



Perspectives at 50: Space Science and Exploration Past, Present, and Future

Les Johnson
Science & Technology Office

September 26, 2019

National Aeronautics and
Space Administration



EXPLORE MARSHALL





Ames Research Center

Aerospace and
Small Spacecraft
Moffett Field, Calif.

**Armstrong Flight
Research Center**

Aeronautical Research
and Testing
Edwards, Calif.

Jet Propulsion Laboratory

Deep Space Robotic
Rovers and Science Missions
Pasadena, Calif.

Johnson Space Center

Human Space Flight
Research and Operations
Houston, Texas

Stennis Space Center

Rocket Propulsion Testing
Bay St. Louis, Miss.

**Michoud
Assembly Facility**

Large Vehicle
Manufacturing
New Orleans, La.

**Marshall Space
Flight Center**

Launch Vehicle Development,
Chemical Propulsion, and
Science Instrument
Development
Huntsville, Ala.

Glenn Research Center

Electric Propulsion and
Small Spacecraft
Technology
Cleveland, Ohio

**Goddard Space
Flight Center**

Science Missions
and Telescopes
Greenbelt, Md.

**NASA
Headquarters**

Washington, D.C.

Langley Research Center

Aviation and Space Research
Hampton, Va.

Kennedy Space Center

Ground Operations
and Services
Cape Canaveral, Fla.

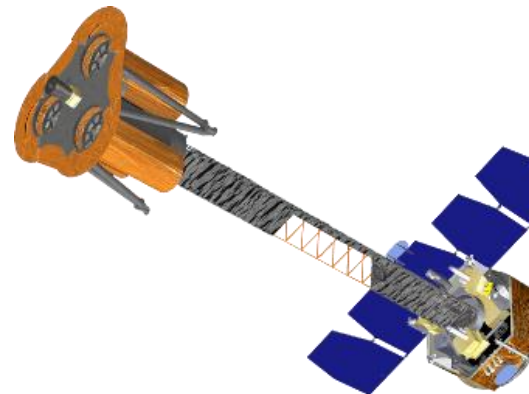


Marshall Space Flight Center

**Traveling To
and Through
Space**



**Living and
Working in Space**



**Supporting Agency
Mission Operations**



**Understanding Our
World and Beyond**

Marshall's Mission Areas

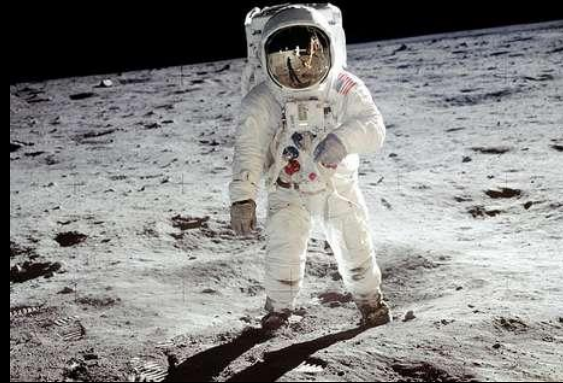
Accomplishments of the Space Age (so far)

Human Exploration

First person in space



First people on the Moon



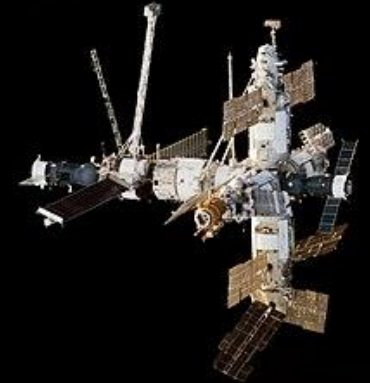
International Space Station



First space walk



First reusable spacecraft



Mir Space Station

Accomplishments of the Space Age (so far)

