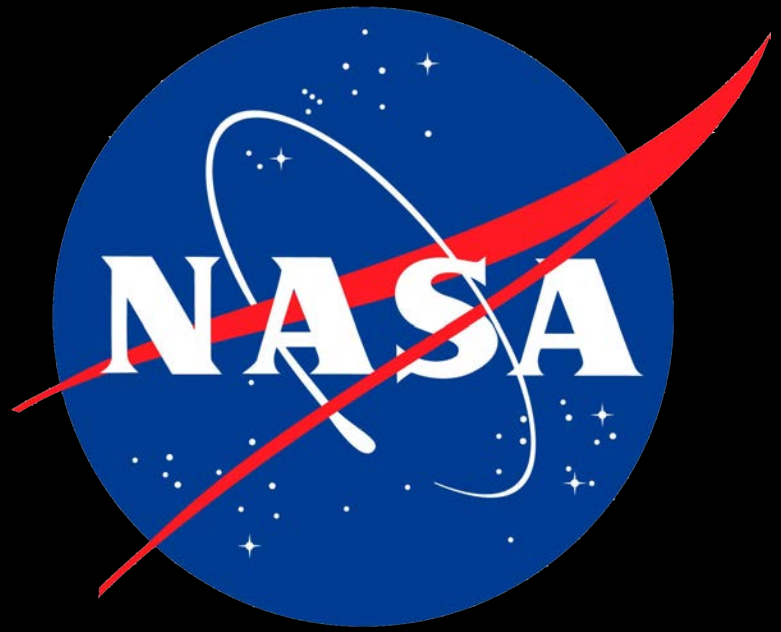
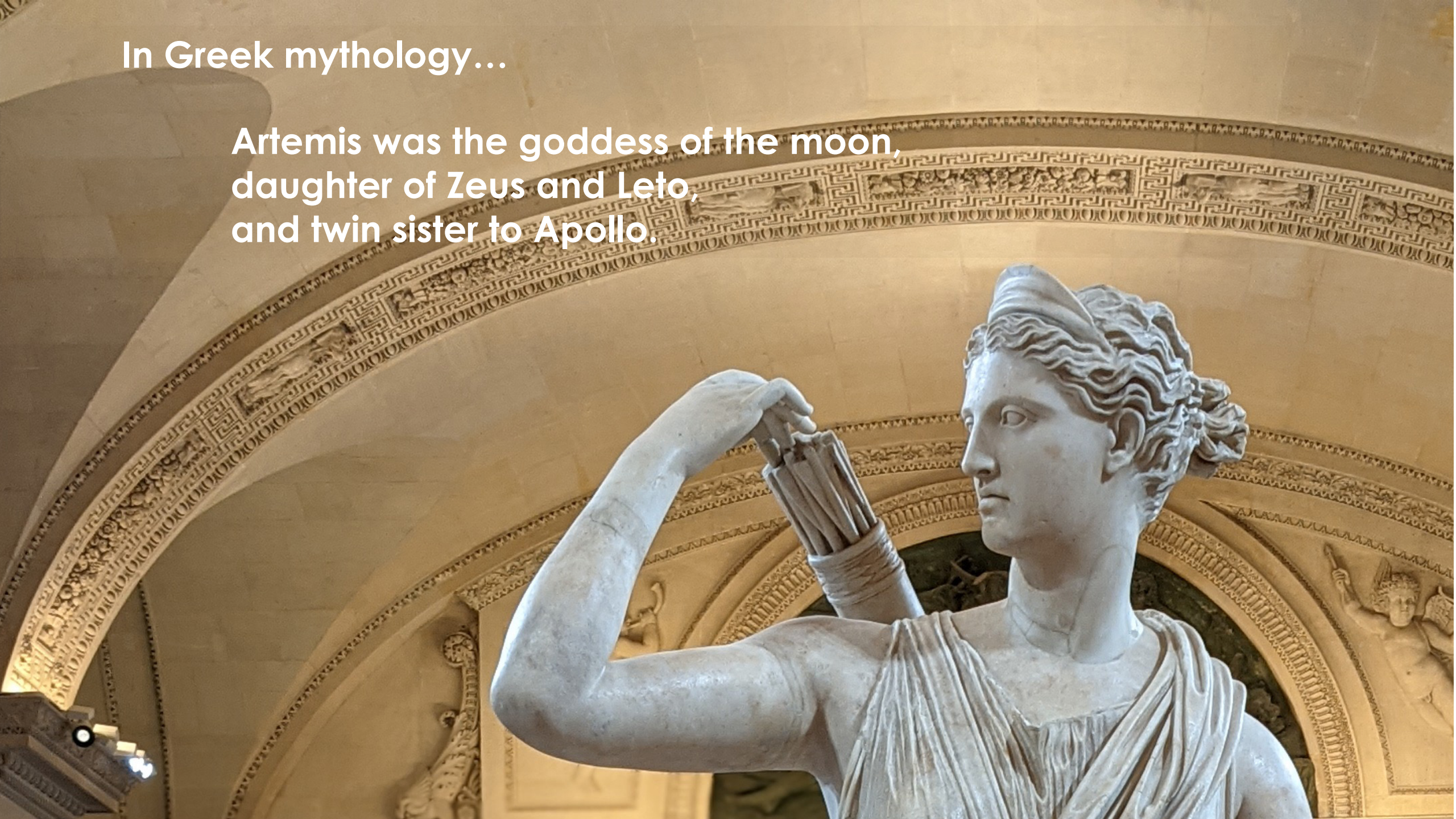
NASA's ARTEMIS Program

On the way to living and working on the Moon…and Beyond



Jennifer Blank ("Dr. Jen")
NASA Ames Research Center in Silicon Valley

10 April 2024



In Greek mythology…

Artemis was the goddess of the moon,
daughter of Zeus and Leto,
and twin sister to Apollo.

Artemis is part of NASA's Moon-to-Mars Architecture

- Develop a long-term human presence on the Moon
- Develop technology for ISRU and Space activities
- Use the Moon as a testing ground to prep for a longer journey to Mars
- Partner with industry, academia, and the international community

Artemis Accords: 36 countries (& counting)

What is Artemis?

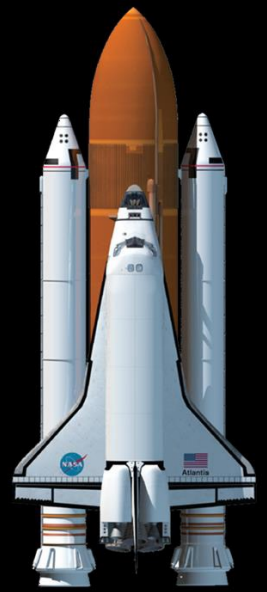
Artemis combines programs into missions.

Artemis Program Facts (summary)

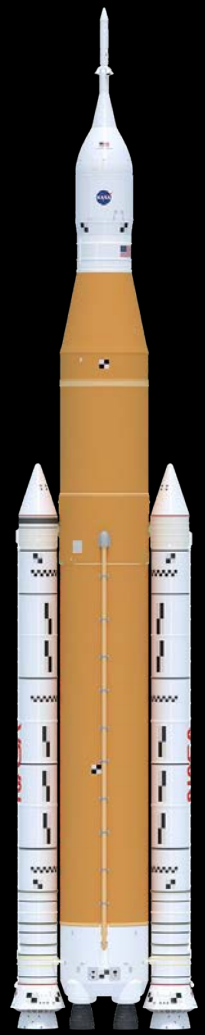
- **Duration**: 2017 – 2030
- **Launch vehicles**: Space Launch System (SLS) + Commercial launch vehicles
- **Crew modules**: Orion, Human Landing System (HLS), Lunar Gateway, Blue Moon Mark I
- **Launch dates (fluid)**:
  - ✓ **Artemis 1**: Snoopy orbits the moon (16 November 2022)
  - **Artemis 2**: Human crew orbits the Moon (No earlier than September 2025)
  - **Artemis 3**: Human crew on the Moon + EHV (No earlier than September 2026)
  - **Artemis 4**: Habitation module to Gateway (2027)
  - **Artemis 5**: ESA module + Canadarm 3 to Gateway, LTV + Crew to the Moon (2030)

Space Launch System (SLS)

STATUE OF LIBERTY
305 ft.



SPACE SHUTTLE
184 ft.



SLS / ORION Block I
322 ft.

SLS / ORION Block II
364 ft.

SATURN 5
363 ft.

