



Moon to Mars and the Artemis Program

17 October 2019

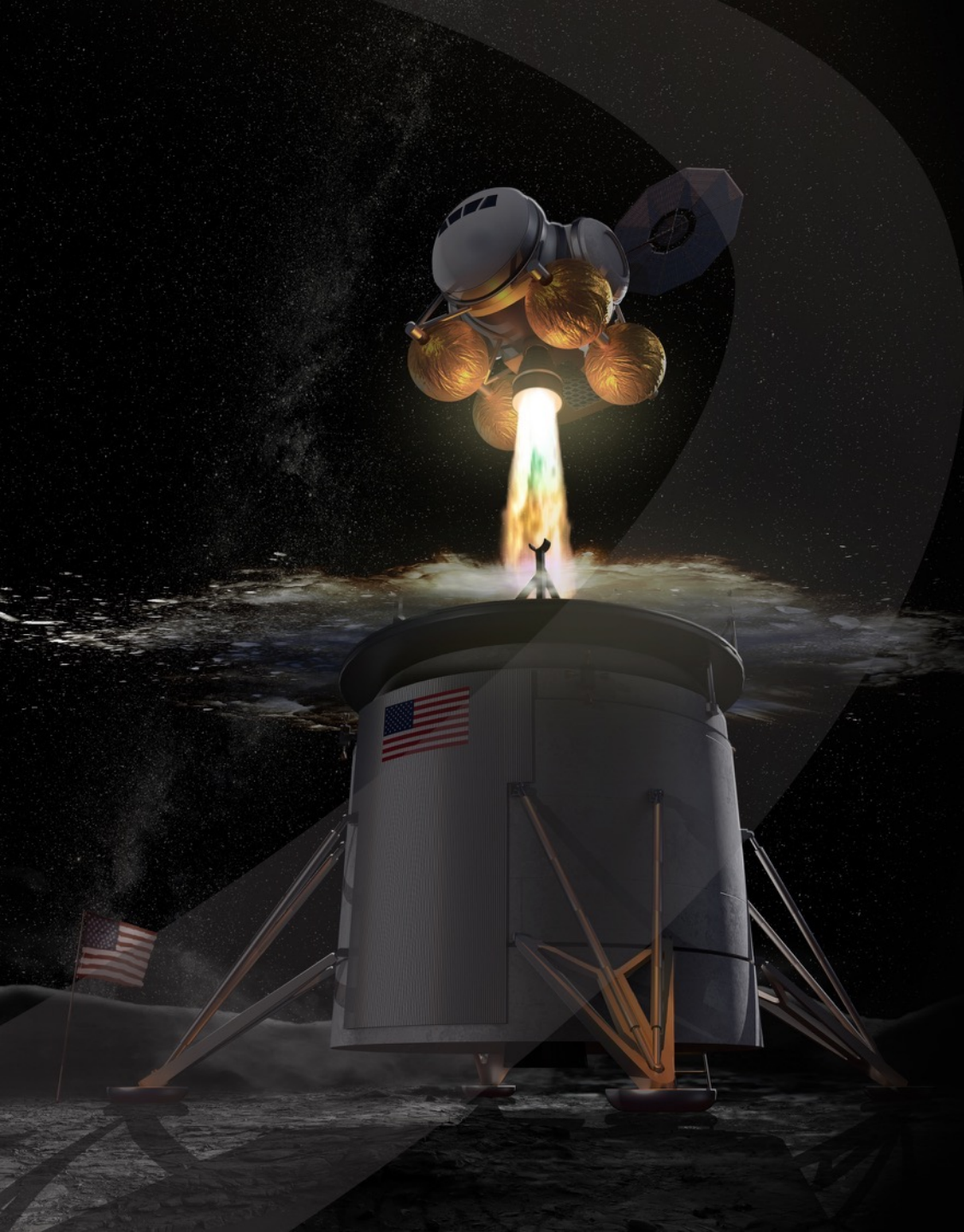
Jacob Bleacher
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Space Policy Directive 1: To The Moon, Then Mars



“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...”



Moon Before Mars

On the Moon, we can take reasonable risks while astronauts are just three days away from home.

