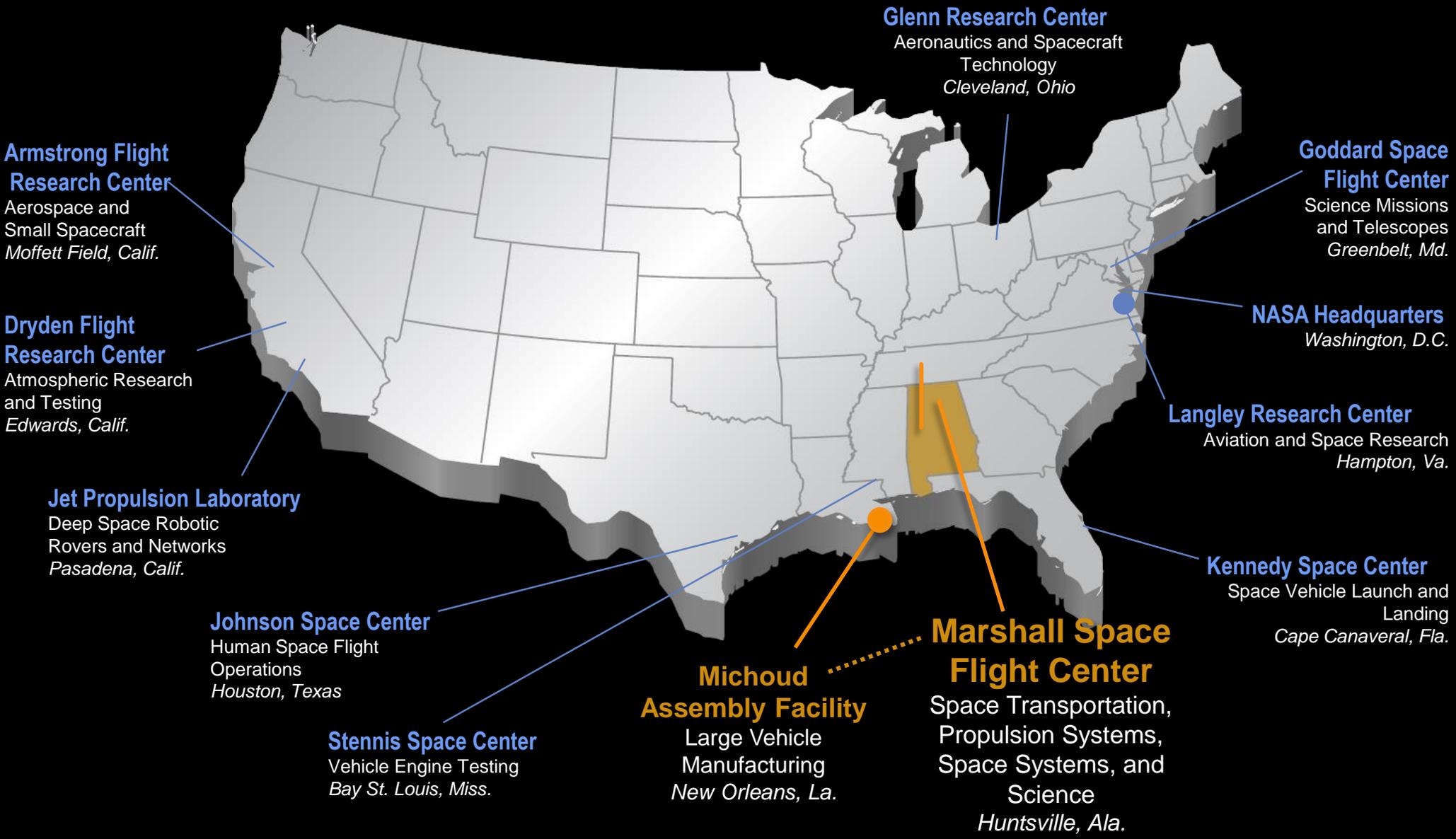


# NASA's Advanced Concepts Office at the George C. Marshall Space Flight Center



Les Johnson  
NASA MSFC / ED04

# NASA Around the Country



**Supporting NASA's mission with unique engineering expertise.**

# Marshall Profile



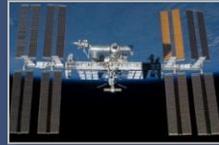
**\$2B expenditures nationally**  
(\$1.2B in Alabama)



**6,000 employees**  
(FY13: 2,446 civil service)



**3<sup>rd</sup> largest employer**  
in the Huntsville –  
Madison County area



**4 core product lines**  
supported by more than  
125 unique and  
specialized facilities

## Part of an Aerospace/Defense/Commercial Technical Community

- Redstone Arsenal – home to 18 primary Federal organizations
- Cummings Research Park – 2<sup>nd</sup> largest in U.S. and 4<sup>th</sup> largest in the world
- Huntsville's concentration of high-tech workers is 2<sup>nd</sup> in the nation



# What is the NASA MSFC Advanced Concepts Office?

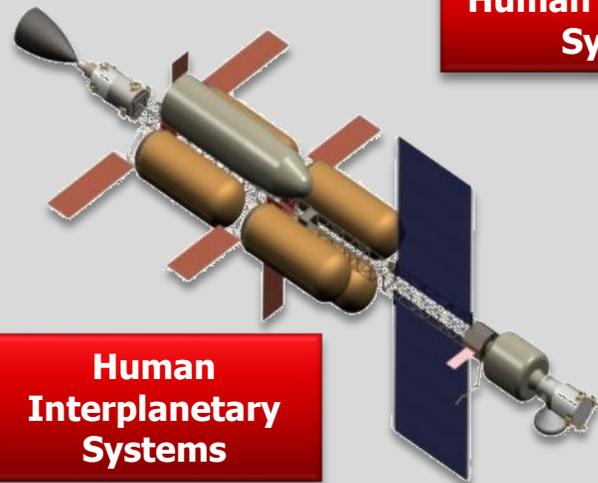
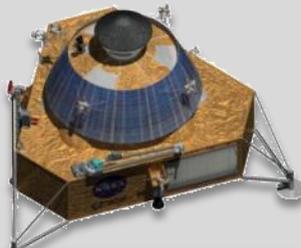
***We answer the questions:  
Will it work?  
What will it look like?  
What is the preliminary design?***



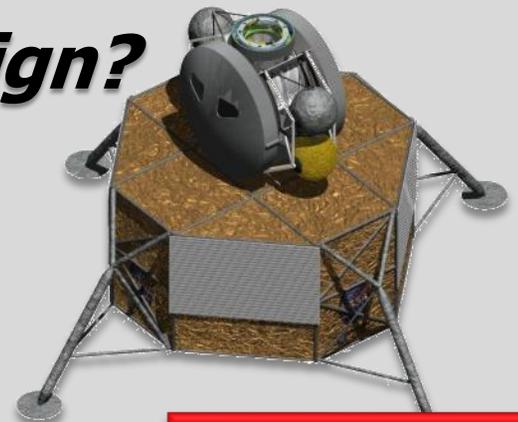
**Launch Vehicle Systems**



**Robotic & Science Systems**



**Human Interplanetary Systems**

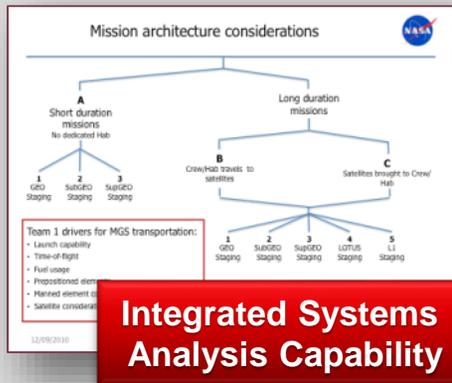


**Human Exploration Systems**

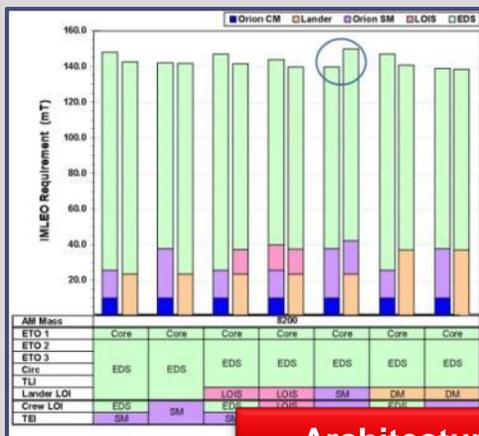


# How Does Advanced Concepts Work?

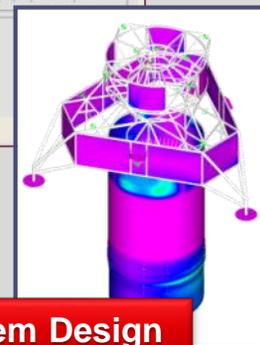
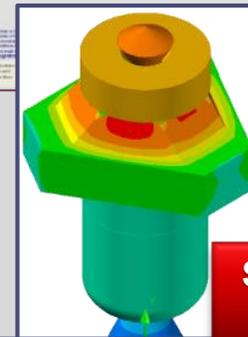
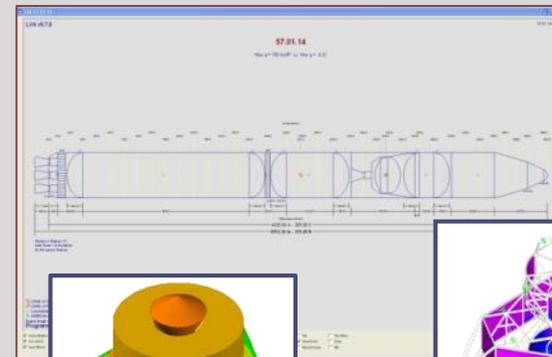
## We Utilize Multi-Disciplined Teams Within the Office to Provide Fully Integrated Assessments of Missions and Their Elements



