National Aeronautics and
Space Administration

NASA Advisory Council

NASA Human Exploration and Operations Overview;

Ken Bowersox
Associate Administrator, Acting
Human Exploration and Operations Mission Directorate

The Artemis Program

Artemis is the twin sister of Apollo and goddess of the Moon in Greek mythology. Now, she personifies our path to the Moon as the name of NASA's program to return astronauts to the lunar surface by 2024.

When they land, Artemis astronauts will step foot where no human has ever been before: the Moon's South Pole.

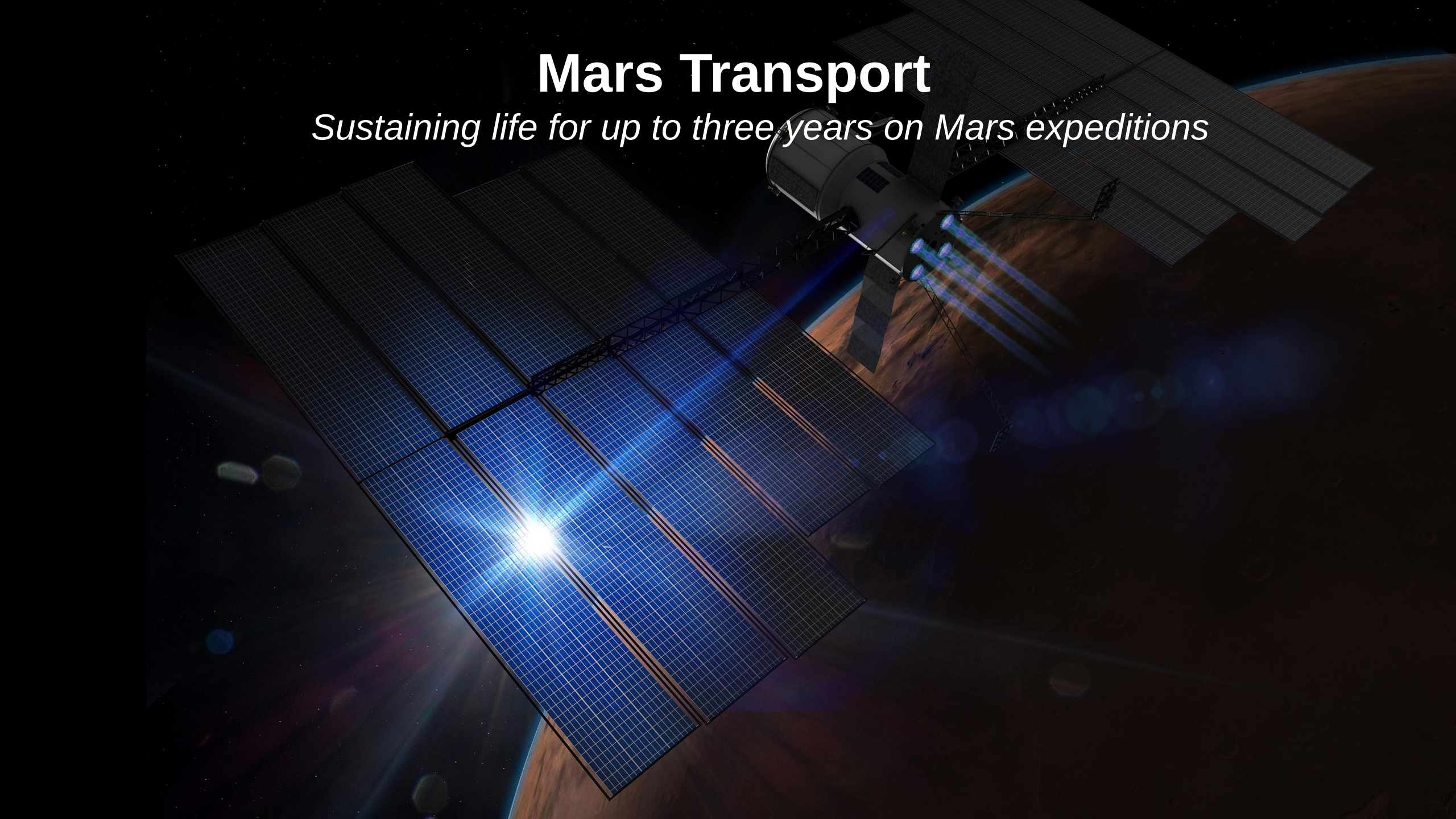
With the horizon goal of sending humans to Mars, Artemis begins the next era of exploration.

Space Policy Directive 1: To The Moon, Then Mars

“Lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities. Beginning with missions beyond low-Earth orbit, the United States will lead the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars and other destinations…”

Mars Transport

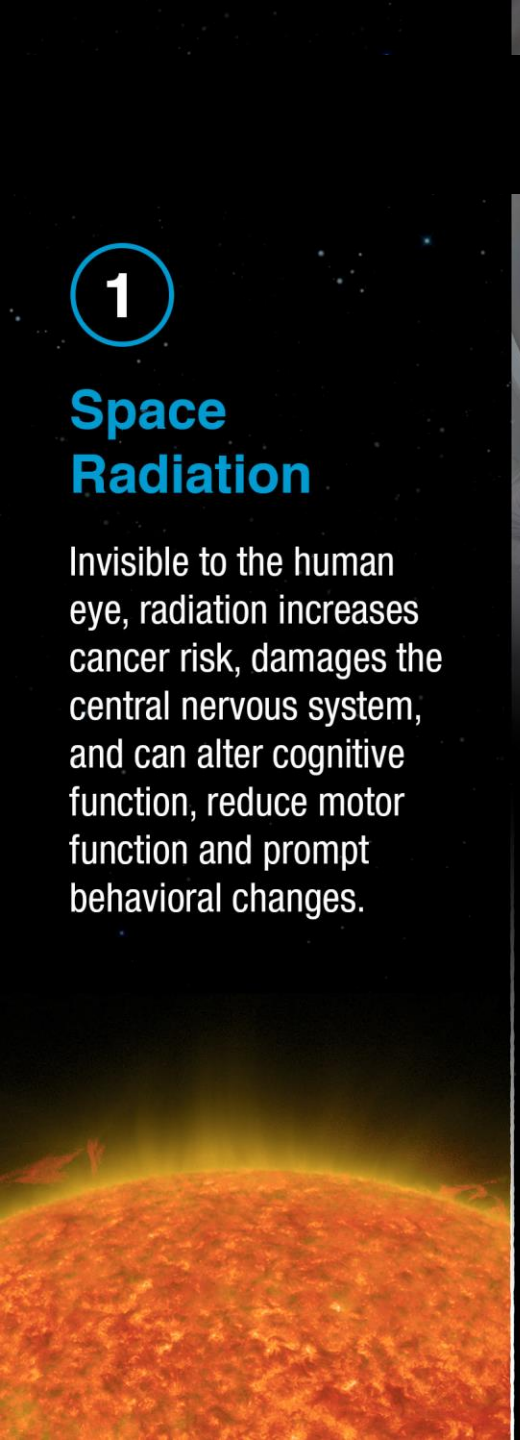
Sustaining life for up to three years on Mars expeditions

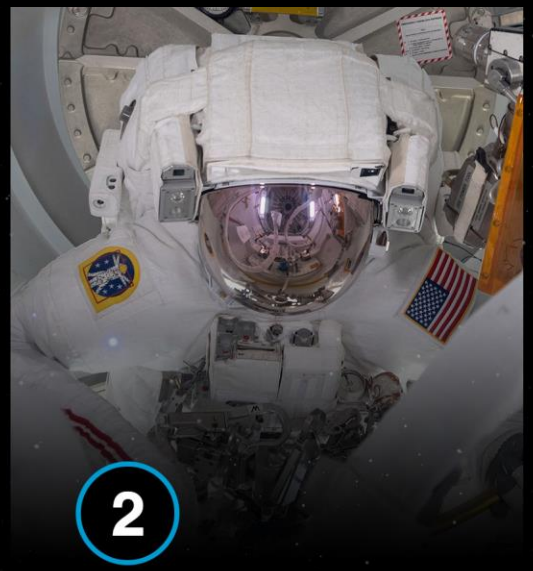


5 Hazards Of Human Spaceflight

1 Space Radiation

Invisible to the human eye, radiation increases cancer risk, damages the central nervous system, and can alter cognitive function, reduce motor function and prompt behavioral changes.



