National Aeronautics and Space Administration

NASA's Exploration Campaign

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Science Mission Directorate, NASA

Space Weather Workshop
03 April 2019

Supporting National Space Policy Directives

SPD-1: Reinvigorating America's Human Space Exploration Program

"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."

SPD-2: Streamlining Regulations on the Commercial Use of Space

"It is the policy of the executive branch to be prudent and responsible when spending taxpayer funds, and to recognize how government actions, including Federal regulations, affect private resources.

It is therefore important that regulations adopted and enforced by the executive branch promote economic growth; minimize uncertainty for taxpayers, investors, and private industry; protect national security, public-safety, and foreign policy interests; and encourage American leadership in space commerce."

SPD-3: National Space Traffic Management

"For decades, the United States has effectively reaped the benefits of operating in space to enhance our national security, civil, and commercial sectors. Our society now depends on space technologies and space-based capabilities for communications, navigation, weather forecasting, and much more.

Given the significance of space activities, the United States considers the continued unfettered access to and freedom to operate in space of vital interest to advance the security, economic prosperity, and scientific knowledge of the Nation."

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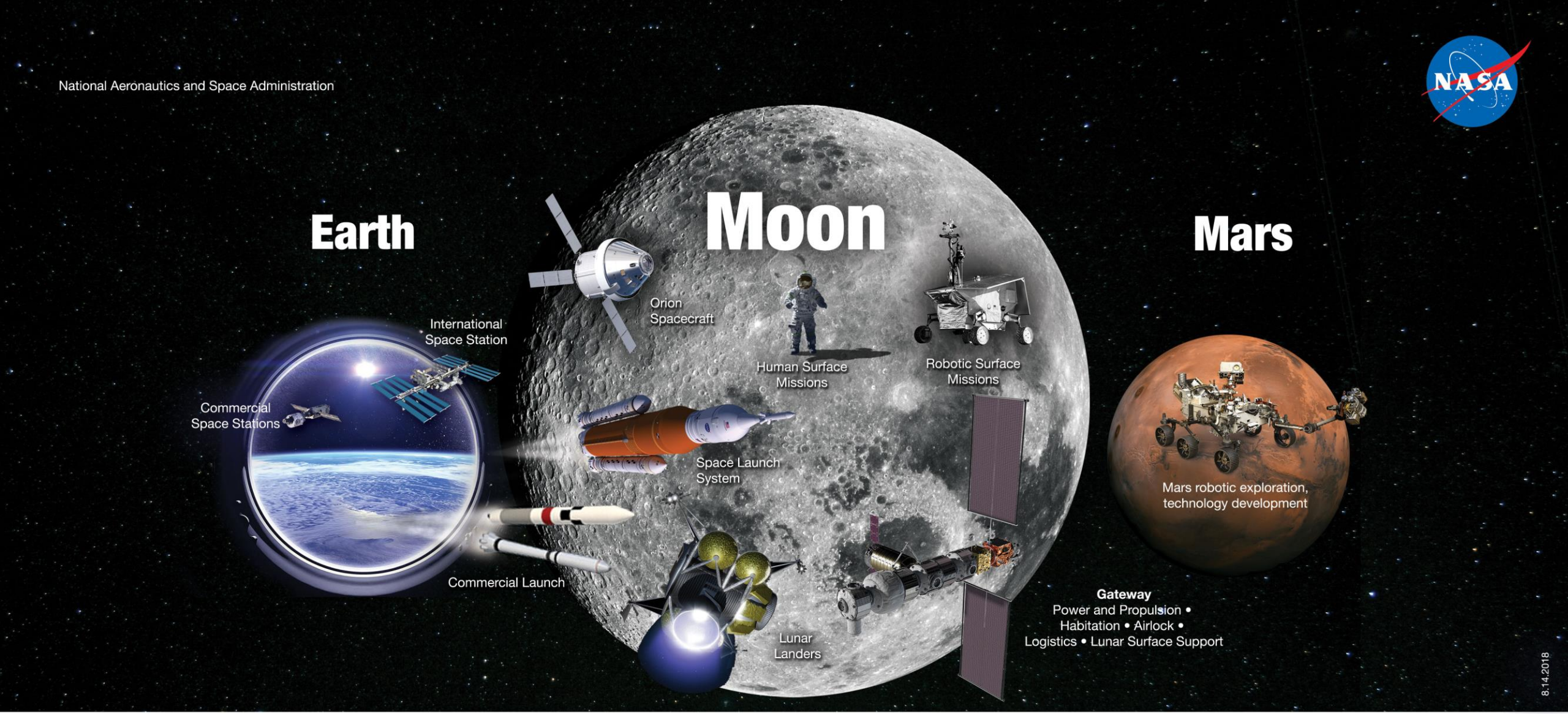


