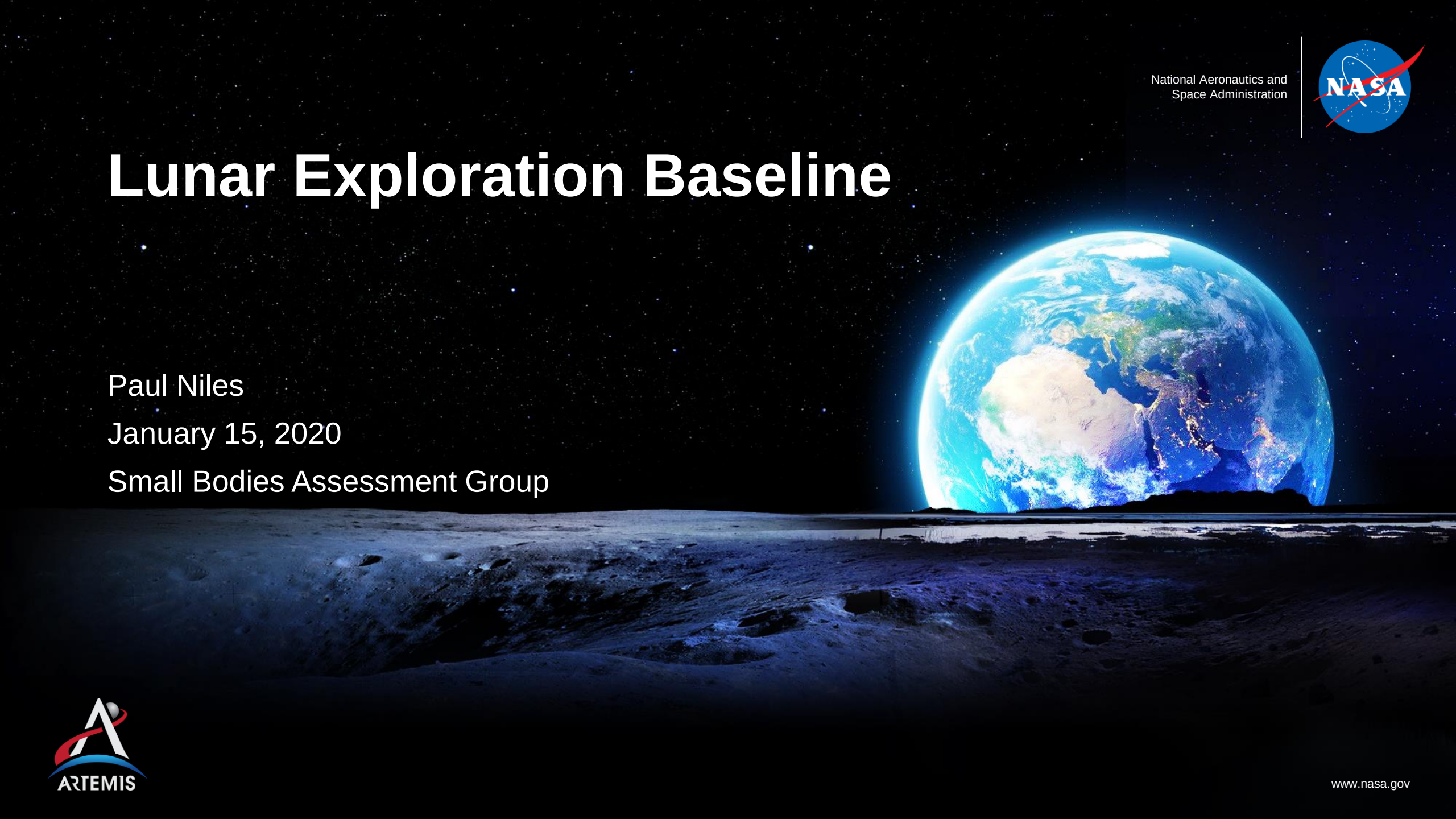
National Aeronautics and Space Administration

# Lunar Exploration Baseline



Paul Niles

January 15, 2020

Small Bodies Assessment Group

ARTEMIS

# 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…"

# Why go to The Moon?

Proves technologies and capabilities for sending humans to Mars

Establishes American leadership and strategic presence

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 and international partnerships in deep space

