

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


Updated 5/16/2019



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 "APOLLO 50th NEXT GIANT LEAP" sign.

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

An astronaut in a white spacesuit is shown from the chest up, floating in space. The astronaut's helmet is prominent, reflecting the red surface of Mars. The background features a large, detailed view of the Moon's cratered surface, a smaller view of the Earth in the distance, and a starry black sky. The text 'EXPLORE MOON to MARS' is overlaid in the top right corner.

EXPLORE MOON *to* MARS

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	Significant Station; multi-element	Phase One; Absolute 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 first. Access to Global locations.
Partners	Commercial and international opportunities; interoperability standards	Much stronger commercial engagement sooner, international opportunities outside the critical path; interoperability standards enable all partners
Launch Vehicles	SLS and commercial	SLS with increased number of commercial launches
Mission Duration	7 day lunar sorties	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 Towards 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.

Artemis Phase 1: To the Lunar Surface by 2024



MARS 2020

ARTEMIS 1: FIRST HUMAN SPACECRAFT TO THE MOON IN THE 21st CENTURY

ARTEMIS 2: FIRST HUMANS TO THE MOON IN THE 21st CENTURY

FIRST HIGH POWER SOLAR ELECTRIC PROPULSION (SEP) SYSTEM

FIRST PRESSURIZED CREW MODULE DELIVERED TO GATEWAY

ARTEMIS 3: CREWED MISSION TO GATEWAY AND LUNAR SURFACE

Commercial Lunar Payload Services

- CLPS delivered science and technology payloads

Descent Element Test

- First large-scale lander on the Moon

Early South Pole Crater Rim Mission(s)

- First robotic landing on eventual human lunar return and ISRU site
- First ground truth of polar crater volatiles

Humans on the Moon - 21st Century

First crew leverages infrastructure left behind by previous missions

LUNAR SOUTH POLE CRATER 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



Artemis 1

First flight test of SLS and Orion as an integrated system

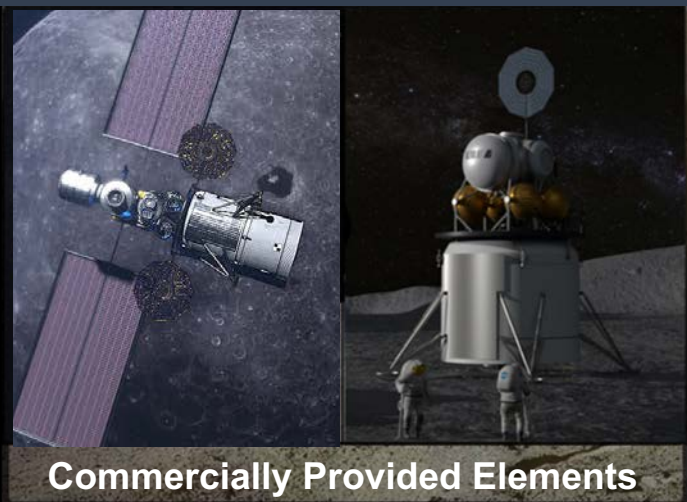
Artemis 2

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.



PPE

Power Propulsion Element arrives at NRHO via commercial rocket

Crew Module

Small pressurized crew module launches to Gateway on a commercial rocket

Descent Element

Descent Element launches to Gateway on commercial rocket

Transfer Element

Transfer Element launches to Gateway on commercial rocket

Ascent Element

Ascent Element launches to Gateway on commercial rocket

The Power of SLS and Orion

A low-angle photograph of the Space Shuttle SLS and Orion spacecraft being mated to the External Tank and Solid Rocket Boosters on the Vehicle Assembly Building. The SLS is the large orange and white rocket, and the Orion is the white spacecraft. The scene is illuminated by bright lights, creating a dramatic effect against a dark sky.

