

National Aeronautics and
Space Administration



SmallSats supporting Deep Space Human Exploration

August 06, 2018

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Advanced Exploration Systems, HEOMD, NASA HQ



Background about me...



COLLEGE OF ENGINEERING
CAL POLY POMONA



1990



1990



1997



2001



2003



2006



2007

National Advisory Committee for Aeronautics



Joseph S. Ames



NACA

Langley

Ames

Lewis

Dryden

NASA

1915

1939

1940

1946

1958

National Aeronautics and Space Administration

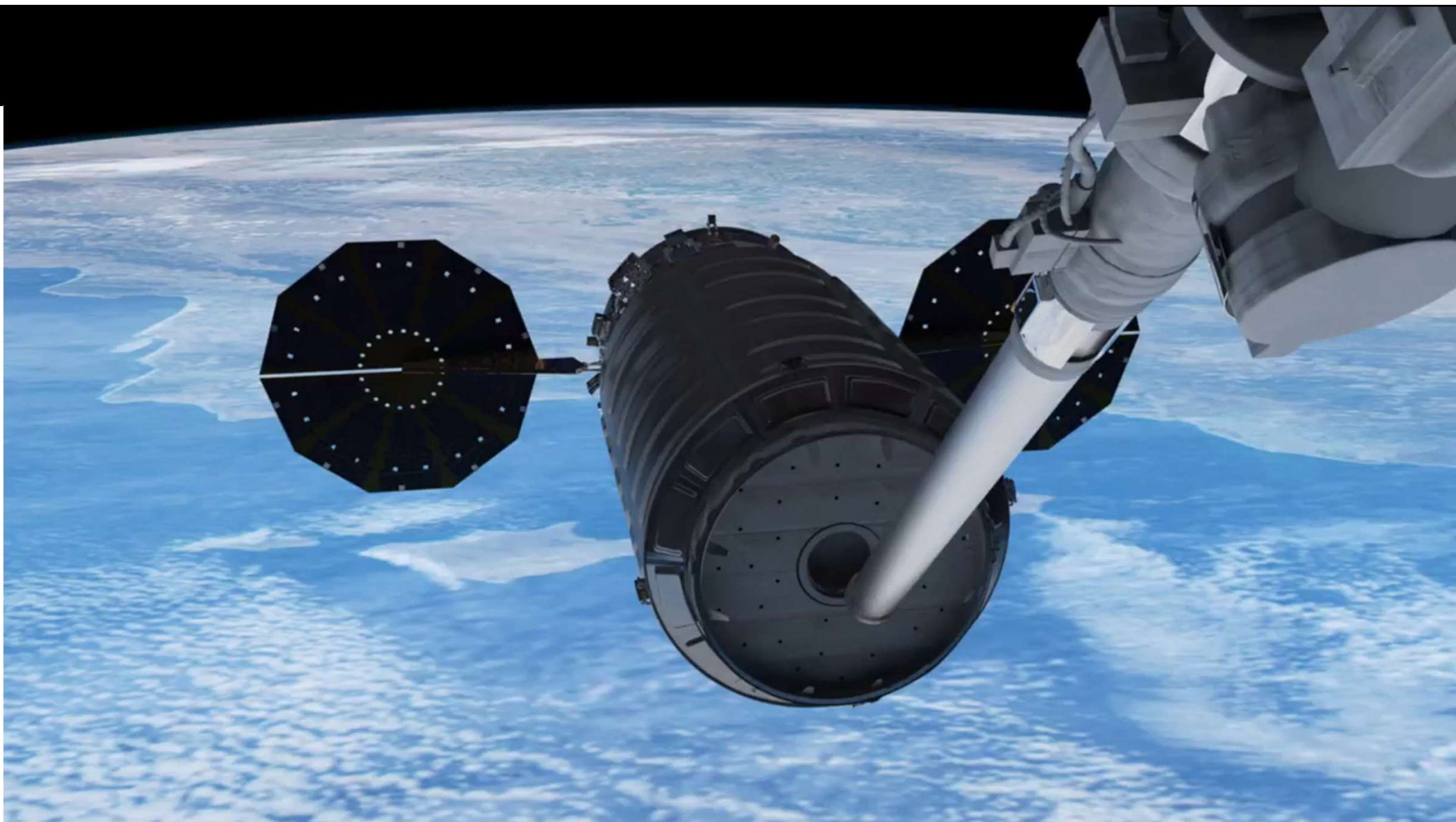


