National Aeronautics and Space Administration

Human Exploration Strategy

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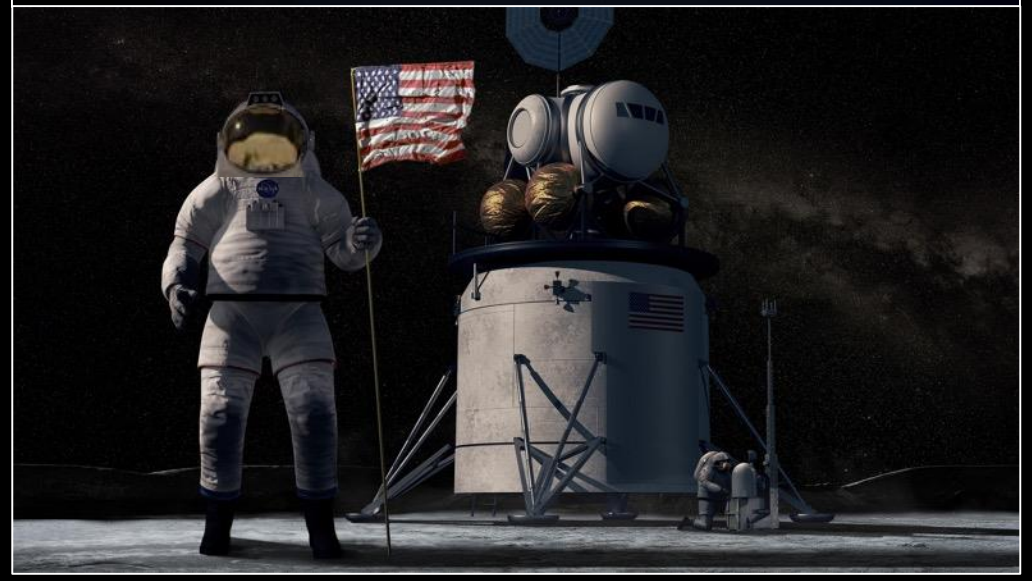
Space Policy Directive 1: To the Moon, then Mars

"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…"

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



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.