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
Sustainable Low-Earth Capability	 ISS MCB (transition) LEO Commercialization Studies		Commercial Crew Test Flights and Certification Other LEO Commercialization Activities (in work): <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 			
Development/Procurement Starts Now (2019)						
Sustainable Lunar Orbit Staging Capability	AA 2 NextSTEP Hab ground prototypes complete	 Artemis 1 uncrewed test flight + 13 CubeSats, 7 lunar (under review)	 Artemis 2 crewed test flight (under review)	 CLV w/tug Min Hab	 3 CLVs TV, Descent, and Ascent Modules	 Artemis 3 Crew + Surface Logistics
Sustainable Lunar Surface Exploration	 CLPS opportunity Candidate Tech Insertion Opportunities	 CLPS opportunity NDL ↑	 CLPS opportunity NDL, ISRU ↑	 CLPS opportunity NDL, ISRU, & HPSC ↑	 Enhanced Science and Exploration Capability	 Human Lunar Landing CLPS opportunity HPSC, NDL, ISRU, haz. detection, CFM, & TRN ↑

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
- Provides building block for the future, expanded capabilities on and around the Moon

Gateway Phase One

Lunar Transport System (Ascent, Descent, Transfer)

Orion/European Service Module



Lunar Science by 2024

Polar Landers and Rovers

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

Non-Polar Landers and Rovers

- Ability to explore scientifically valuable terrains not explored by Apollo.
Examples include:
 - Land at a lunar swirl and make the first surface magnetic measurement
 - Visit young volcanic features such as Ina to understand volcanic evolution
- PI-led instruments - Discovery-class science such as geophysical network and visiting lunar volcanic region

Artemis 1 – Cube Satellite Program

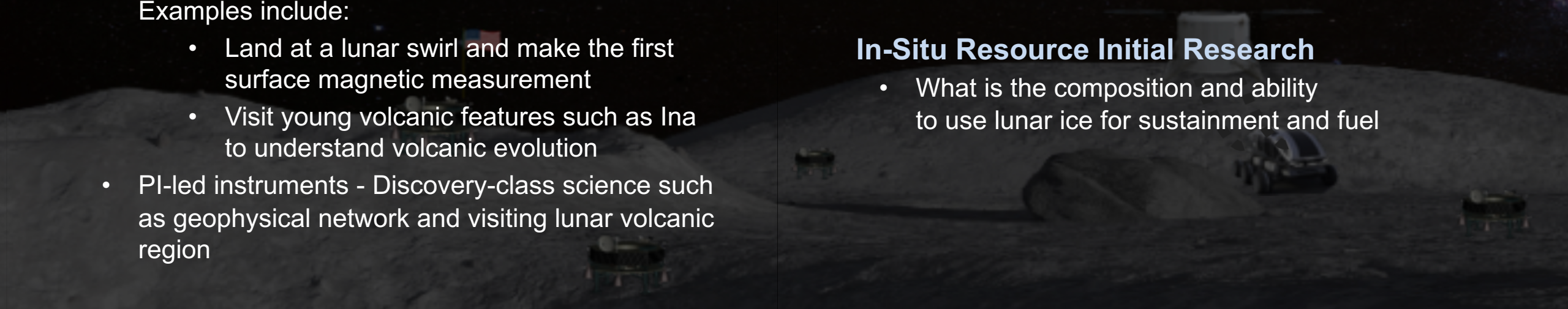
- Over a dozen satellites will be launch as part of Artemis 1

Orbital Data

- Cubesats delivered by CLPS providers, or comm/relay spacecraft could acquire new scientifically valuable datasets
- Global mineral mapping (including resource identification), global elemental maps, improved volatile mapping

In-Situ Resource Initial Research

- What is the 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

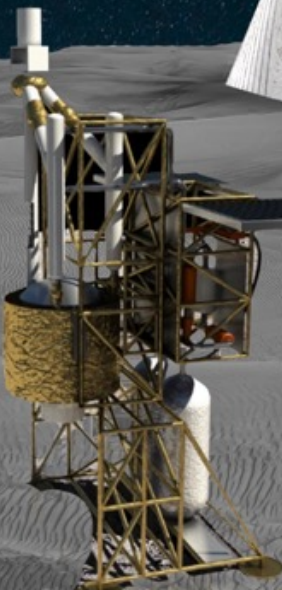


Lunar Dust
Mitigation



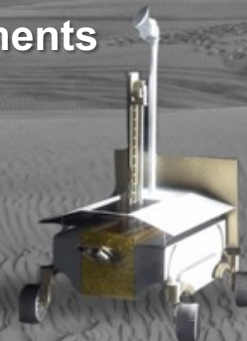
Surface
Excavation/Construction

In Situ
Resource
Utilization



Extreme Environments

Extreme Access



Lunar Surface
Power



Lunar Surface Innovation Initiative

A full-page background image featuring an astronaut in a white space suit with a large, clear helmet visor. The astronaut is positioned in the lower right foreground, looking towards the viewer. The visor reflects the astronaut's face and the surrounding space. In the background, the Earth is visible as a small blue and white sphere on the left, and the Moon is a large, cratered grey sphere on the right. The sky is a deep black with scattered white stars. The overall scene is set in outer space.

