



**FORWARD TO THE MOON:
NASA's Strategic Plan for
Lunar Exploration**


Updated 6/06/2019



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.

A photograph of Vice President Mike Pence speaking at a podium. He is wearing a dark suit, a white shirt, and a red tie. The podium features the NASA logo and the text "APOLLO 50th NEXT GIANT LEAP". To the right of the podium is a sign that says "U.S. Space & Rocket Center". The background is dark with some blue lighting and a large screen displaying the Apollo 50th anniversary logo.

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.

Why Go to the Moon?

Establishes American leadership and strategic presence

Proves technologies and capabilities for sending humans to Mars

Inspires a new generation and encourages careers in STEM

Leads civilization changing science and technology

Expands the U.S. global economic impact

Broadens U.S. industry & international partnerships in deep space

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.

American Leadership in Space Exploration



EARTH ORBIT

- Grow a robust commercial space industry with a constant human presence
- Expand our international partnerships through the ISS
- Conduct exploration science and technology demonstrations aboard ISS
- Continue critical earth science research
- New jobs through in-space manufacturing and assembly
- Low-Earth orbit launches us to farther destinations



LUNAR ORBIT

- The next step for commercial space development
- Conduct ground-breaking decadal science
- A new venue to strengthen international partnerships
- Stepping stone and training ground for extending human presence into deep space
- Sustainable and affordable human and robotic programs



LUNAR SURFACE

- Seed investments in commercial lunar landers
- Opportunities to develop technologies for long-term survival
- Explore and exploit space resources
- Create a foothold on a new frontier



MARS & BEYOND

- America's next giant leap – reaching new worlds
- Push the boundaries of human knowledge
- Answer the question of 'are we alone?'
- Unlock the mysteries of the universe



THE ARTEMIS PROGRAM

PHASE ONE:
South Pole by 2024



Strategic Changes to Achieve 2024



Feature	Previous 2028 Target Features	Revised Target features for 2024 crew
Gateway	multi-element platform	minimum configuration
Crew Size	Sizing for up to 4 crew to the lunar surface	2 to surface initially with up to 2 crew on-orbit
Access	Global	South Pole
Partners	Commercial and international partner contributions prior to crewed lunar surface mission; interoperability standards provide opportunities	Much stronger commercial engagement sooner, international opportunities remain; interoperability standards enable all partners
Launch Vehicles	SLS and commercial	SLS with earlier use of commercial launch vehicles
Mission Duration	7 day lunar sortie	Trade lower number of mission days as needed
Schedule	2028 with a paced approach	Focused urgency and energy to accomplish 2024
NASA Organizational Change	<p>Landing humans on the surface of the Moon in 2024 will require changes to established internal and external policies, procedures, and processes including: Legal/Procurement, Budget/Resources, Staffing/Workforce, Governance/Organization</p> <p>Teams across the agency are working detailed recommendations in these, and other categories to support meeting the 2024 objective</p>	