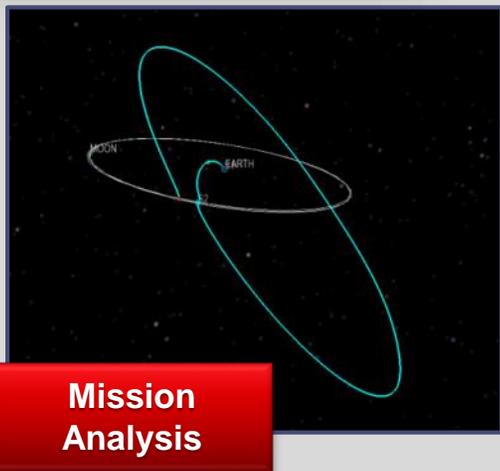
**Integrated Systems Analysis Capability**



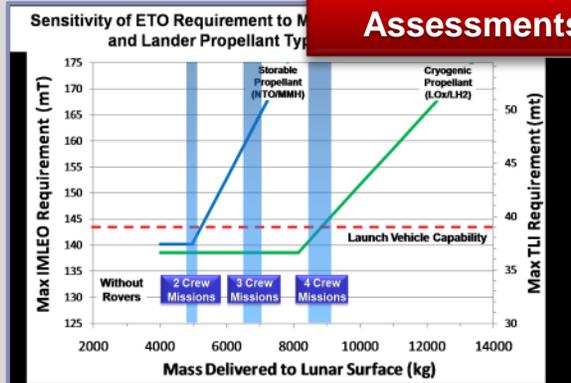
**Architecture Assessments**



**Subsystem Design & Analysis**



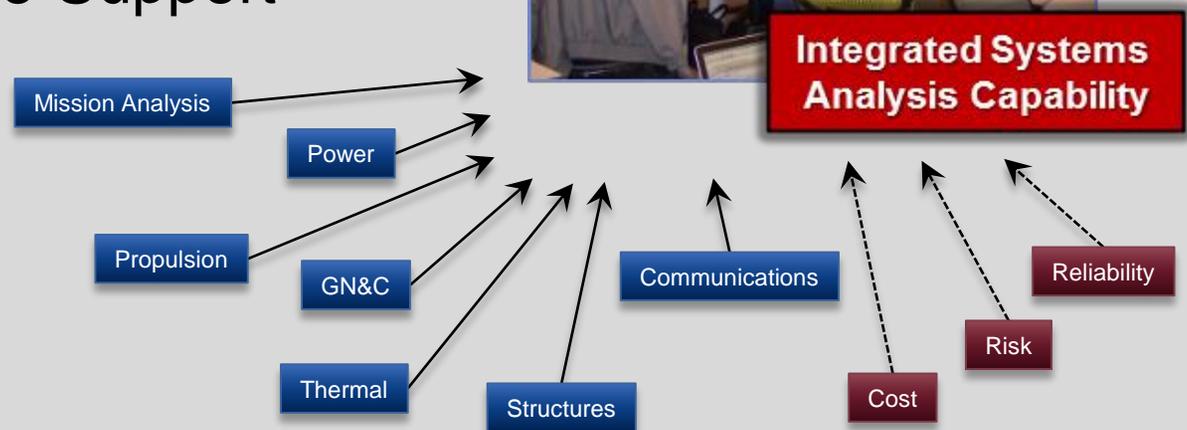
**Mission Analysis**





# Collaborative Design Teams

- ◆ The ACO Design Teams are established, co-located teams of systems and design engineers
- ◆ Other disciplines or specific expertise are matrixed into the team as necessary
- ◆ Scientific Areas of Interest
- ◆ Programmatic Support
- ◆ Additional Discipline Support



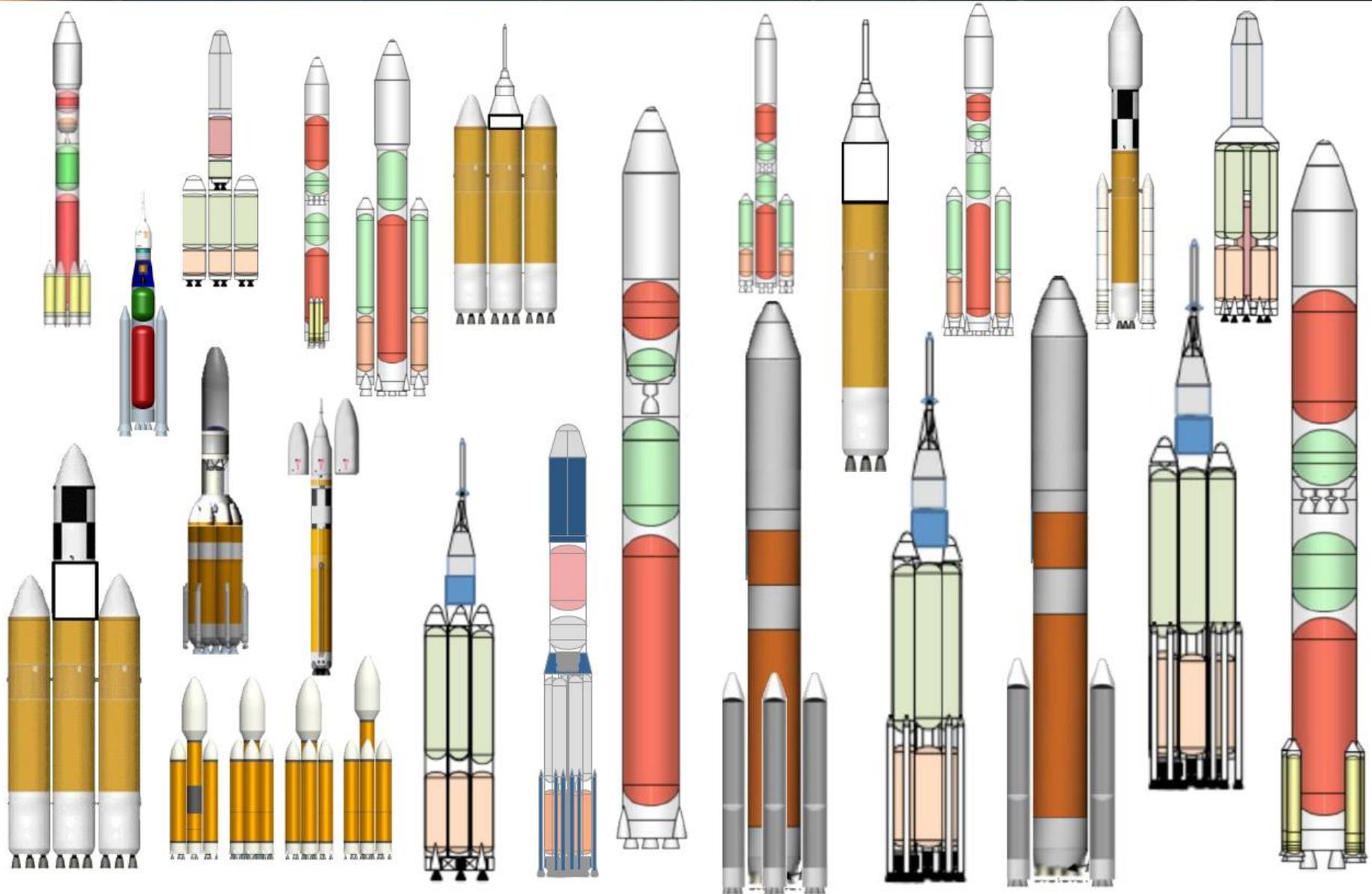


# Space Launch: Advancing the Legacy of Human Exploration





# ACO Traded >8000 Options



*"This enterprise is not for the faint of heart."  
—Wayne Hale*

# THE WORLD'S MOST POWERFUL ROCKET



## **Orion:**

Carries astronauts into deep space

## **Stage Adapters:**

The Orion stage adapter will be the first new SLS hardware to fly.