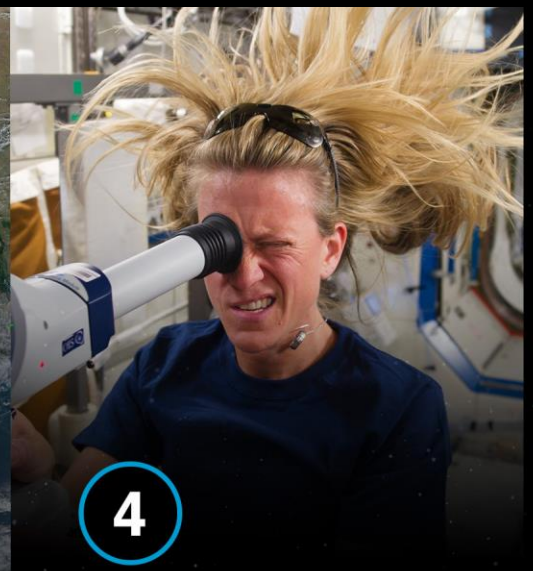


2 Isolation and Confinement

Sleep loss, circadian desynchronization, and work overload may lead to performance reductions, adverse health outcomes, and compromised mission objectives.

3 Distance from Earth

Planning and self-sufficiency are essential keys to a successful mission. Communication delays, the possibility of equipment failures and medical emergencies are some situations the astronauts must be capable of confronting.

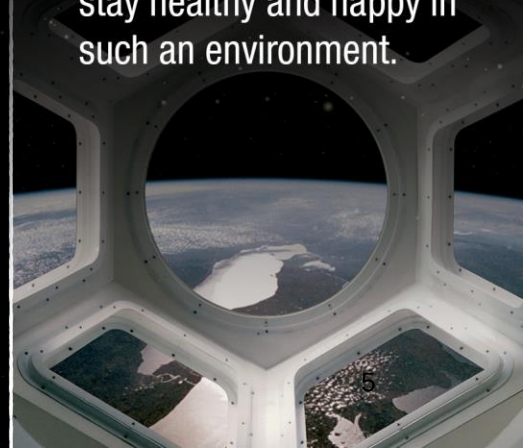


4 Gravity (or lack thereof)

Astronauts encounter a variance of gravity during missions. On Mars, astronauts would need to live and work in three-eighths of Earth's gravitational pull for up to two years.

5 Hostile/Closed Environments

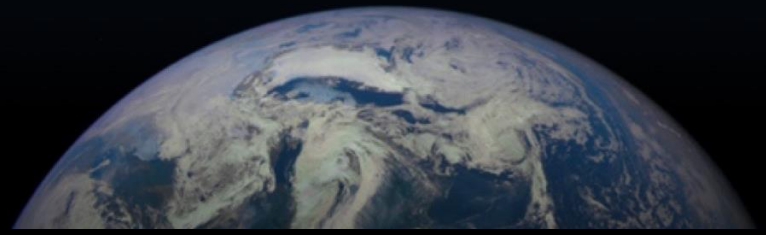
The ecosystem inside a vehicle plays a big role in everyday astronaut life. Important habitability factors include temperature, pressure, lighting, noise, and quantity of space. It's essential that astronauts stay healthy and happy in such an environment.



Mission Needs Drive Design

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

Developing Exploration Capabilities

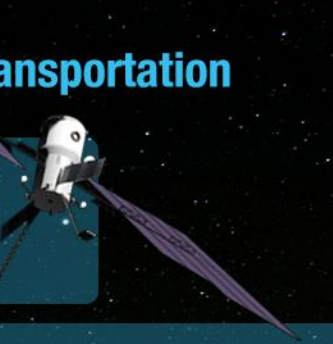
From Low Earth Orbit to the Moon and Mars

International Space Station (ISS)

Notional Commercial Platform

Gateway

Mars-Class Transportation



Advanced Communications
Advanced Propulsion
Automated In-Space Assembly

Fire Detection, Suppression and Cleanup
Medical Autonomy, Human Health, and Food Systems
Long-Duration Environmental Control and Life Support Systems (ECLSS)
Autonomous Environmental Monitoring and Vehicle Operations
In-Space Manufacturing
Next Generation Spacesuits

Radiation Monitoring and Protection

Entry Descent and Landing (EDL) Including Precision Landing

Earth Surface

Lunar Surface

Mars Surface

Cryogenic Fluid Management
In-Situ Resource Utilization (ISRU)
Sustainable Power

Earth-Independent Crew Operations with Communications Delay
Autonomous Egress/Post Landing Operations

Sustainable and Efficient Human Exploration

Evolving Environmental Control and Life Support Systems (ECLSS)

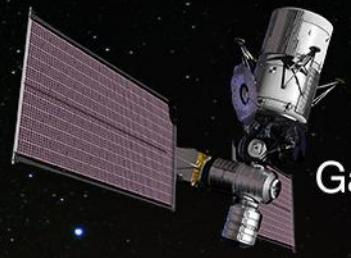
Evolution of ECLSS ISS to Exploration

International Space Station (ISS)

Continue ECLSS Testbed in Low-Earth Orbit (LEO)

Notional Commercial Platform

Infuse Exploration ECLSS as Applicable



Gateway

Infuse Exploration ECLSS into Mars Transport and Surface

Mars-class Transportation

Surface Systems Ground Test

Lunar Surface Short Duration and Regenerative ECLSS

Mars Surface Regenerative ECLSS

International Interoperability Standards

Preparing for deep space exploration

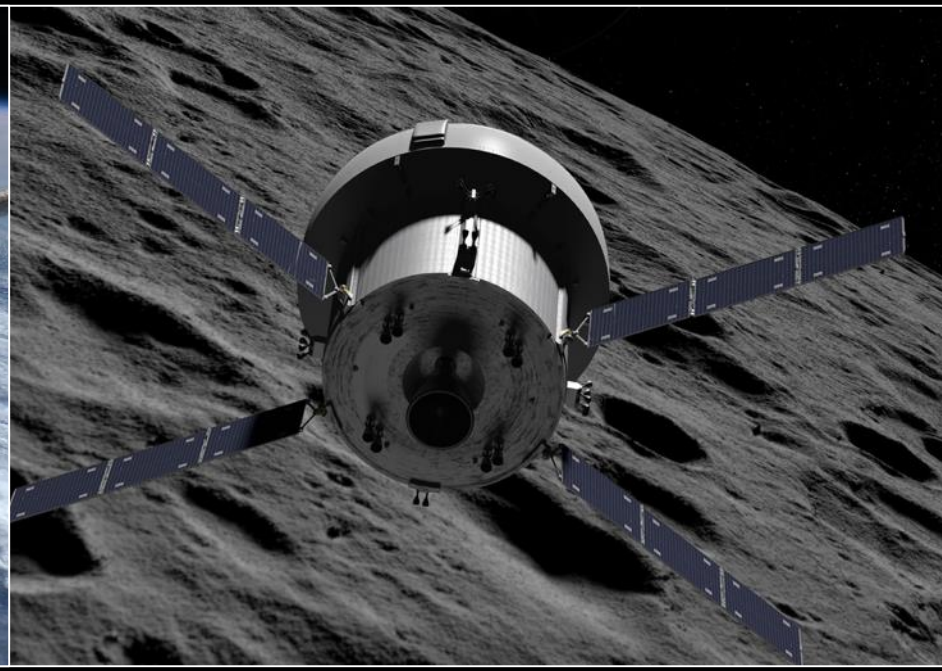
Draft Deep Space Interoperability System Standards Posted for feedback on March 1, 2018