N



EXPLORATION





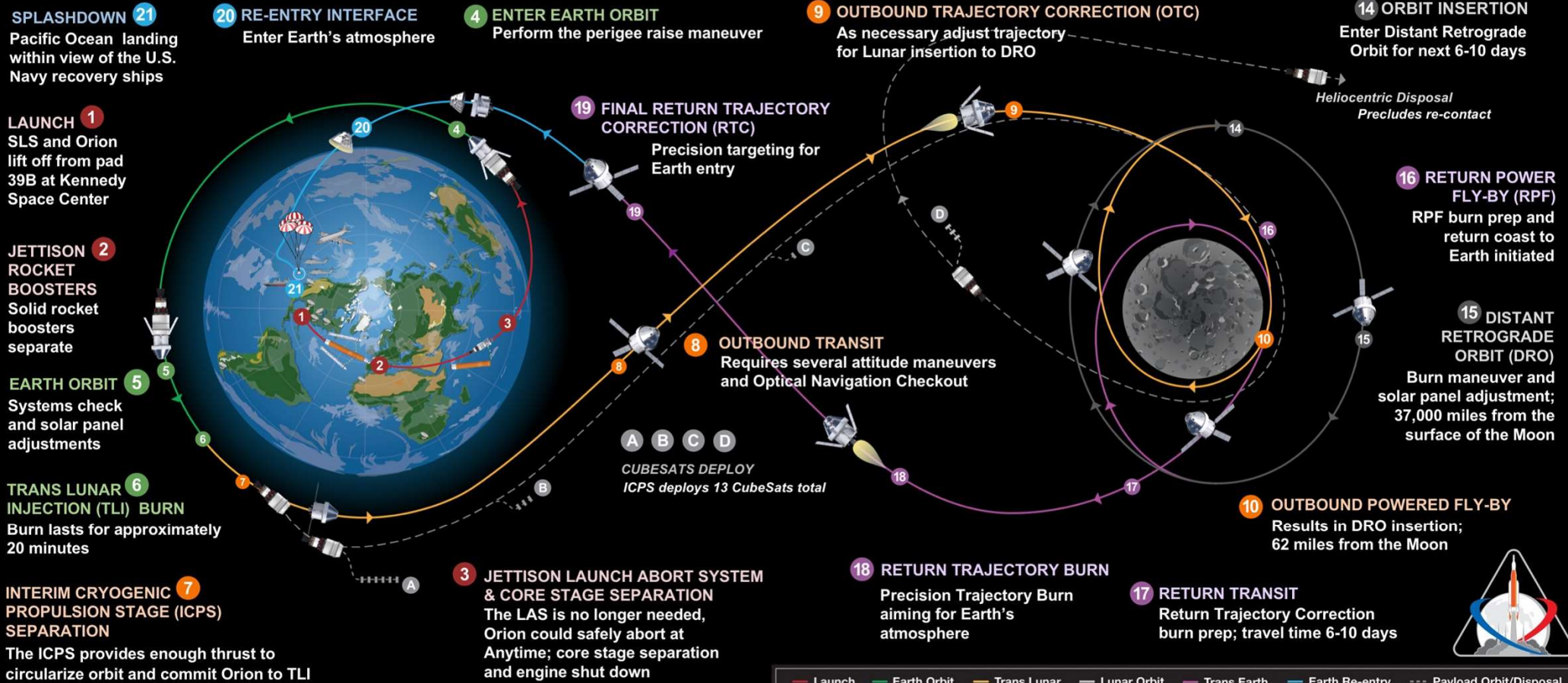
NASA'S DEEP SPACE EXPLORATION SYSTEM

The Orion spacecraft and Space Launch System rocket, launching from a modernized Kennedy spaceport is foundational to extending human presence deeper into the solar system.



EXPLORATION MISSION-1

The first uncrewed, integrated flight test of NASA's Orion spacecraft and Space Launch System rocket, launching from a modernized Kennedy spaceport

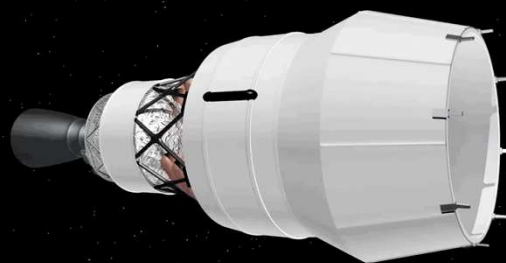
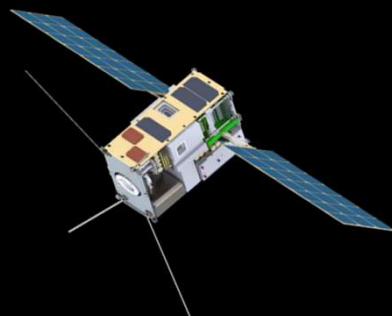