## **Interim Cryogenic Propulsion Stage:**

Based on the Delta IV Heavy upper stage; the power to leave Earth

## **Core Stage:**

Newly developed for SLS, the Core Stage towers more than 200 feet tall

## **Solid Rocket Boosters:**

Built on Space Shuttle hardware; more powerful for a new era of exploration

## **RS-25 Engines:**

Space Shuttle engines for the first four flights are already in inventory

# THE ROCKETS, THE MISSIONS



235 ft.

**Capability to Low-Earth Orbit (LEO):**  
26 metric tons

**Payload:**  
Critical crew module systems and  
Basic LAS/SM structure

## DELTA IV HEAVY



322.4 ft.

**Capability to Low-Earth Orbit (LEO):**  
70 metric tons

**Payload:**  
Full Orion (Unmanned)

## SPACE LAUNCH SYSTEM (SLS)

### ORION'S FLIGHT TEST

**OBJECTIVE:**

Acquire data at beyond-Earth orbit reentry velocities

**DISTANCE FROM EARTH:**

**3,600 miles**

**DURATION:**

5 Hours

### EXPLORATION MISSION ONE (EM-1)

**OBJECTIVE:**

System readiness for astronauts to travel farther than humans have ever gone before

**DISTANCE FROM EARTH:**

Will break the distance record reached by the most remote Apollo spacecraft, and then **30,000 miles farther out (275,000 total miles)**

**DURATION:**

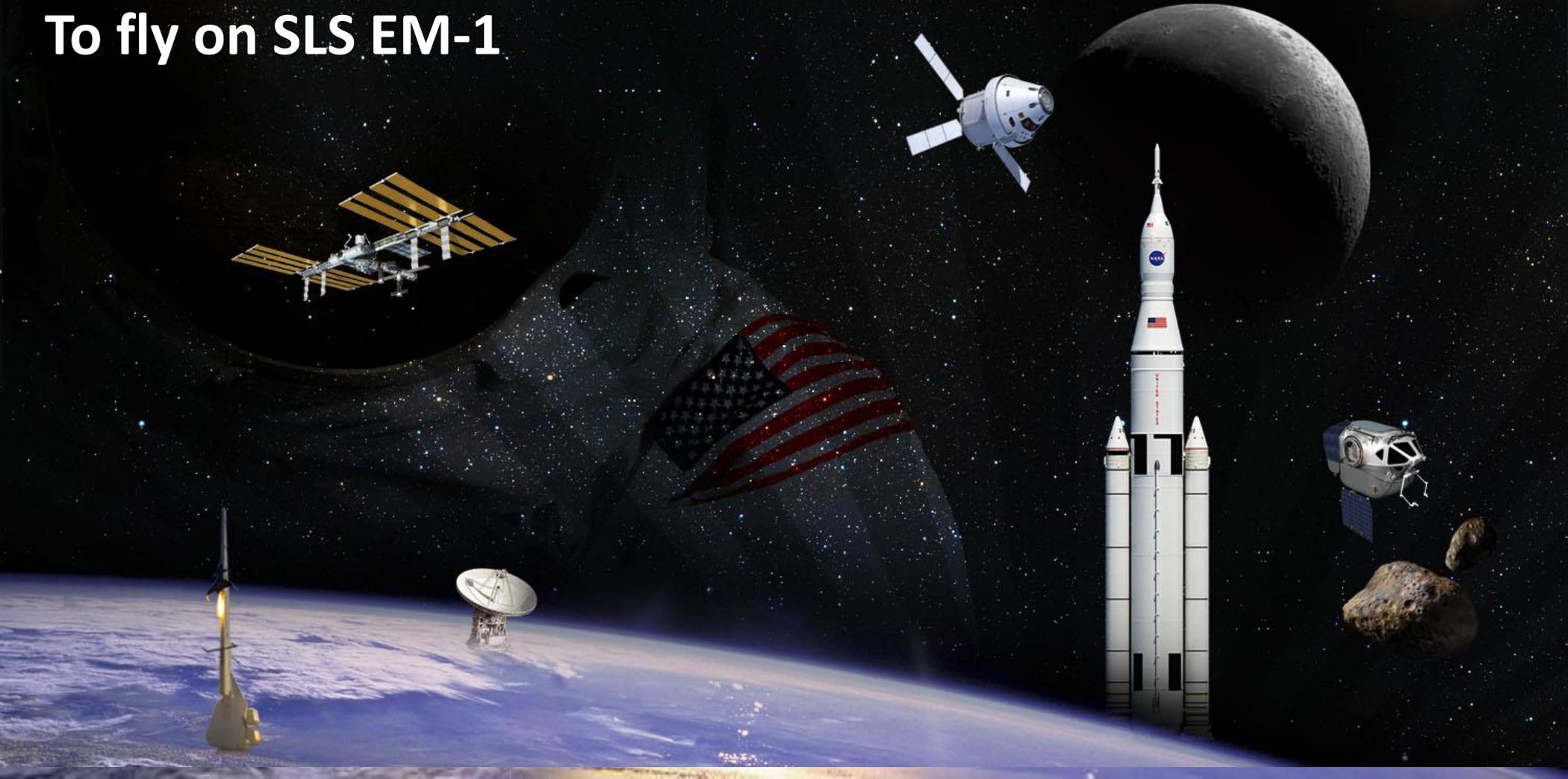
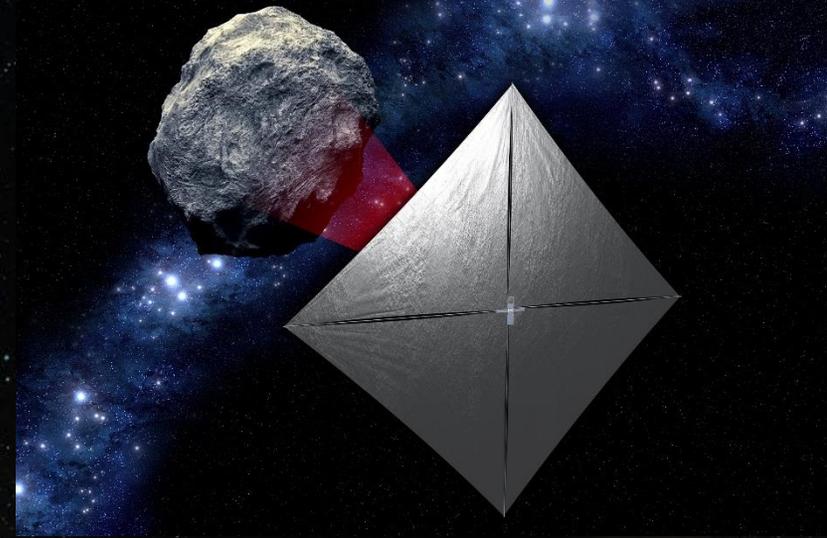
22 days