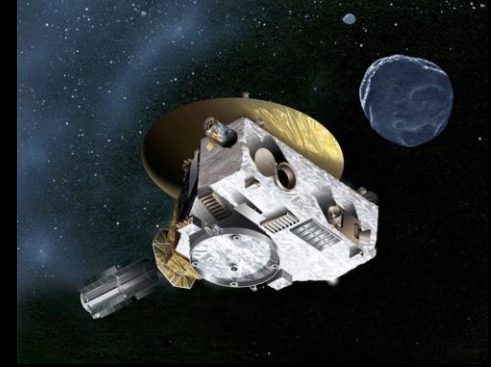
Robotic Exploration



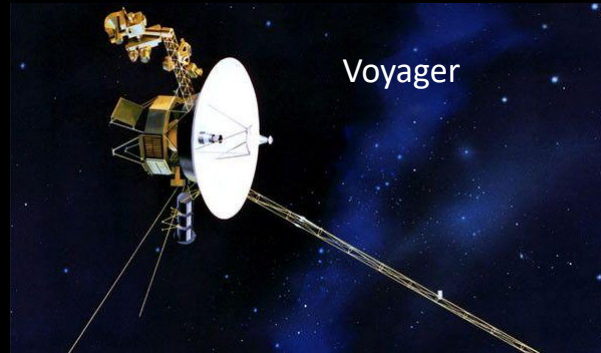
Venera on Venus



New Horizons past Pluto



Voyager

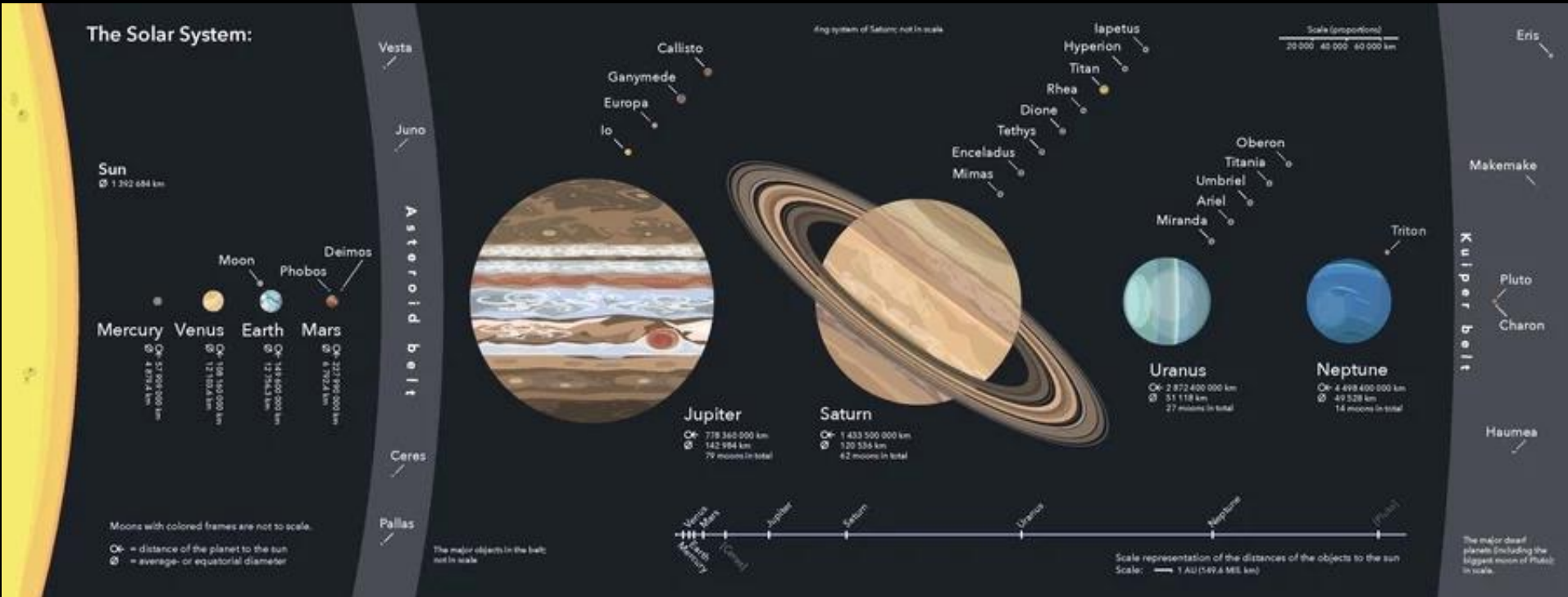


Asteroid sample returns



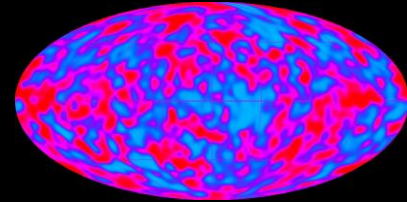
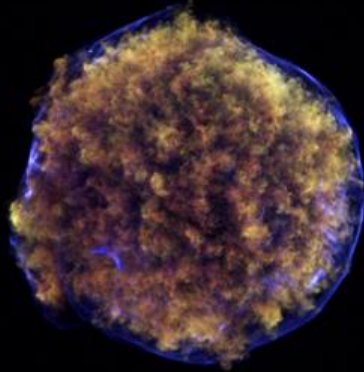
Accomplishments of the Space Age (so far)