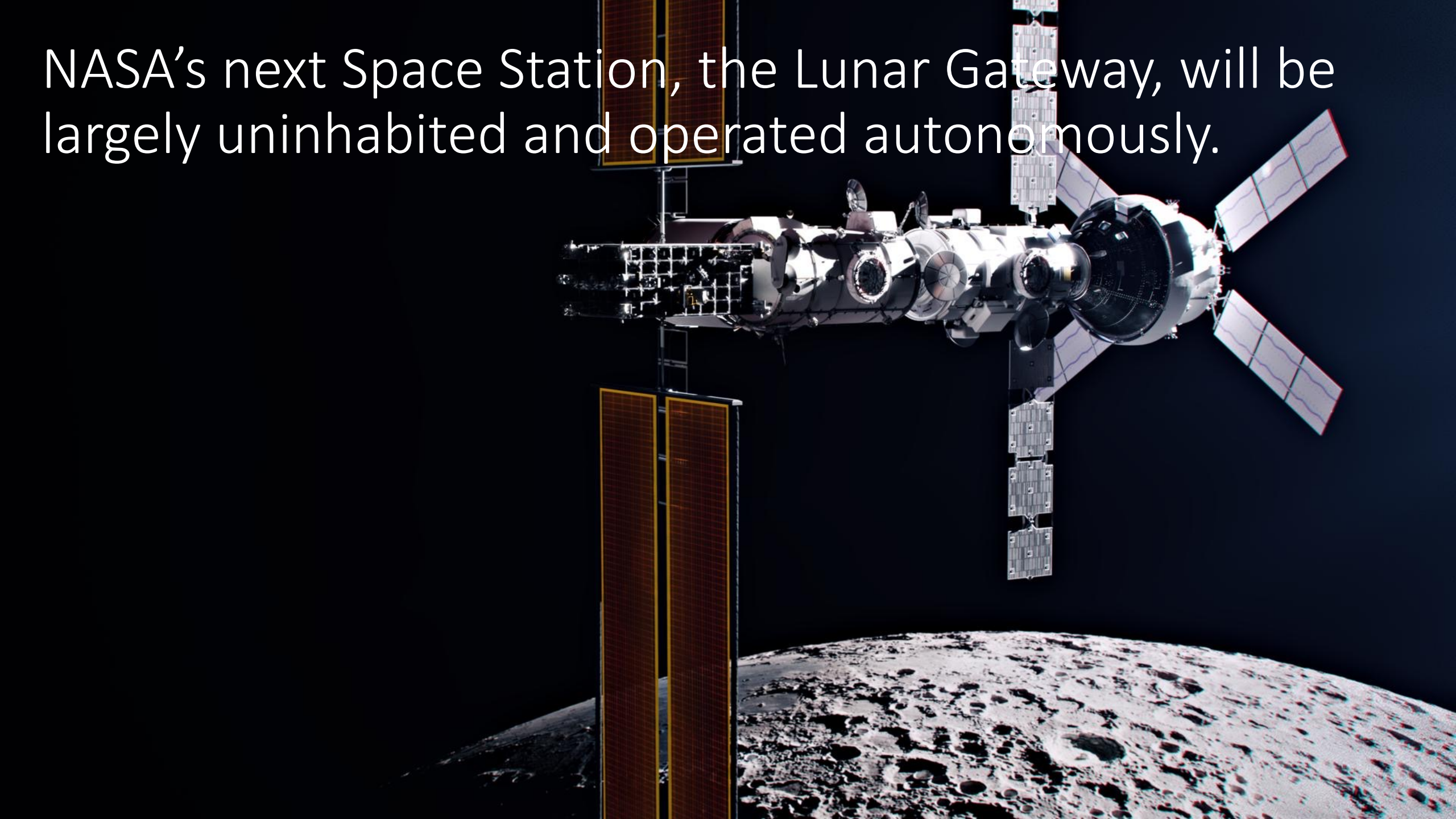
The Orion Spacecraft

Astronauts for NASA's Artemis II mission stand in front of their Orion crew capsule, expected to carry Reid Wiseman, commander, Victor Glover, pilot, and mission specialists Christina Hammock Koch and Jeremy Hansen, with the Canadian Space Agency, as NASA Deputy Administrator Pam Melroy speaks at a press conference at the Kennedy... *Purchase Licensing Rights* **Read more**

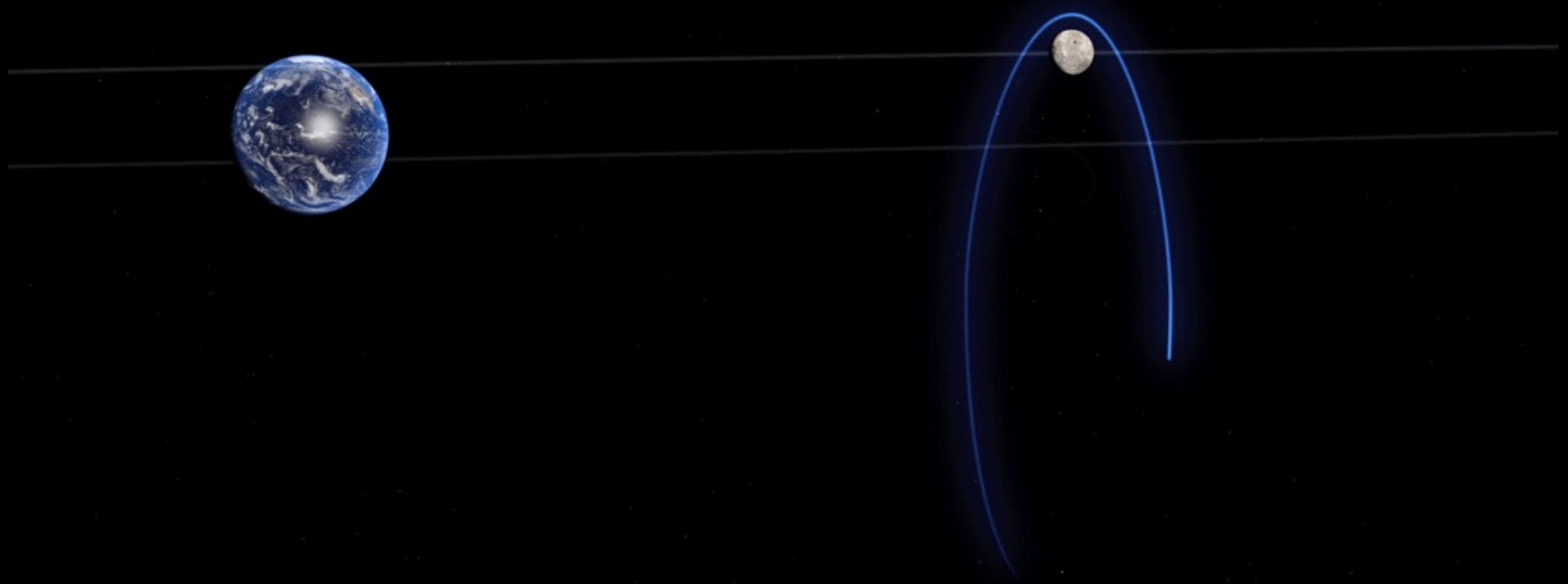
Human Landing Systems

Image: @KenKirtland17

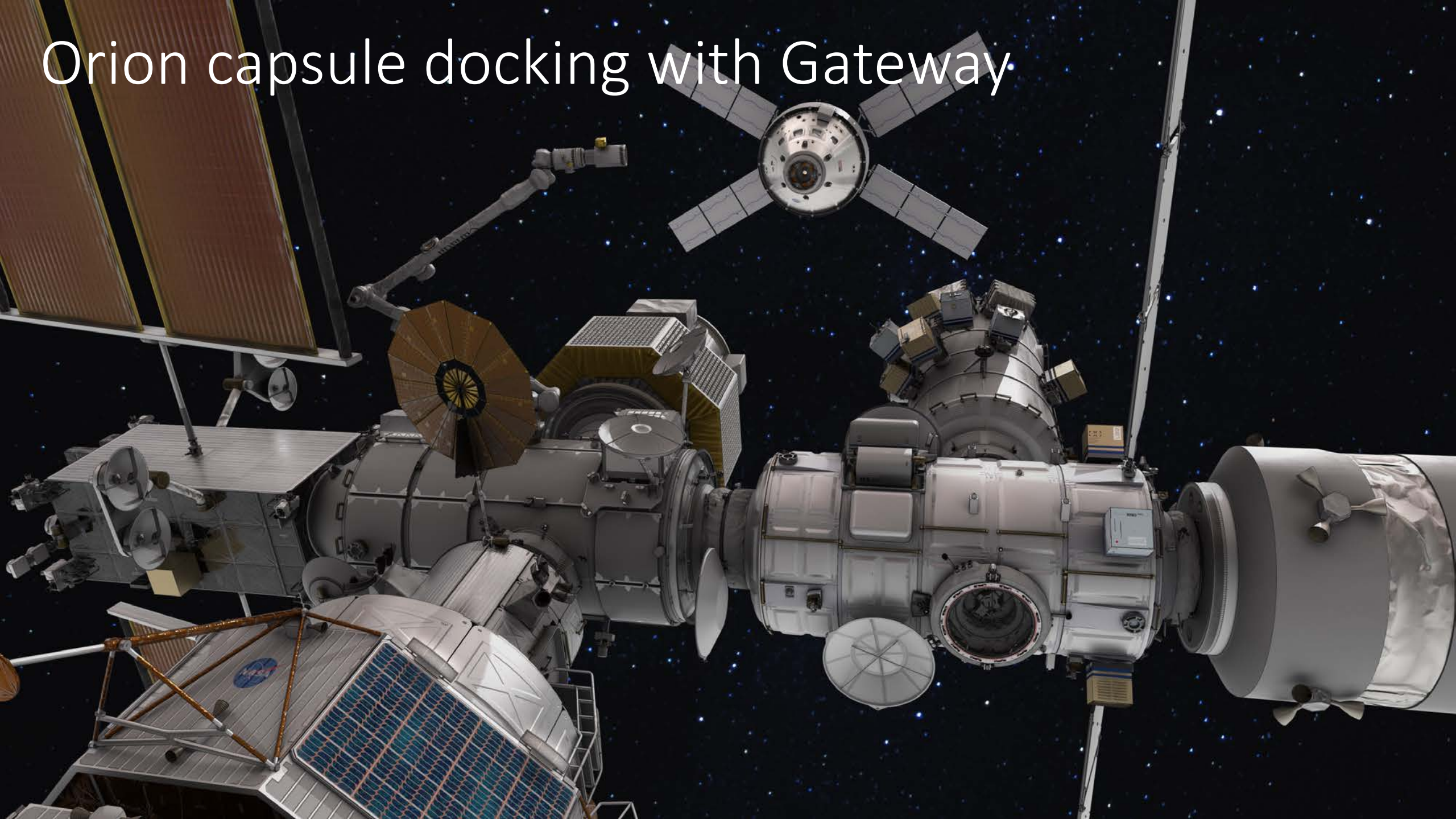
NASA’s next Space Station, the Lunar Gateway, will be largely uninhabited and operated autonomously.