- Avionics
- Communications
- Environmental Control and Life Support Systems
- Power
- Rendezvous
- Robotics
- Thermal

www.InternationalDeepSpaceStandards.com

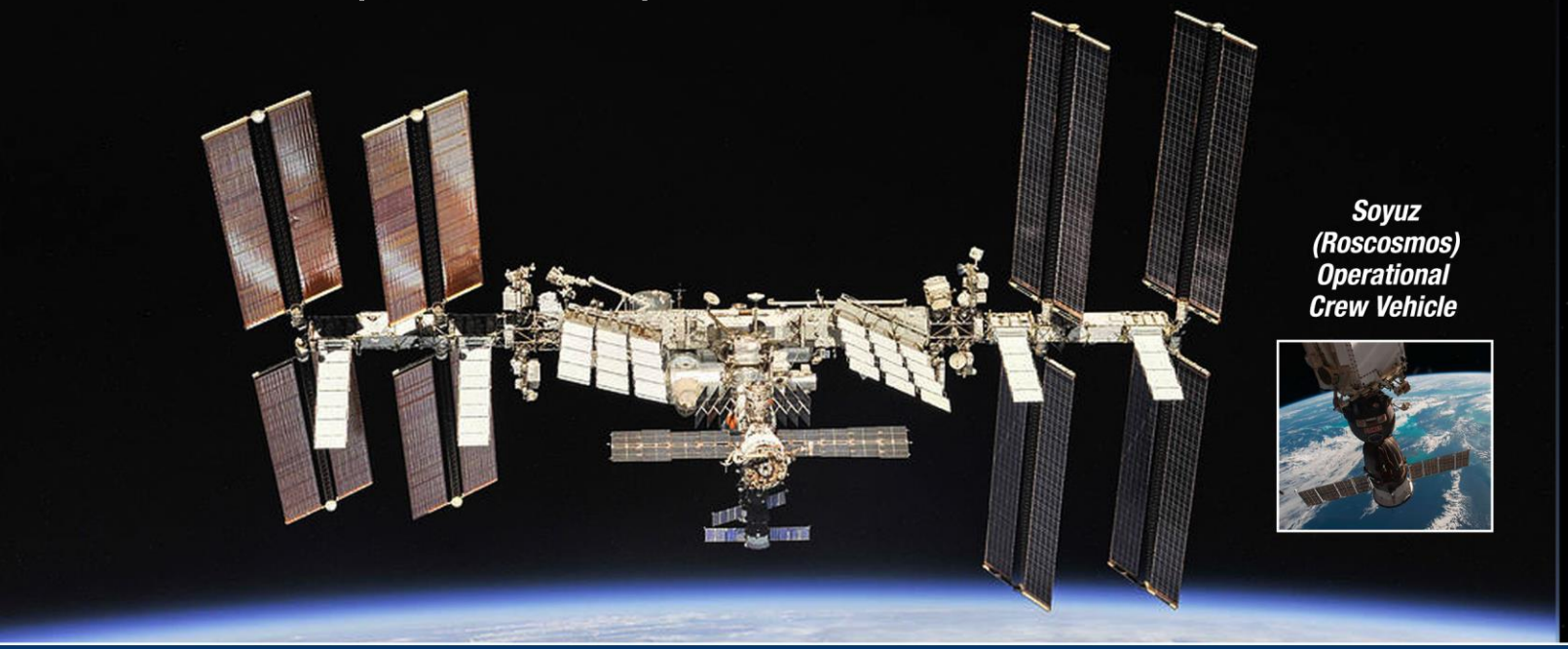
International Cooperation

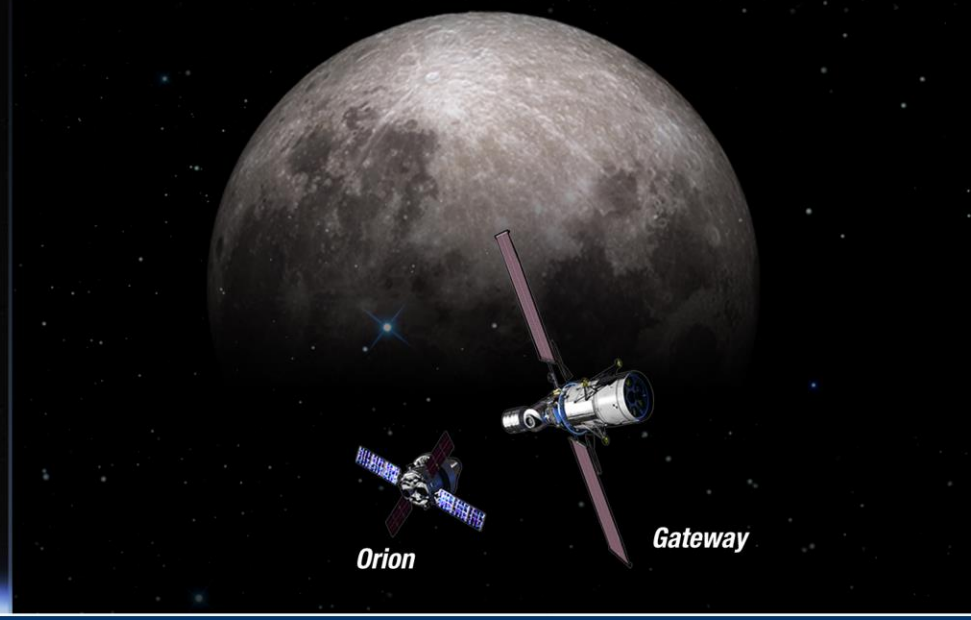
NASA is leading and facilitating a sustainable open architecture program that is open to and relies on international and commercial partners



The International Space Station

The Centerpiece of Exploration and Model for a New Future in Space





Continuous and ongoing cargo and crew operations aboard space station, along with commercial and international partnerships, allows human exploration to advance at a sustainable pace