National Aeronautics and Space Administration

# Near Earth Asteroid Scout

## To fly on SLS EM-1

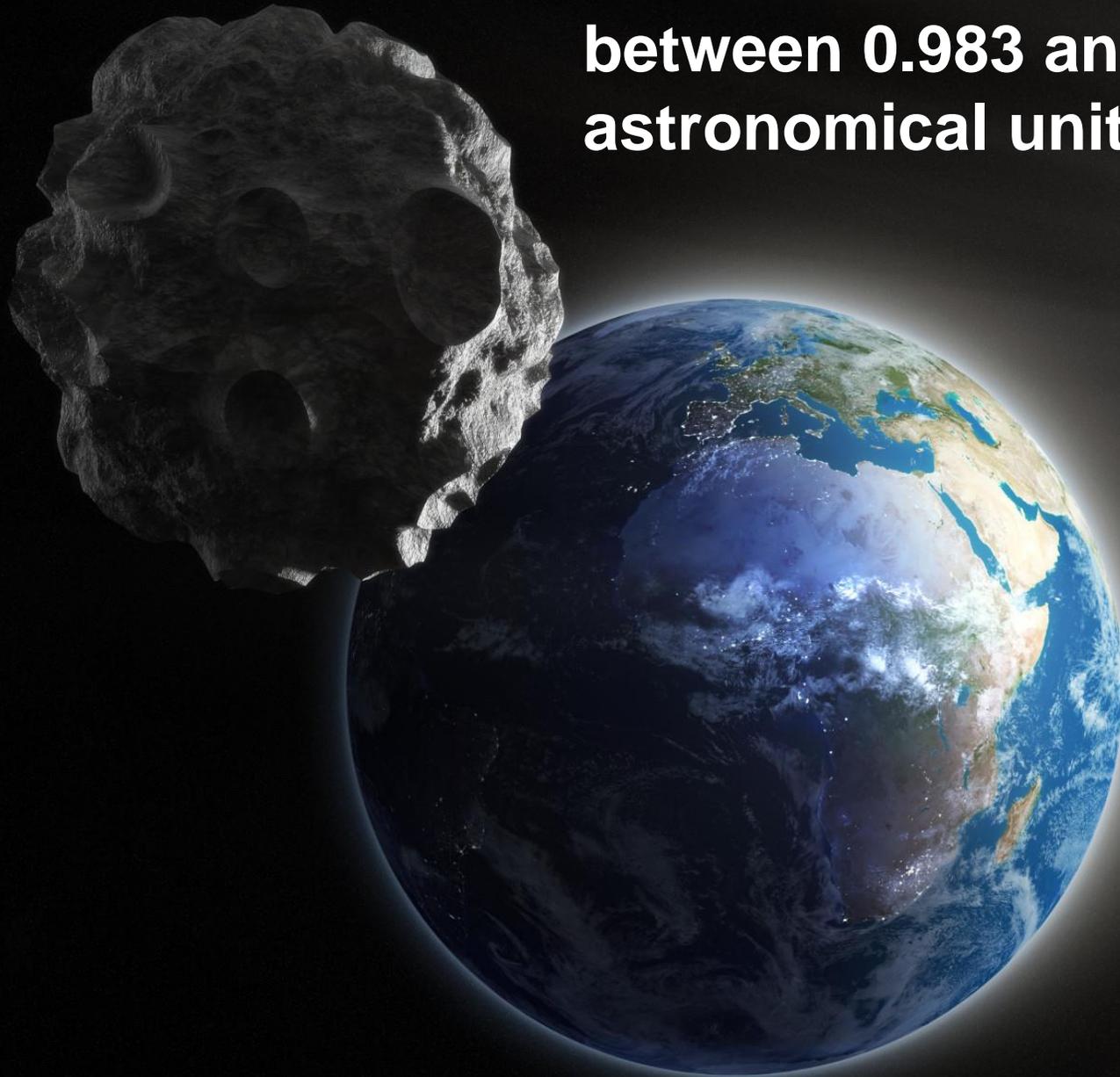




# Near Earth Asteroids – Why Visit One?

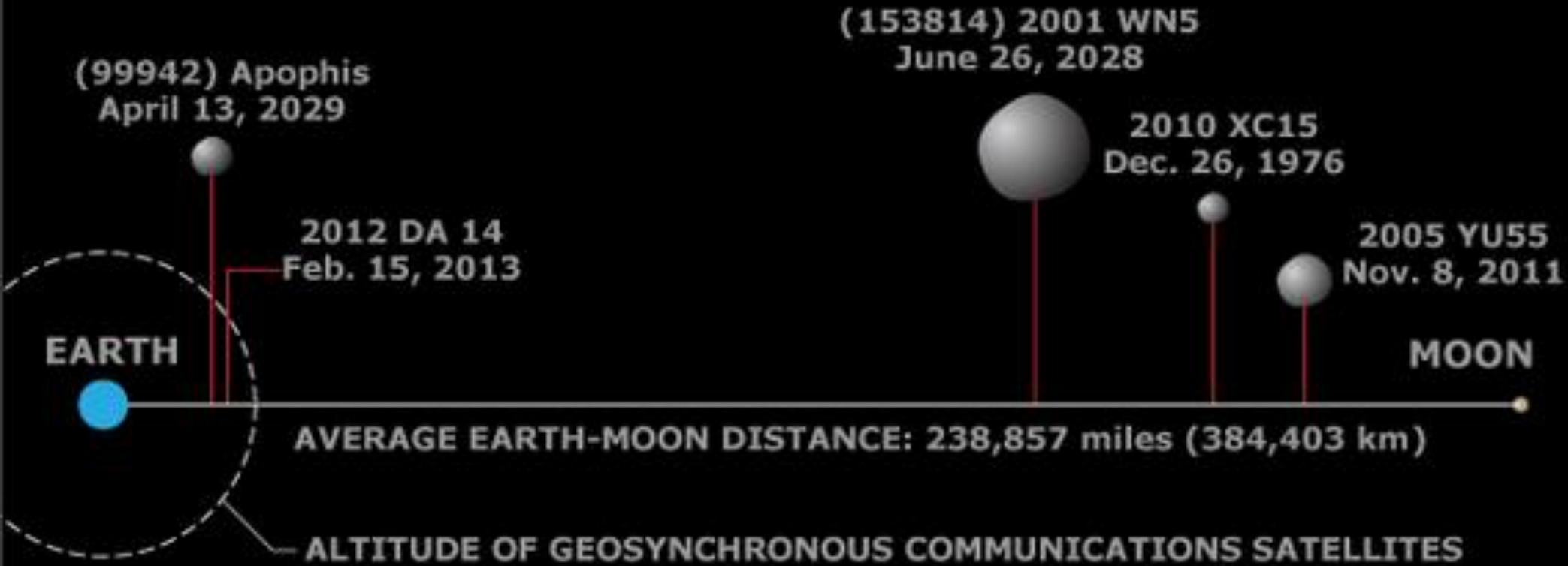


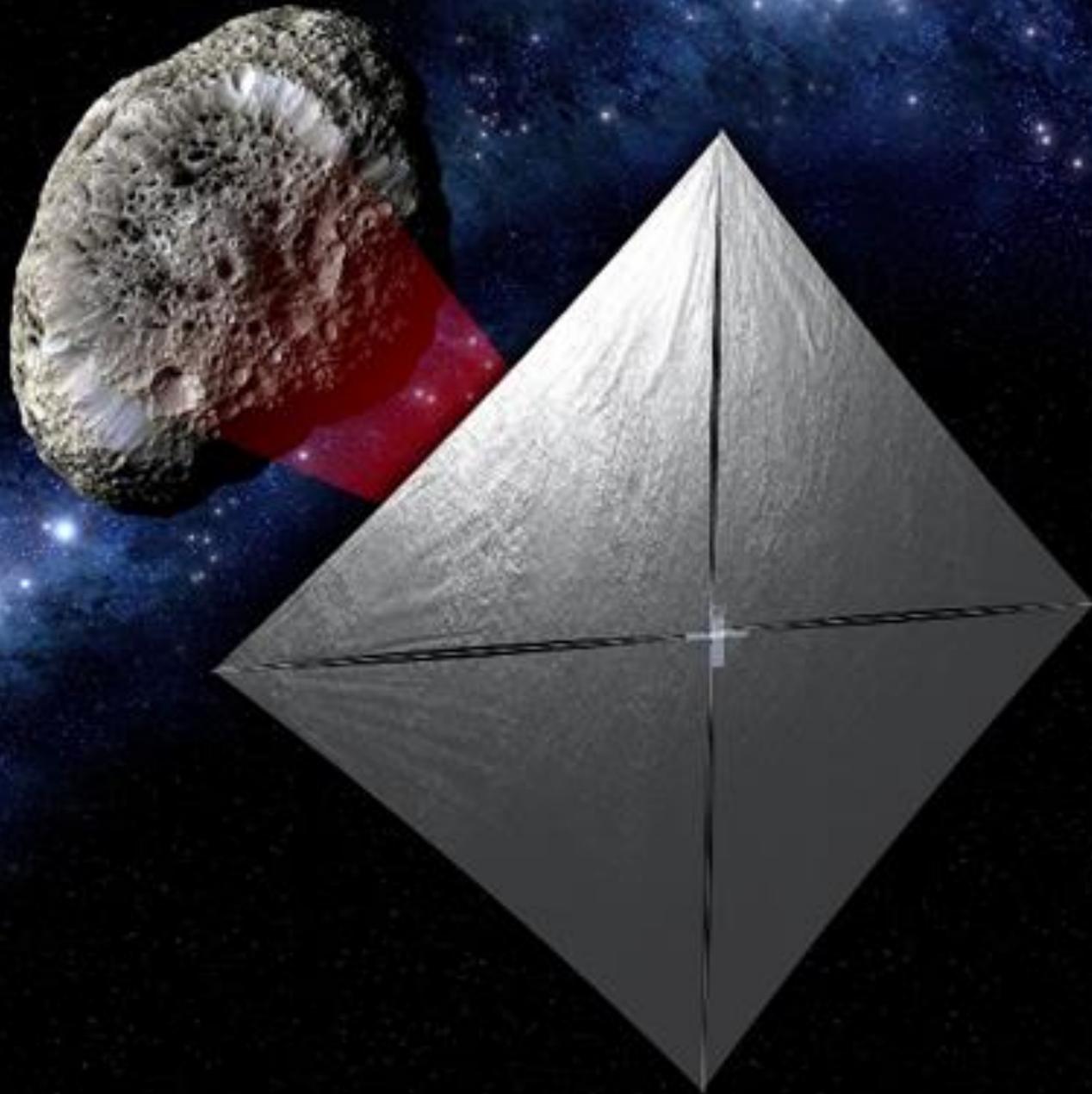
**NEA's have orbits that lie partly between 0.983 and 1.3 astronomical units from the Sun.**