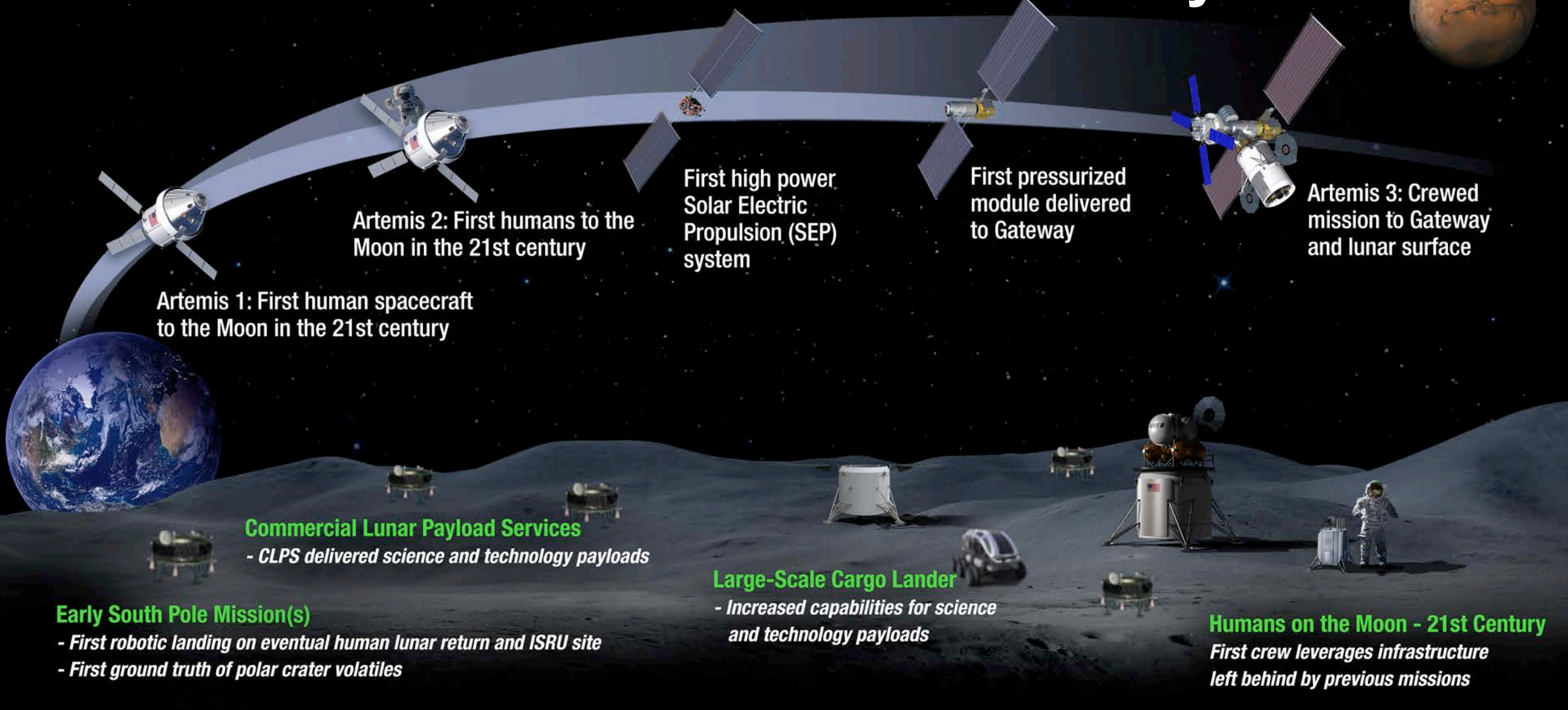
A Budget Increase Toward 2024



- The FY2020 budget amendment provides an **increase** of **\$1.6 billion** above the president's initial **\$21 billion** budget request with no money taken from existing NASA programs. This is the **boost** NASA needs.
 - \$1 billion to accelerate development of human lunar transportation systems to take astronauts to the surface and back to Gateway*
 - \$651 million towards the completion of SLS and Orion to support a 2024 landing.
 - \$132 million for new technologies to help astronauts live and work on the lunar surface and in deep space.
 - \$90 million for Science to increase robotic exploration at the lunar South Pole in advance of astronauts.

** Focusing Gateway on just the capabilities needed for Phase 1 allowed for a \$321M scope reduction and shifts potential development and expanded capabilities for Gateway into Phase 2.*