The Lunar Gateway will have a Near Rectilinear Halo Orbit (NRHO)



Orion capsule docking with Gateway



ARTEMIS I Success!

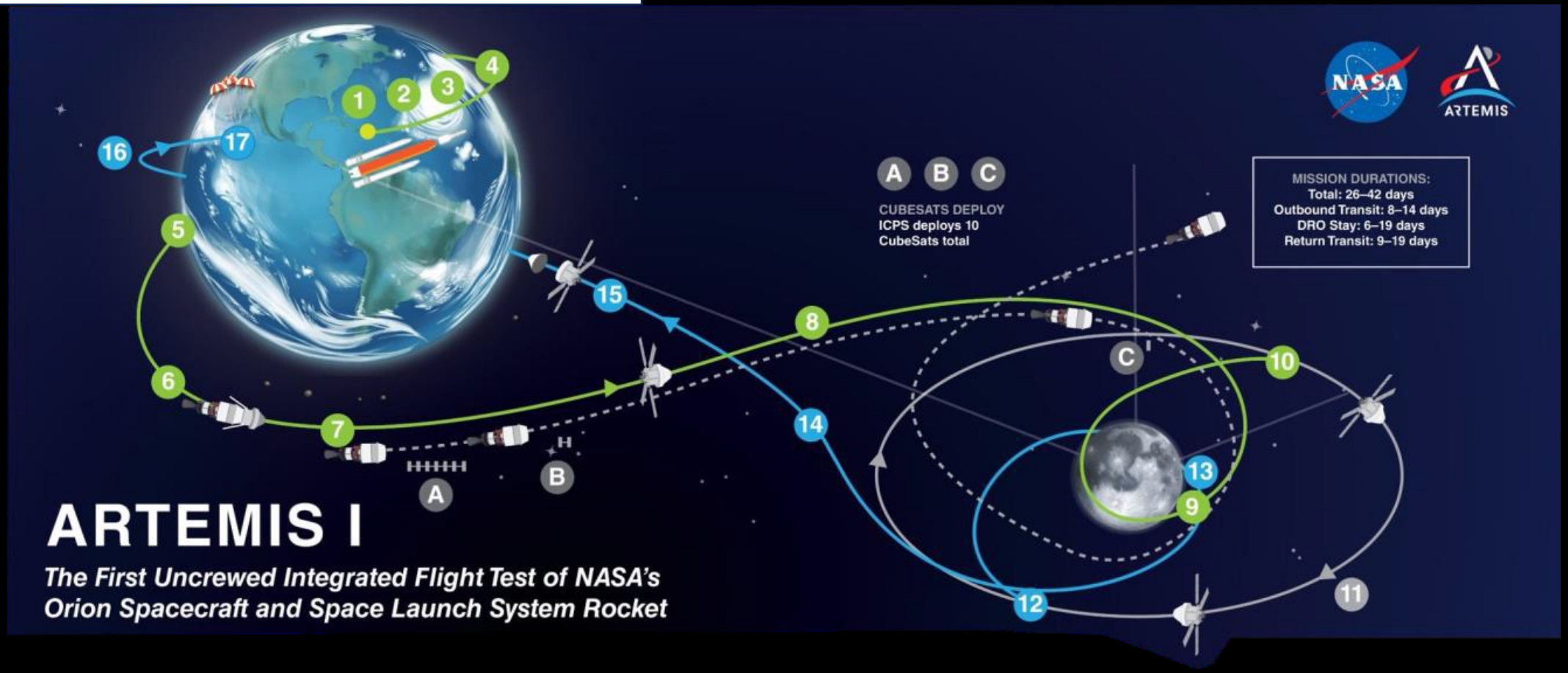
SUCCESSFUL LAUNCH OF MOST POWERFUL ROCKET IN THE WORLD