Mapping and Visiting the Solar System

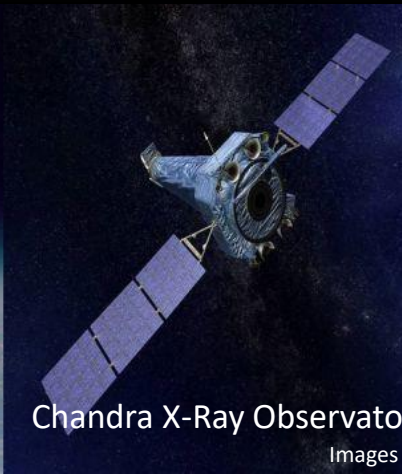


Accomplishments of the Space Age (so far)

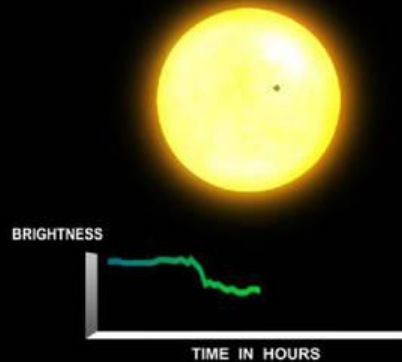
Imaging and Studying the Universe



Hubble Space Telescope



Chandra X-Ray Observatory



Kepler and Transiting
Exoplanet Survey Satellite



Cosmic Background
Explorer

Images Courtesy of NASA

Accomplishments of the Space Age (so far)

Commercialization of Low Earth Orbit

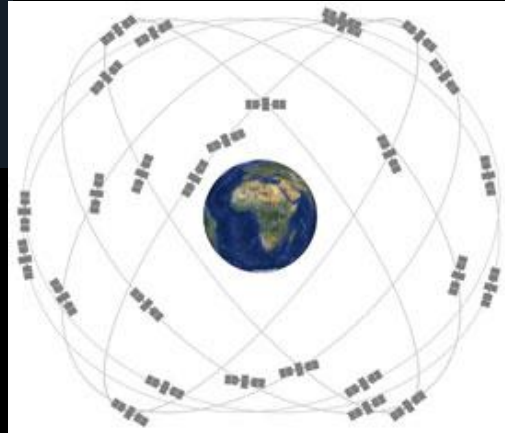
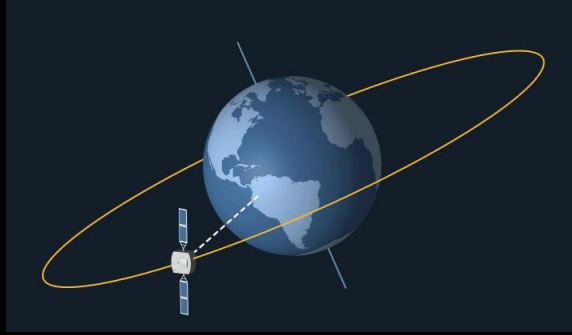