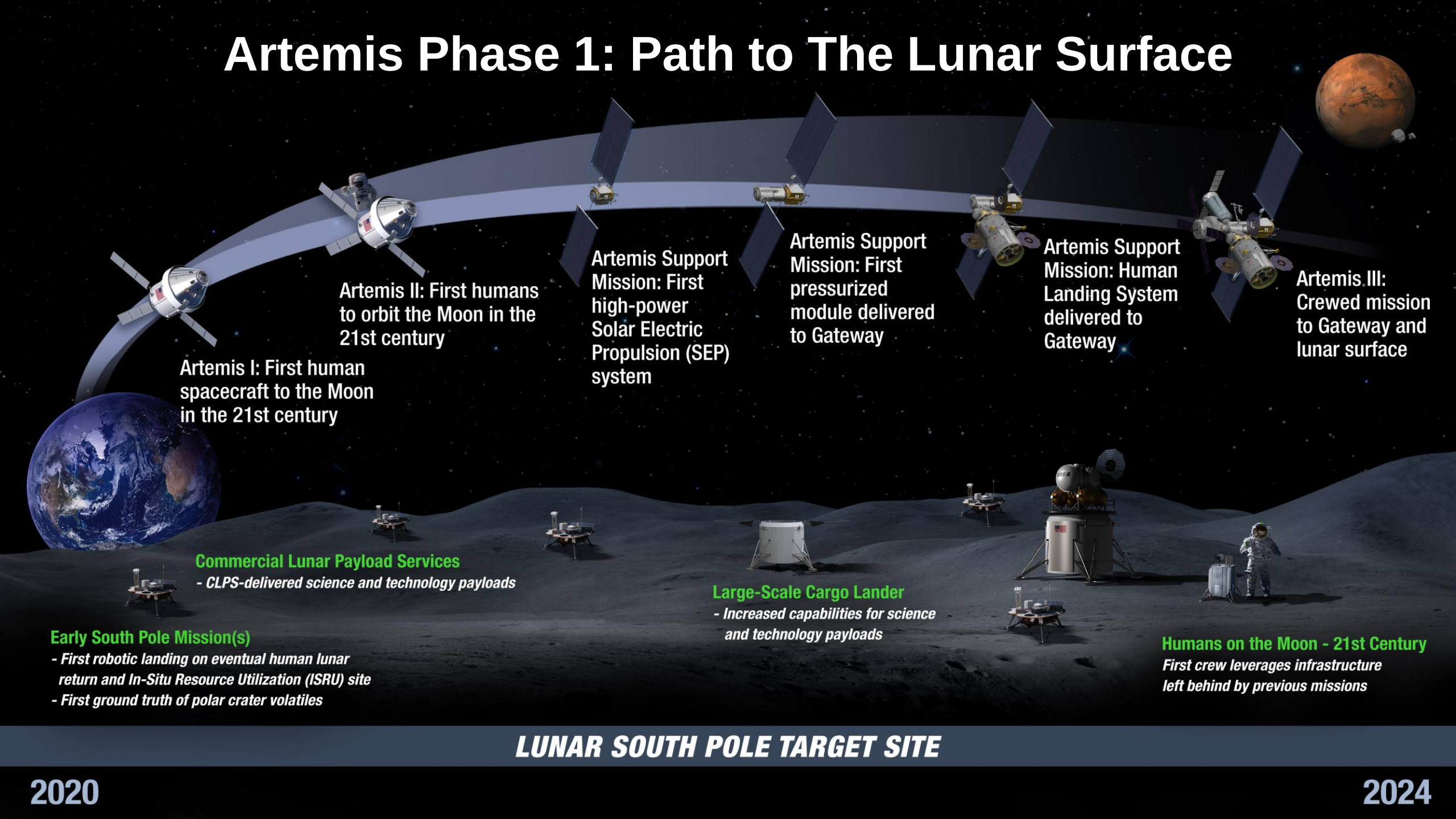
CARGO

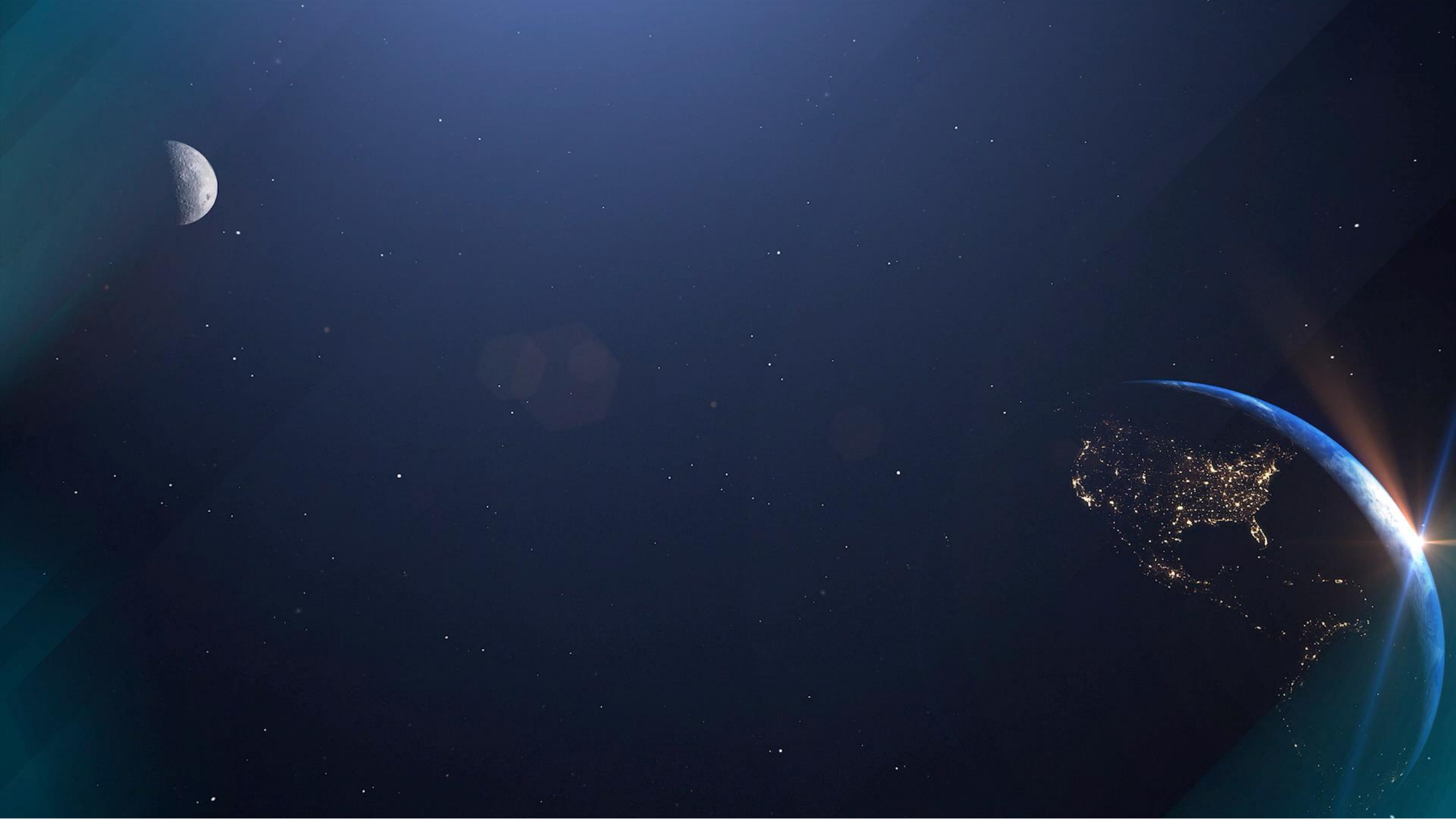
CREW

Commercializing Low-Earth Orbit

Transitioning U.S. human spaceflight in low-Earth orbit to commercial operations, supporting NASA and the needs of an emerging private sector