Snoopy in Space

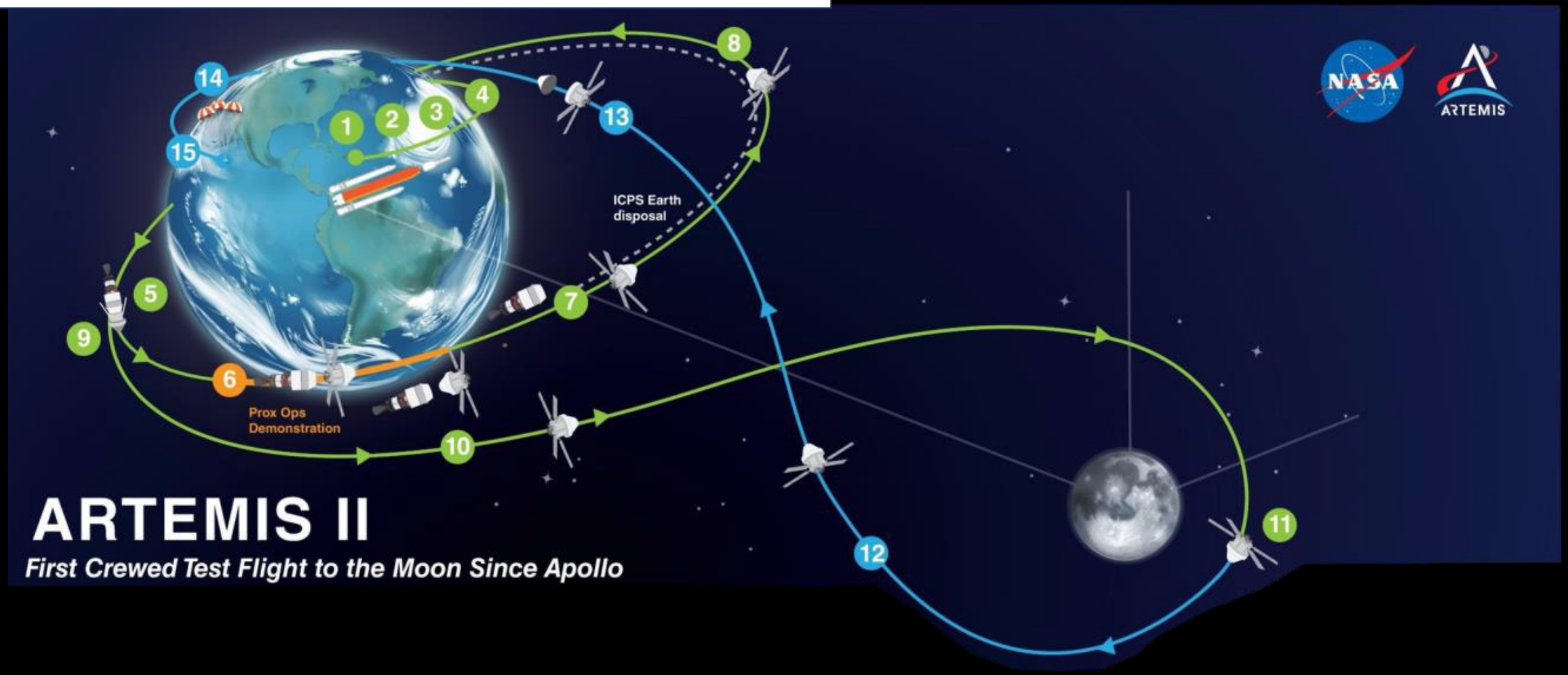
ORION HEADED TO THE MOON

ORION IN DISTANT RETROGRADE ORBIT CAPTURES MOON TRANSIT IN FRONT OF EARTH

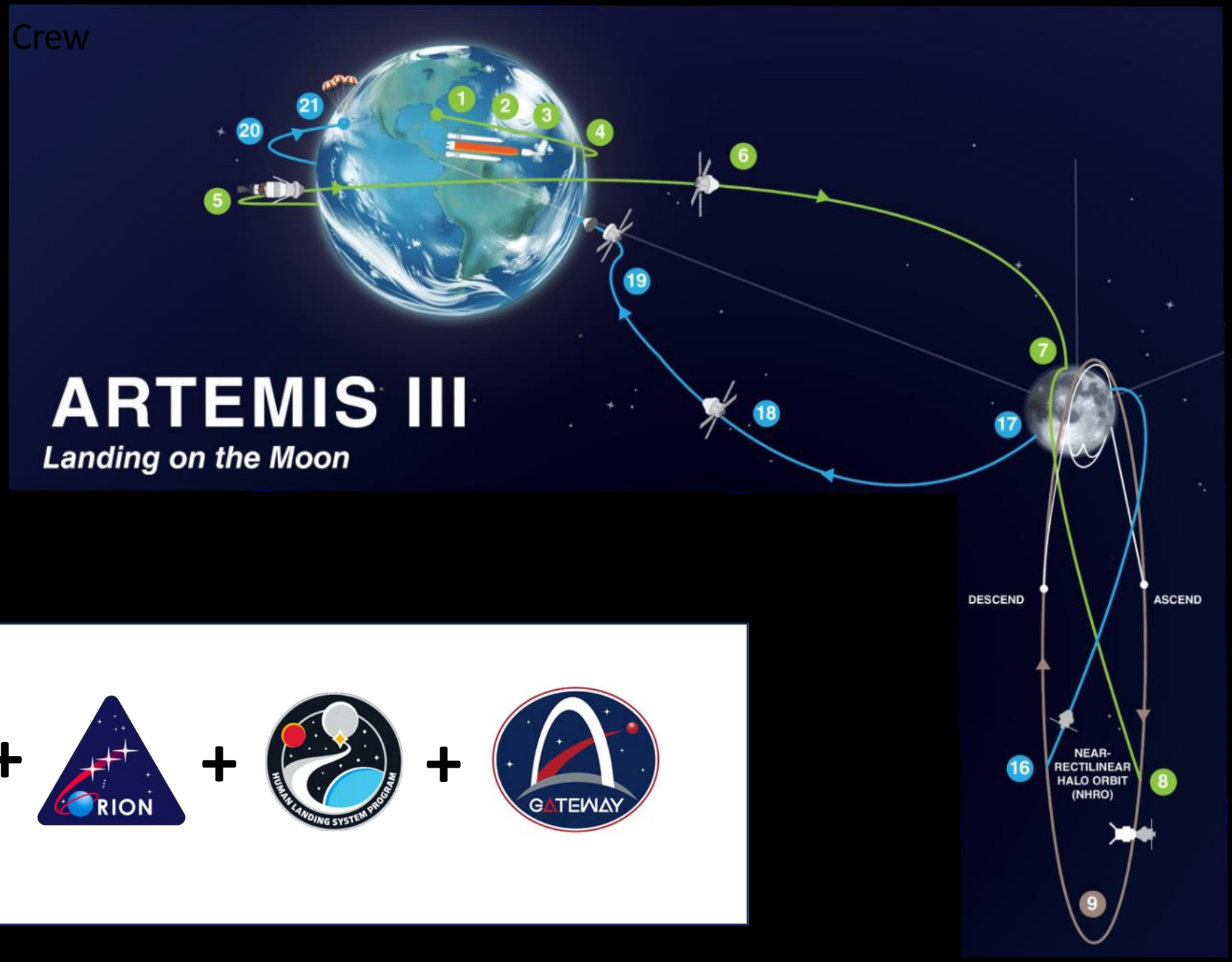
ARTEMIS = SLS + ORION



ARTEMIS = SLS + ORION + crew



Crew



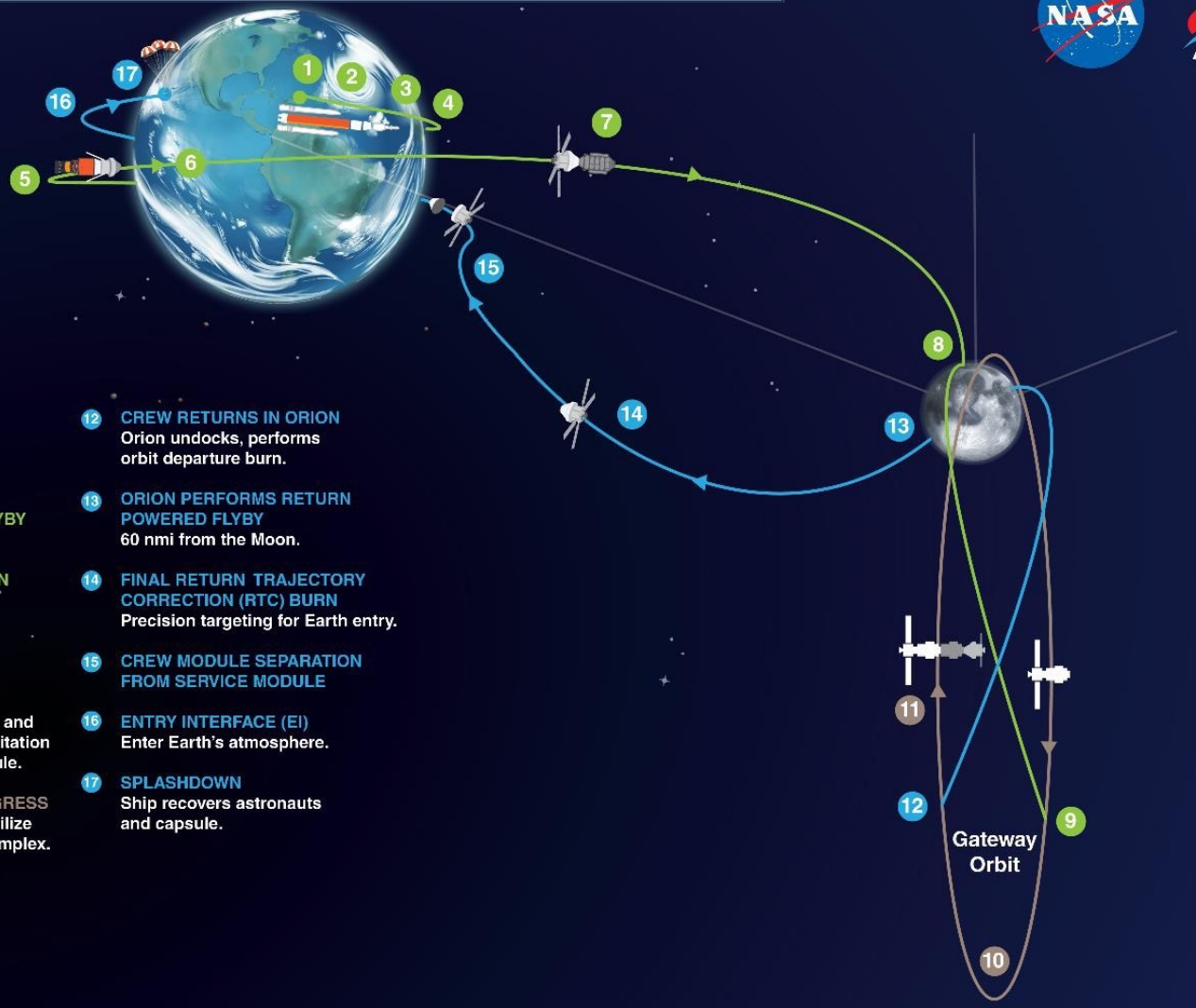
ARTEMIS = SLS + ORION + HUMAN LANDING SYSTEM PROGRAM + GATEWAY