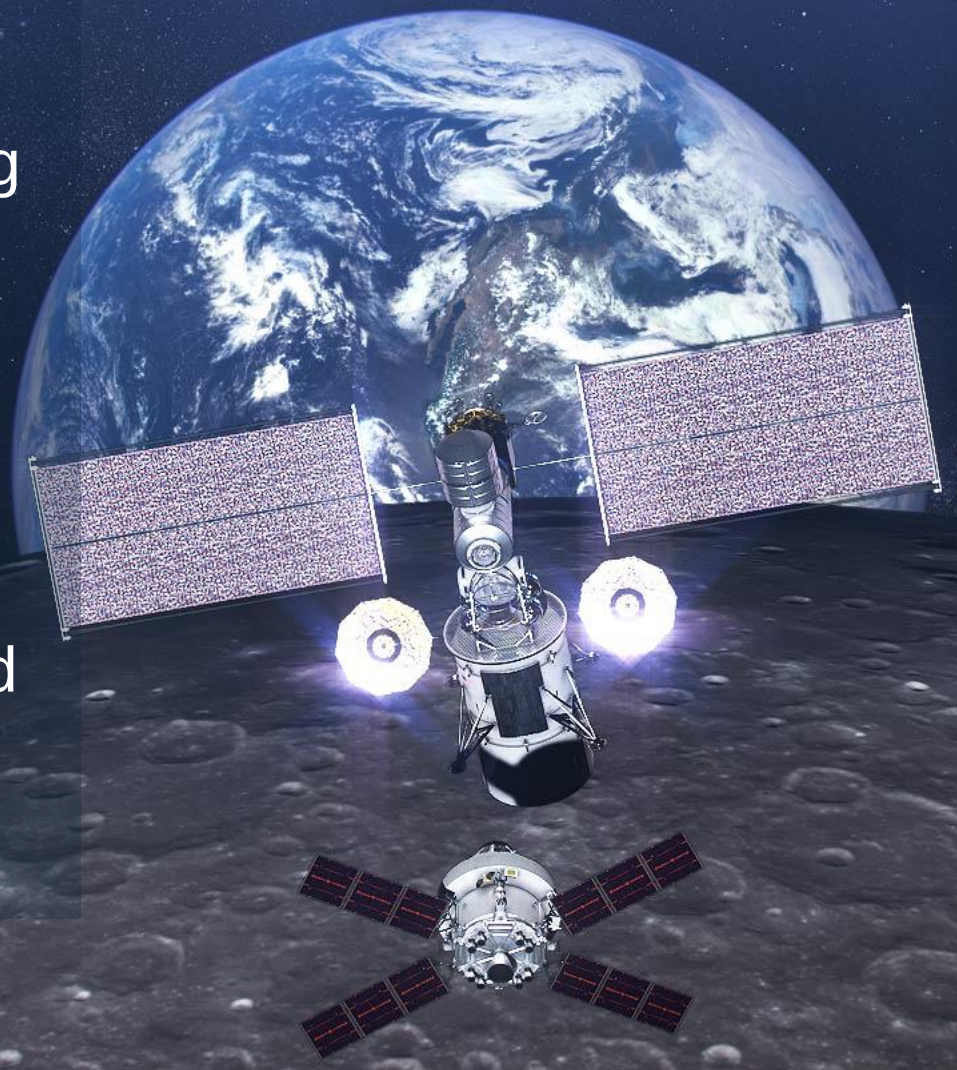
Phase 1 & Phase 2 Definitions

Phase 1: Today – 2024
Human surface landing

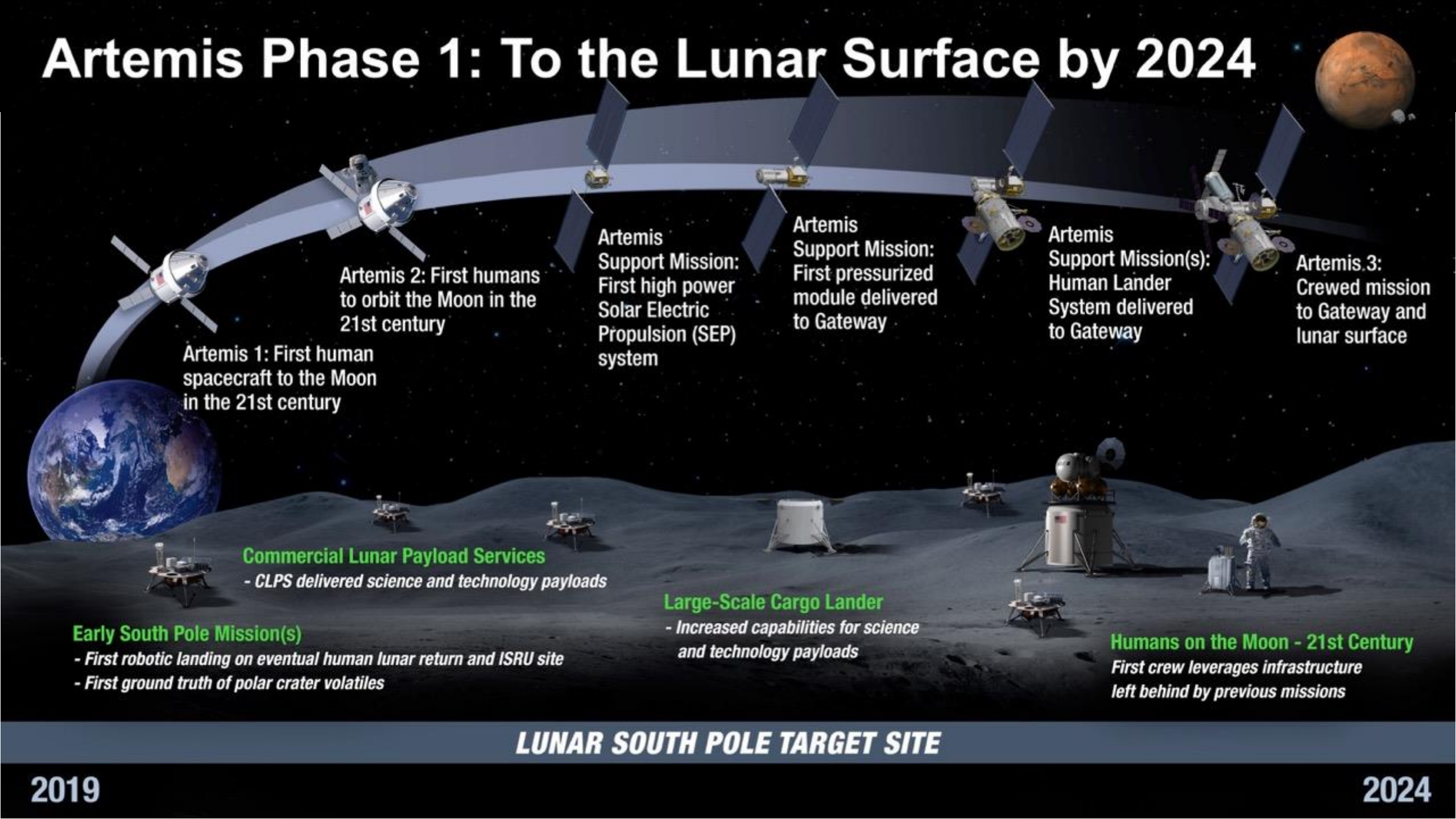
Missions and systems required to achieve landing humans on the surface of the Moon in 2024