Total distance traveled: 1.3 million miles – Mission duration: 25.5 days – Re-entry speed: 24,500 mph (Mach 32) – 13 CubeSats deployed

EM-1 Secondary Payloads



INTERIM
CRYOGENIC
PROPULSION
STAGE



13 CUBESATS SELECTED TO FLY ON EM-1

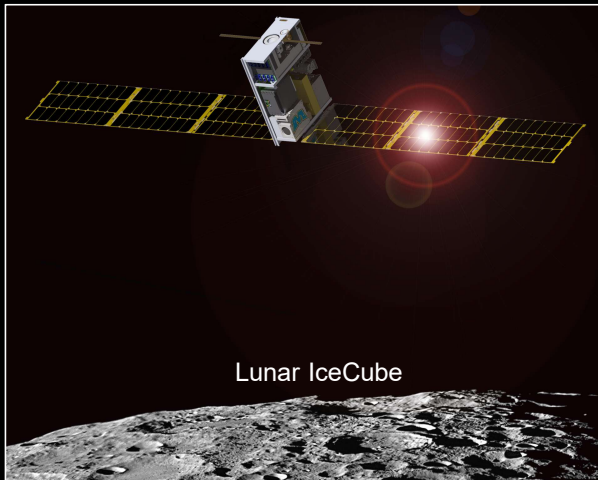
- Lunar Flashlight
 - Near Earth Asteroid Scout
 - Bio Sentinel
 - LunaH-MAP
 - CuSP
 - Lunar IceCube
 - LunIR
 - EQUULEUS (JAXA)
 - OMOTENASHI (JAXA)
 - ArgoMoon (ESA)
 - STMD Centennial Challenge
- Winners: CU-E3, CisLunar Explorers,
& Team Miles



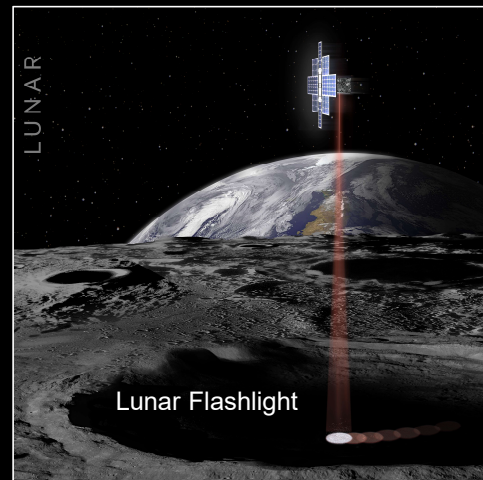
HEOMD/AES Deep Space SmallSats: SLS EM-1 Secondary Payloads



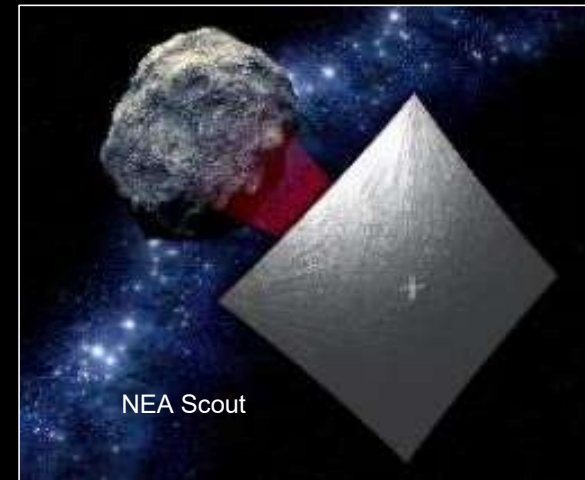
LunIR



Lunar IceCube



Lunar Flashlight



NEA Scout



BioSentinel

AES SmallSat Missions selected to contribute to key Human Exploration Strategic Knowledge Gaps and to Advance Key Technologies

HEOMD/AES Deep Space SmallSats: Deep Space Station 17 (DSS-17)



LRO Demonstrations:

- Routinely Tracking LRO at S-band
- Intermediate Frequency (IF) Systems and DSN Downlink Equipment (DCD, DTT) Verified
- LRO Telemetry Blocks Sent Directly from DSS-17 to JPL DSOC over the NASA Mission Backbone- verifying DSS-17 Signal Path

MarCO Demonstrations:

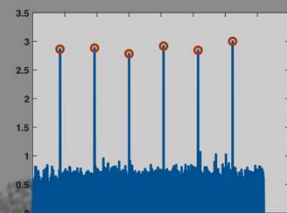
- Downlink Using X-Band Feed and DSN Equipment
- Downlink Using X-Band Feed and MarCO Receiver System
- OMSPA Using X-Band Feed and Custom SDR-based Multiple Receiver System

First OMSPA Demonstration with a CubeSat

Expands DSN capabilities by utilizing non-NASA assets to provide communication and navigation services to small spacecraft missions to the Moon and inner solar system.