There we will prove technologies and mature systems necessary to live and work on another world before embarking on what could be a 2-3 year mission to Mars.

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.



Phase 1 & Phase 2 Definitions

Phase 1: Today – 2024

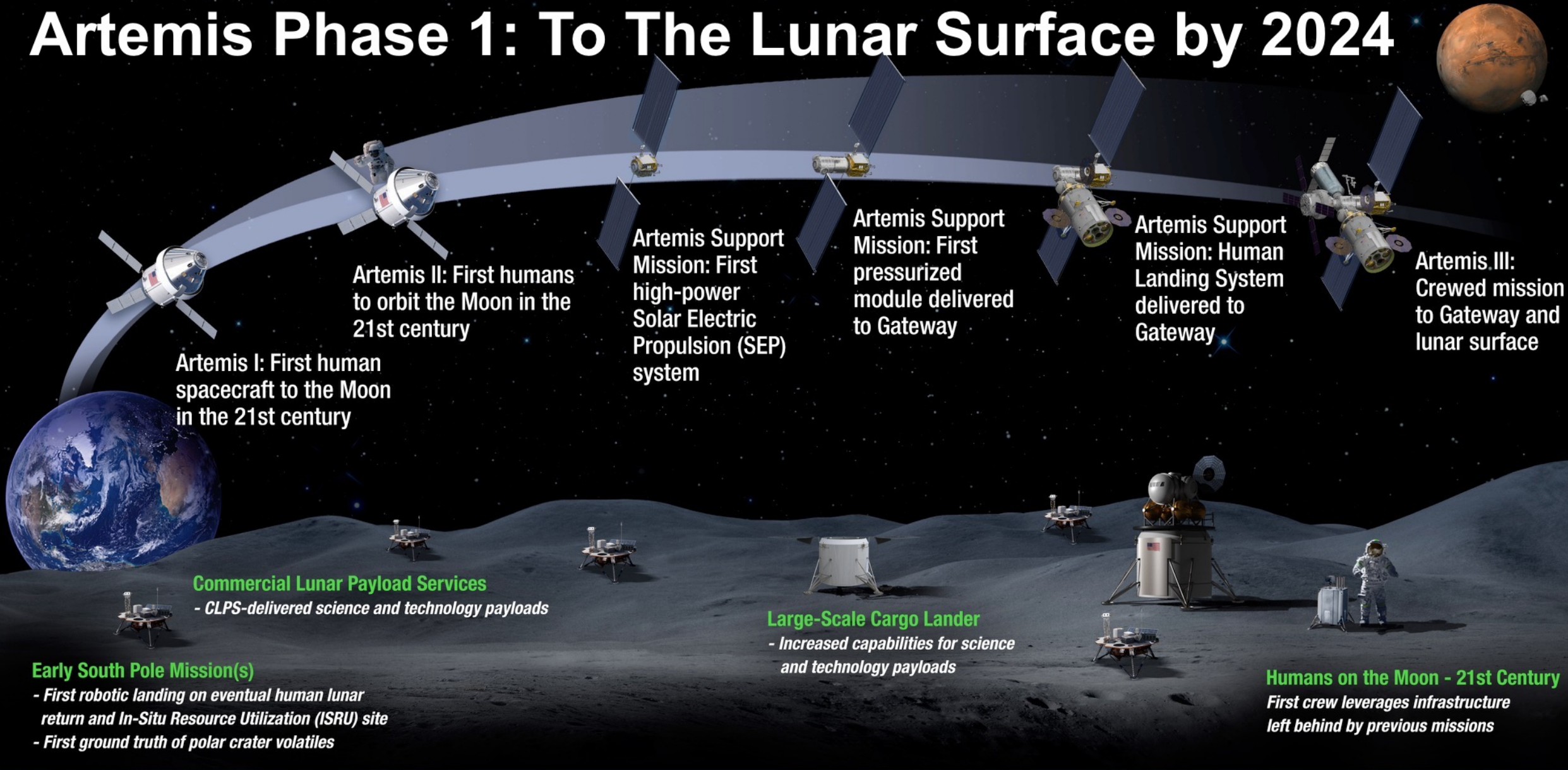
Missions and systems required to achieve landing humans on the surface of the Moon in 2024