EXPLORE

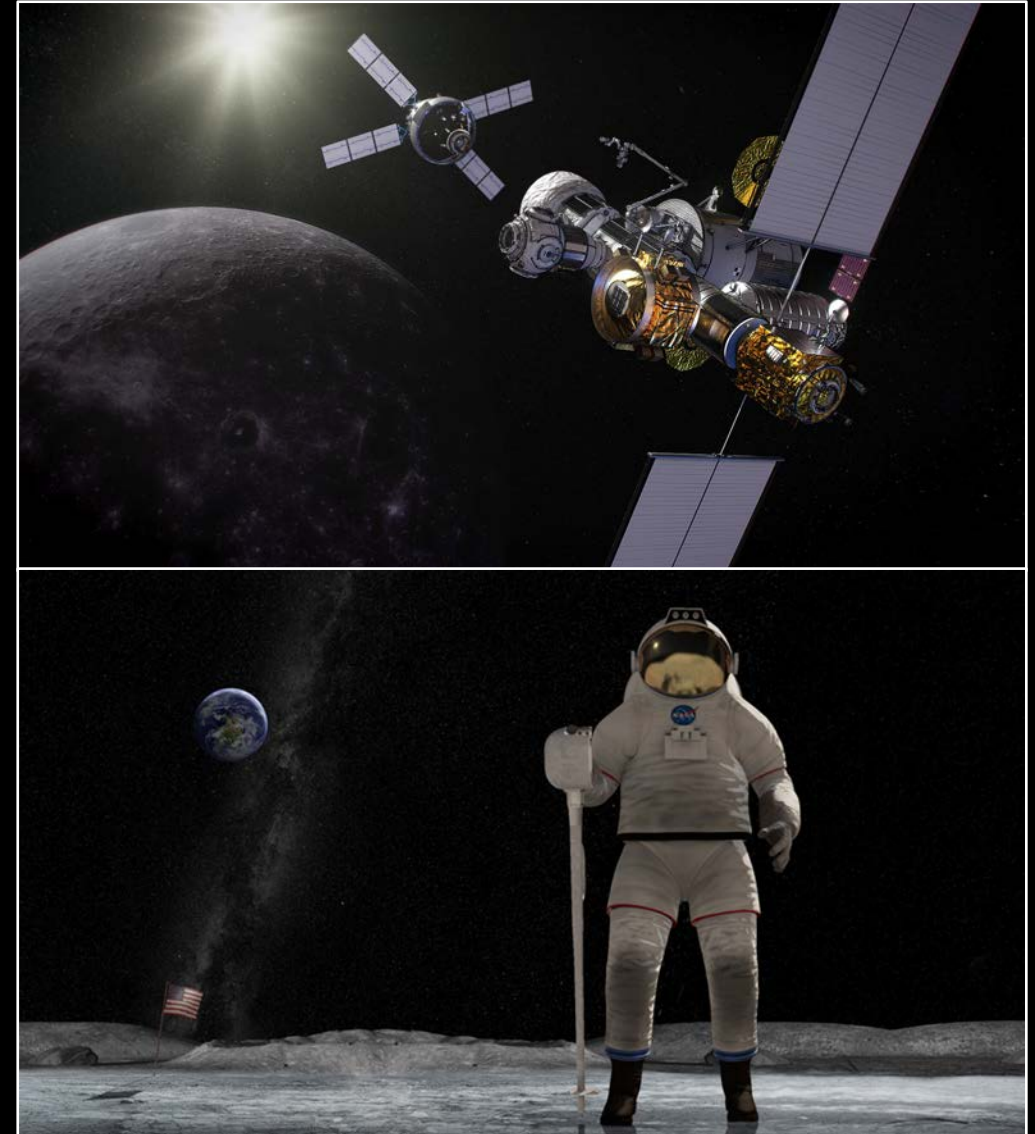
MOON_{to}MARS

THE ARTEMIS PROGRAM

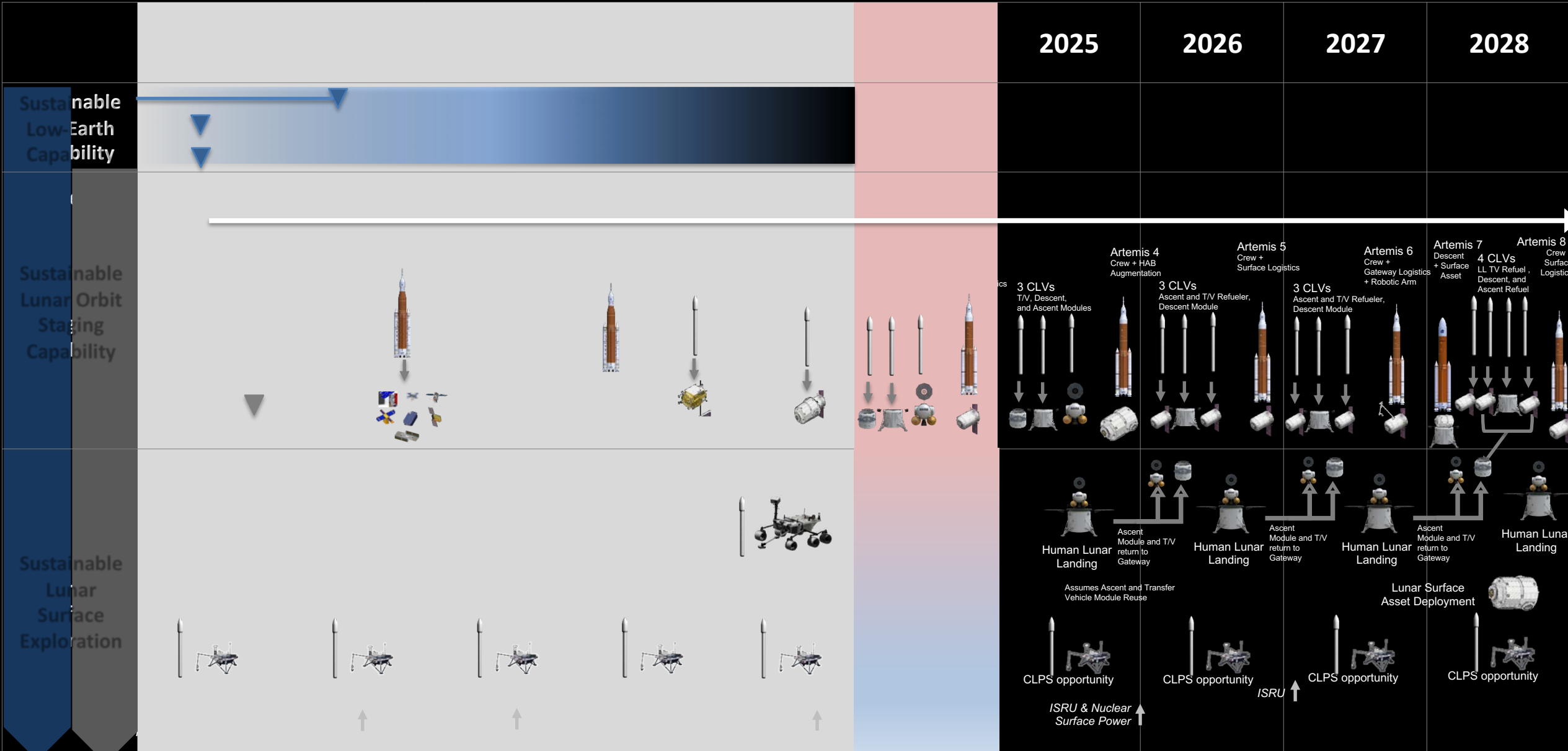
PHASE 2:
**Sustainability at the Moon and
on to Mars**

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 exploration operations that will 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