# 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.

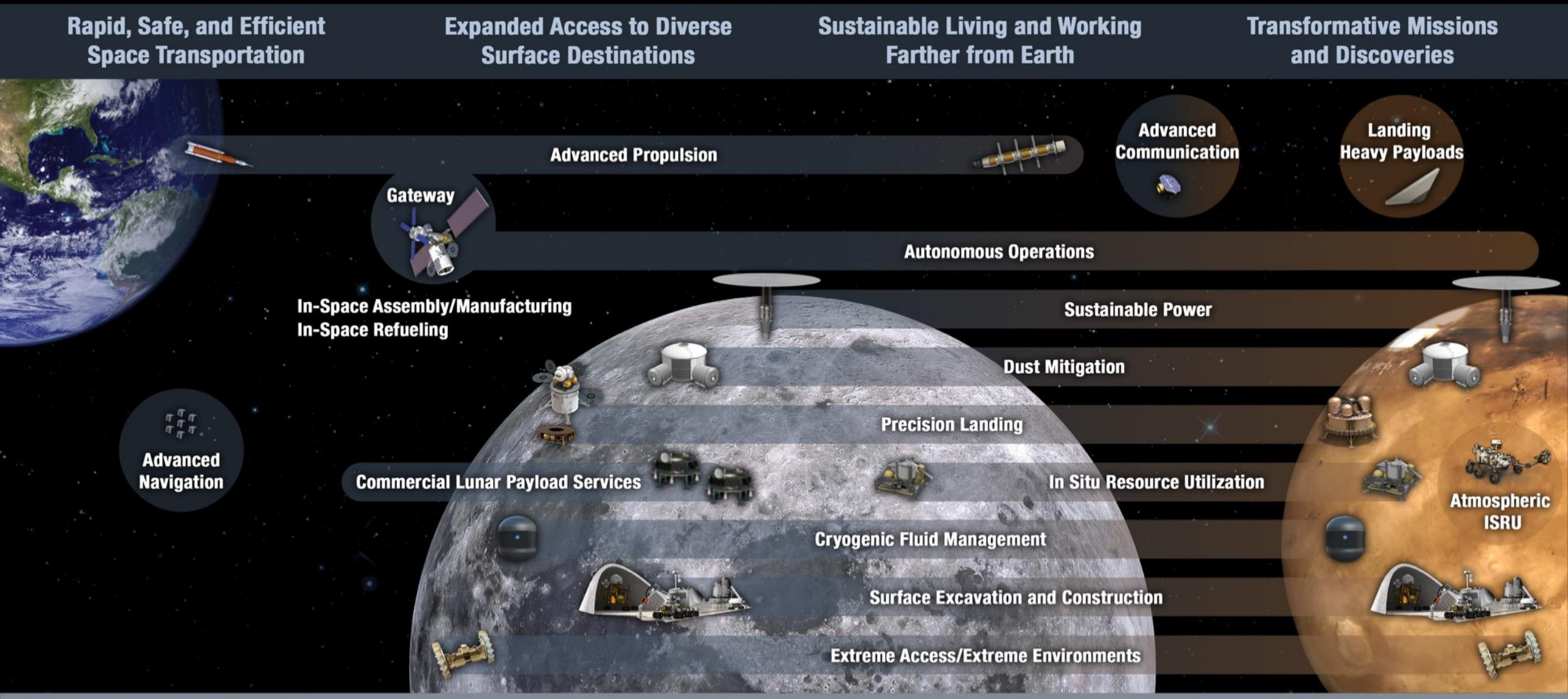
# The Artemis Program

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.