Enabling interplanetary research with small spacecraft platforms

Develops an operational capability to support EM-1 SmallSat missions



First 5 Demodulated Frames from MarCO OMSPA Demonstration on May 6, 2018 from DSS-17,
D. Abraham, Z. Towfic, S. Finley (JPL)
C. Conner, M. Stratton, R. Kroll (Morehead State)



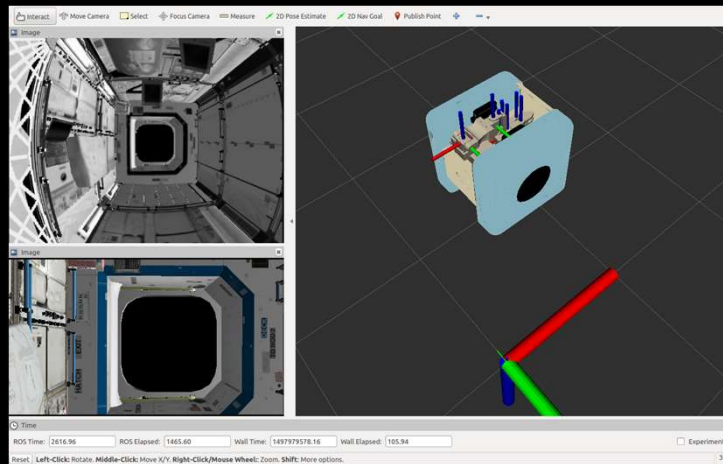
MSU – Mission Ops Center



A



Astrobee... Next Generation Free Flyer Robot



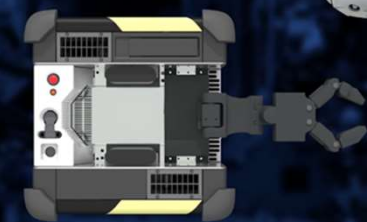
2006 - 2019

- six cameras
- touchscreen
- speaker
- microphone
- signal lights
- laser pointer



Astrobee

CIMON



Int-ball

Astrobee

CIMON

Early 2019

GATEWAY

A spaceport for human and robotic exploration to the Moon and beyond

HUMAN ACCESS TO & FROM LUNAR SURFACE

Astronaut support and teleoperations of surface assets.

U.S. AND INTERNATIONAL CARGO RESUPPLY

Expanding the space economy with supplies delivered aboard partner ships that also provide interim spacecraft volume for additional utilization.

INTERNATIONAL CREW

International crew expeditions for up to 30 days as early as 2024. Longer expeditions as new elements are delivered to the Gateway.

SAMPLE RETURN

Pristine Moon or Mars samples robotically delivered to the Gateway for safe processing and return to Earth.

COMMUNICATIONS RELAY

Data transfer for surface and orbital robotic missions and high-rate communications to and from Earth.

SCIENCE AND TECH DEMOS

Support payloads inside, affixed outside, free-flying nearby, or on the lunar surface. Experiments and investigations continue operating autonomously when crew is not present.

SIX DAYS TO ORBIT THE MOON

The orbit keeps the crew in constant communication with Earth and out of the Moon's shadow.

A HUB FOR FARTHER DESTINATIONS

From this orbit, Vehicles can embark to multiple destinations: The Moon, Mars and beyond.

GATEWAY SPECS



4 Crew Members



30-90 Day Crew Missions



125 m³ Pressurized Volume



Up to 75mt with Orion docked

ACCESS



384,000 km from Earth

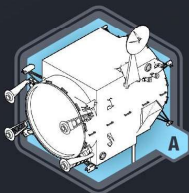
Accessible via NASA's SLS as well as international and commercial ships.

GATEWAY

An exploration and science outpost in orbit around the Moon

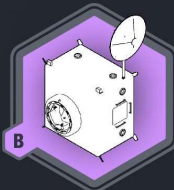
Power and Propulsion Element:

Power, communications, attitude control, and orbit control and transfer capabilities for the Gateway.