Artemis Phase 1: Path to The Lunar Surface

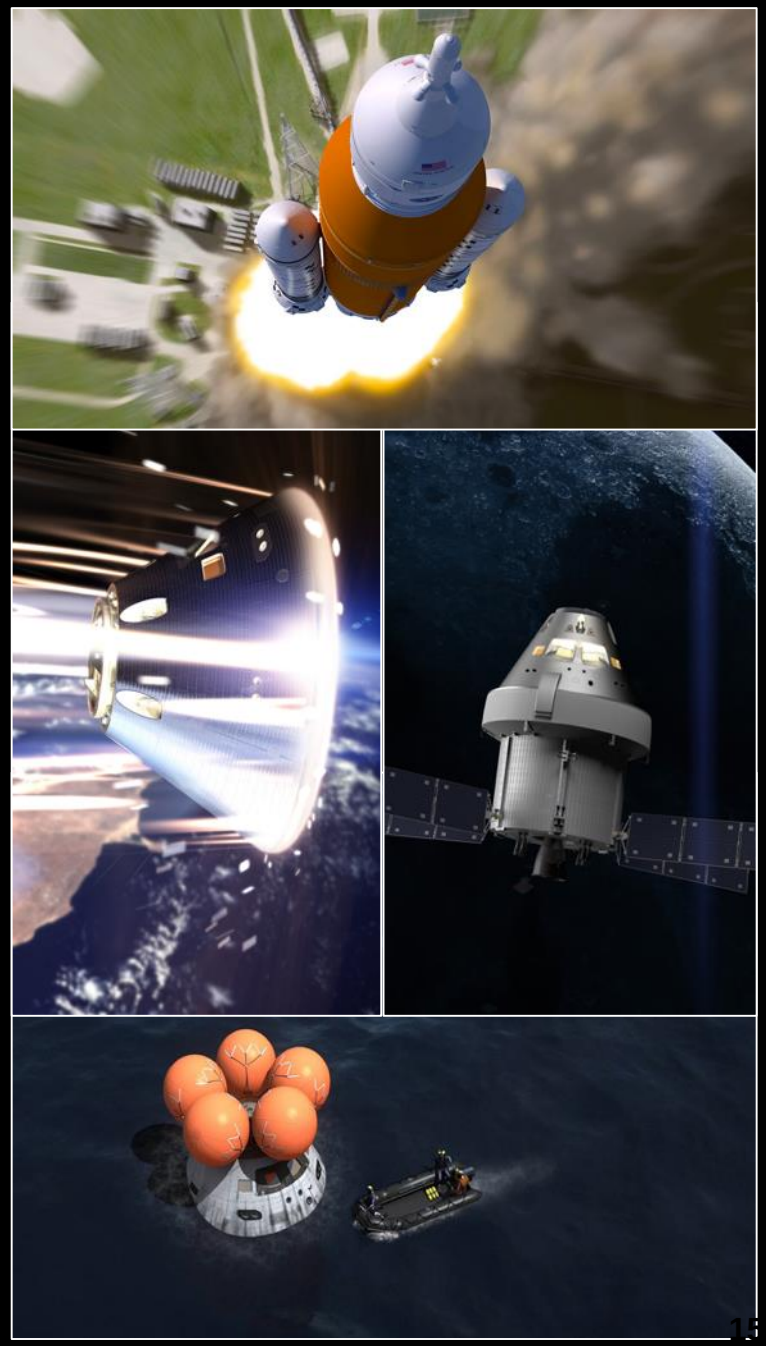




ARTEMIS I Mission Priorities

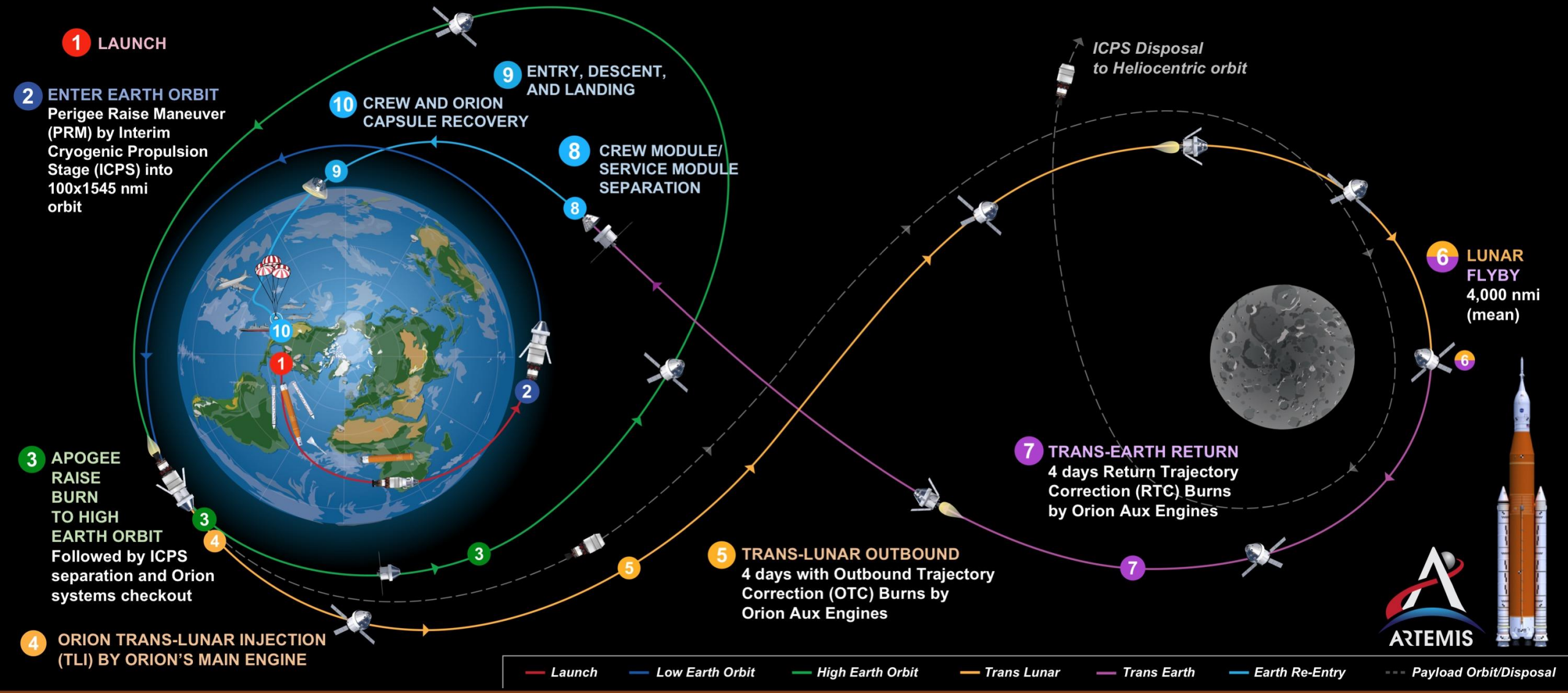
A flight test that will enable NASA to fly crew to the Moon and back on Artemis II:

1. **Demonstrate Orion heatshield at lunar entry velocities**
2. **Operate Systems in Flight Environment**
3. **Retrieve Spacecraft**
4. **Complete Remaining Objectives**: Perform residual mission in the absence of system failures and conduct all mission content as planned



ARTEMIS II

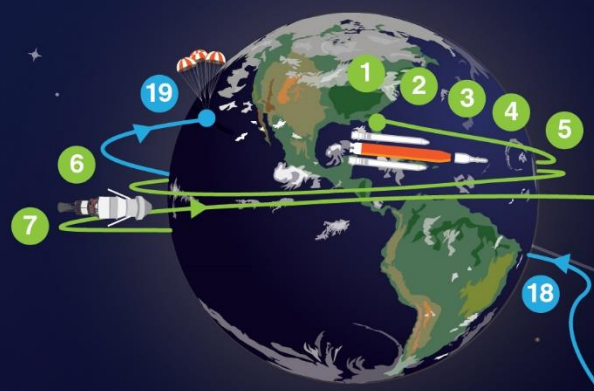
Crewed Hybrid Free Return Trajectory, demonstrating crewed flight and spacecraft systems performance beyond Low Earth Orbit (LEO)



SLS Configuration (Block 1) with Human Rated ICPS | 15x1200 nmi (27.8x2222.4 km) insertion orbit | 28.5 deg inclination