# Famous Flybys of Near-Earth Objects

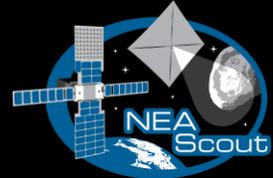
*Note: asteroids are shown to scale with each other but are greatly magnified compared to the Earth and Moon.*





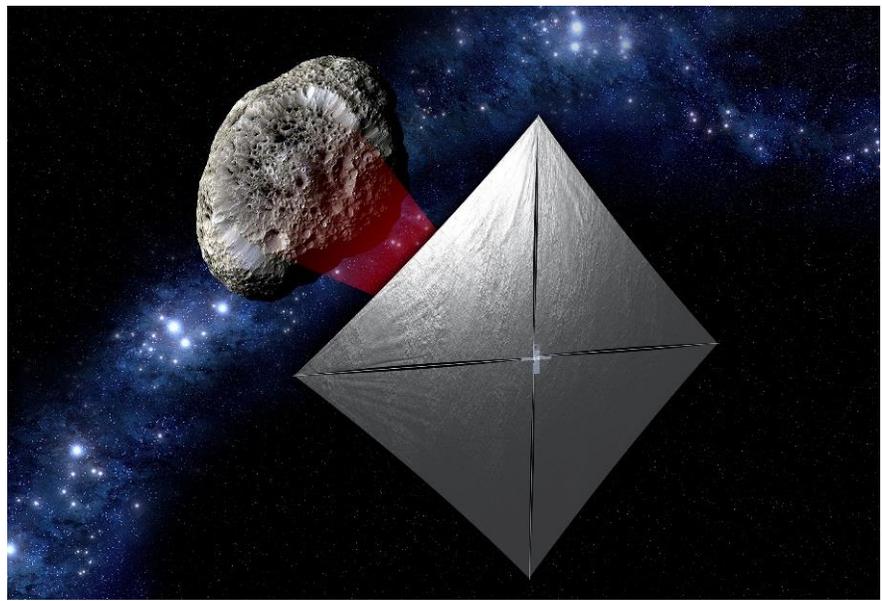


# Near Earth Asteroid Scout Overview



## The Near Earth Asteroid Scout Will

- Image/characterize an asteroid
- Demonstrate a low cost asteroid reconnaissance capability



## Key Spacecraft & Mission Parameters

- 6U cubesat (20 cm X 10 cm X 30 cm)
- ~85 m<sup>2</sup> solar sail propulsion system
- Manifested for launch on the Space Launch System (EM-1/2017)
- Up to 2.5 year mission duration
- 1 AU (93,000,000 mile) maximum distance from Earth

## Solar Sail Propulsion System Characteristics

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

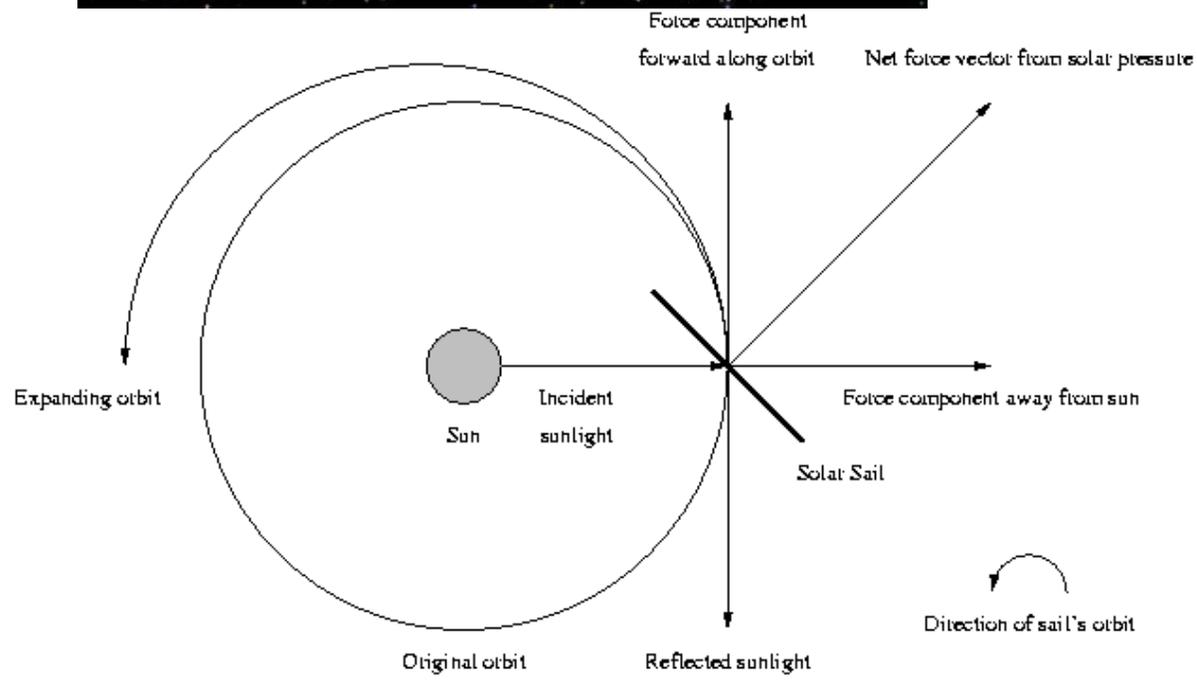
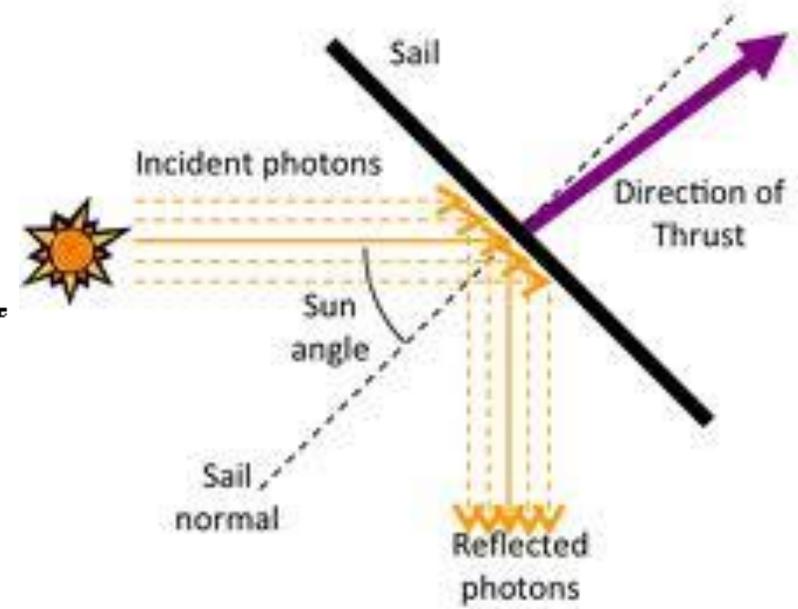
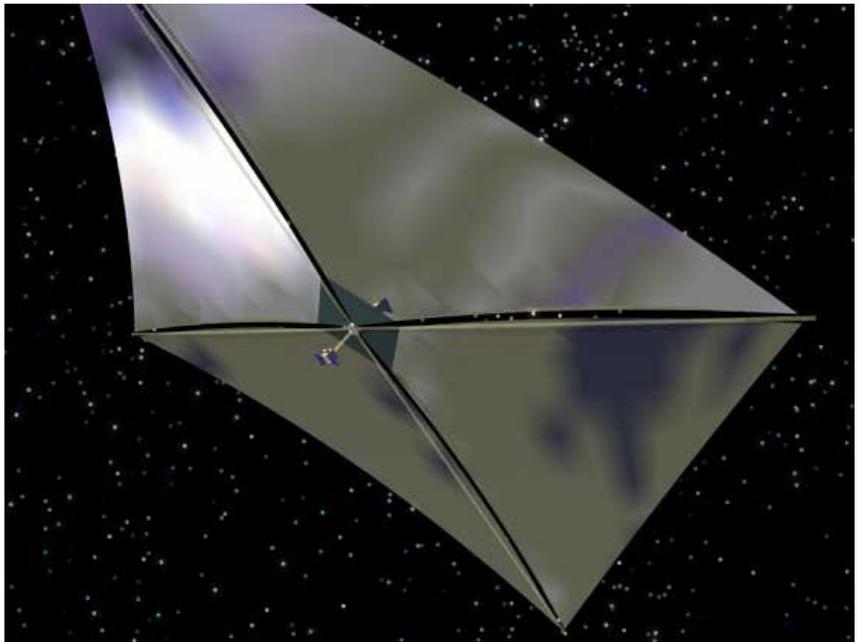