Artemis Phase 1: To the Lunar Surface by 2024



LUNAR SOUTH POLE TARGET SITE

2019

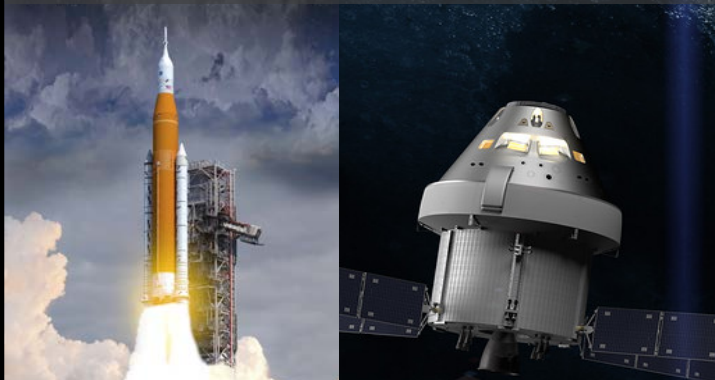
2024

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

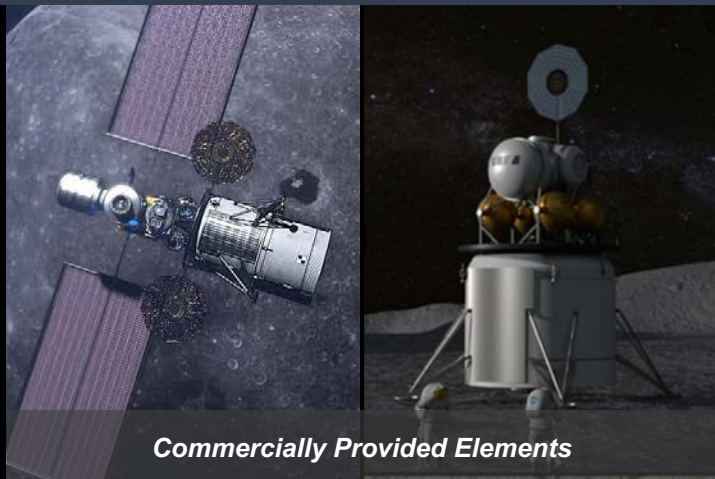
Artemis 2

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 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.

The Power of SLS and Orion



ORION

The only spacecraft capable of carrying and sustaining crew on missions to deep space, providing emergency abort capability, and safe re-entry from lunar return velocities

SLS

The only rocket with the power and capability required to carry astronauts to deep space onboard the Orion spacecraft

NATIONAL CAPABILITY

The SLS and Orion programs (including Exploration Ground Support at Kennedy Space Center) leverages over 3,800 suppliers and over 60,000 workers across all 50 states