Image Courtesy of gps.gov



All Other Images Courtesy of NASA

THE NASA CHARGE TO THE MOON



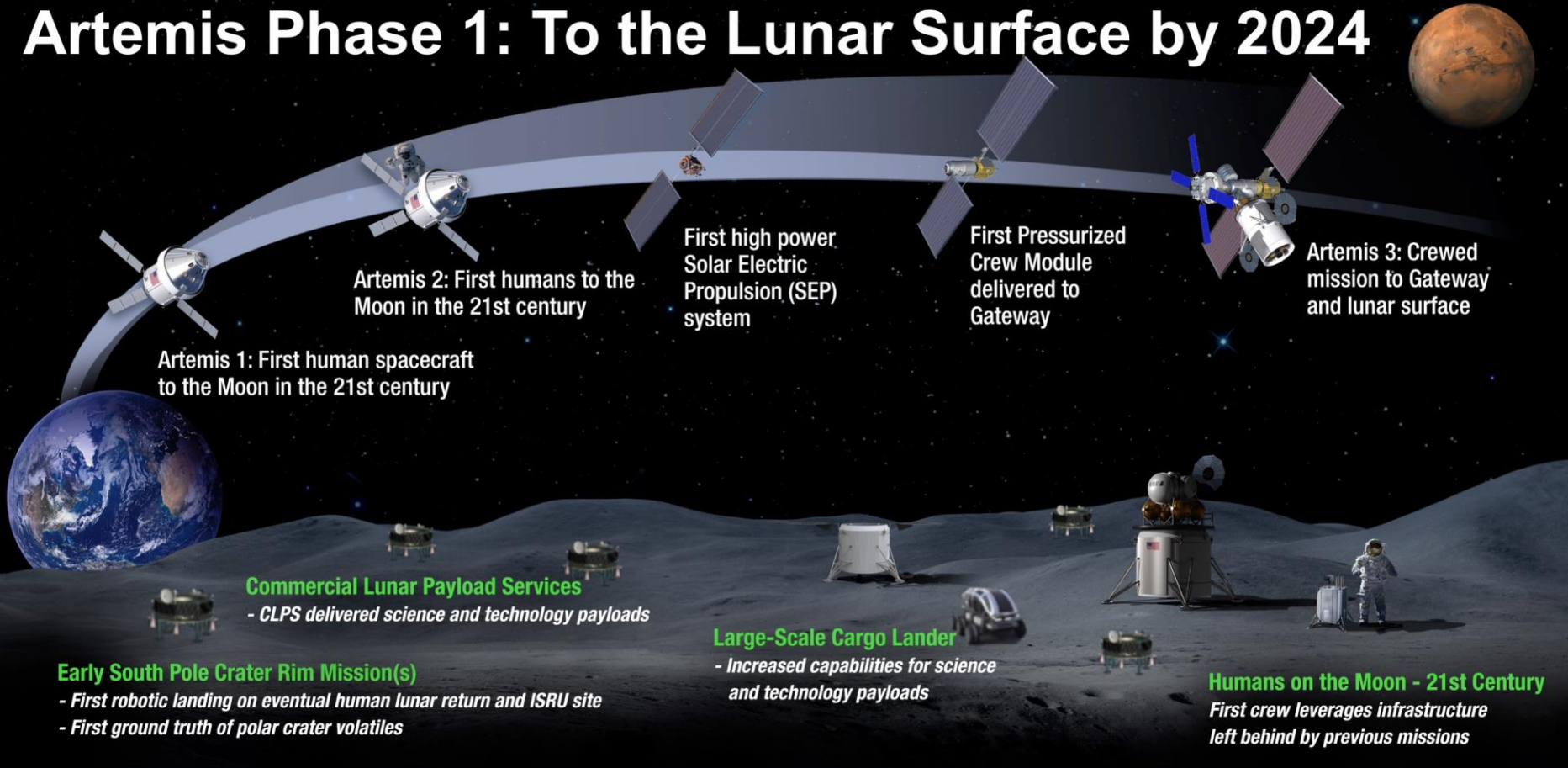
In keeping with SPD-1, NASA is charged with landing the first American woman and next American man at the South Pole of the Moon by 2024, followed by a sustained presence on and around the Moon by 2028.

NASA will “use all means necessary” to ensure mission success in moving us forward to the Moon.



Vice President Mike Pence speaks about NASA’s mandate to return American astronauts to the Moon and on to Mars at the U.S. Space & Rocket Center in Huntsville, Alabama.

Artemis Phase 1: To the Lunar Surface by 2024



LUNAR SOUTH POLE TARGET SITE

2019

2024



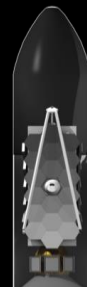
Space Launch System

NASA'S SPACE LAUNCH SYSTEM

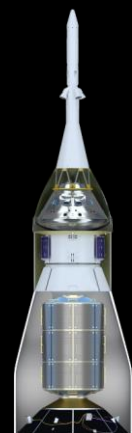
UNIQUE CAPABILITY FOR EXPLORATION

VOLUME

- Block 1B: **Double the volume** of any contemporary heavy lift vehicle
- **Only vehicle** that can carry the Orion and a co-manifested payload to the Moon



8.4 m x 27.4 m
fairing with
large-aperture
telescope



Orion
with
Gateway
Missions

MASS

- Block 1B: Can launch **50% more mass** than any contemporary launch vehicle
- Block 2: Mars-enabling capability of **greater than 45 metric tons** to Trans Lunar Injection



Contemporary
Heavy Lift



SLS
Block 1B



SLS
Block 2

DEPARTURE ENERGY

- **Reduce transit times by half or greater** to the outer solar system
- Enables larger payloads to **deep space destinations**



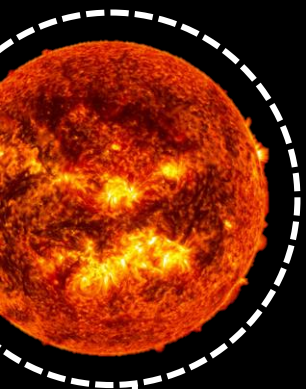


ARTEMIS 1

FULL SYSTEMS CHECKOUT PRIOR TO CREWED MISSIONS

Artemis 1 SECONDARY PAYLOADS

SMALLSATS TO BE DEPLOYED FROM THE ORION STAGE ADAPTER

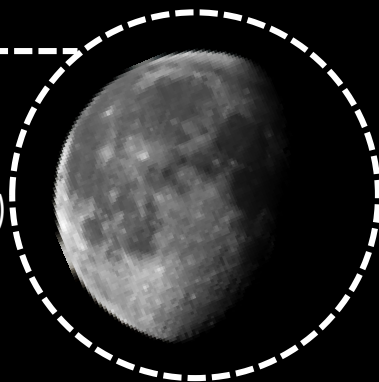


SUN

- CuSP (Southwest Research Institute)