Phase 2: by 2028

Establish a sustainable long-term presence on and around the Moon



Artemis Phase 1: To The Lunar Surface by 2024



Artemis I: First human spacecraft to the Moon in the 21st century

Artemis II: First humans to orbit the Moon in the 21st century

Artemis Support Mission: First high-power Solar Electric Propulsion (SEP) system

Artemis Support Mission: First pressurized module delivered to Gateway

Artemis Support Mission: Human Landing System delivered to Gateway

Artemis III: Crewed mission to Gateway and lunar surface

Commercial Lunar Payload Services
- CLPS-delivered science and technology payloads

Large-Scale Cargo Lander
- Increased capabilities for science and technology payloads

Early South Pole Mission(s)
- First robotic landing on eventual human lunar return and In-Situ Resource Utilization (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 TARGET SITE

2020

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 I

First flight test of SLS and Orion as an integrated system

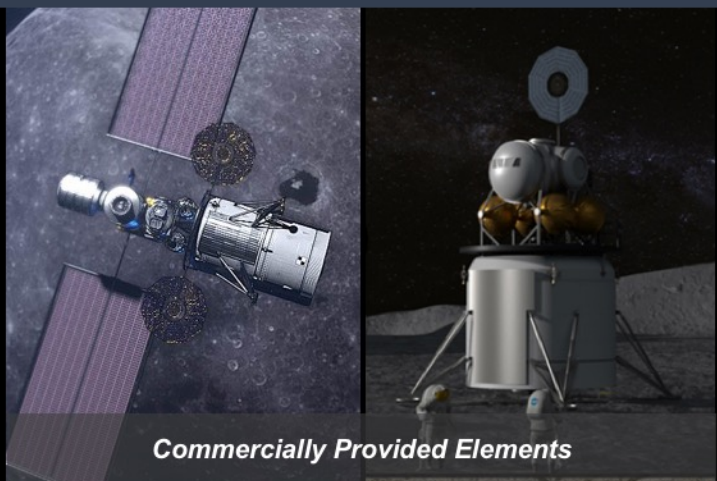
Artemis II

First flight of crew to the Moon aboard SLS and Orion

Artemis III

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

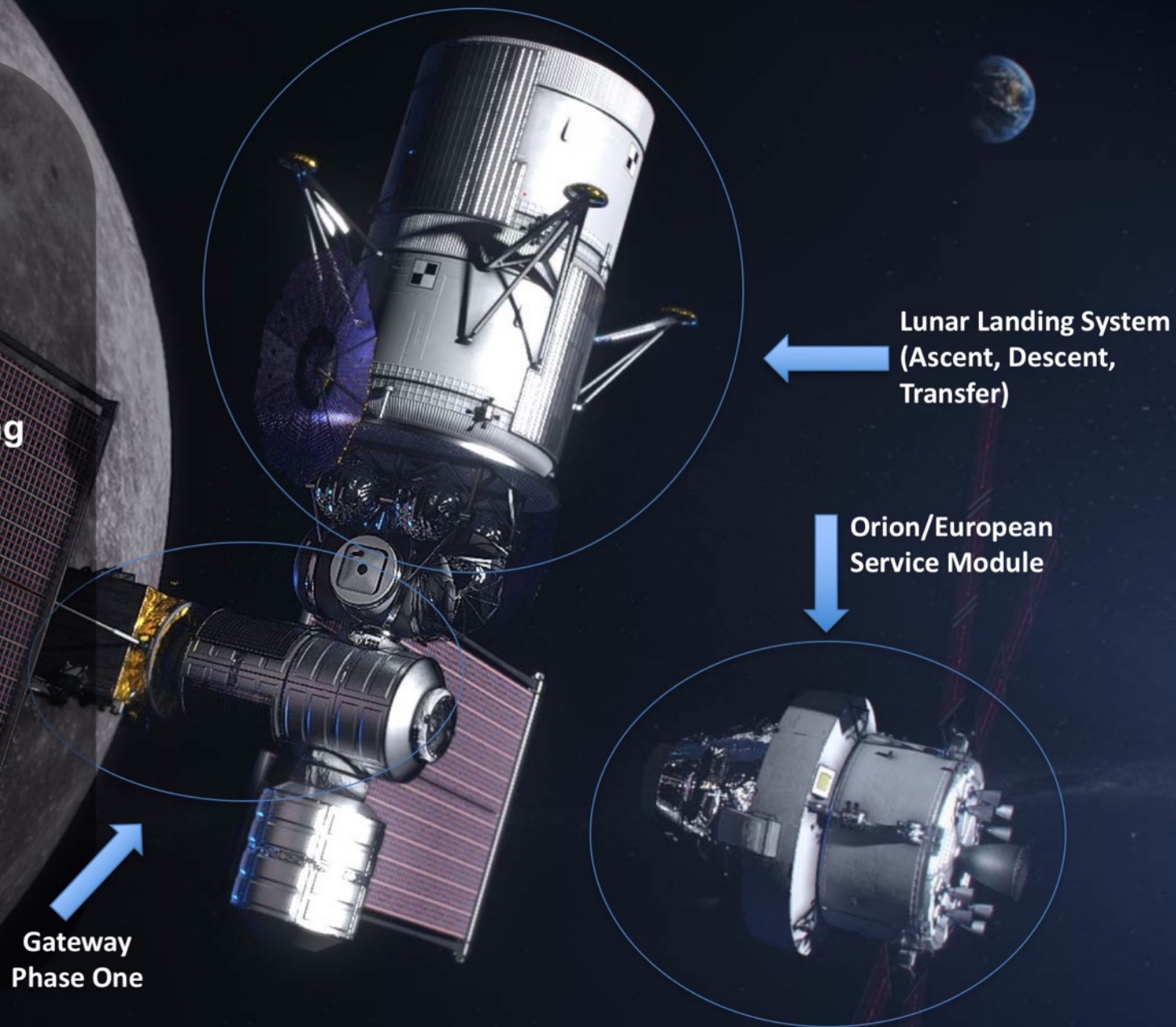
Ascent

Ascends from lunar surface to Gateway

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

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





Human Landing System

NextSTEP Appendix H: Human Landing System

- Synopsis Issued: April 8, for **Ascent Element**
- Synopsis updated: April 26, for **development, integration, and crewed demonstration of integrated landing system**
- Draft solicitation: July 19
- Second draft solicitation: Aug 30
- Final solicitation: Sept 30

Risk reduction studies and prototypes contracted separately under Appendix E in March 2019 are ongoing

Surface Suit

Exploration Extravehicular Mobility Unit (xEMU)

- In-house build for 2024 expedition
- Testing component and full suit on ISS through 2023
- RFI issued Oct. 4 seeking industry input on transitioning production line to private sector for 2025 and beyond



Lunar Science by 2024

A black and white photograph of a lunar surface. In the foreground, a robotic arm extends from the right side, holding a small, rectangular container filled with dark, granular material, likely lunar soil or rock. The background shows the undulating, cratered terrain of the moon under a dark 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