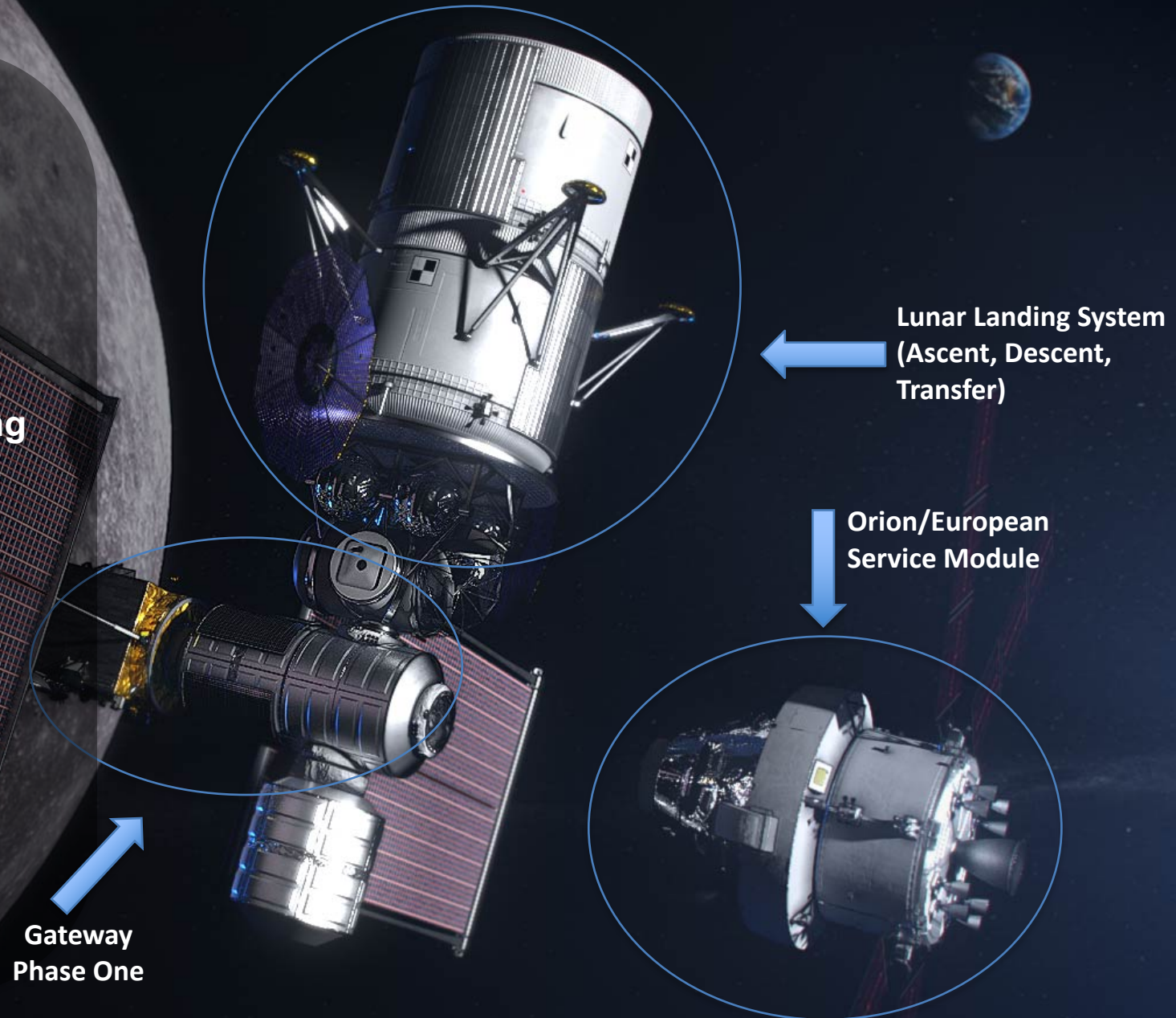
Integrated Artemis Manifest: 2019-2024



	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	
Sustainable Low-Earth Capability	<p>Commercial Crew Test Flights and Certification</p> <ul style="list-style-type: none"> ISS MCB (transition) LEO Commercialization Studies 		<p>Other LEO Commercialization Activities (in work):</p> <ul style="list-style-type: none"> Multi-Agency Working Group (through NSpC) ISS Capabilities Pricing Policy Government LEO Research Policy (through NSpC) LEO Commercial Capabilities Solicitation 								
Sustainable Lunar Orbit Staging Capability	<p>Development/Procurement Starts Now (2019)</p>										
Sustainable Lunar Surface Exploration	<p>AA-2</p> <p>NextSTEP Hab ground prototypes complete</p> <p>CLPS opportunity</p> <p>Candidate Tech Insertion Opportunities</p>	<p>Artemis 1 uncrewed test flight + 13 CubeSats, 7 lunar (under review)</p> <p>CLPS opportunity</p> <p>NDL ↑</p>	<p>Artemis 2 crewed test flight (under review)</p> <p>CLPS opportunity</p> <p>NDL, ISRU ↑</p>	<p>Artemis 3 Crew + Surface Logistics</p> <p>CLPS opportunity</p> <p>NDL, ISRU, & HPSC ↑</p>	<p>CLV w/tug Mini-Hab</p> <p>Enhanced Science and Exploration Capability</p> <p>CLPS opportunity</p> <p>HPSC, NDL, ISRU, haz. detection, CFM, & TRN ↑</p>	<p>3 CLVs TV, Descent, and Ascent Modules</p> <p>Human Lunar Landing</p> <p>CLPS opportunity</p>	<p>Artemis 4 Crew + HAB Augmentation</p> <p>Human Lunar Landing</p> <p>CLPS opportunity</p> <p>ISRU & Nuclear Surface Power ↑</p>	<p>Artemis 5 Crew + Surface Logistics</p> <p>Human Lunar Landing</p> <p>CLPS opportunity</p> <p>ISRU ↑</p>	<p>Artemis 6 Crew + Gateway Logistics + Robotic Arm</p> <p>Human Lunar Landing</p> <p>CLPS opportunity</p>	<p>Artemis 7 Descent + Surface Asset</p> <p>Human Lunar Landing</p> <p>CLPS opportunity</p>	<p>Artemis 8 Crew + Surface Logistics</p> <p>Human Lunar Landing</p> <p>CLPS opportunity</p> <p>Lunar Surface Asset Deployment</p>

Gateway is Essential for 2024 Landing

- 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



Lunar Science by 2024

A black and white photograph of a lunar surface. In the foreground, a robotic arm with a bucket is visible, containing a sample of lunar soil. The background shows the dark, cratered terrain of the moon under a bright sky.