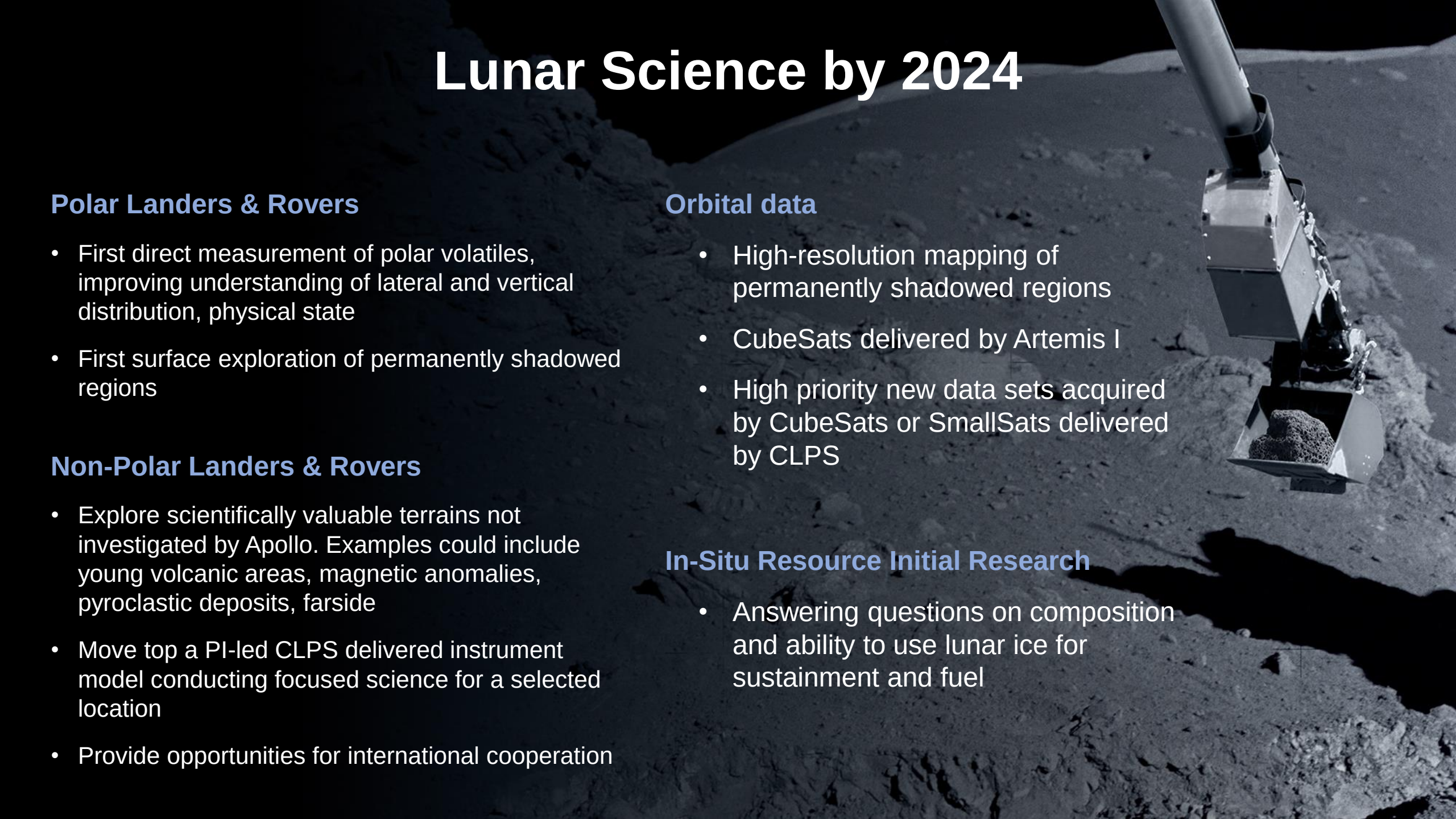
With the horizon goal of sending humans to Mars, Artemis begins the next era of exploration.

# Reaching The Moon And Mars Faster With NASA Technology




2020 | GO | LAND | LIVE | EXPLORE | 203X

# Lunar Science by 2024



## Polar Landers & Rovers

- First direct measurement of polar volatiles, improving understanding of lateral and vertical distribution, physical state
- First surface exploration of permanently shadowed regions

## Non-Polar Landers & Rovers

- Explore scientifically valuable terrains not investigated by Apollo. Examples could include young volcanic areas, magnetic anomalies, pyroclastic deposits, farside
- Move top a PI-led CLPS delivered instrument model conducting focused science for a selected location
- Provide opportunities for international cooperation

## Orbital data

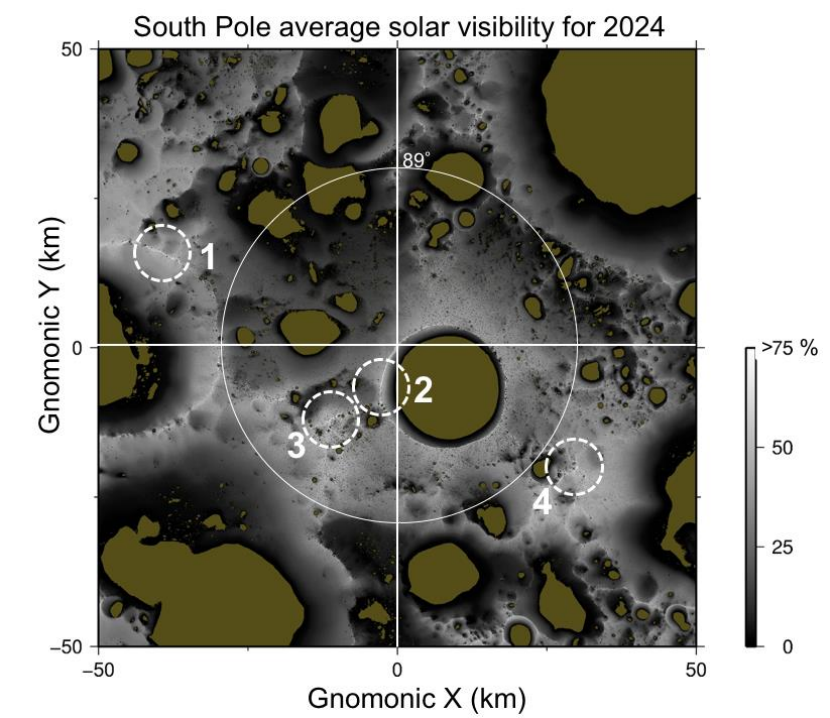
- High-resolution mapping of permanently shadowed regions
- CubeSats delivered by Artemis I
- High priority new data sets acquired by CubeSats or SmallSats delivered by CLPS