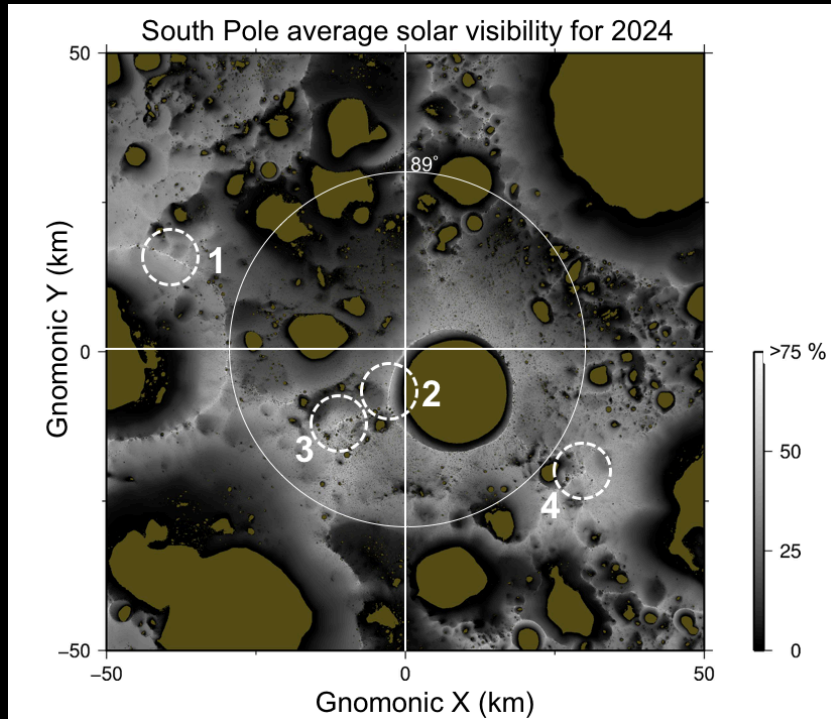
Orbital Data

- 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

American Strategic Presence on the Moon – High solar illumination areas within 2 degrees (<50 km) of the lunar south pole.



High Priorities for Sustained Surface Activities

Four highly illuminated areas shown above:

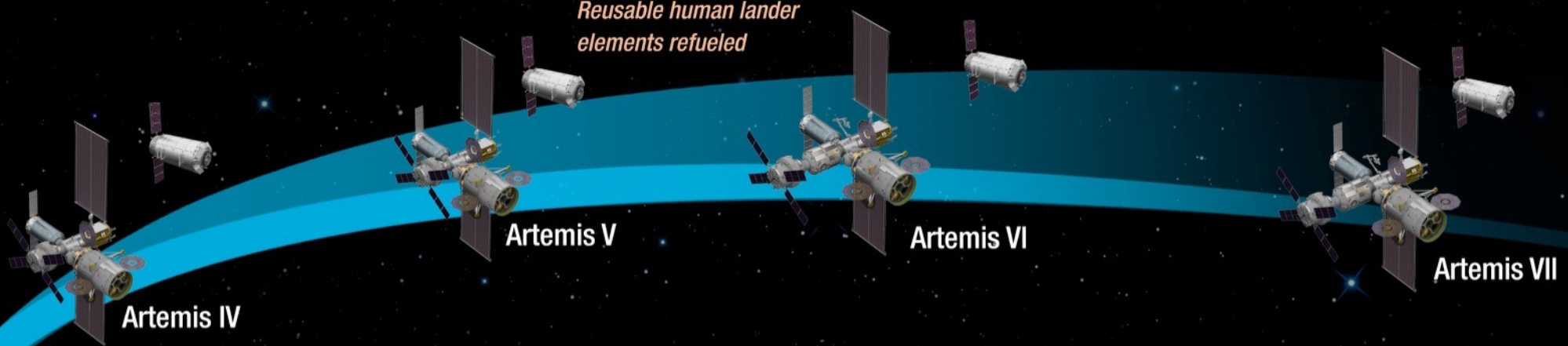
1. De Gerlache Rim,
2. Shackleton Rim
3. Shackleton – De Gerlache Ridge
4. Plateau near Shackleton

- **Long duration access to sunlight:** A confirmed resource providing power and minimal temperature variations
- **Surface roughness and slope:** Finding the safest locations for multiple landing systems, robotic and astronaut mobility
- **Direct to Earth communication:** Repeatable Earth line-of-sight communication for mission support
- **Permanently Shadowed Regions and Volatiles:** Learning to find and access water ice and other resources for sustainability

Artemis Phase 2: Building Capabilities For Mars Missions



Reusable human lander elements refueled



Artemis IV

Artemis V

Artemis VI

Artemis VII

Artemis Support Mission
Lunar surface asset deployment for longer surface expeditions

CLPS opportunities



SUSTAINABLE LUNAR ORBIT STAGING CAPABILITY AND SURFACE EXPLORATION

MULTIPLE SCIENCE AND CARGO PAYLOADS

INTERNATIONAL PARTNERSHIP OPPORTUNITES

TECHNOLOGY AND OPERATIONS DEMONSTRATIONS FOR MARS

2025

2029

Science After 2024

Human and Robotic Missions Provide Unique Science Opportunities

ON GATEWAY

- Deep space testing of Mars-forward systems
- Hosts groundbreaking science study and observation
- 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
- Studying lunar impact craters to understand impact cratering
- Setting up complex surface science instrumentation
- Informing and supporting sustained human presence