Polar Landers and Rovers

- First direct measurement of polar volatiles, improving understanding of lateral and vertical distribution, physical state, and chemical composition
- Provide geology of the South-Pole Aitken basin, largest impact in the solar system

Non-Polar Landers and Rovers

- Explore scientifically valuable terrains not investigated by Apollo, including landing at a lunar swirl and making first surface magnetic measurement
- Using PI-led instruments to generate Discovery-class science, like establishing a geophysical network and visiting a lunar volcanic region to understand volcanic evolution

Orbital Data

- Deploy multiple CubeSats with Artemis 1
- Potential to acquire new scientifically valuable datasets through CubeSats delivered by CLPS providers or comm/relay spacecraft
- Global mineral mapping, including resource identification, global elemental maps, and improved volatile mapping

In-Situ Resource Initial Research

- Answering questions on composition and ability to use lunar ice for sustainment and fuel



High
Performance
Spaceflight
Computing



Precision
Landing

Solar
Electric
Propulsion



Space Technology for 2024 and Beyond



Cryofluid
Management

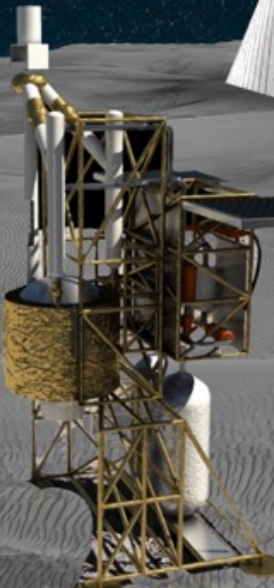


Lunar Dust
Mitigation



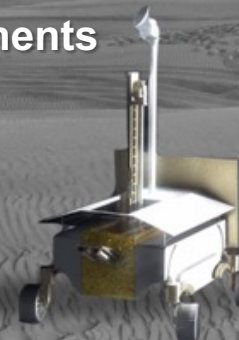
Surface
Excavation/Construction

In Situ
Resource
Utilization



Extreme Environments

Extreme Access



Lunar Surface
Power



Lunar Surface Innovation Initiative



THE ARTEMIS PROGRAM

**PHASE 2:
Sustainability at the Moon
and on to Mars**

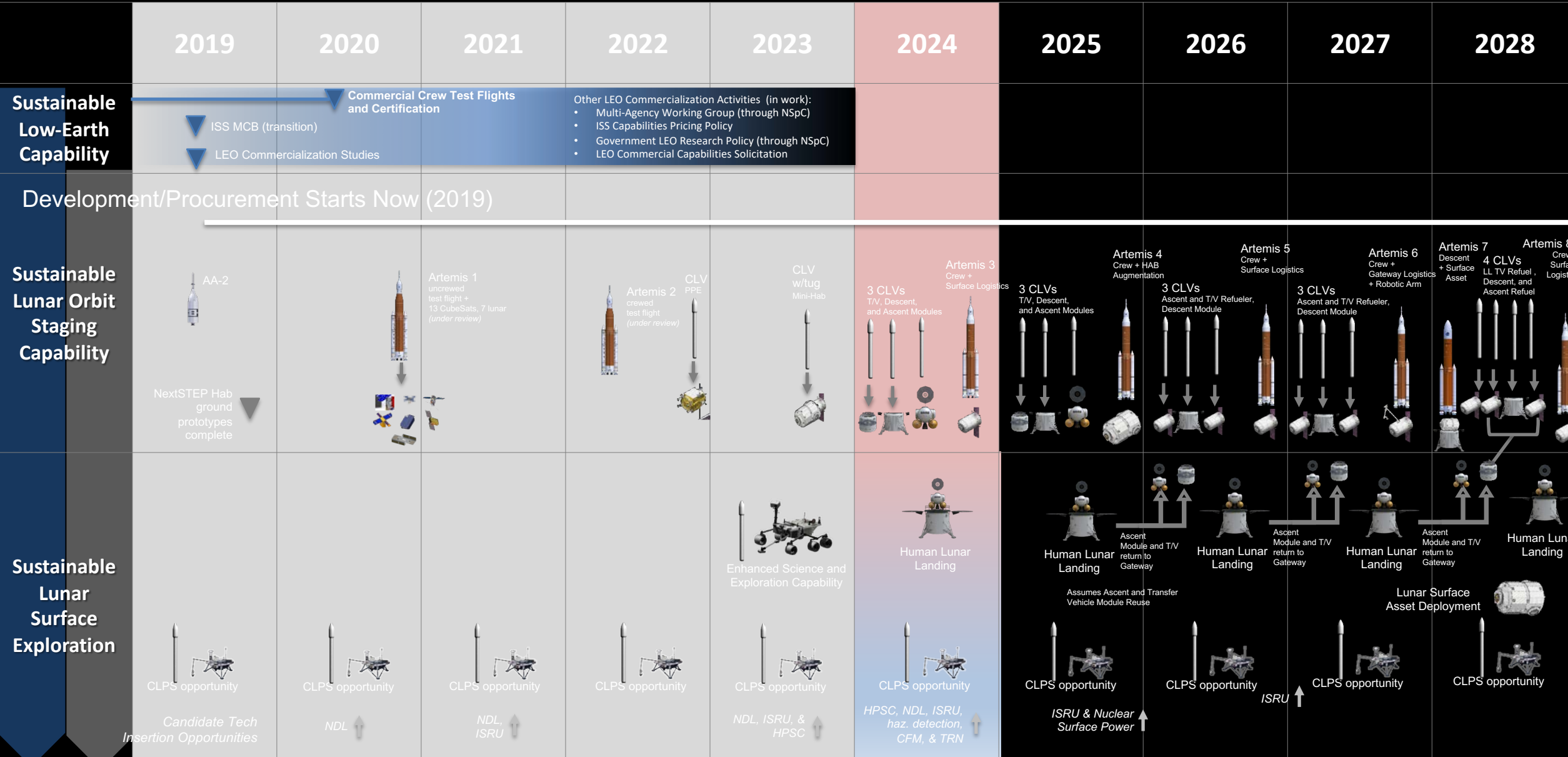


Sustainability at the Moon and on to Mars

- The U.S. leading in exploration and setting the standards for the Moon
- Unbound potential for partnerships and collaboration
- Meaningful, long-duration human missions