Phase 2: 2028

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

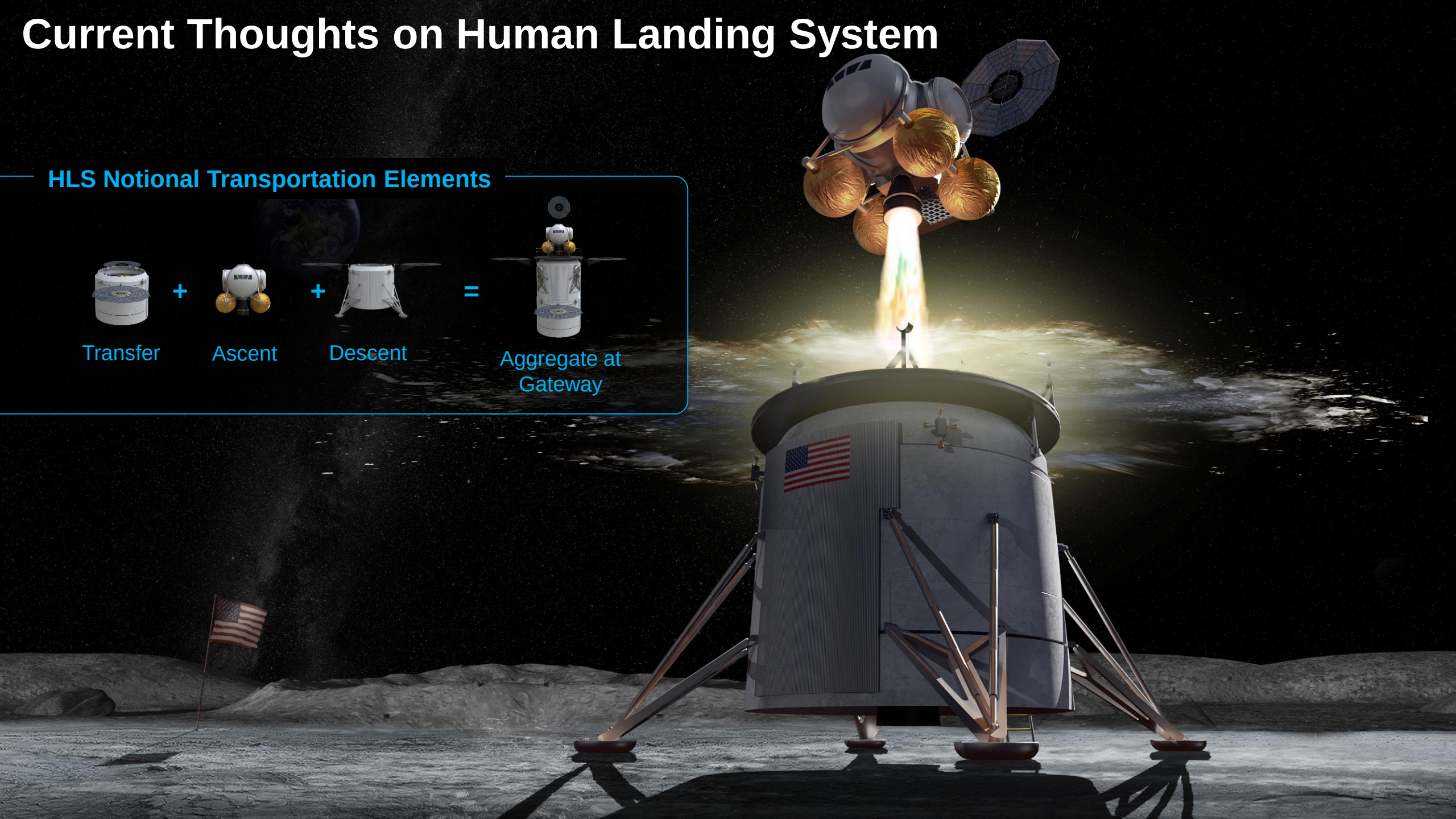


Artemis Phase 1: To the Lunar Surface by 2024



Current Thoughts on Human Landing System

HLS Notional Transportation Elements



DEVELOPMENT IS UNDERWAY

2024

Develop essential hardware and systems required for a 2024 landing

CREW

At least 2 on the South Pole

SUITS

Initial capability suit

EXPEDITION DURATION

Hours-Days
(open trade)

ROCKETS
(examples)

PARTNERS

Significant collaboration with U.S. industry

Potential opportunities for international partners

ACCESS

REUSABILITY

Desired, but not required

2028

Establish a sustainable human lunar presence with robust, reusable systems

CREW

Up to 4 on the Moon

SUITS

Sustained capability suit

EXPEDITION DURATION

Days-Weeks
(open trade)

ROCKETS
(examples)

PARTNERS

U.S. industry and international collaboration

ACCESS

Increased mobility from the pole; global access through robotic landings and possible human expeditions