ARTEMIS = SLS + ORION + HUMAN LANDING SYSTEM PROGRAM + GATEWAY

NASA ARTEMIS

ARTEMIS IV

International Habitation Module delivery to Gateway



1. **LAUNCH**
   SLS with I-HAB payload and crewed Orion lift-off from Kennedy Space Center.
2. **JETTISON ROCKET BOOSTERS, FAIRINGS, AND LAUNCH ABORT SYSTEM**
3. **CORE STAGE MAIN ENGINE CUT OFF**
   With separation.
4. **ENTER EARTH ORBIT**
   Perform the perigee raise maneuver. Systems check and solar panel adjustments.
5. **TRANS LUNAR INJECTION BURN**
   Exploration Upper Stage commits Astronauts in Orion and I-HAB to lunar trajectory.
6. **ORION TUGS I-HAB TO MOON**
   Orion separation from USA, docking with I-HAB and extraction from USA followed by Orion tug of I-HAB to NRHO and EUS disposal.
7. **ORION OUTBOUND TRANSIT TO MOON**
   Requires several outbound trajectory burns.
8. **ORION OUTBOUND POWERED FLYBY**
   60 nmi from the Moon.
9. **GATEWAY ORBIT INSERTION BURN**
   Orion performs burn to establish rendezvous point and executes rendezvous and docking.
10. **INTERNATIONAL HABITATION MODULE ARRIVAL AT GATEWAY**
    I-HAB docking with Orion to Power and Propulsion Element (PPE) and Habitation and Logistic Outpost (HALO) module.
11. **I-HAB ACTIVATION AND CREW INGRESS**
    Astronauts ingress, activate and utilize I-HAB as part of larger Gateway complex.
12. **CREW RETURNS IN ORION**
    Orion undocks, performs orbit departure burn.
13. **ORION PERFORMS RETURN POWERED FLYBY**
    60 nmi from the Moon.
14. **FINAL RETURN TRAJECTORY CORRECTION (RTC) BURN**
    Precision targeting for Earth entry.
15. **CREW MODULE SEPARATION FROM SERVICE MODULE**
16. **ENTRY INTERFACE (EI)**
    Enter Earth's atmosphere.
17. **SPLASHDOWN**
    Ship recovers astronauts and capsule.

ARTEMIS V

ESPRIT delivery to Gateway followed by Crewed Lunar Landing

1 **LAUNCH**
SLS with ESPRIT payload and crewed Orion lift-off from Kennedy Space Center.

2 **JETTISON ROCKET BOOSTERS, FAIRINGS, AND LAUNCH ABORT SYSTEM**

3 **CORE STAGE MAIN ENGINE CUT OFF**
With separation.

4 **ENTER EARTH ORBIT**
Exploration Upper Stage performs circularization of Low Earth Orbit. Systems check and solar panel adjustments.

5 **TRANS LUNAR INJECTION BURN**
Exploration Upper Stage commits Astronauts in Orion and ESPRIT to lunar trajectory.

6 **ORION TUGS ESPRIT TO MOON**
Orion separation from USA, docking with ESPRIT and extraction from USA followed by Orion tug of ESPRIT to Gateway orbit and EUS disposal.

7 **ORION OUTBOUND TRANSIT TO MOON**
Perform periodic outbound trajectory correction maneuvers.

8 **ORION OUTBOUND POWERED FLYBY**
Lunar gravity assist, fly 60 nmi from the Moon.

9 **GATEWAY ORBIT INSERTION BURN**
Orion performs burn to establish rendezvous point and executes rendezvous.

10 **ESPRIT REFUELING MODULE ARRIVAL AT GATEWAY**
Orion docking with ESPRIT to Gateway.

11 **ESPRIT AND GERS ACTIVATION**
Astronauts activate and checkout ESPRIT and GERS as part of larger Gateway complex.

12 **LUNAR LANDING PREPARATION**
Crew activates Lander and prepares for departure.

13 **LANDER UNDOCKING AND SEPARATION**

14 **LANDER ENTERS LOW LUNAR ORBIT**
Two astronauts descent to lunar touchdown.

15 **LUNAR SURFACE EXPLORATION**
Astronauts conduct week long surface mission including moon walks, rover ops, and surface science.

16 **ORION REMAINS IN LUNAR GATEWAY ORBIT**
Other two astronauts tend to Gateway during lunar surface mission.

17 **LANDER ASCENDS TO LOW LUNAR ORBIT**

18 **LANDER PERFORMS RENDEZVOUS AND DOCKING**

19 **CREW RETURNS IN ORION**
Crew transfers science samples to Orion for return, undocks, performs departure burn.

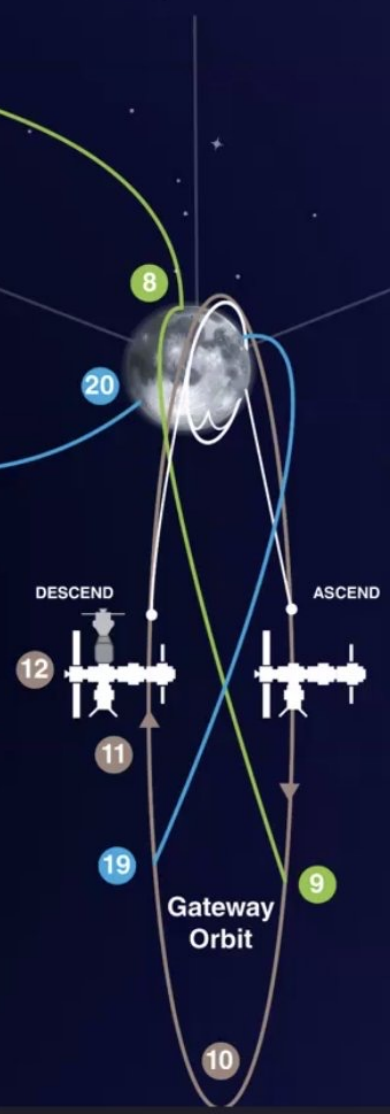
20 **ORION PERFORMS RETURN POWERED FLYBY**
Lunar gravity assist, fly 60 nmi from the Moon.

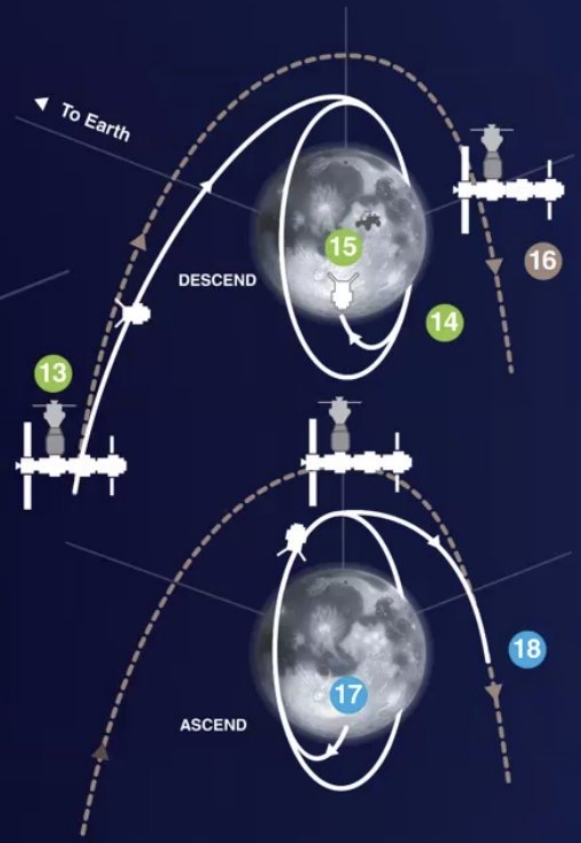
21 **FINAL RETURN TRAJECTORY CORRECTION BURN**
Precision targeting for Earth entry.