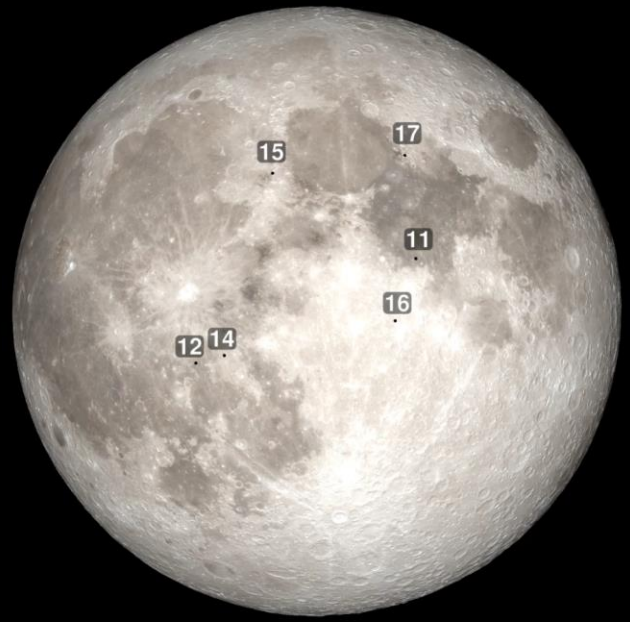
## In-Situ Resource Initial Research

- 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.