REUSABILITY

Enables sustainability

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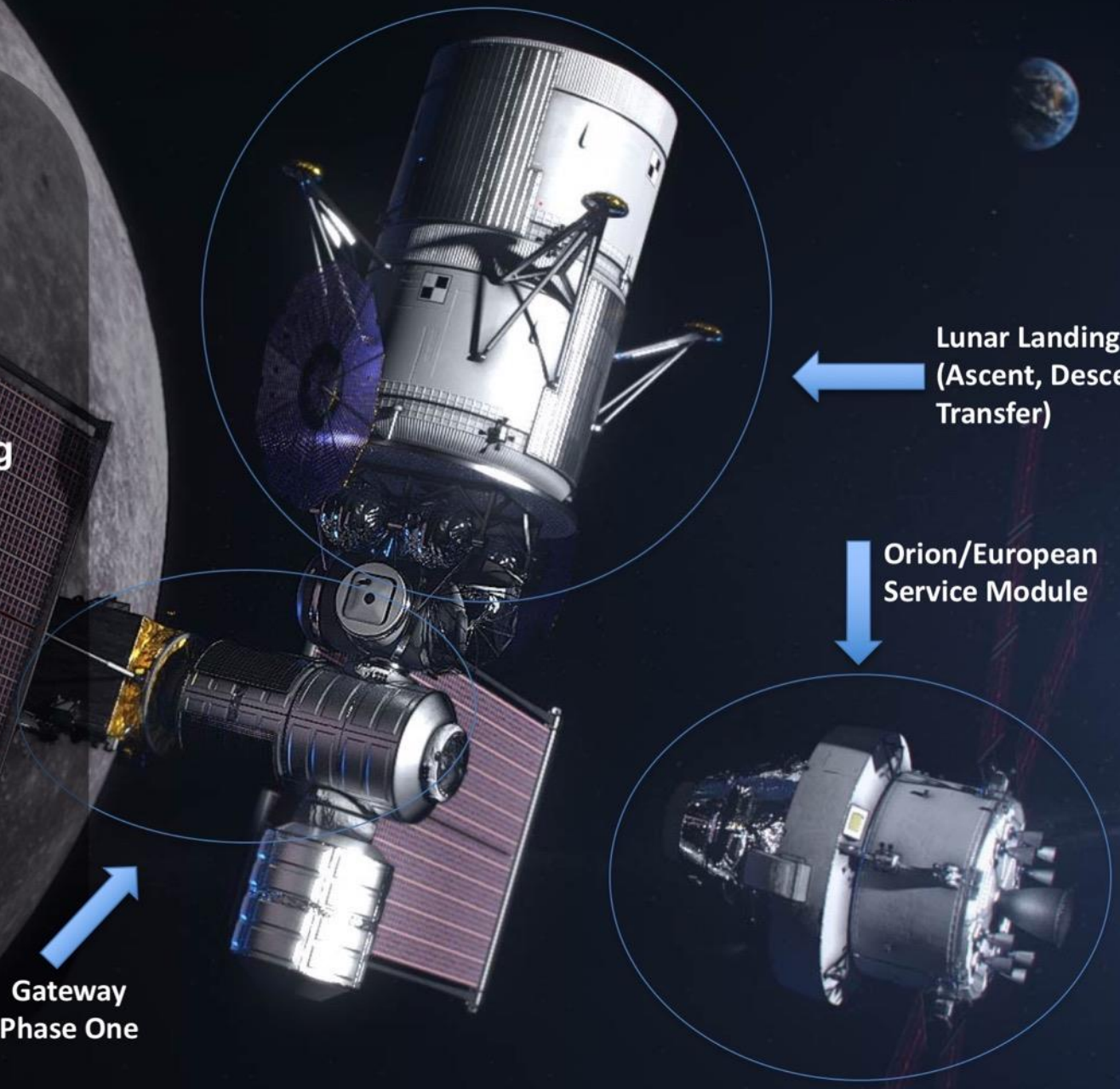
Gateway is Essential for 2024 Landing