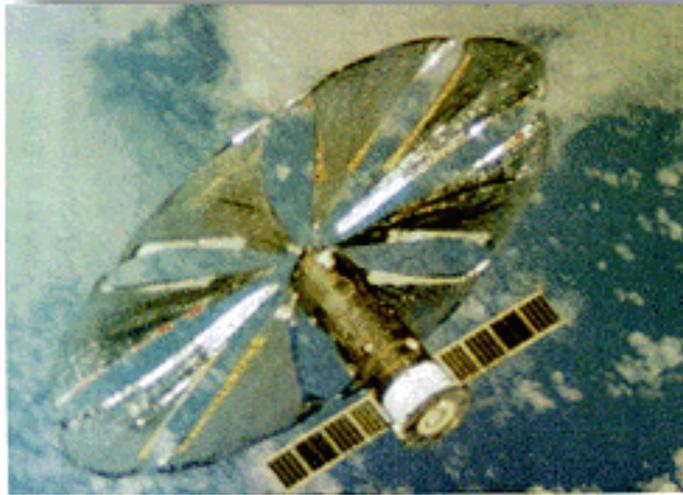
# How does a solar sail work?



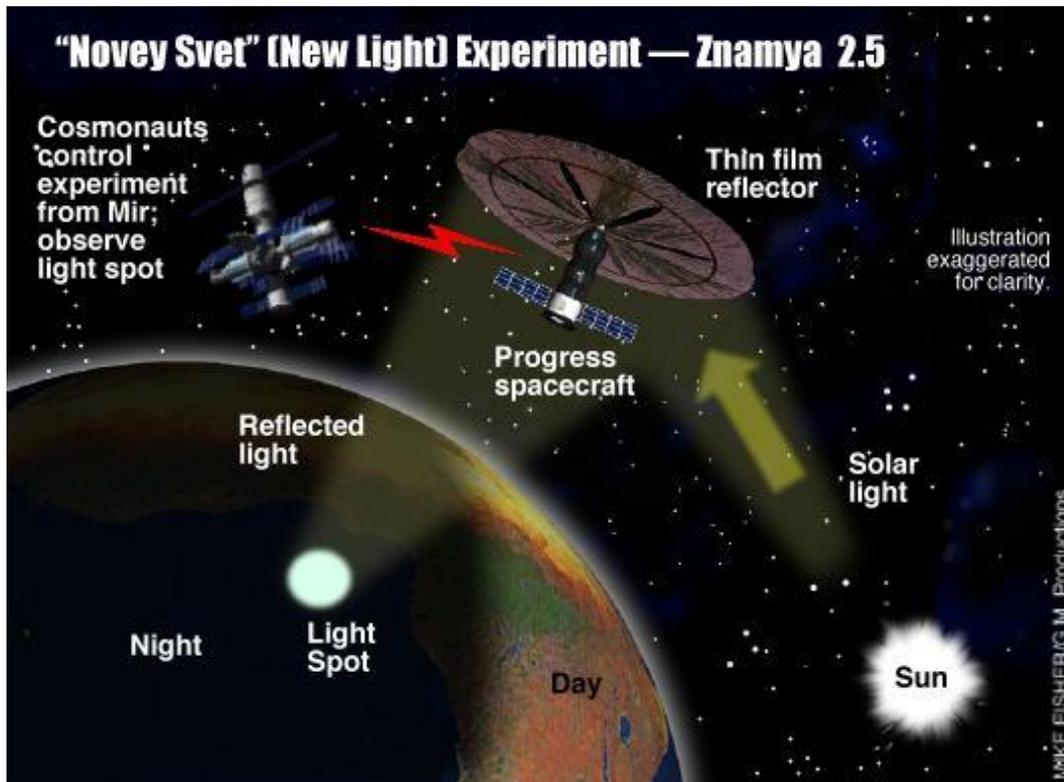
Solar sails use photon "pressure" or force on thin, lightweight reflective sheet to produce thrust.



# Znamya (Space Mirror)

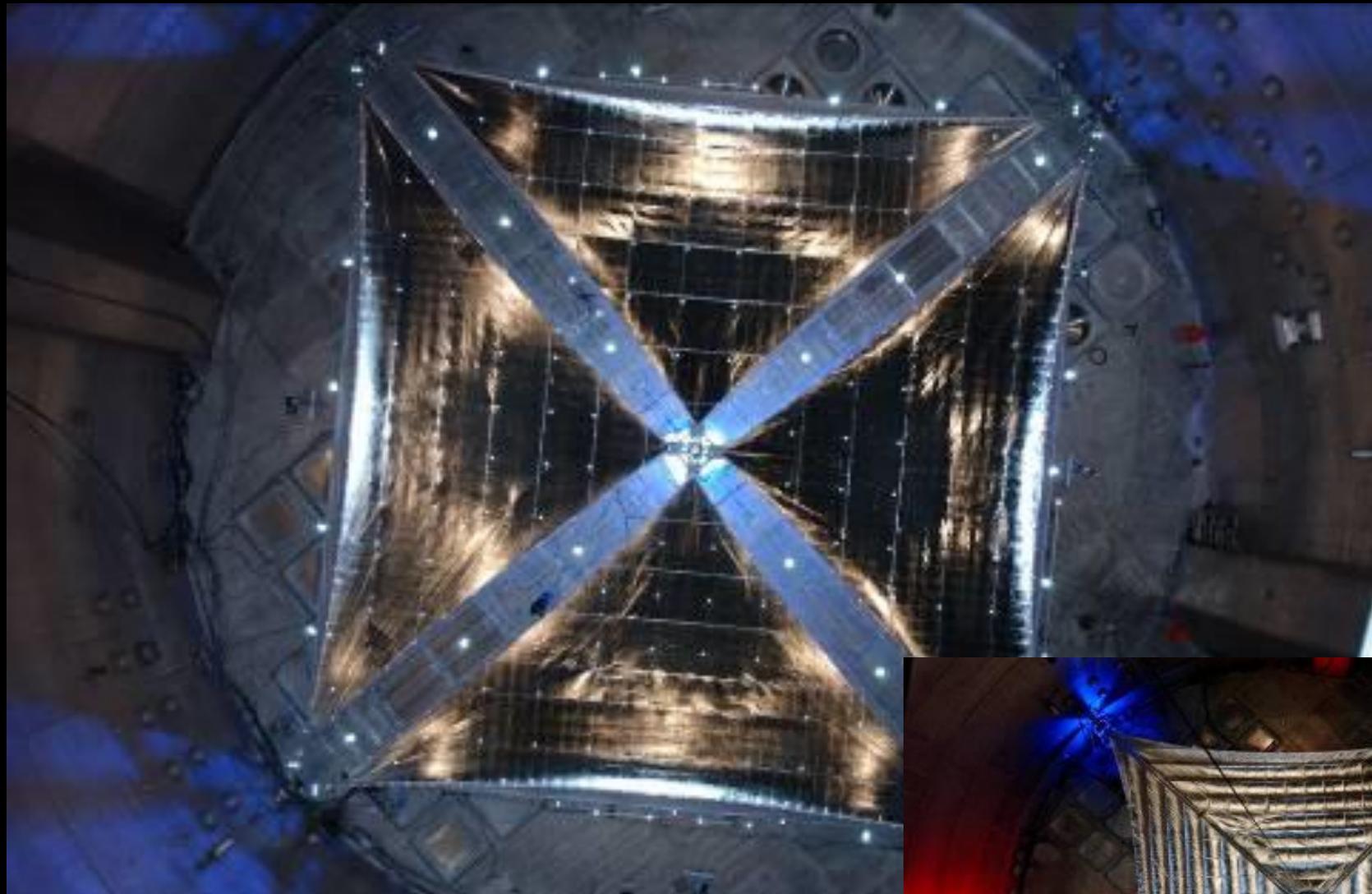


- ◆ Russian experiment that flew on Progress after undocking from Mir Space Station in 1993.
- ◆ Purpose was to reflect sunlight onto the ground from space.
- ◆ 20-m diameter sail successfully deployed
- ◆ 5-km spot illuminated Europe from France to Russia moving at 8 km/sec.
- ◆ Follow-on mission flew, but was damaged during deployment.