MOON

- Lunar Flashlight (NASA)
- Lunar IceCube (Morehead State University)
- LunaH-Map (Arizona State University)
- OMOTENASHI (JAXA)
- LunIR (Lockheed Martin)
- EQUULEUS (JAXA)

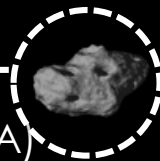


EARTH-MOON

- ArgoMoon (ESA/ASI)

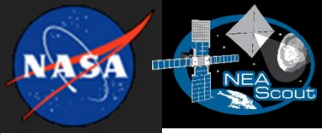
ASTEROID

- NEA Scout (NASA)



...AND MORE

- Biosentinel (NASA)
- Cislunar Explorers (Cornell University)
- CU-E³ (University of Colorado Boulder)
- Team Miles (Miles Space)

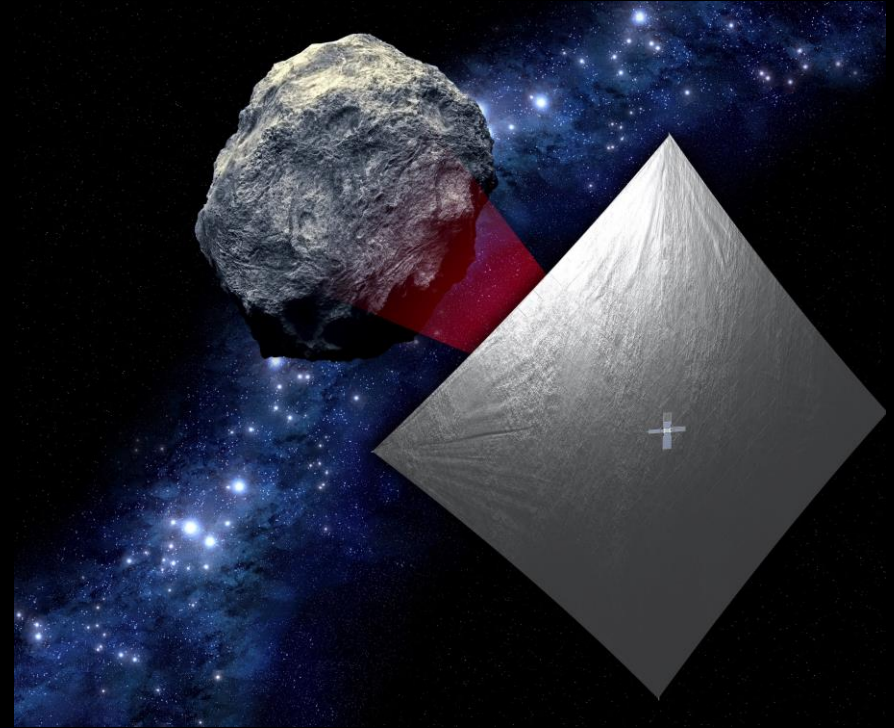


Near Earth Asteroid Scout

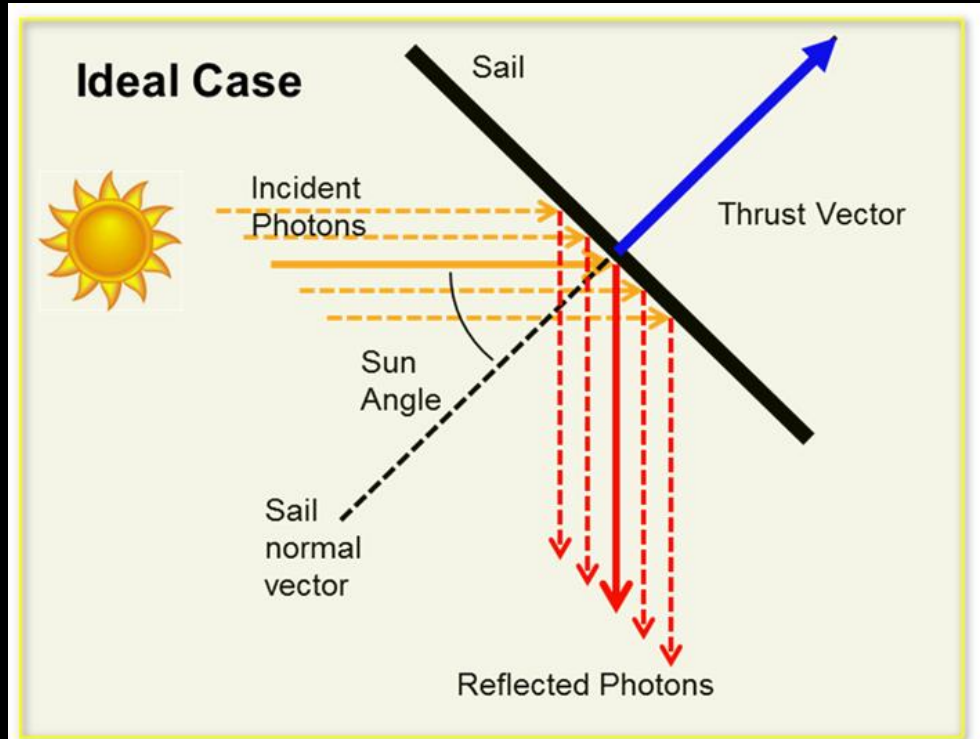