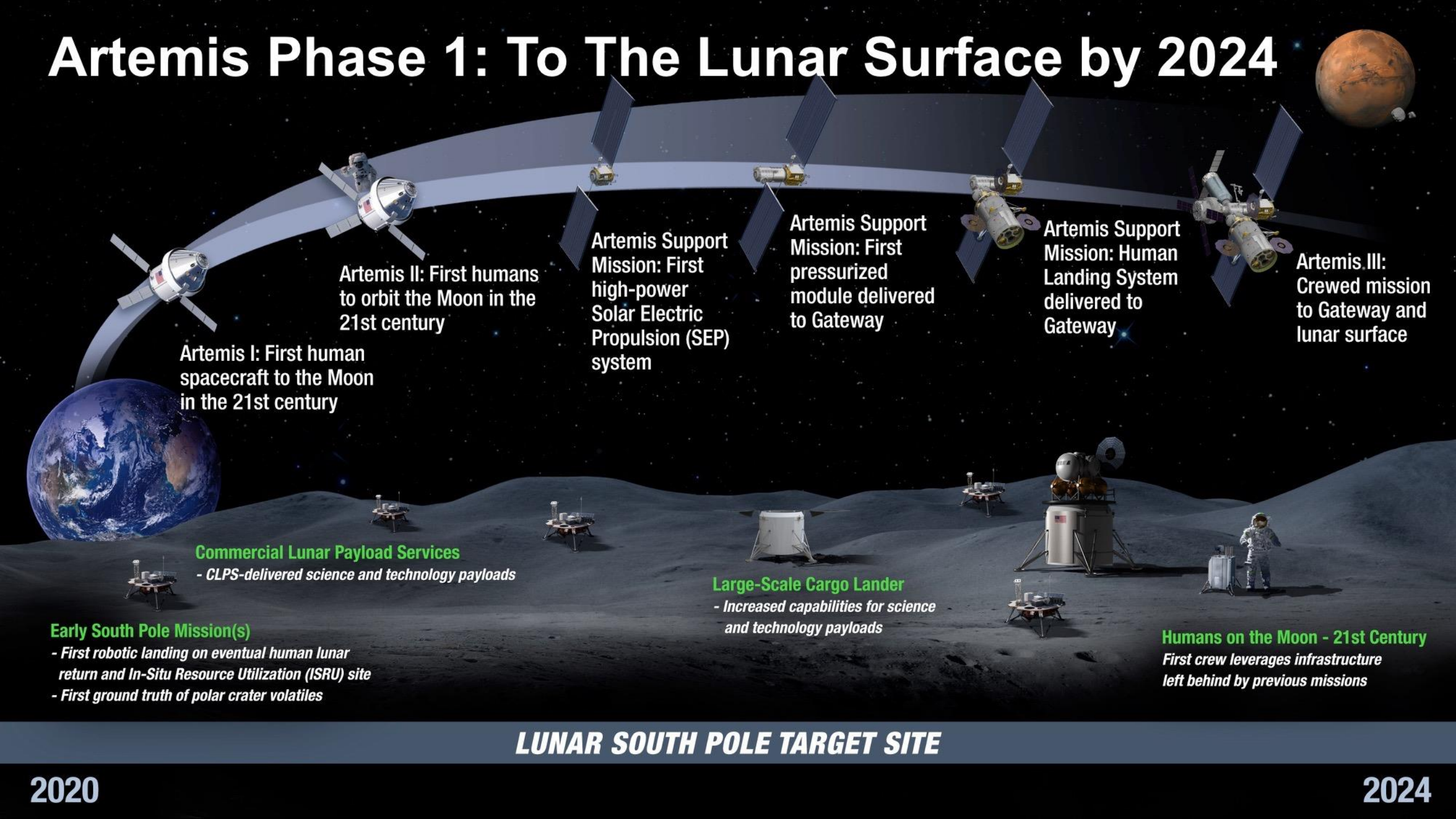




**Four highly illuminated areas shown above:**
1. De Gerlache Rim,
2. Shackleton Rim