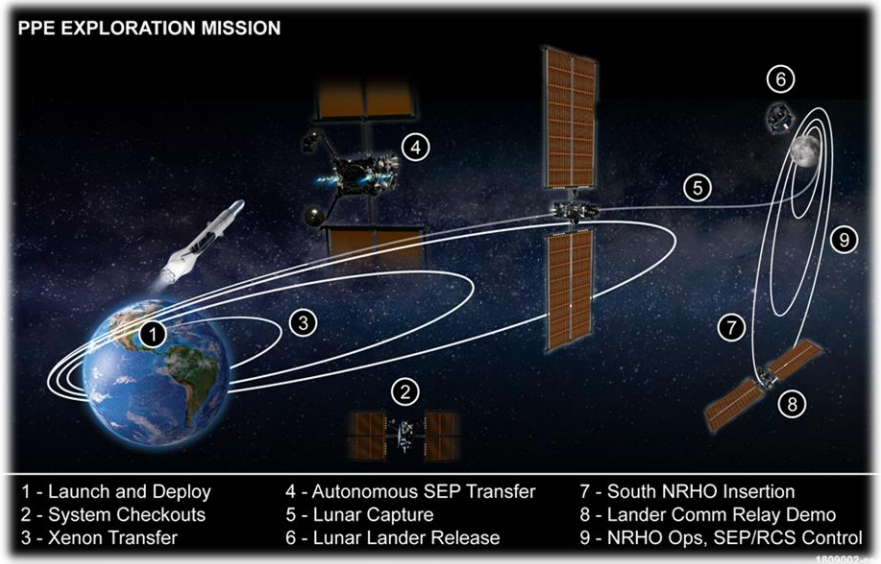
- Initial Gateway focuses on the minimum systems required to support a 2024 human lunar landing while also supporting Phase 2
- Provides command center and aggregation point for 2024 human landing
- Establishes strategic presence around the Moon – US in the leadership role
- Creates resilience and robustness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



Summary of Maxar's PPE approach

Leverage heritage reliability, proven development approach, and the scalable 1300-class platform as the basis for a PPE demonstration mission culminating with delivery of PPE to NASA in the target NRHO

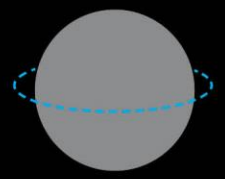
- **Power – 60 kW+ provided by Roll Out Solar Array (ROSA) and Maxar's 1300 commercial power subsystem**
- **Propulsion – Leverage NASA development of 12.5 kW Electric Propulsion (EP), and internal Maxar advanced EP development, with Maxar expertise in system accommodation of EP elements**
- **Communications – Ka-band relay from Lunar vicinity to Earth, accommodations for future optical communications payloads**
- **Guidance Navigation and Control – Utilize proven approaches for station keeping, momentum management, and autonomous low thrust electric orbit transfer**
- **Gateway Interfaces – Support all interfaces with elements of Gateway including docked components, visiting vehicles, robotics, science payloads, Orion, and Human Landing System elements**
- **Payload Transfer – 1000kg for lunar lander or science instruments**



GATEWAY ORBIT

Cislunar space offers innumerable orbits for consideration, each with merit for a variety of operations. The Gateway will support missions to the lunar surface and serve as a staging area for exploration farther into the solar system, including Mars.

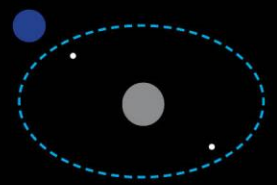
ORBIT TYPES



LOW LUNAR ORBITS

Circular or elliptical orbits close to the surface. Excellent for remote sensing, difficult to maintain in gravity well.

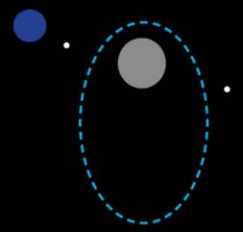
» Orbit period: 2 hours



DISTANT RETRO-GRADE ORBITS

Very large, circular, stable orbits. Easy to reach from Earth, but far from lunar surface.

» Orbit period: 2 weeks



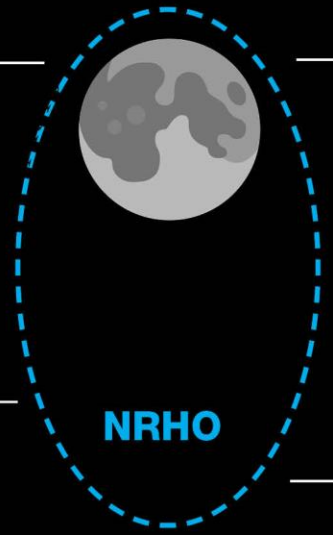
HALO ORBITS

Fuel-efficient orbits revolving around Earth-Moon neutral-gravity points.

» Orbit period: 1-2 weeks

NEAR-RECTILINEAR HALO ORBIT (NRHO)

1,500 km at its closest to the lunar surface, 70,000 km at its farthest.



ACCESS

Easy to access from Earth orbit with many current launch vehicles. Staging point for both lunar surface and deep space destinations.

ENVIRONMENT

Deep space environment useful for radiation testing and experiments in preparation for missions to the lunar surface and Mars.

SCIENCE

Favorable vantage point for Earth, sun and deep space observations.

COMMUNICATIONS

Provides continuous view of Earth and communication relay for lunar farside.

SURFACE OPERATIONS

Supports surface telerobotics, including lunar farside. Provides a staging point for planetary sample return missions.