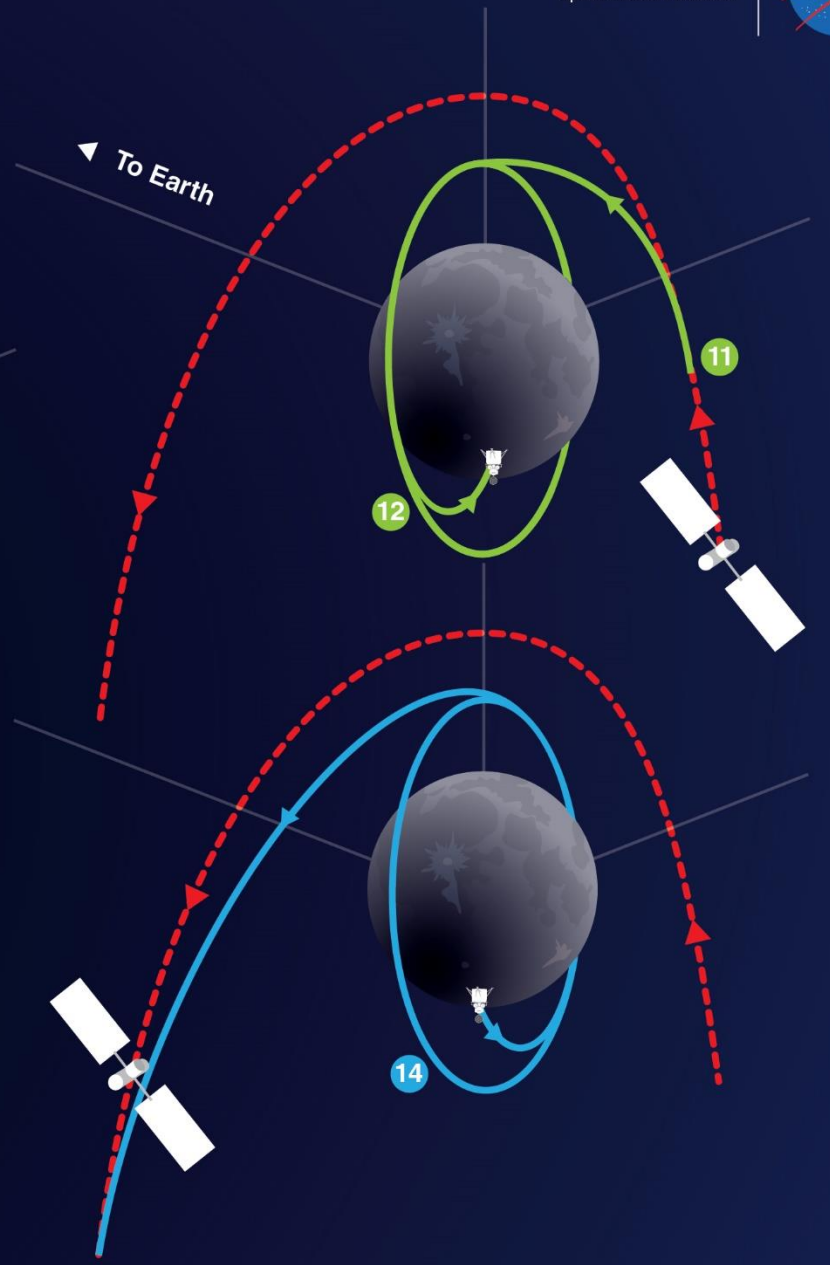
4 astronauts | Mission duration: 10 Days | Re-entry speed: 24,500 mph (Mach 32)

National Aeronautics and Space Administration



ARTEMIS III

Landing on the Moon in 2024



1. **LAUNCH** — SLS and Orion lift off from Kennedy Space Center
2. **JETTISON ROCKET BOOSTERS** — Solid rocket boosters separate
3. **JETTISON LAUNCH ABORT SYSTEM (LAS)** — The LAS is no longer needed, Orion could safety abort
4. **CORE STAGE MAIN ENGINE CUT OFF** — With separation
5. **ENTER EARTH ORBIT** — Perform the perigee raise maneuver
6. **EARTH ORBIT** — Systems check and solar panel adjustments
7. **TRANS LUNAR INJECTION BURN** — Burn lasts for approximately 20 minutes
8. **ORION OUTBOUND TRANSIT TO MOON** — Requires several attitude maneuvers
9. **ORION OUTBOUND POWERED FLYBY**
10. **GATEWAY ORBIT INSERTION BURN** — Orion performs burn and rendezvous to dock to the Gateway
11. **HUMAN LANDING SYSTEM (HLS)** — Undocks from Gateway
12. **HLS ENTERS LOW LUNAR ORBIT** — Descends to lunar touchdown
13. **GATEWAY/ORION REMAIN IN LUNAR GATEWAY ORBIT** — During lunar surface mission
14. **HLS ASCENDS LOW LUNAR ORBIT** — Then to Gateway Orbit to dock with Gateway
15. **CREW RETURNS TO ORION** — Undocks from Gateway, and departs Gateway Orbit
16. **ORION RETURN POWERED FLYBY**
17. **ORION TRANSITS TO EARTH**
18. **ENTRY INTERFACE** — Enter Earth's atmosphere
19. **SPLASHDOWN** — Pacific Ocean landing within view of U.S. Navy recovery ships

Achieving 2024 – A Parallel Path to Success

Artemis will see government and commercial systems moving in parallel to complete the architecture and deliver crew

CREW

NASA Programs SLS and Orion

Artemis 1

First flight test of SLS and Orion as an integrated system

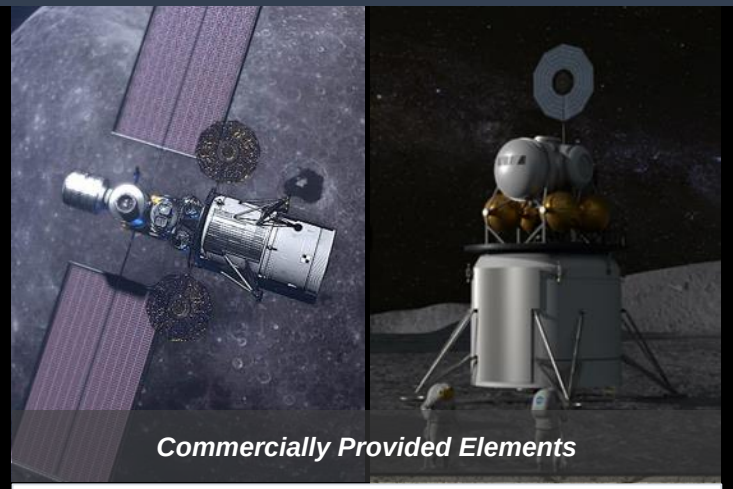
Artemis 2

First flight of crew to the Moon aboard SLS and Orion

Artemis 3

First crew to the lunar surface; Logistics delivered for 2024 surface mission

Between now and 2024, U.S. industry delivers the launches and human landing system necessary for a faster return to the Moon and sustainability through Gateway.



Commercially Provided Elements

CARGO

PPE

Power and Propulsion Element arrives at NRHO via commercial rocket

Pressurized Module

Small area for crew to check out systems prior to lunar transfer and decent

Human Landing System

Transfer

Transfers lander from Gateway to low lunar orbit

Descent

Descends from Transfer Vehicle to lunar surface

Ascent

Ascends from lunar surface to Gateway

Up to three commercial rocket launches, depending on distribution of the Transfer, Descent, and Ascent functions.

Deep Space Exploration Systems

Status and progress of SLS, Orion and Ground Systems

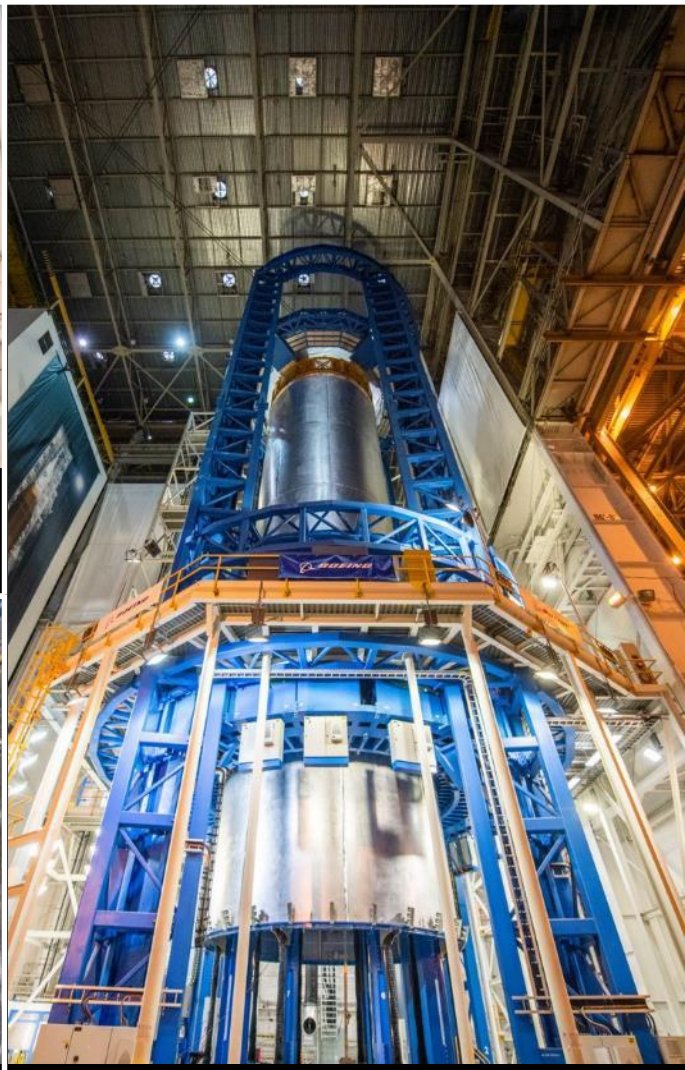
SLS Progress Toward Artemis I
Flight Articles