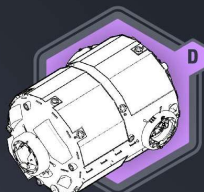
ESPRIT:

Science airlock, additional propellant storage with refueling, and advanced lunar telecommunications capabilities.



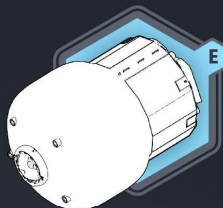
U.S. Utilization Module:

Small pressurized volume for additional habitation capability.



Habitation Modules:

Pressurized volumes with environmental control and life support, fire detection and suppression, water storage and distribution.



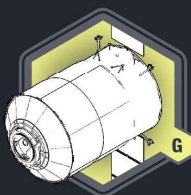
Robotic Arm:

Mechanical arm to berth and inspect vehicles, install science payloads.



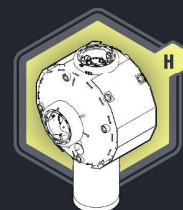
Logistics and Utilization:

Cargo deliveries of consumables and equipment. Modules may double as additional utilization volume.



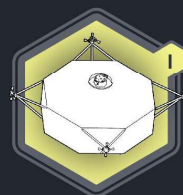
Airlock:

Enables spacewalks, potential to accommodate docking elements.



Sample Return Vehicle:

A robotic vehicle capable of delivering small samples or payloads from the lunar surface to the Gateway.



NASA-led architecture and integration

U.S.

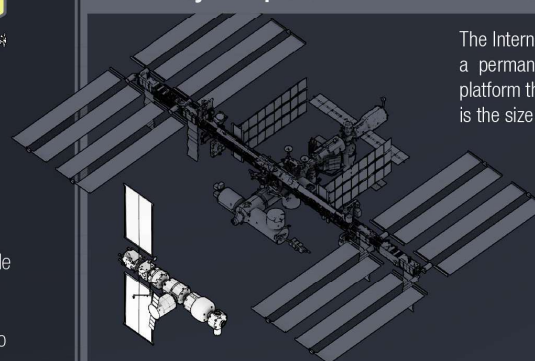
International

TBD: U.S. and/or International

Orion:

U.S. crew module with ESA service module that will take humans farther into deep space than ever before.

Gateway Compared to the International Space Station



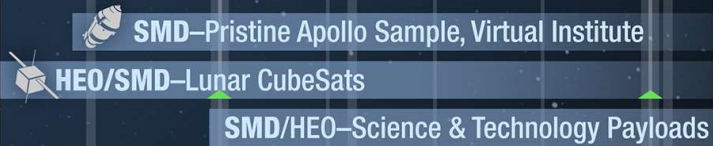
The International Space Station is a permanently crewed research platform that has 11 modules and is the size of a football field.

The Gateway is a much smaller, more focused platform for extending initial human activities into the area around the Moon.