3. Shackleton – De Gerlache Ridge
4. Plateau near Shackleton

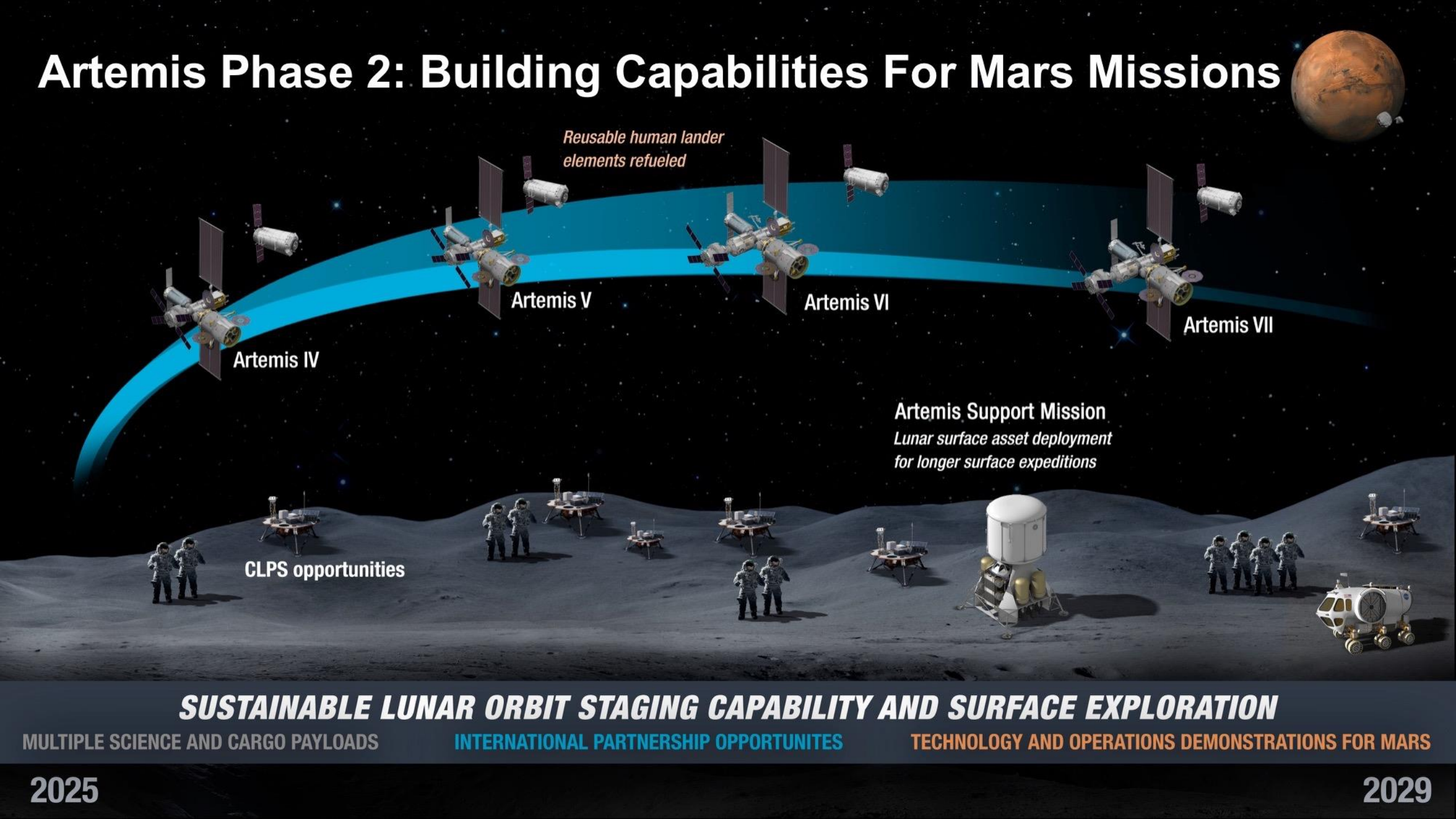
## High Priorities for Sustained Surface Activities