SURFACE TELEROBOTICS TO PROVIDE CONSTANT SCIENCE

- Sending rovers into areas too difficult for humans to explore



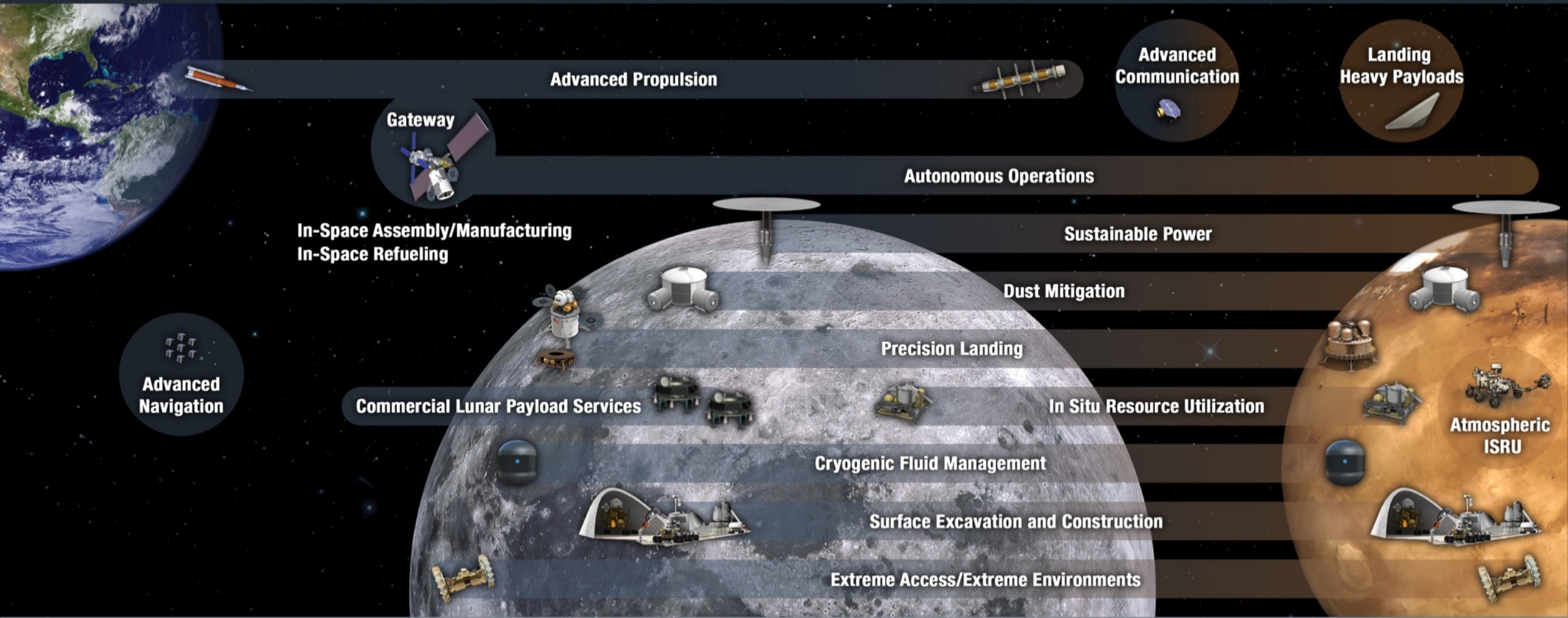
Reaching The Moon And Mars Faster With NASA Technology

Rapid, Safe, and Efficient
Space Transportation

Expanded Access to Diverse
Surface Destinations

Sustainable Living and Working
Farther from Earth

Transformative Missions
and Discoveries



Advanced Propulsion

Advanced
Communication

Landing
Heavy Payloads

Gateway

Autonomous Operations

In-Space Assembly/Manufacturing
In-Space Refueling

Sustainable Power

Dust Mitigation

Precision Landing

Commercial Lunar Payload Services

In Situ Resource Utilization

Atmospheric
ISRU

Cryogenic Fluid Management

Surface Excavation and Construction

Extreme Access/Extreme Environments

Advanced
Navigation

2020

GO | LAND | LIVE | EXPLORE

203X



Questions?