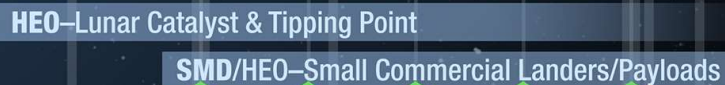
NASA EXPLORATION CAMPAIGN

NOTIONAL LAUNCHES

EARLY SCIENCE & TECHNOLOGY INITIATIVE



SMALL COMMERCIAL LANDER INITIATIVE



MID TO LARGE LANDER INITIATIVE TOWARD HUMAN-RATED LANDER



GATEWAY



2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030

Timelines are tentative and will be developed further in FY 2019

MAY 17 8

What it Takes to Come Home Safely

LOW EARTH RETURN

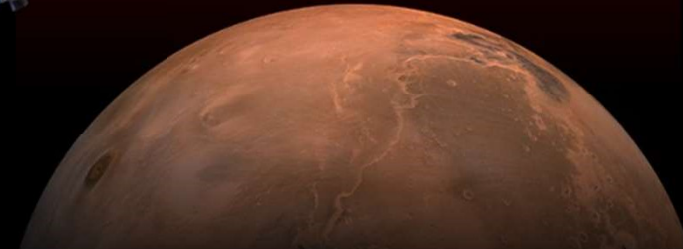
3 HOURS
3,000°F
17,500 MPH
250 MILES

LUNAR RETURN

3 DAYS
5,200°F
24,700 MPH
240,000 MILES

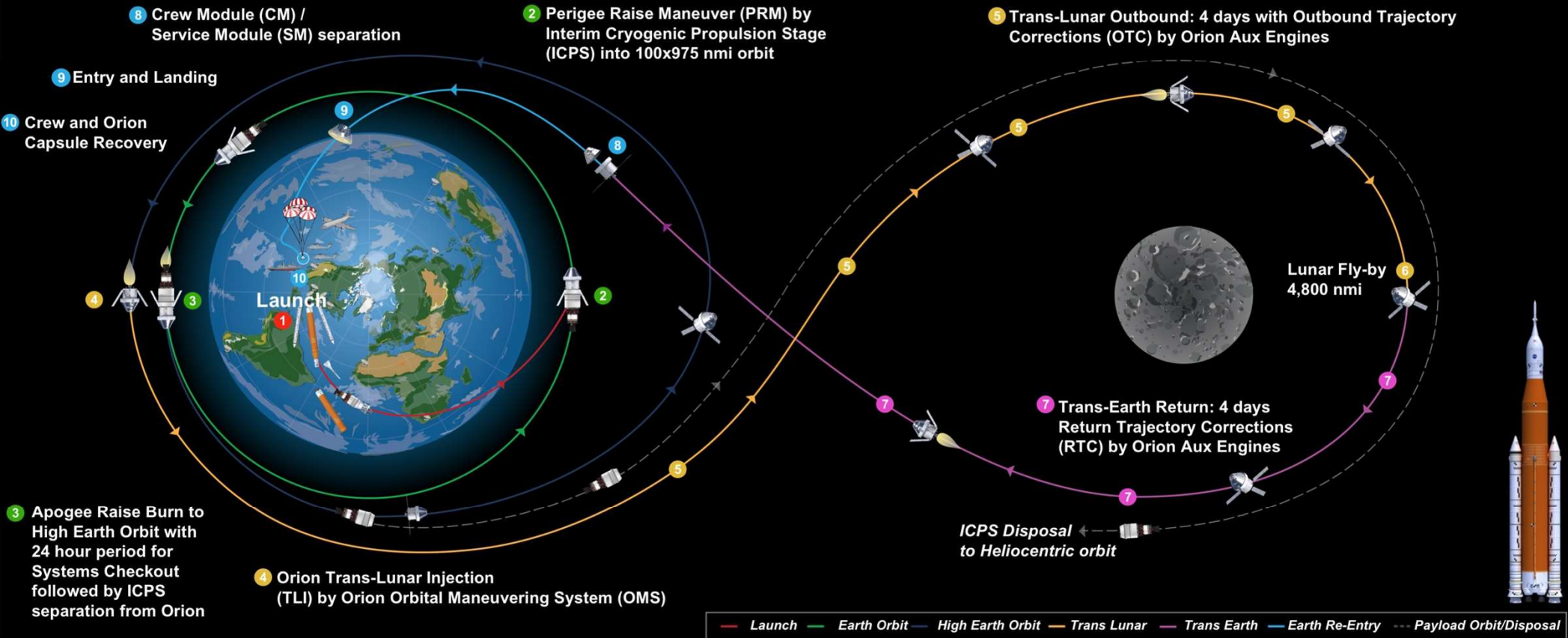
MARS RETURN

9 MONTHS
6,200°F
26,800 MPH
39,000,000 MILES



EXPLORATION MISSION-2

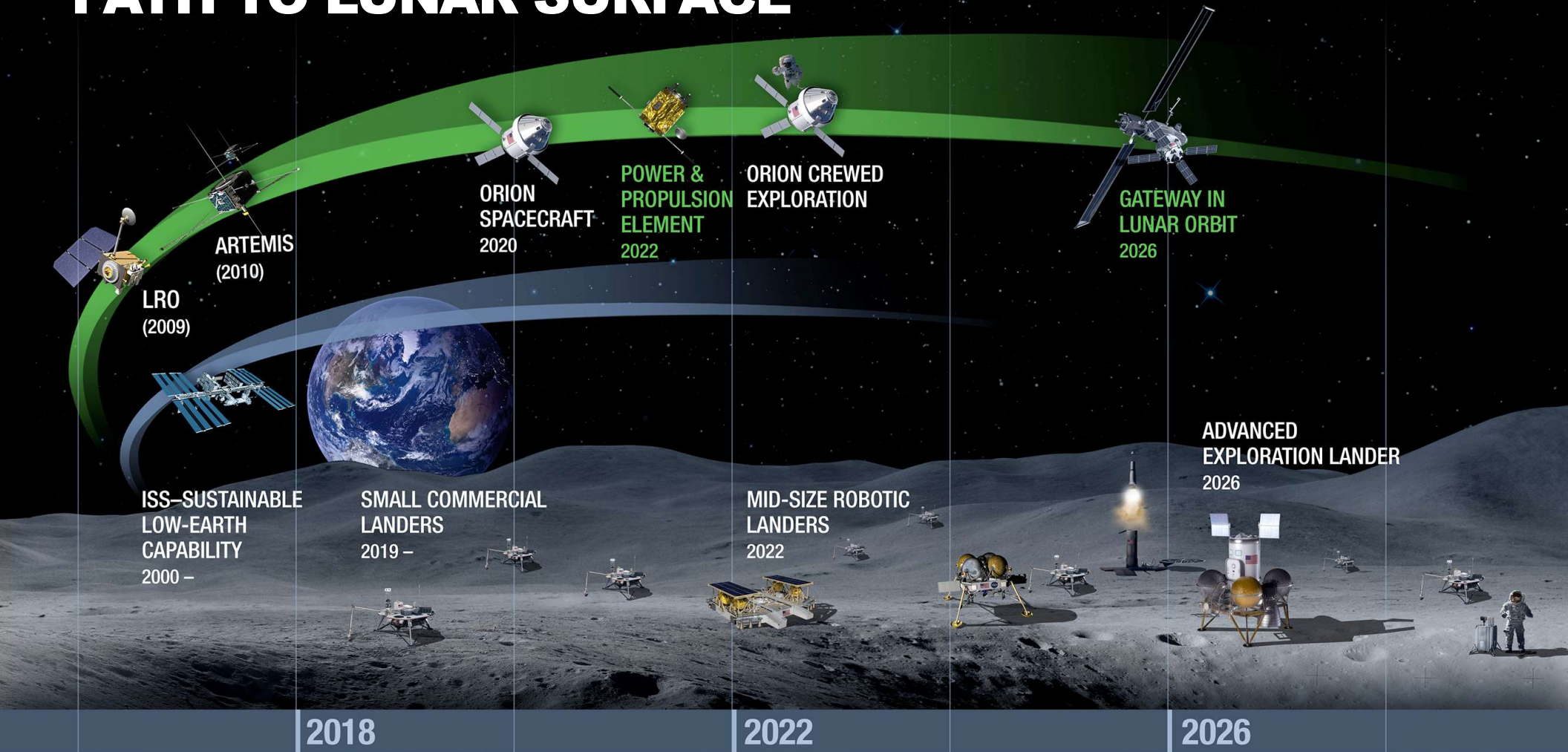
Crewed Hybrid Free Return Trajectory, demonstrating crewed flight and spacecraft systems performance beyond Low Earth Orbit (LEO)