22 **CREW MODULE SEPARATION FROM SERVICE MODULE**

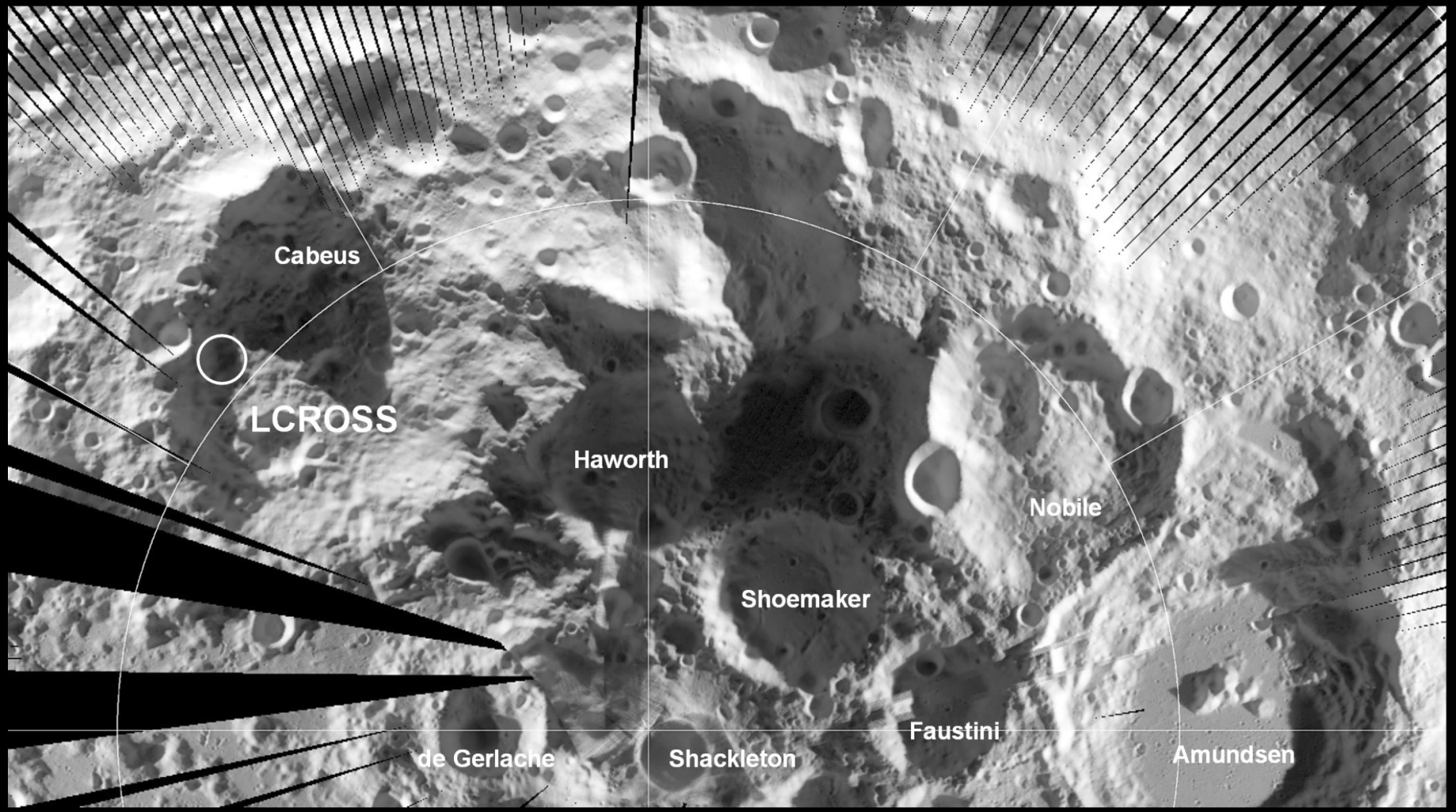
23 **ENTRY INTERFACE**
Enter Earth's atmosphere.

24 **SPLASHDOWN**
Astronaut crew, science sample and capsule recovery by ship.





Artemis targets the Lunar South Pole



Commercial Lander Payload Services (CLPS)

Astrobotic “Peregrine”
18 Jan 2024

Intuitive Machines “Odysseus”
22 Feb 2024 soft (tilted) landing on the Moon

Astrobotic “Griffin”
Will carry VIPER

VIPER: Volatiles Investigating Polar Exploration Rover

Launching late 2024 – NASA's first moon rover will target water ice, which has been detected via lunar orbiters.

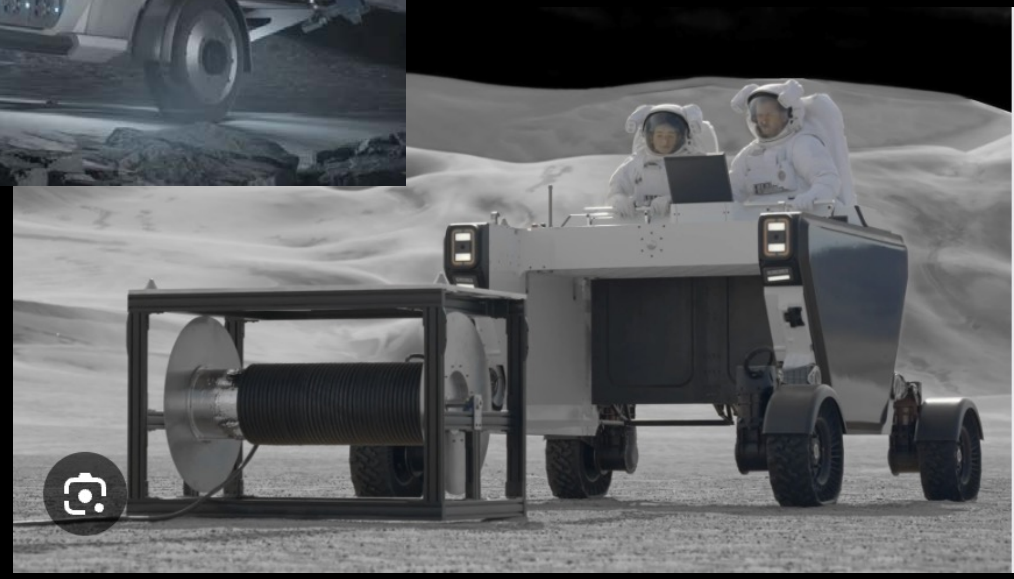
Axiom Space is designing the space suits for Artemis.

The Axiom Extravehicular Mobility Unit (AxEMU) spacesuit | image: axiomspace.com

NASA has commissioned three lunar vehicles designs

Intuitive Machines – racer rover

Lunar Outpost – moon rover

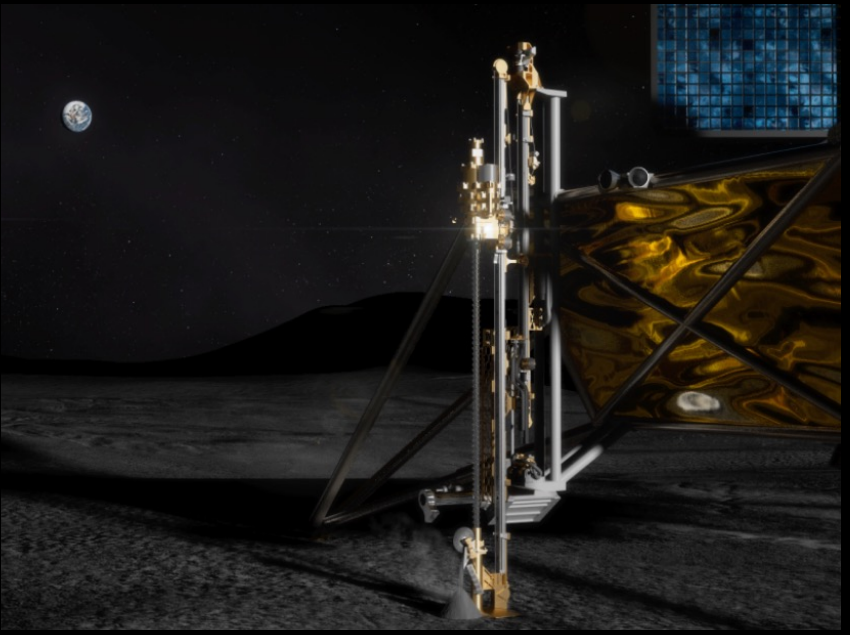


Venturi Astrolab – lunar terrain vehicle

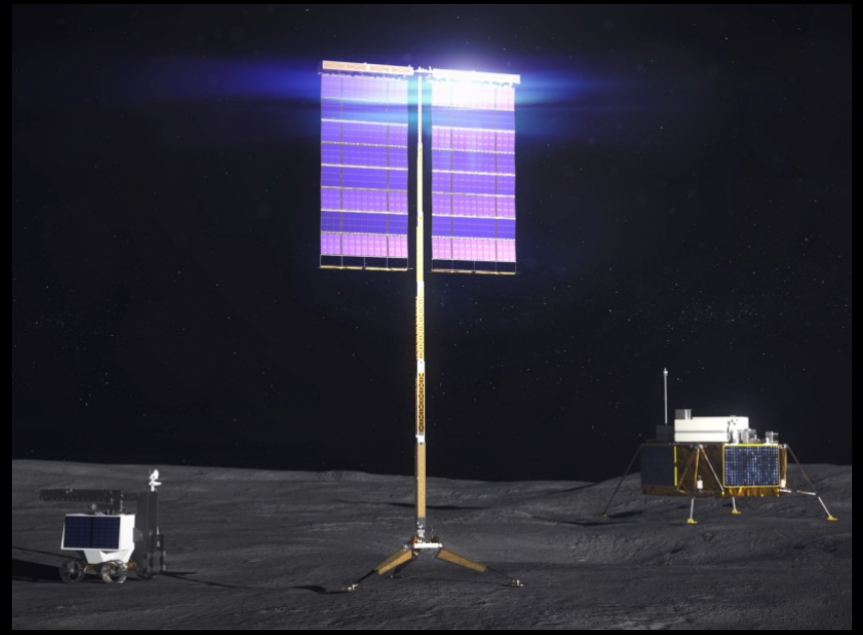
Concept for an initial NASA lunar outpost