America Will Lead

Fly Astronauts on American Spacecraft
Develop New Commercial Space Stations

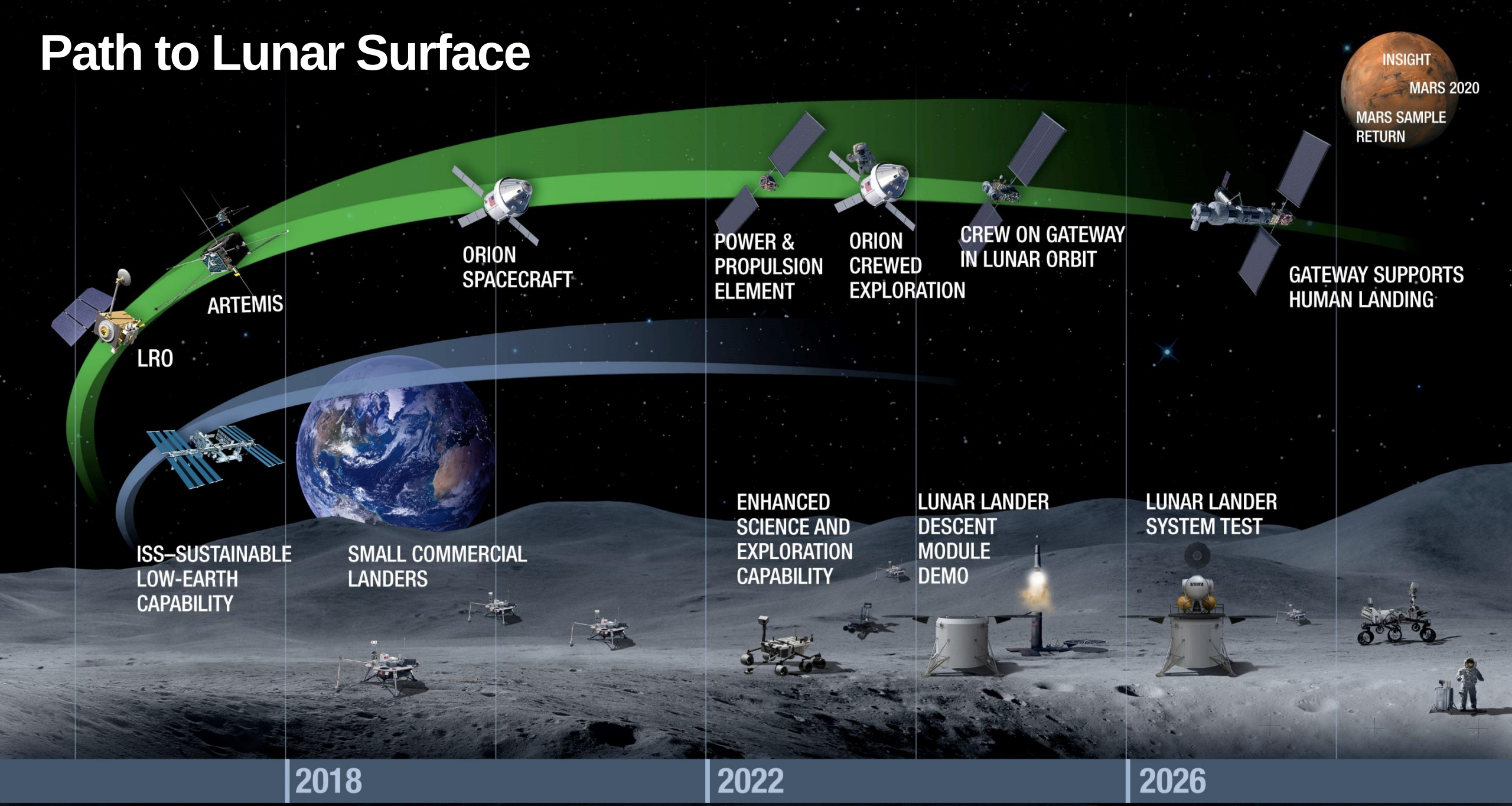
America Will Lead

Fly Astronauts Around the Moon
Establish the First Human Outpost Around the Moon
Develop American Landers to Return Humans to the Moon