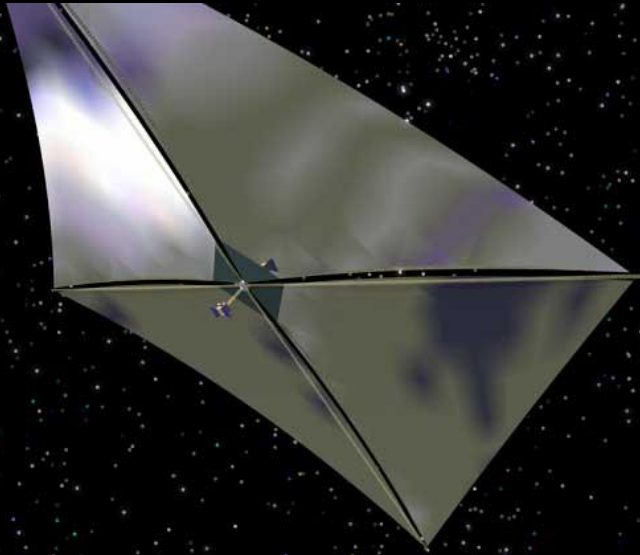
GOALS

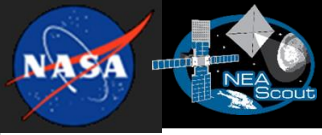
- Characterize one candidate NEA with an imager to address key Strategic Knowledge Gaps (SKGs) for Human Exploration
- Demonstrate low cost capability for NEA detection and reconnaissance
- *(And fly a solar sail in interplanetary space!)*

Measurements: *NEA volume, spectral type, spin and orbital properties, address key physical and regolith mechanical SKGs*

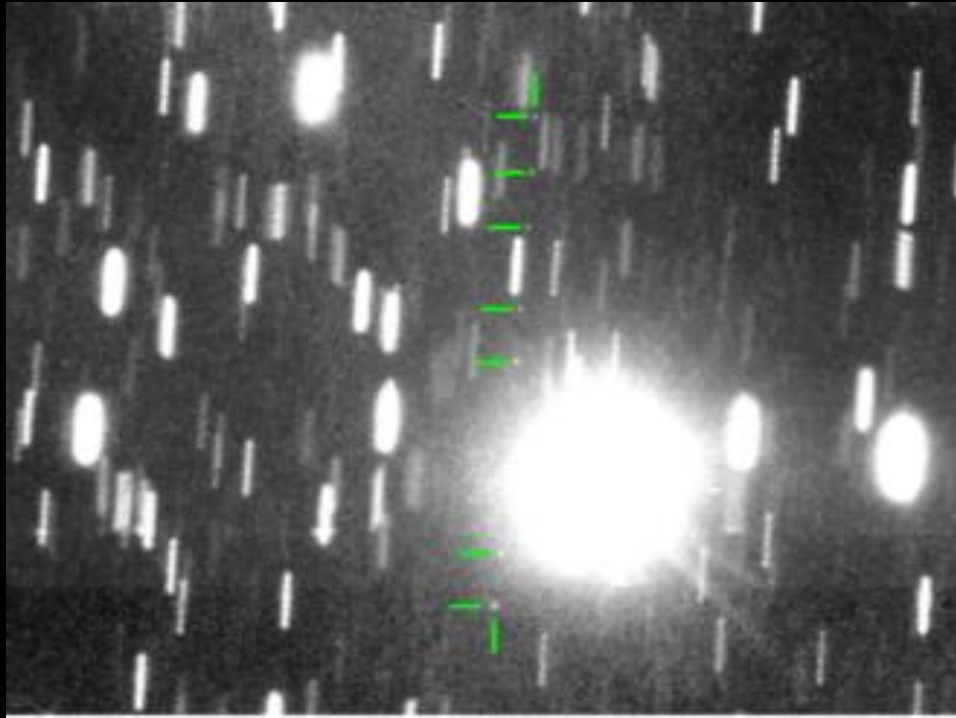


Solar sails use photon “pressure” or force on thin, lightweight reflective sheet to produce thrust.