NASA SpaceTech's Lunar Surface Innovation Initiative (LSII)

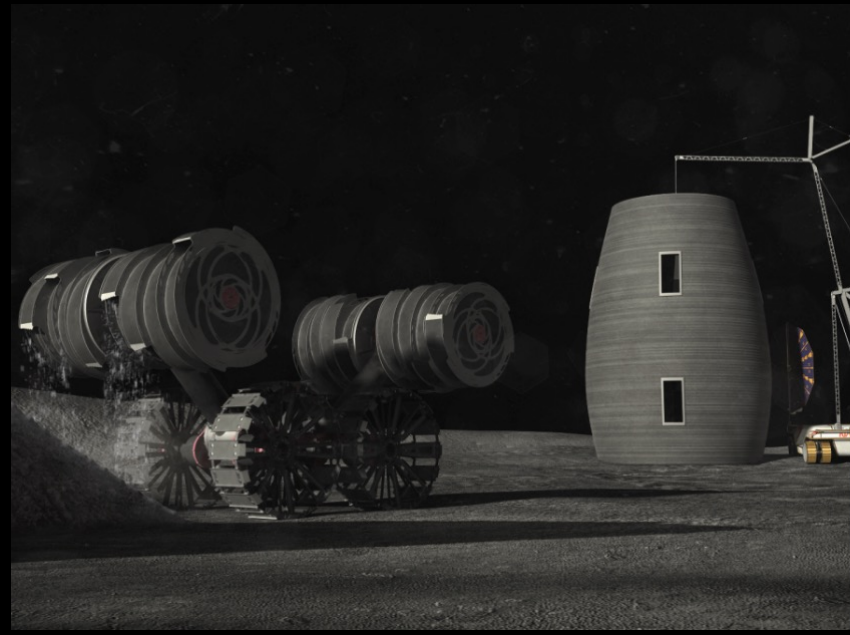
…aims to spur the deployment of technologies needed for lunar surface exploration and accelerate the technology readiness of key systems and components.



1 – ISRU (prime ice drill)



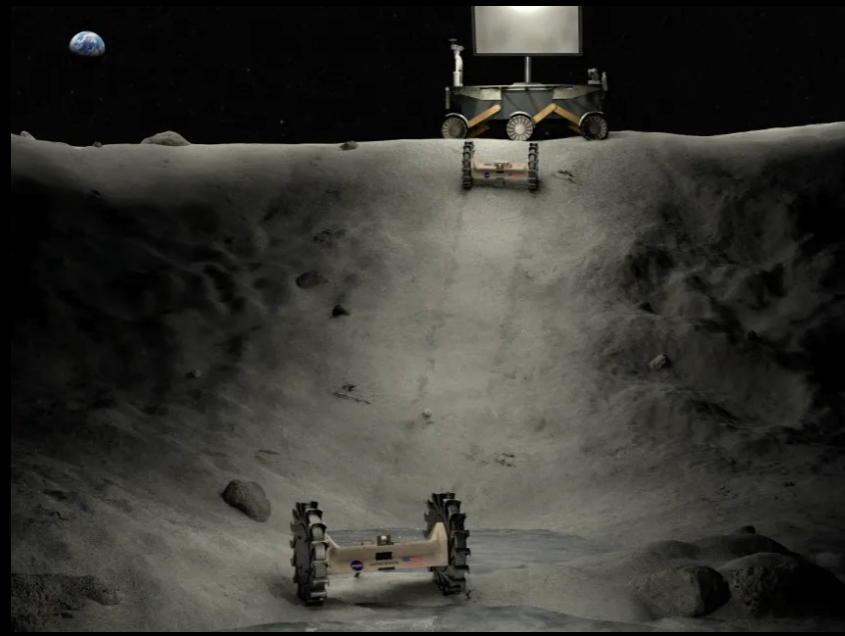
2 – Surface Power (LVSAT)



3 – Excavation + Construction (IPex)

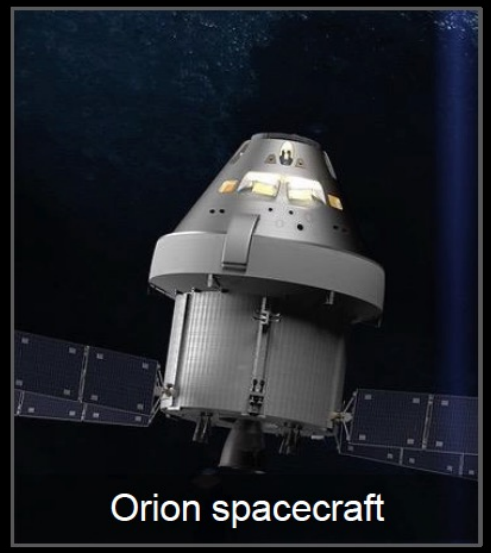
4 – Extreme Environment (BMGG)

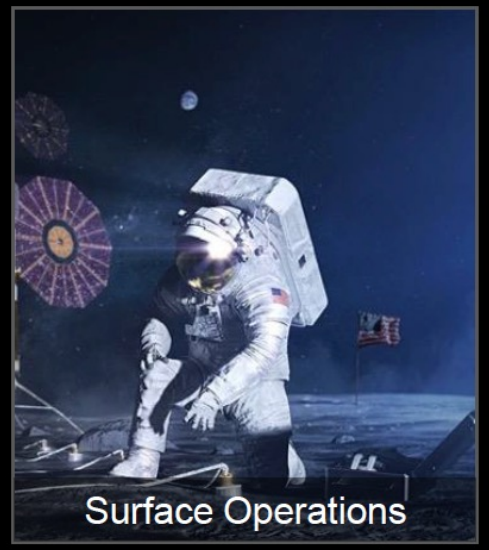
5 – Dust Mitigation (EDS)

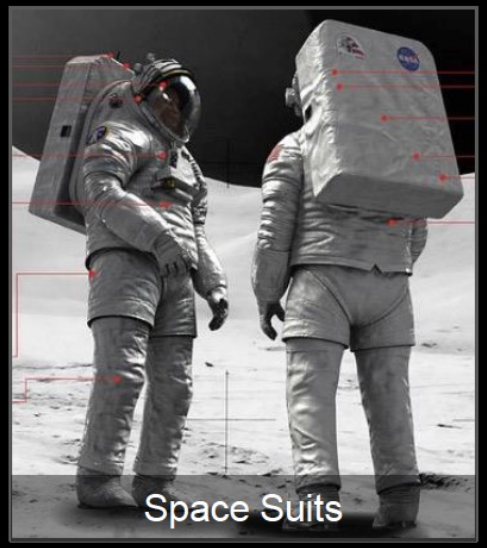


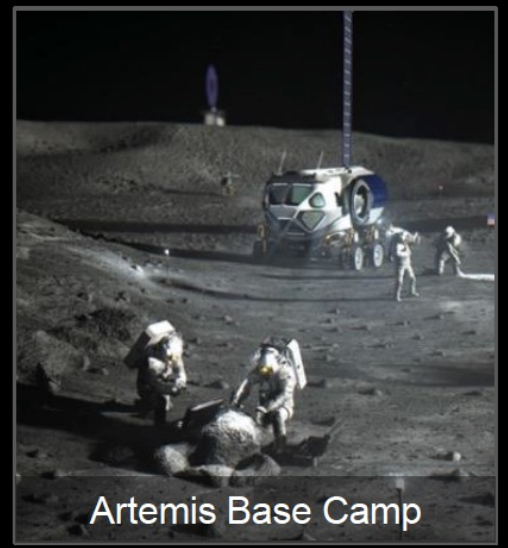
6 – Extreme Access (CADRE)

Artemis is Establishing a Foundation for Deep Space Exploration









Living & Working on the Moon (in the future)

- Initial phase – habitability
- Early phase – resource prospecting, mining
- Later – support infrastructure
- Later – new societies