Lunar Science After 2024



Human and Robotic Missions Provide Unique Science Opportunities

On Gateway

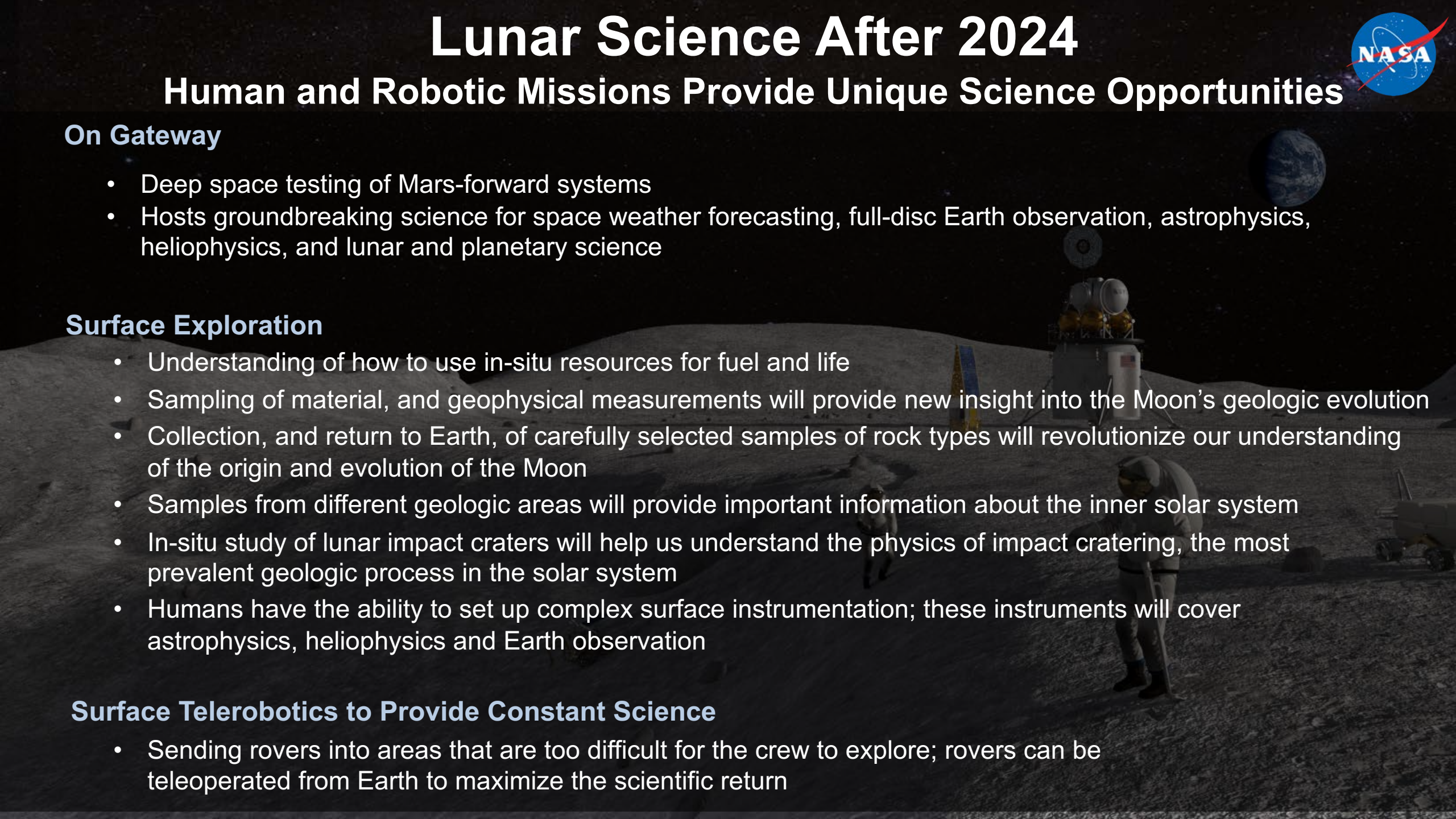
- Deep space testing of Mars-forward systems
- Hosts groundbreaking science for space weather forecasting, full-disc Earth observation, astrophysics, heliophysics, and lunar and planetary science

Surface Exploration

- Understanding of how to use in-situ resources for fuel and life
- Sampling of material, and geophysical measurements will provide new insight into the Moon's geologic evolution
- Collection, and return to Earth, of carefully selected samples of rock types will revolutionize our understanding of the origin and evolution of the Moon
- Samples from different geologic areas will provide important information about the inner solar system
- In-situ study of lunar impact craters will help us understand the physics of impact cratering, the most prevalent geologic process in the solar system
- Humans have the ability to set up complex surface instrumentation; these instruments will cover astrophysics, heliophysics and Earth observation

Surface Telerobotics to Provide Constant Science

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





Let's go! *The time is now.*

We have the capability

We have the purpose

We have the charge

We have the responsibility





NASA