# NASA Ground Tested Solar Sails



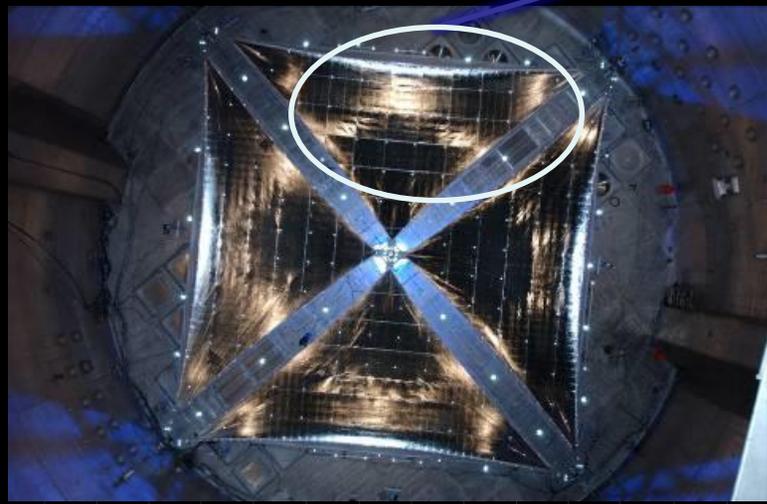


# NanoSail-D Demonstration Solar Sail



10 m<sup>2</sup> sail

Made from tested ground demonstrator hardware



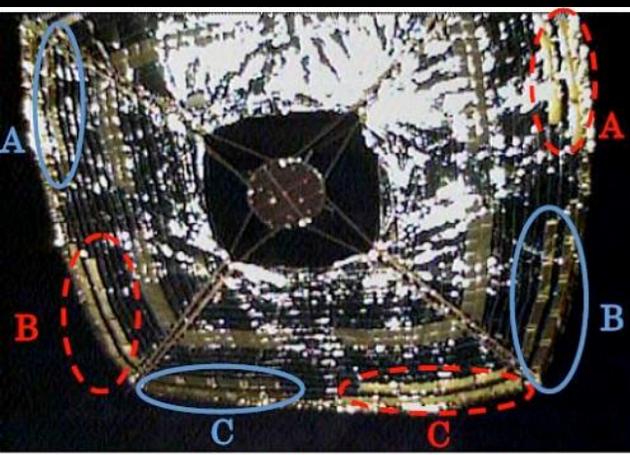


# NanoSail-D in Flight





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



Liquid crystal device power was off.

Liquid crystal device power was on.



# NEA Scout Approximate Scale



Deployed Solar Sail



School Bus



Human

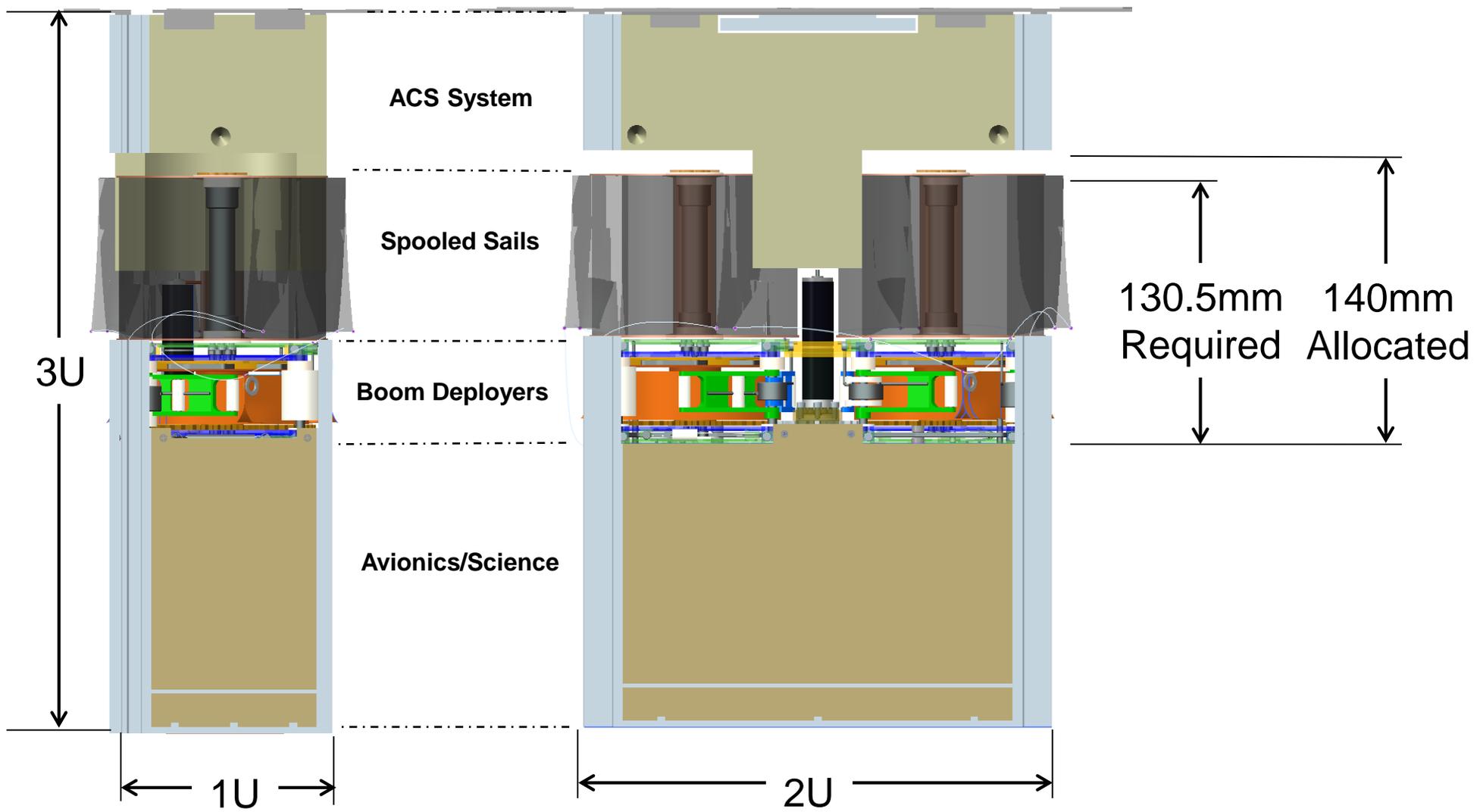
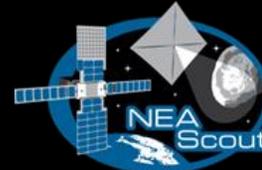
6U Stowed Flight System