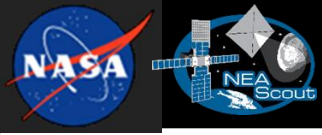
Target Asteroid: 1991 VG



- 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

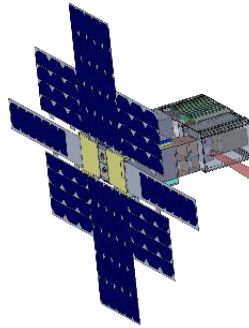
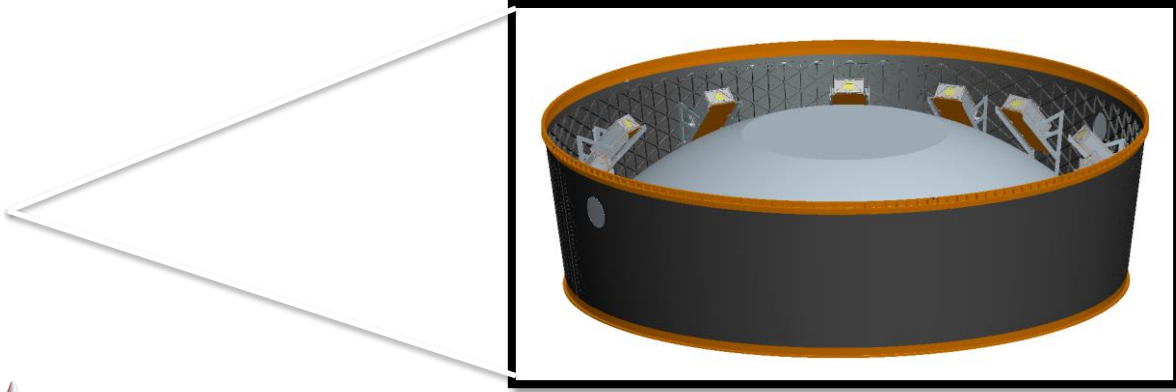
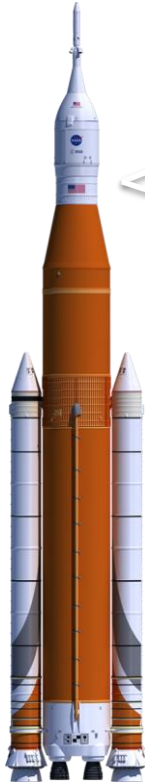
Near-Earth Asteroid 1991VG (marked with green lines) on 2017 May 30. This is a composite of 7 images obtained with the ESO VLT. These images have been combined, tracking the position of the asteroid. The stars appear trailed due to the motion of the asteroid during each series.

Credit Hainaut/Micheli/Koschny

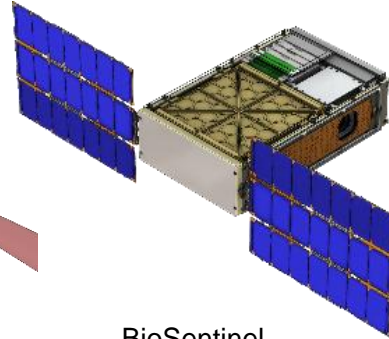


NEA Scout Launch

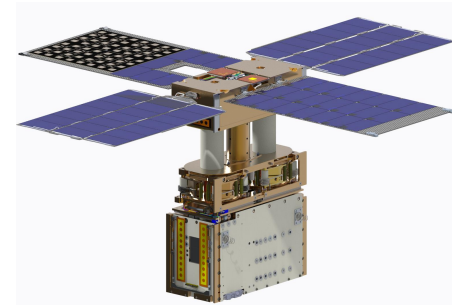
NEA Scout is one of 13 secondary payloads launching on Artemis-1