America Will Lead

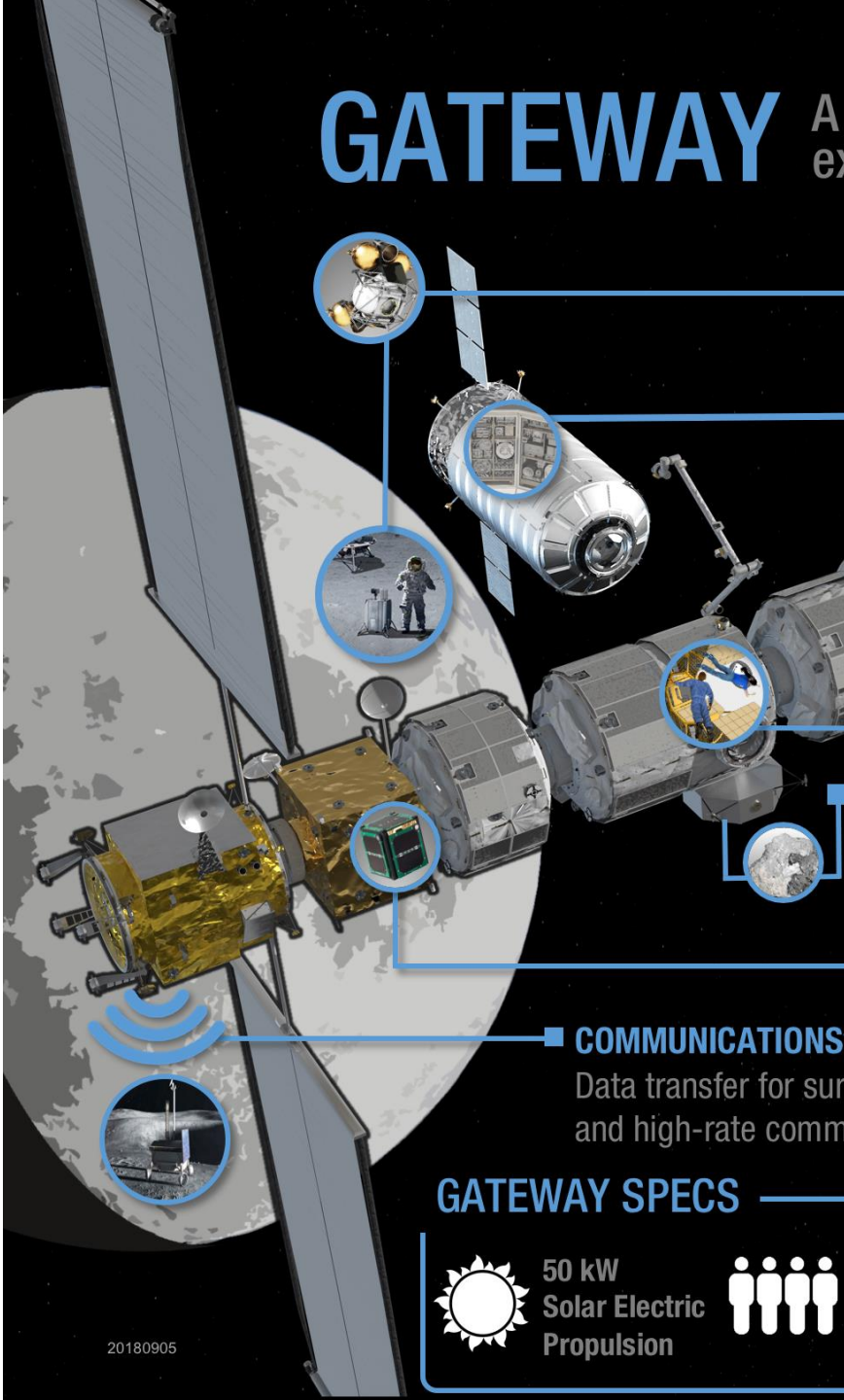
Return the First Scientific Collection from Mars
Practice a Round-trip Leading to Humans to Mars

Path to Lunar Surface



GATEWAY

A spaceport for human and robotic exploration of the Moon and beyond



HUMAN ACCESS TO & FROM LUNAR SURFACE

Astronaut support and teleoperations of surface assets.