Folded, spooled and packaged in here

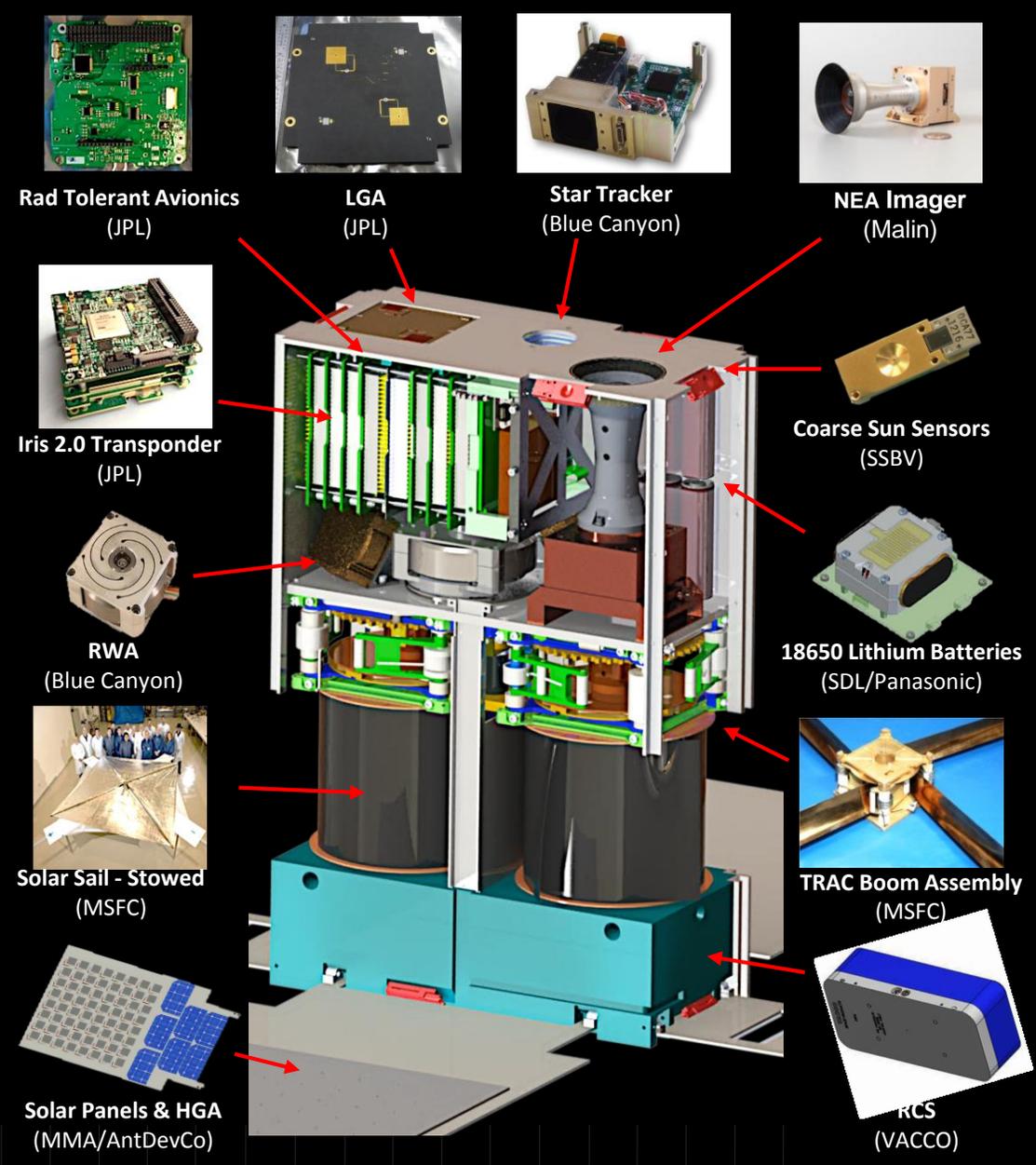


# Solar Sail Volume Envelope

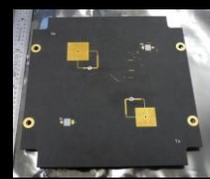




# NEA Scout Flight System Overview



Rad Tolerant Avionics (JPL)



LGA (JPL)



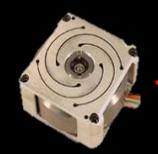
Star Tracker (Blue Canyon)



NEA Imager (Malin)



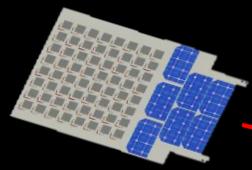
Iris 2.0 Transponder (JPL)



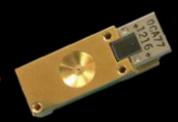
RWA (Blue Canyon)



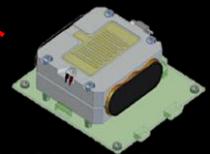
Solar Sail - Stowed (MSFC)



Solar Panels & HGA (MMA/AntDevCo)



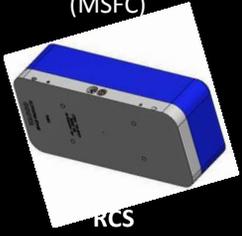
Coarse Sun Sensors (SSBV)



18650 Lithium Batteries (SDL/Panasonic)



TRAC Boom Assembly (MSFC)



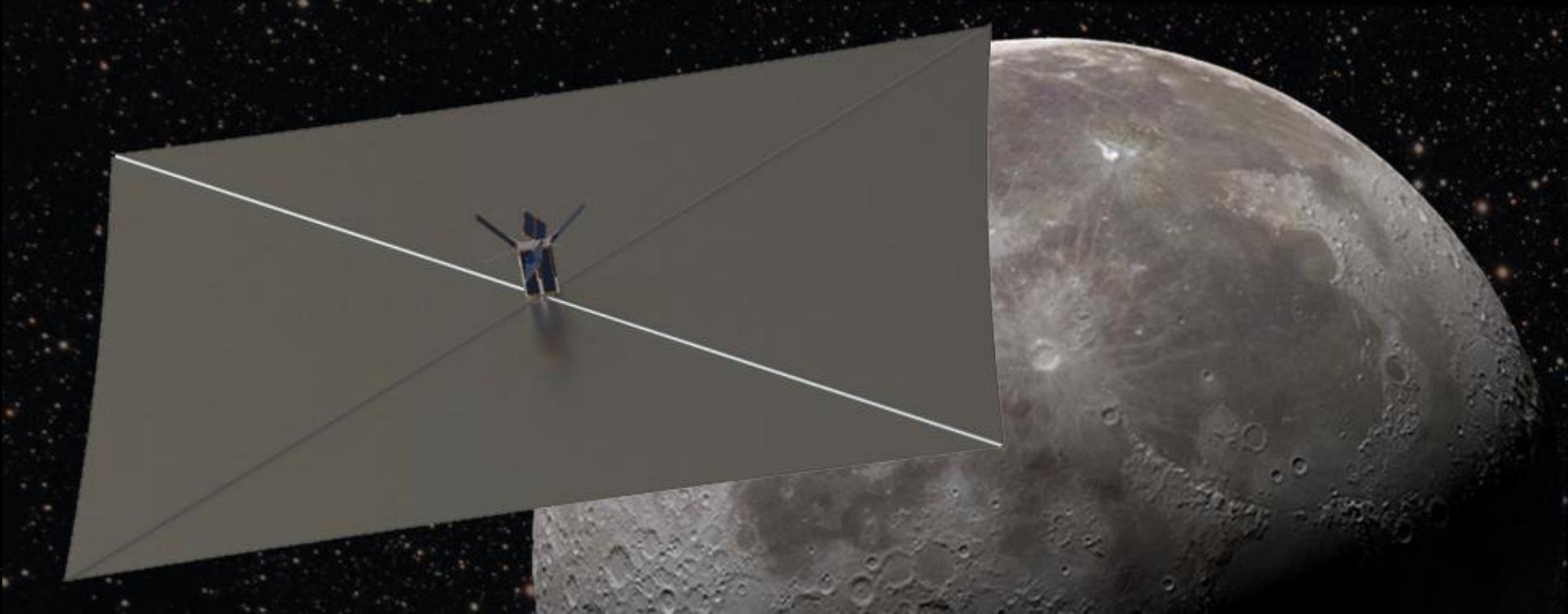
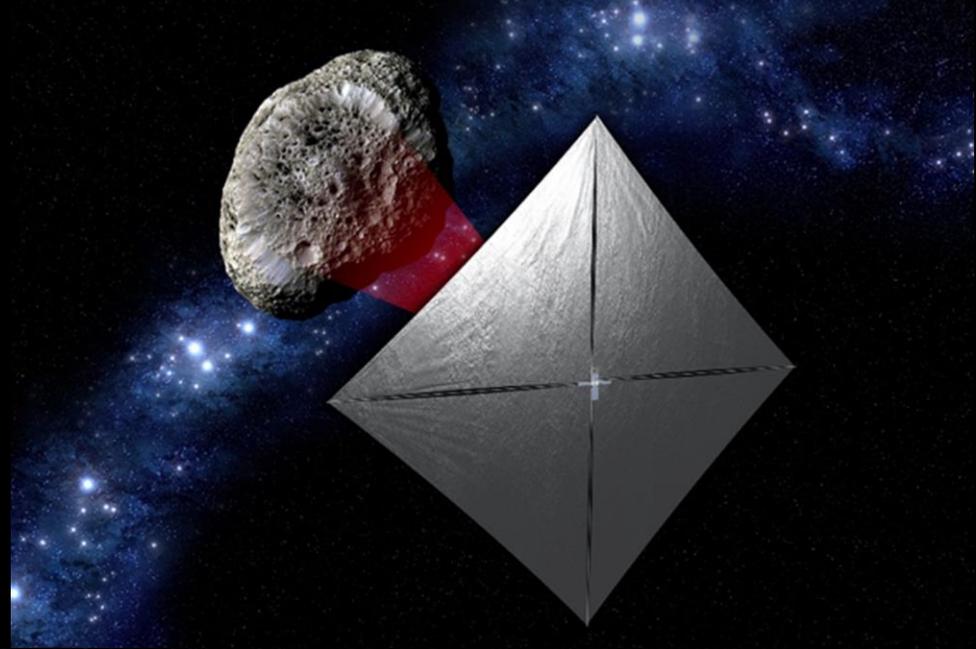
RCS (VACCO)



# NEA Scout and Lunar Flashlight

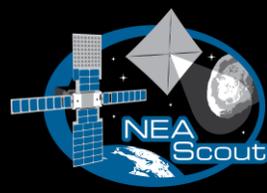


**Both Use Solar Sail Propulsion  
and 6U CubeSats**





# Lunar Flashlight Objective



*Sunlight is reflected off the sail down to the lunar surface. Light reflected off the lunar surface enters the spectrometer to distinguish water ices from regolith.*





# Conclusions



**MSFC develops space flight systems for human and robotic science and exploration**

**The Advanced Concepts Office is MSFC's starting point for future space missions within NASA**

**The Space Launch System began in ACO and one day carry humans well beyond Low Earth Orbit**

**NEA Scout and Lunar Flashlight will launch on SLS and demonstrate a new, low-cost capability for robotic exploration of the solar system**