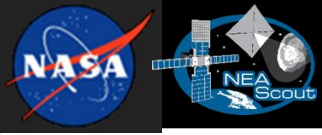
Lunar Flashlight



BioSentinel

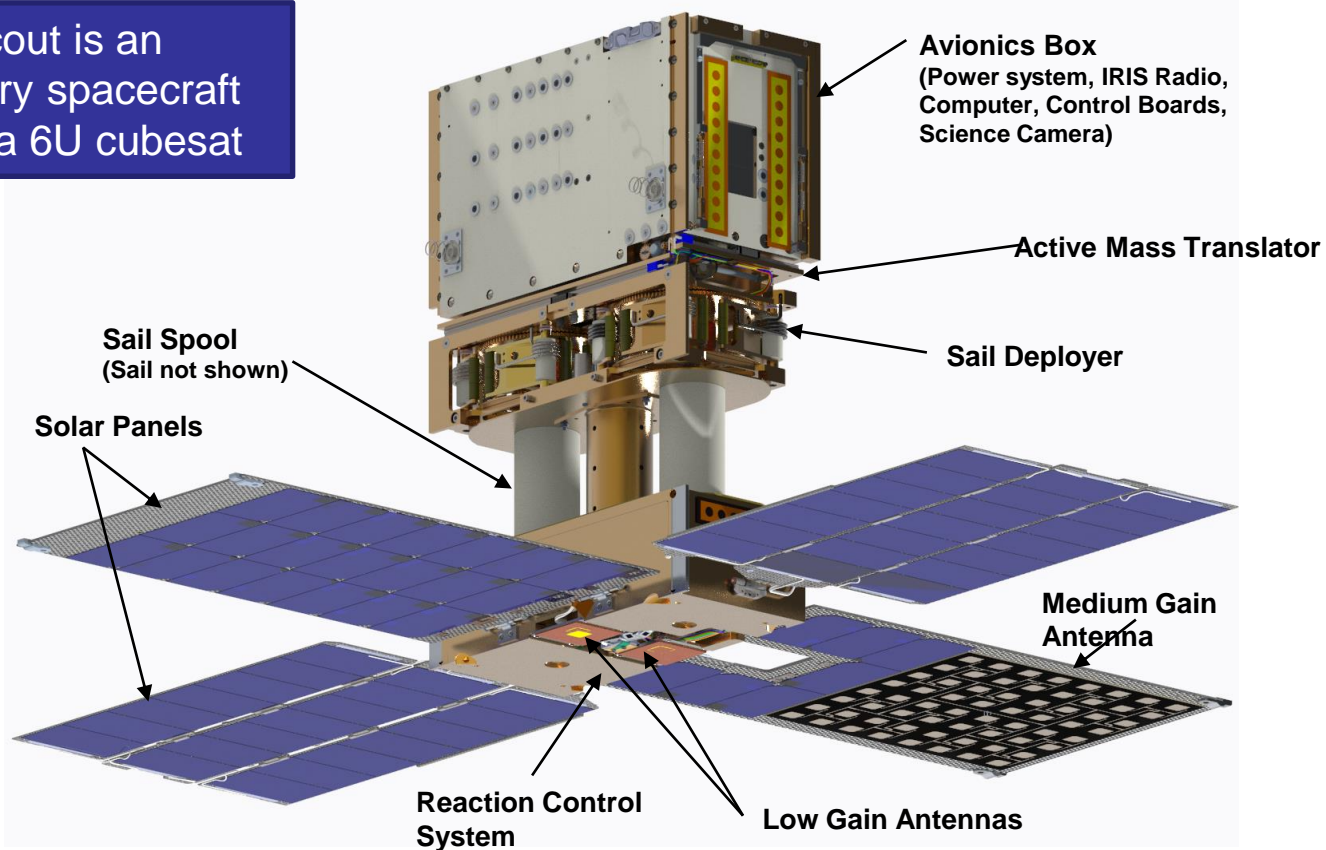


NEA Scout



Spacecraft Overview

NEA Scout is an interplanetary spacecraft stuffed into a 6U cubesat





~9 x ~9m Solar Sail

Deployed Solar Sail



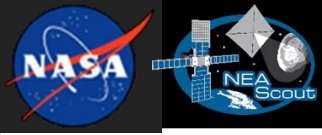
School Bus



6U
Stowed
Flight
System

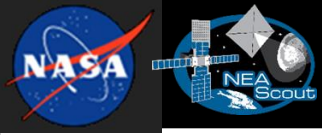


Folded, spooled and packaged in here



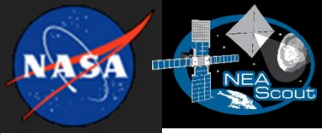
Full Scale EDU Testing





Flight Sail Testing





Flight Sail Testing



Solar Cruiser

The image shows a large, triangular solar sail spacecraft, the Solar Cruiser, positioned in space. The sail is a complex, multi-faceted structure made of a highly reflective material, likely gold-coated polyimide, which is stretched over a central hub and radiating booms. The sail is illuminated by the Sun, which is visible in the upper left corner as a bright, fiery orange and yellow sphere with a turbulent surface. The background is the dark, star-filled expanse of space. The text 'Solar Cruiser' is overlaid in white at the top center.

- 90 kg spacecraft
- 1666 m² solar sail
- Sub-L1 station-keeping



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