SLS Progress Toward Artemis II

All Booster Motor Segments Cast; Seven Complete

Forward Skirt

Liquid Oxygen Tank



Liquid Hydrogen Tank

Two Rs-25s Complete, Controllers Green Run

Engine Section

LVSA, OSA, ICPS Panels

Third Flight and Beyond

Five RL-10s Complete

Booster Processing

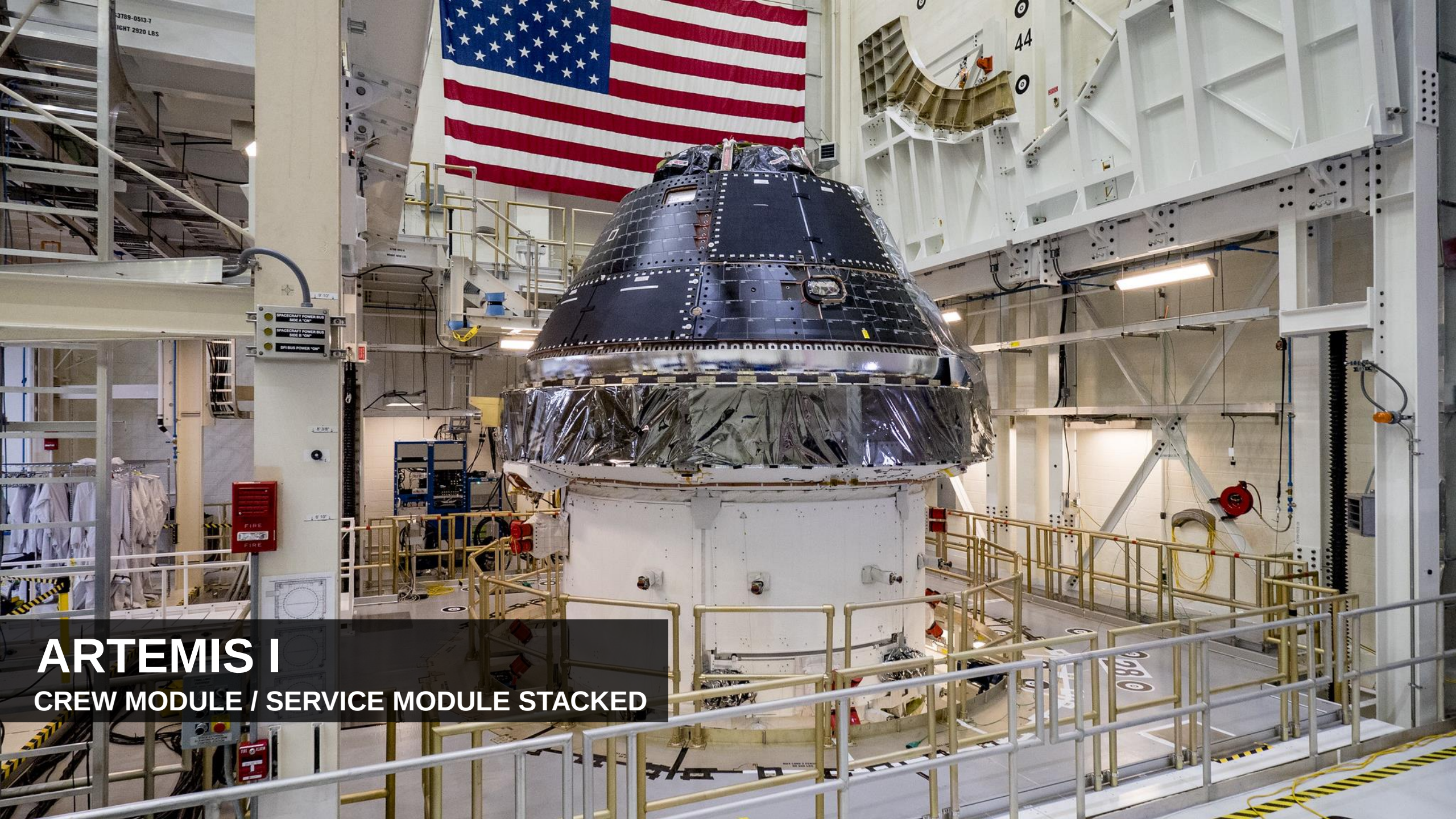
Payload Adapter Manufacturing Demonstration Article