- **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 1: To The Lunar Surface by 2024



# 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

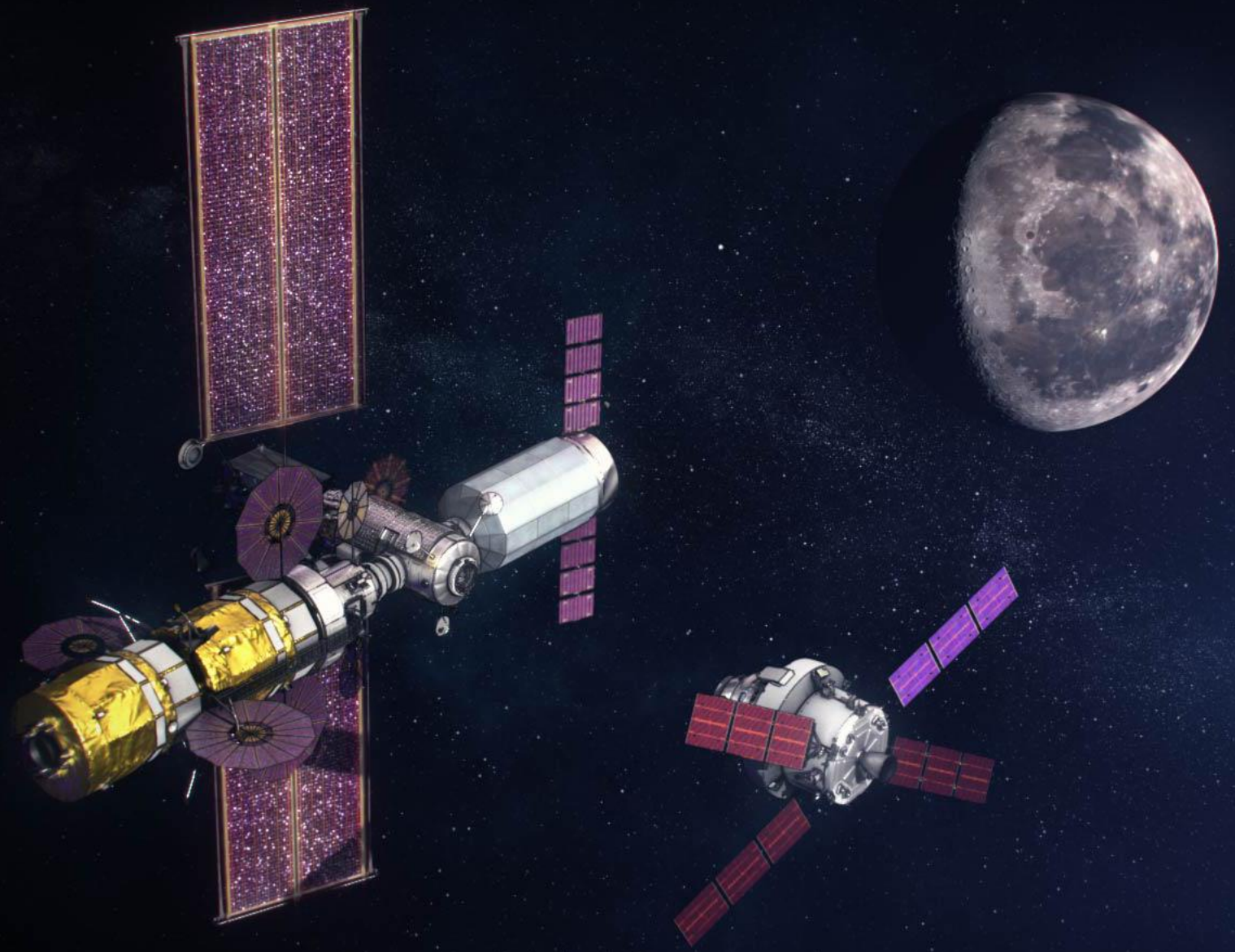
# Gateway

## Today through 2024

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

## Sustainability by 2028

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



# Cislunar Space

*A deep space harbor for expanded human presence*

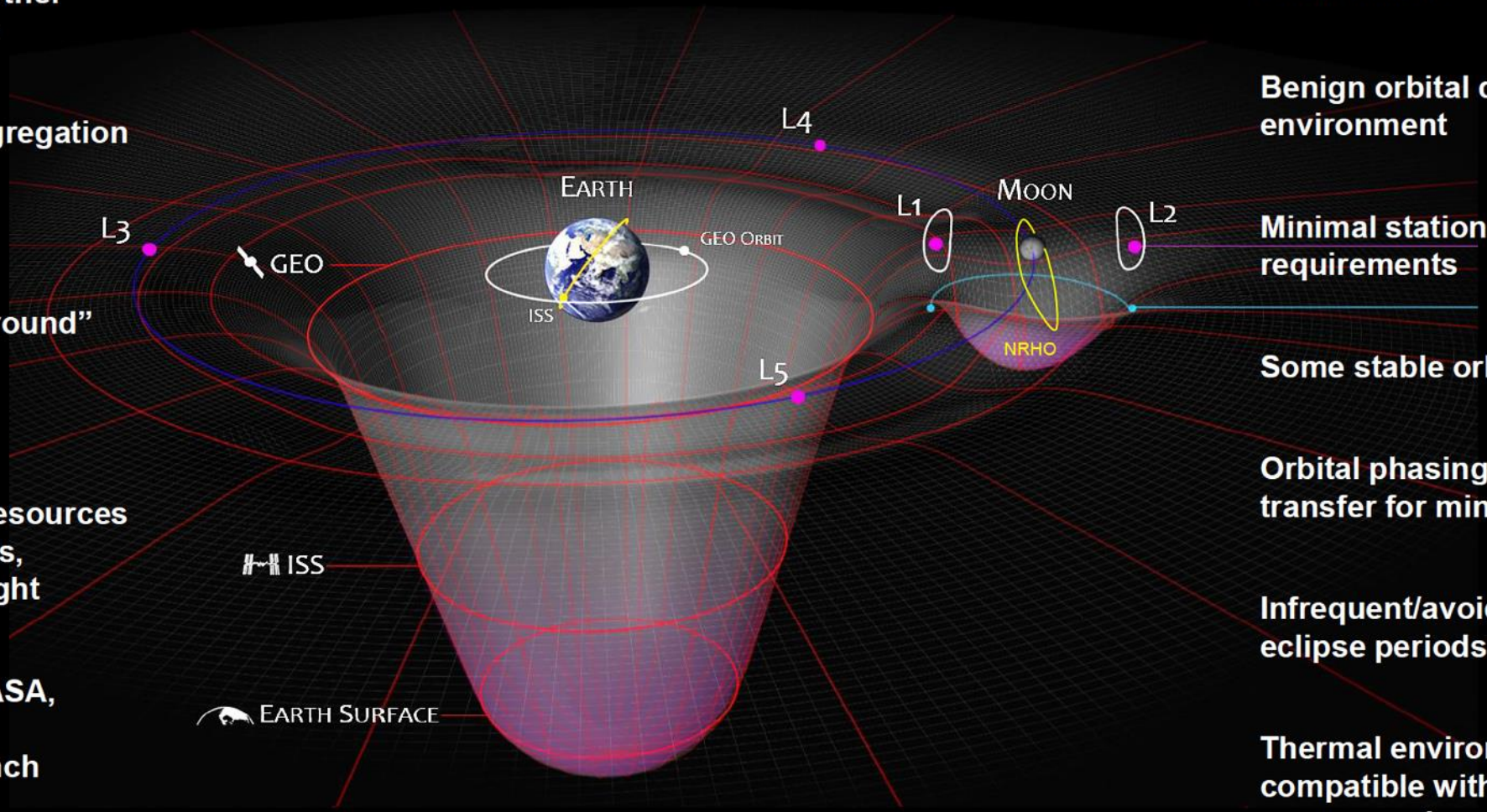
Only ~3 to 5 days away from Earth yet farther than Apollo went