- Testing impacts on human performance and exploration operations to be used for Mars
- Repeatable operations traveling from Earth to the Gateway to the surface with reusable systems
- Unprecedented science outside of Earth's influence
- Maintains strategic presence as a deep space port and refueling depot around the Moon
- Increases international and commercial partnership opportunities, fostering healthy competition



Integrated Artemis Manifest: 2025-2028



Science After 2024

Human and Robotic Missions Provide Unique Science Opportunities

On Gateway

- Deep space testing of Mars-forward systems
- Hosts groundbreaking science for space weather forecasting, full-disc Earth observation, astrophysics, heliophysics, lunar and planetary science
- Mars transit testbed for reducing risk to humans

Surface Exploration

- Understanding how to use in-situ resources for fuel and life
- Revolutionizing the understanding of the origin and evolution of the Moon and inner solar system by conducting geophysical measurements and returning carefully selected samples to Earth
- Studying lunar impact craters to understand physics of the most prevalent geologic process in the solar system, impact cratering
- Setting up complex surface instrumentation for astrophysics, heliophysics and Earth observation
- Informing and supporting sustained human presence through partial gravity research in physical and life sciences, from combustion to plant growth

Surface Telerobotics to Provide Constant Science

- Sending rovers into areas too difficult for humans to explore; rovers can be teleoperated from Earth to maximize the scientific return



Lets go. *The time is now.*

We have the capability

We have the purpose

We have the charge

We have the responsibility





*Concept image