RS-25 HIP-bonded Main Combustion Chamber

Tooling for USA

EUS Weld Confidence Articles

Additive Manufactured POGO Accumulator



ARTEMIS I

CREW MODULE / SERVICE MODULE STACKED

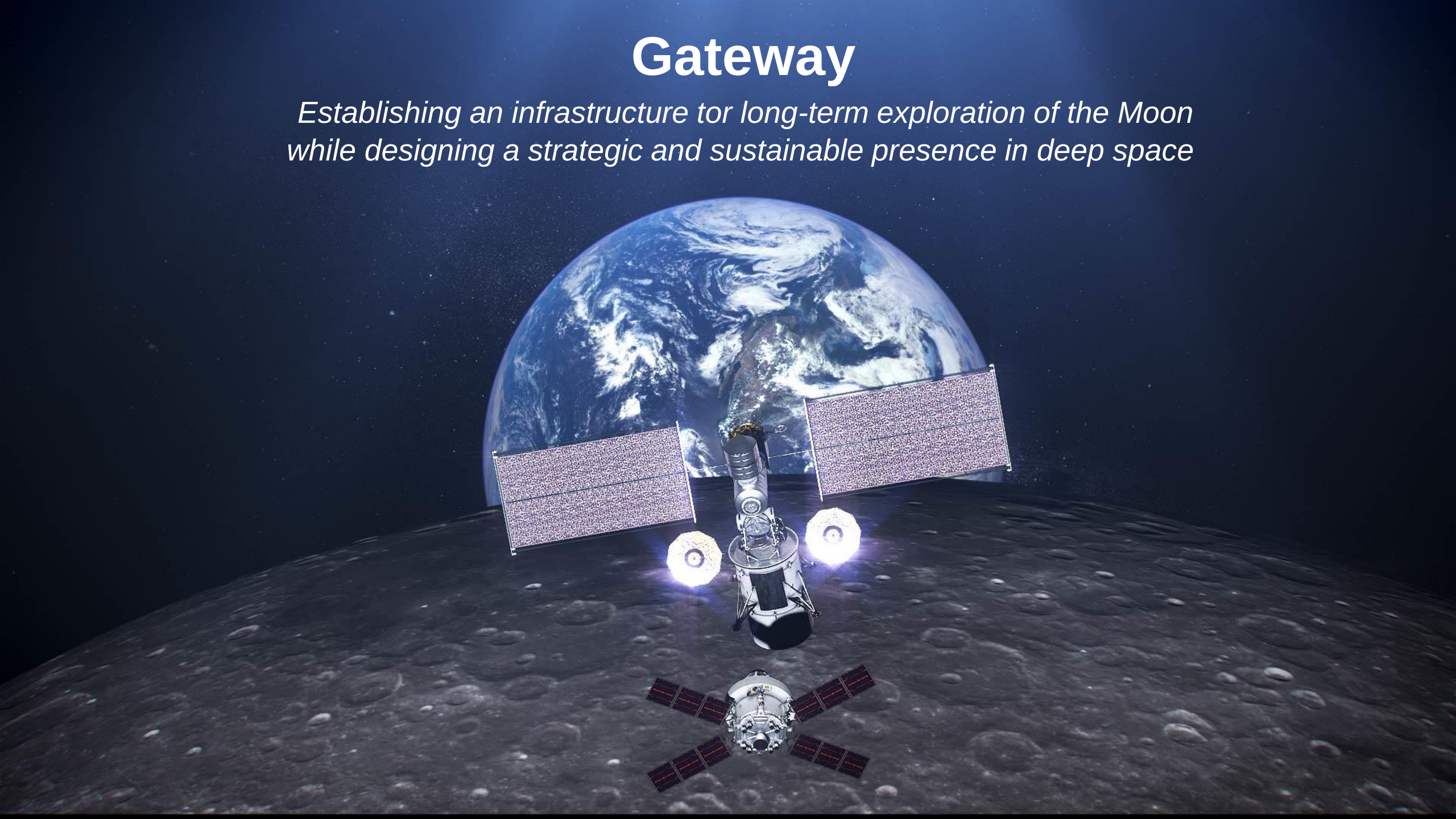

ARTEMIS I
STRUCTURAL TEST ARTICLE

ARTEMIS I

INTEGRATED TEST LAB

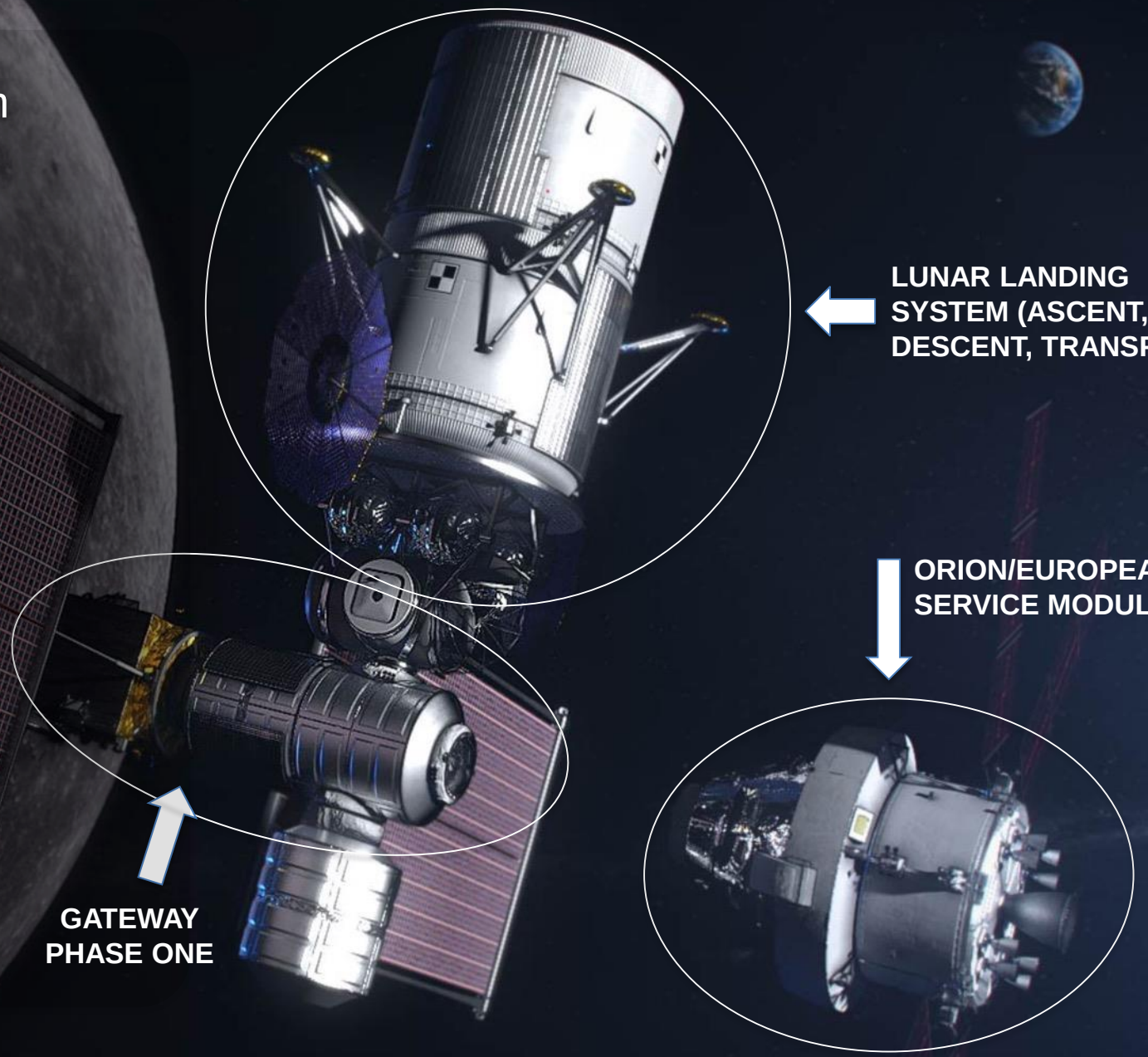
Gateway

Establishing an infrastructure tor long-term exploration of the Moon while designing a strategic and sustainable presence in deep space

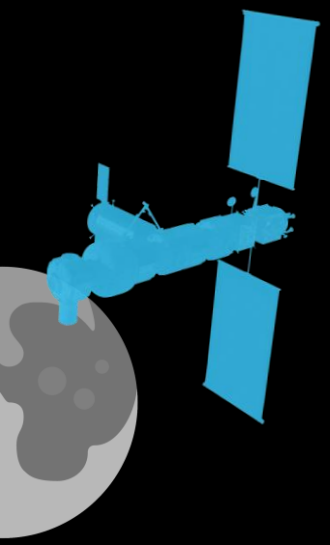


Gateway Enables Exploration of the Moon and Mars

- Initial Gateway focuses on the minimum systems required to support a 2024 human lunar landing while also supporting Phase 2
- Provides command center and aggregation point for 2024 human landing
- Establishes strategic presence around the Moon – US in the leadership role
- Creates resilience and robustness in the lunar architecture
- Open architecture and interoperability standards provides building blocks for partnerships and future expansion



Potential Gateway Science Opportunities



CREWS LIVING AND WORKING IN THE DEEP SPACE ENVIRONMENT

- Human health and performance associated with living and working in deep space

ELEMENTS WILL HAVE INTERNAL AND EXTERNAL PAYLOAD ACCOMMODATIONS

- Earth science, heliophysics, astrophysics, lunar/planetary science, and fundamental physics
- Technology and capability testing for future exploration destinations
- Combined radiation effects and microgravity on biological organisms

LUNAR SURFACE OPPORTUNITIES

- Crewed and robotic surface missions
- Sample return
- Lander and systems development

OTHER CISLUNAR LOCATIONS ACCESSIBLE

- Potential for use of logistics modules as science platforms post departure from Gateway, including heliocentric disposal orbit
- Variations of NRHO, Low Lunar Orbit, Distant Retrograde Orbit, Earth-Moon Lagrange Points

GATEWAY COMMUNICATIONS RELAY

- Coverage of lunar poles, craters/valleys and lunar farside not possible from Earth
- Teleoperations of surface assets by crew or Earth-based operators
- In support of small satellite communications relay

Human Landing System

Providing crew access to the lunar surface

NASA will develop increasingly larger, and reusable landers for humans

Our solicitation is open and we are looking forward to innovative concepts from U.S. industry

Sustained Surface Activities

The Moon’s unique science platform will advance our understanding of our home planet and our solar system

Modernized Space Suits

NASA is preparing to build the modernized spacesuits for 2024, called *Exploration Extravehicular Mobility Unit*, or xEMU

The 2024 suits will be built in-house; we have released a request for information inviting thoughts from U.S. industry of how to shift production to the private sector for 2025 and beyond

QUESTIONS?