Ideal mission aggregation location

The next "high ground" beyond GEO

Access to local resources including volatiles, gravity and sunlight

Accessible by NASA, commercial, and international launch systems




True deep space radiation environment

Benign orbital debris environment

Minimal station keeping requirements

Some stable orbits

Orbital phasing and transfer for minimal energy

Infrequent/avoidable eclipse periods

Thermal environment compatible with cryogenic oxygen and methane

# Power and Propulsion Element

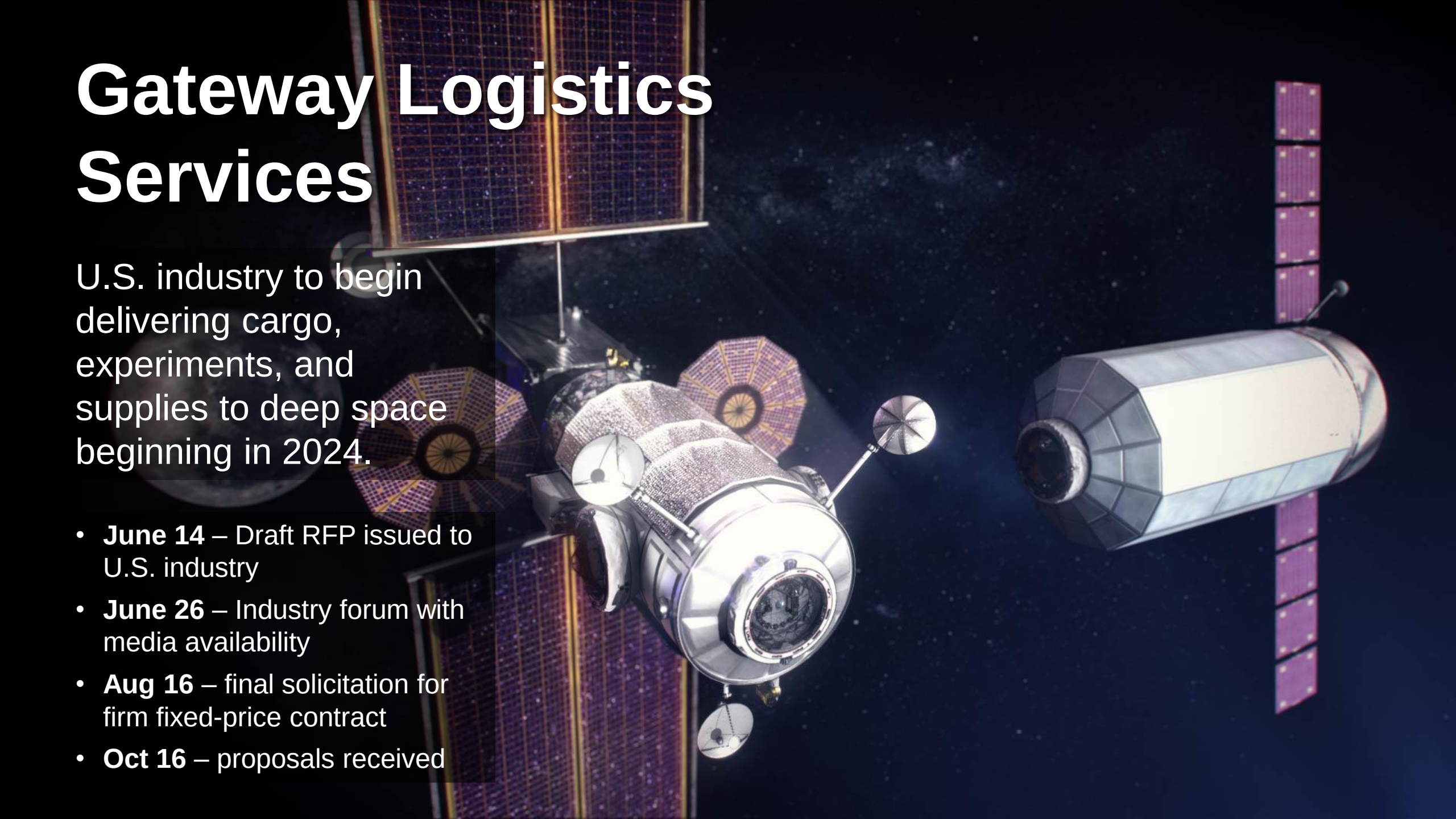
- **Power** – 60 kW+ provided by Roll Out Solar Array (ROSA) and Maxar's 1300 commercial power subsystem
- **Propulsion** – Leverage NASA development of 12.5 kW Electric Propulsion (EP), and internal Maxar advanced EP development, with Maxar expertise in system accommodation of EP elements
- **Communications** – Ka-band, X-band
- **Guidance Navigation and Control**
- **Gateway Interface Support** –docked components, visiting vehicles, robotics, science payloads, Human Landing System
- **Payload Transfer** – 1000kg for lunar lander or science instruments

# Gateway HALO

**(Habitation and Logistics Outpost)**

- RFP issued to Northrop Grumman
- Minimum capability necessary to support a lunar mission, with significant reliance on Orion life support and crew systems

# Gateway Logistics Services



U.S. industry to begin delivering cargo, experiments, and supplies to deep space beginning in 2024.

- **June 14** – Draft RFP issued to U.S. industry
- **June 26** – Industry forum with media availability
- **Aug 16** – final solicitation for firm fixed-price contract
- **Oct 16** – proposals received

# Human Landing System

**NextSTEP Appendix H:** Human Landing System

- April 8, 2019 – Synopsis Issued for **Ascent Element**
- April 26 – Synopsis updated for **development, integration, and crewed demonstration of integrated landing system**
- July 19 – Draft solicitation
- Aug 30 – Second draft solicitation
- Sept 30 – Final solicitation
- Nov 5 – Proposals received

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

# Let's go. *The Time is Now.*

We have the capability

We have the purpose

We have the charge

We have the responsibility