Lunar Science by 2024

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

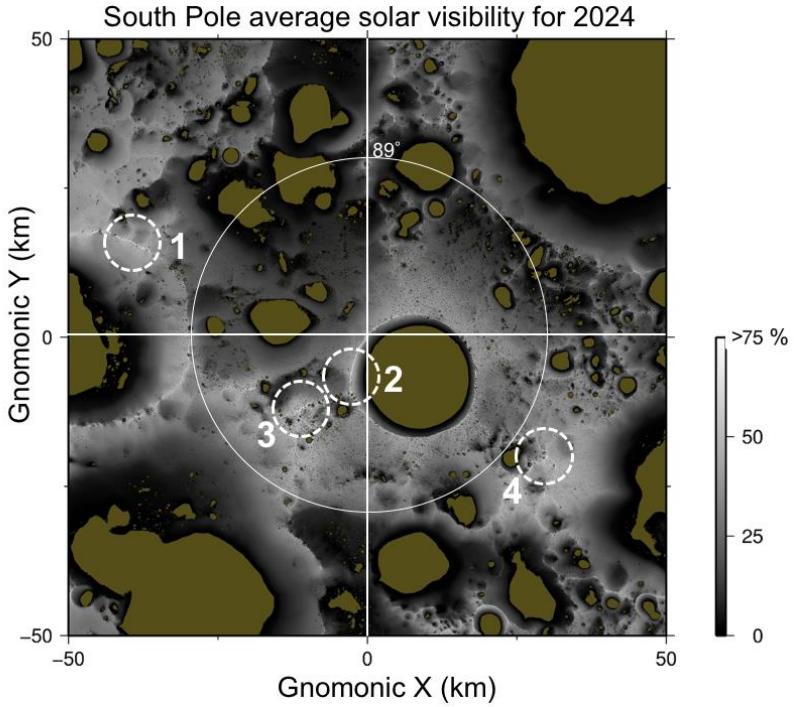
- Deploy multiple CubeSats with Artemis 1
- Potential to acquire new scientifically valuable datasets through CubeSats delivered by CLPS providers or comm/relay spacecraft
- Global mineral mapping, including resource identification, global elemental maps, and improved volatile mapping

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.



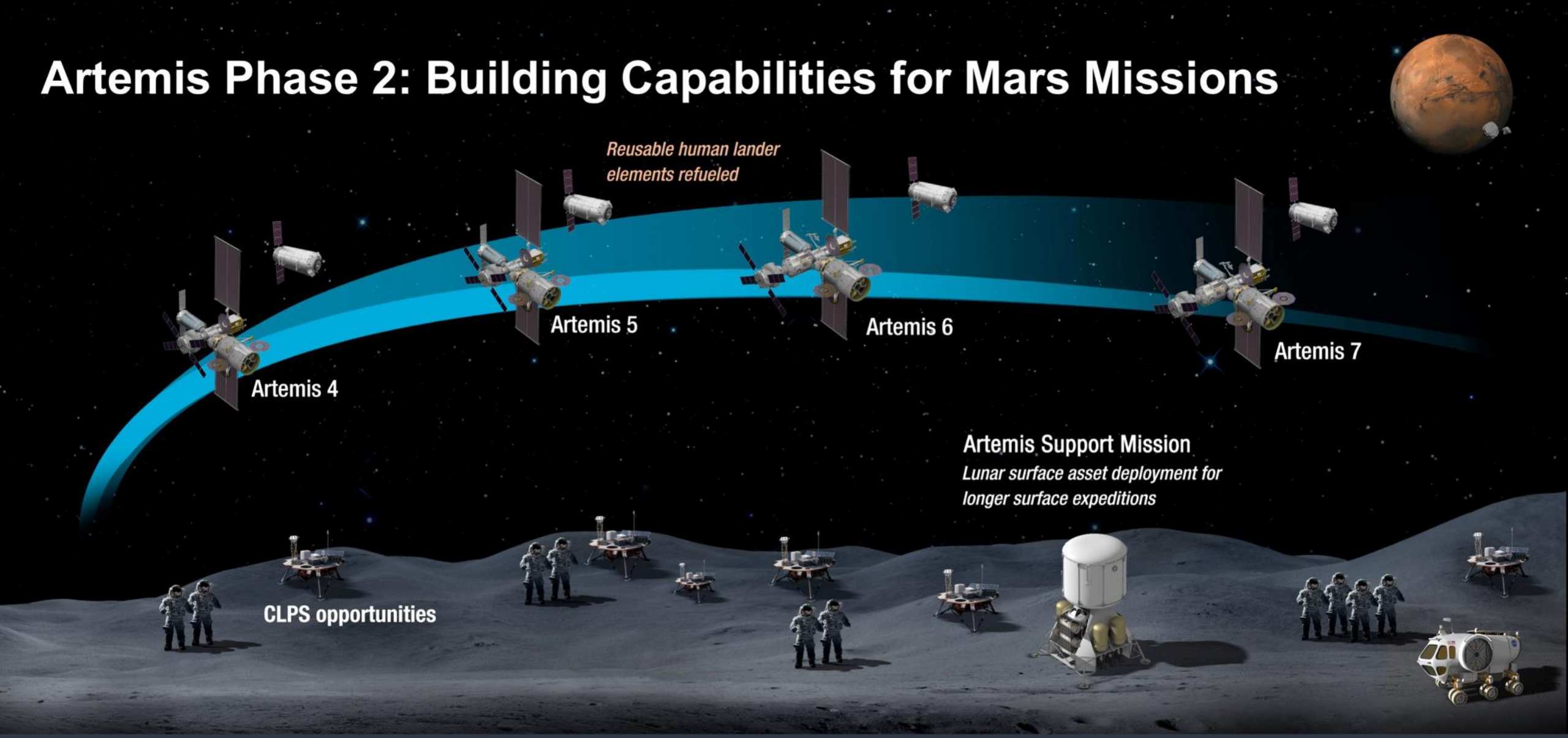
Four highly illuminated areas shown above:

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

High Priorities for Sustained Surface Activities

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

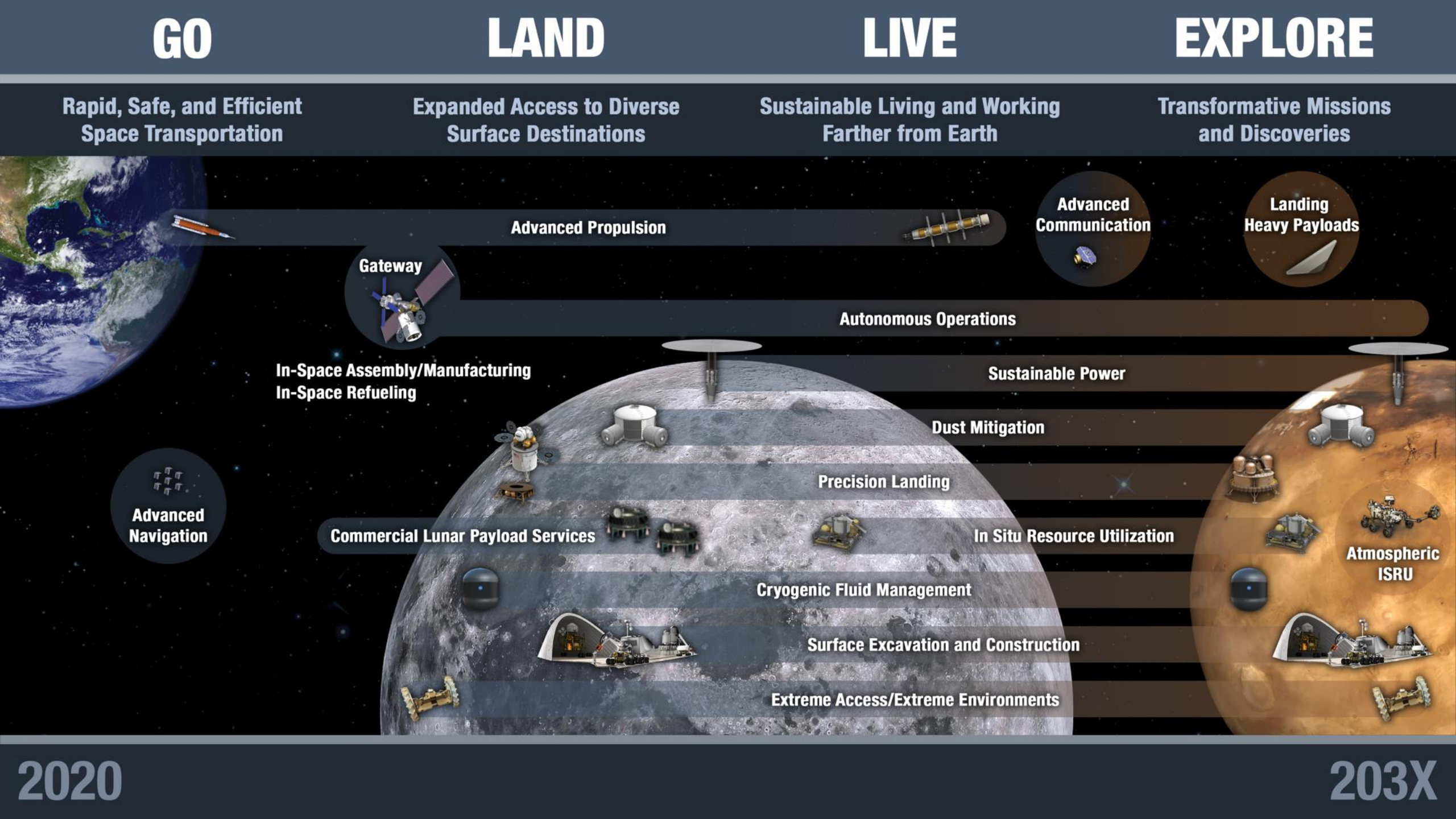
Artemis Phase 2: Building Capabilities for Mars Missions