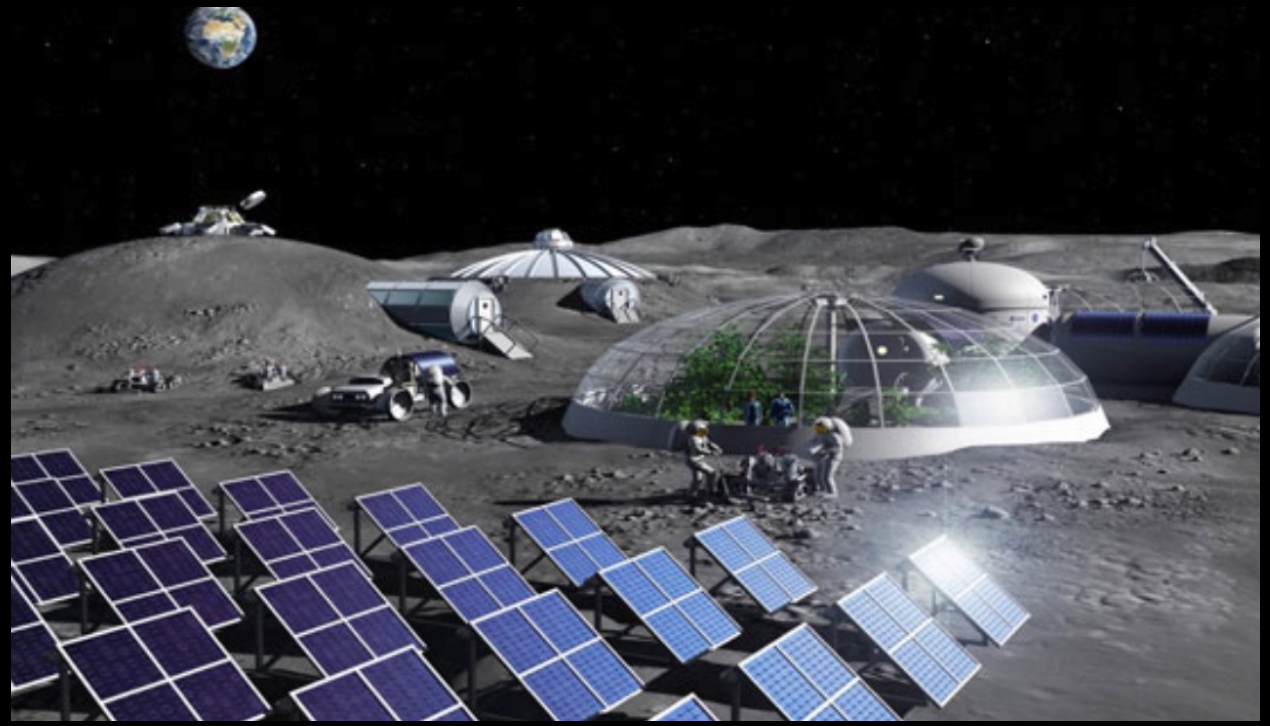


Image: moonvillage.org

Lunar Resources

- Metals (Al, Ti, Ca, REEs)
- Regolith building material
- Water ice
- He-3
- Solar power potential
- Low gravity environment

Challenges for Habitation

- Large diurnal temperature swing (thermal regulation)
- Radiation (protection)
- Dust / small, ionized particles (mechanical issues)
- Need air to breath
- Need food to eat

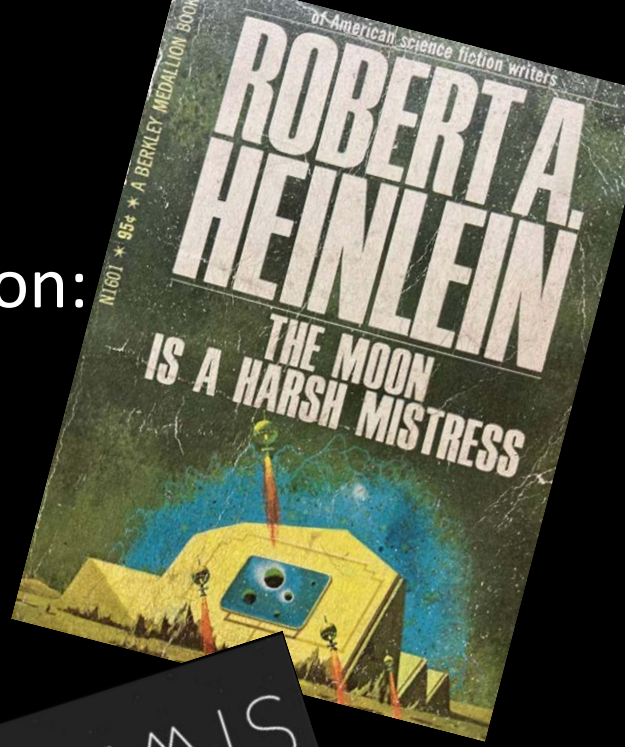
Where would I live, on the Moon? In a Lava Tube!

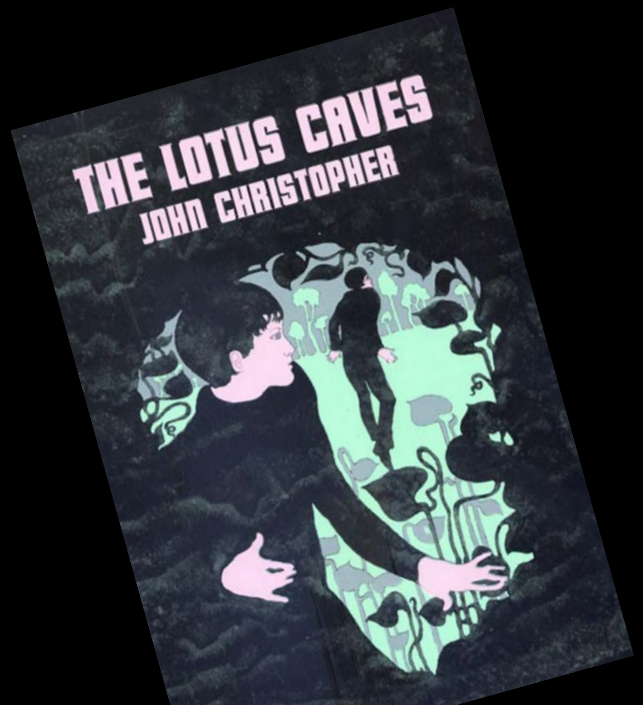
Lunar skylight –
~100m opening

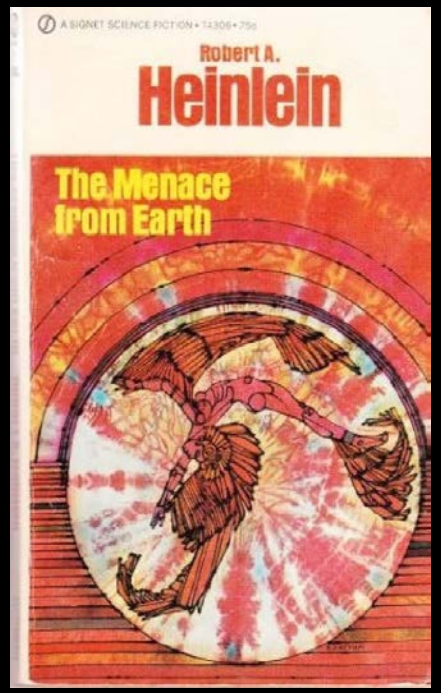
NASA's BRAILLE project conducts autonomous, multi-robot operational tests in a cave in N. California.

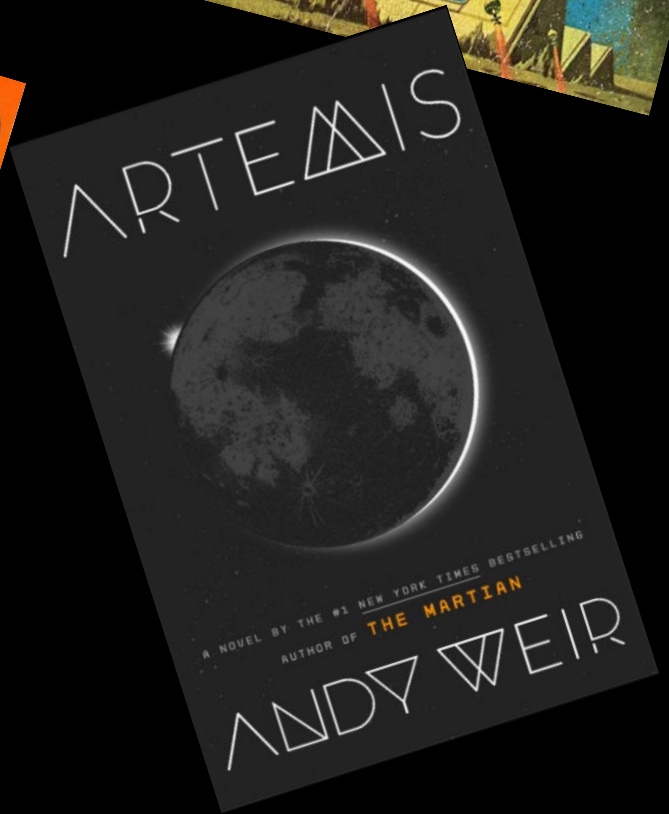
Reading recommendations

- Fun books set on the Moon or about the journey to the Moon:
  - The Moon is a Harsh Mistress (Robert A Heinlein; 1966)
  - The Lotus Caves (John Christopher; 1969)
  - The Menace from Earth (Robert Heinlein; 1959)
  - Prelude to Space (Arthur Clarke; 1947)
  - Artemis (Andy Weir; 2017)









If you aim higher than you expect, you could reach higher than you dreamed.

— Richard Branson —