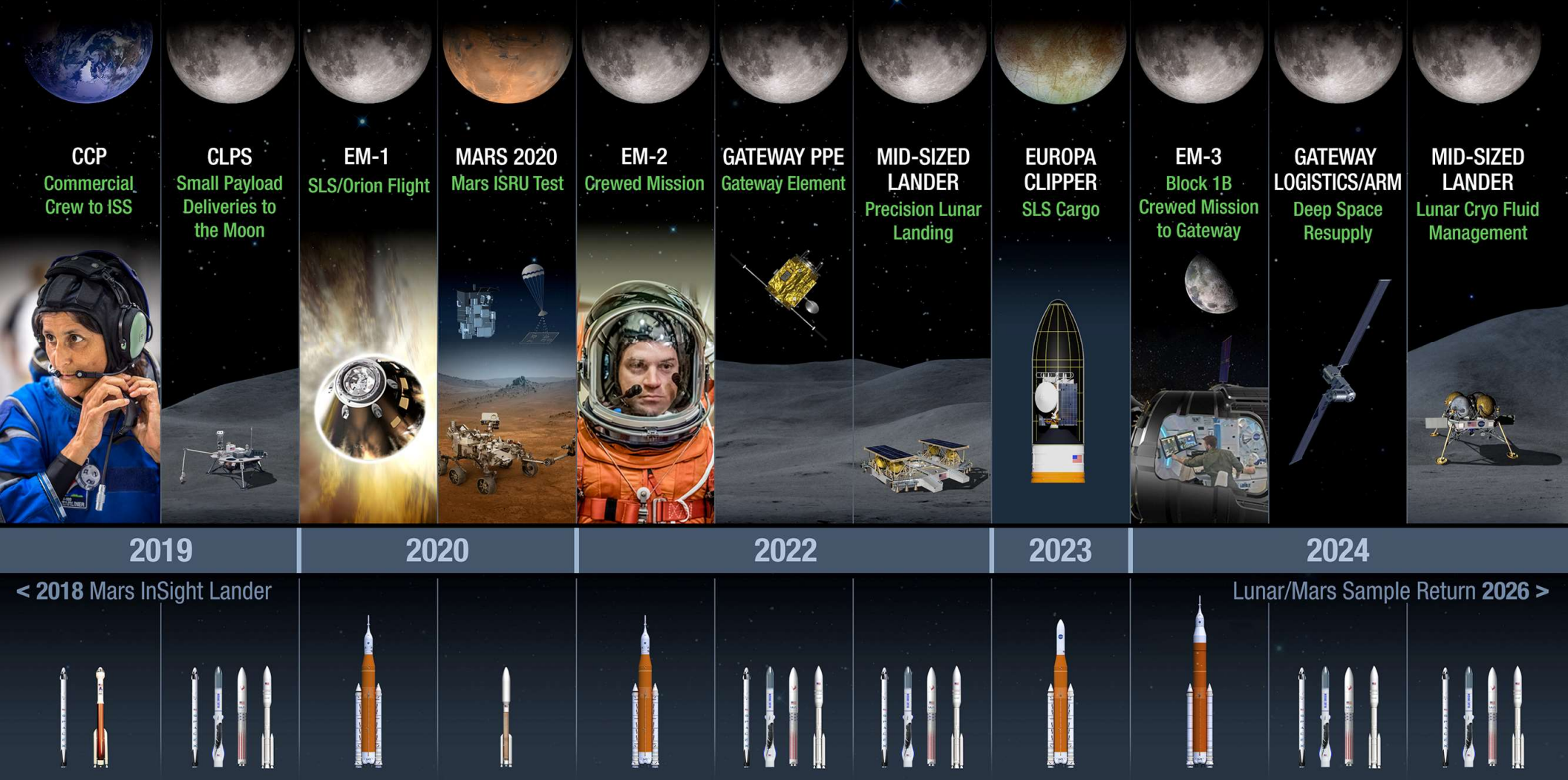
SLS Configuration (Block 1) with Human Rated ICPS | 22x975 nmi (40.7x1806 km) insertion orbit | 28.5 deg inclination

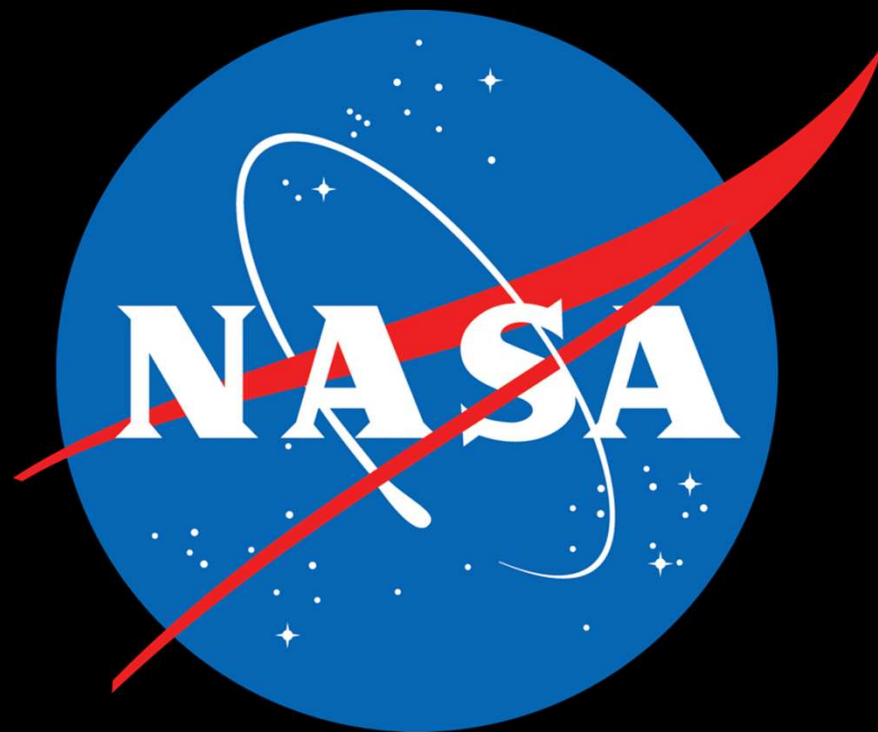
4 astronauts | Total distance traveled: 1,090,320 km – Mission duration: 9 Days – Re-entry speed: 24,500 mph (Mach 32)

PATH TO LUNAR SURFACE



Exploration Firsts





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