SUSTAINABLE LUNAR ORBIT STAGING CAPABILITY AND SURFACE EXPLORATION

MULTIPLE SCIENCE AND CARGO PAYLOADS | INTERNATIONAL PARTNERSHIP OPPORTUNITES | TECHNOLOGY AND OPERATIONS DEMONSTRATIONS FOR MARS

2025 — 2029


GO
LAND
LIVE
EXPLORE
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
Advanced Navigation
Commercial Lunar Payload Services
In Situ Resource Utilization
Atmospheric ISRU
Cryogenic Fluid Management
Surface Excavation and Construction
Extreme Access/Extreme Environments
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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

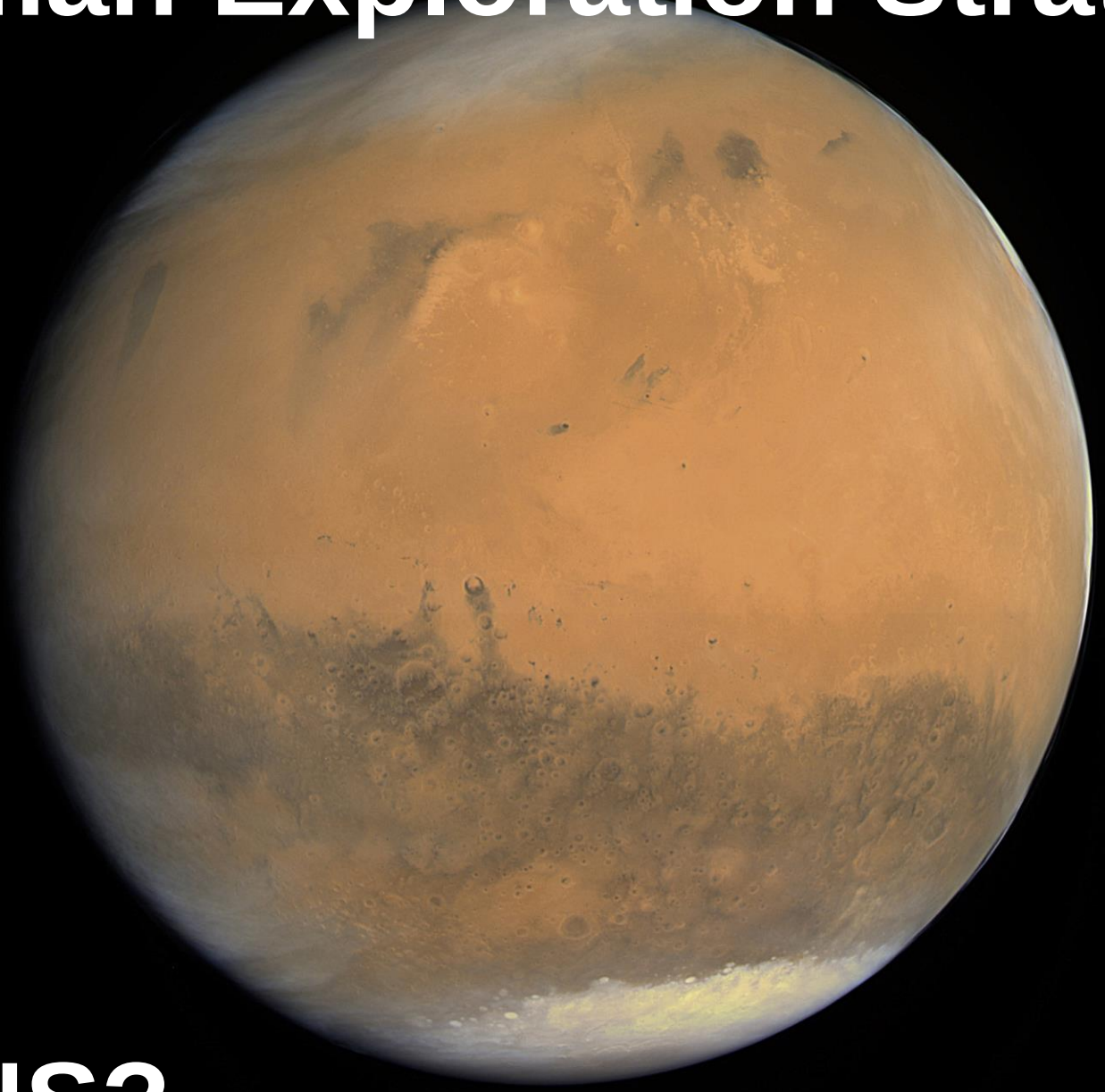
Surface Exploration

- 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

Human Exploration Strategy



QUESTIONS?