U.S. AND INTERNATIONAL CARGO RESUPPLY

Expanding the space economy with supplies delivered aboard partner ships that also provide interim spacecraft volume for additional utilization.

INTERNATIONAL CREW

International crew expeditions for up to 30 days as early as 2024. Longer expeditions as new elements are delivered to the Gateway.

SAMPLE RETURN

Pristine samples robotically delivered to the Gateway for safe processing and return to Earth.

SCIENCE AND TECH DEMOS

Support payloads inside, affixed outside, free-flying nearby, or on the lunar surface. Experiments and investigations continue operating autonomously when crew is not present.

COMMUNICATIONS RELAY

Data transfer for surface and orbital robotic missions and high-rate communications to and from Earth.

SIX DAYS TO ORBIT THE MOON

The orbit keeps the crew in constant communication with Earth and out of the Moon's shadow.

A HUB FOR FARTHER DESTINATIONS

From this orbit, vehicles can embark to multiple destinations: The Moon, Mars and beyond.

GATEWAY SPECS

- 50 kW Solar Electric Propulsion
- 4 Crew Members
- 30-90 Day Crew Missions
- 125 m^3 Pressurized Volume
- Up to 75 mt with Orion docked

ACCESS

384,000 km from Earth

Accessible via NASA's SLS as well as international and commercial ships.

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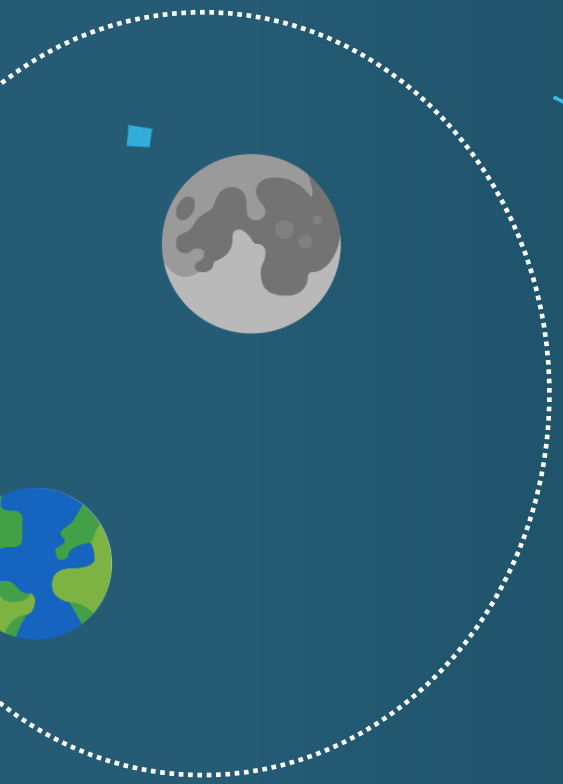
Gateway in Exploration



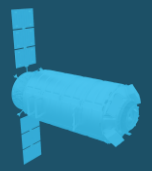
IN CISLUNAR VICINITY

COMMUNICATIONS RELAY

- Coverage of lunar poles, craters/valleys and lunar farside not possible from Earth
- Teleoperations of surface assets by crew or Earth-based operators
- In support of CubeSats and small satellite communications relay

NAVIGATION

- Extending utility of Earth-based GPS constellation
- Aid in navigation for vicinity satellites and surface assets, especially at poles



UTILIZATION OF LOGISTICS MODULES

Potential to use logistics modules as science platforms post departure from Gateway

- Platform to Low-Lunar Orbit (“tug”)
- Platform in Heliocentric disposal orbit

- Planning external payloads workshop for 2019 – experiment interfaces, locations, platform designs
  - Improved understanding of Gateway capabilities/operations and science communities
  - Inform robotics design and operations, external accommodation locations
  - Inform science leadership teams – future experiment opportunities and funding needs
- Gateway utilization plan capturing concepts – expecting draft review in summer

Gateway in Exploration

FROM THE MOON

COMMUNICATIONS RELAY
Data transfer for surface missions

NAVIGATION
Robotic and human lunar mission navigation

SAMPLE RETURN
Pristine samples robotically delivered to the Gateway for safe processing and return to Earth

TELEOPERATIONS
Surface assets

SURFACE ACCESS
Robotic and Human mission support

- **Small lander technology development, refueling, and reusability**
- **Exploration systems development leading to human lunar landers**

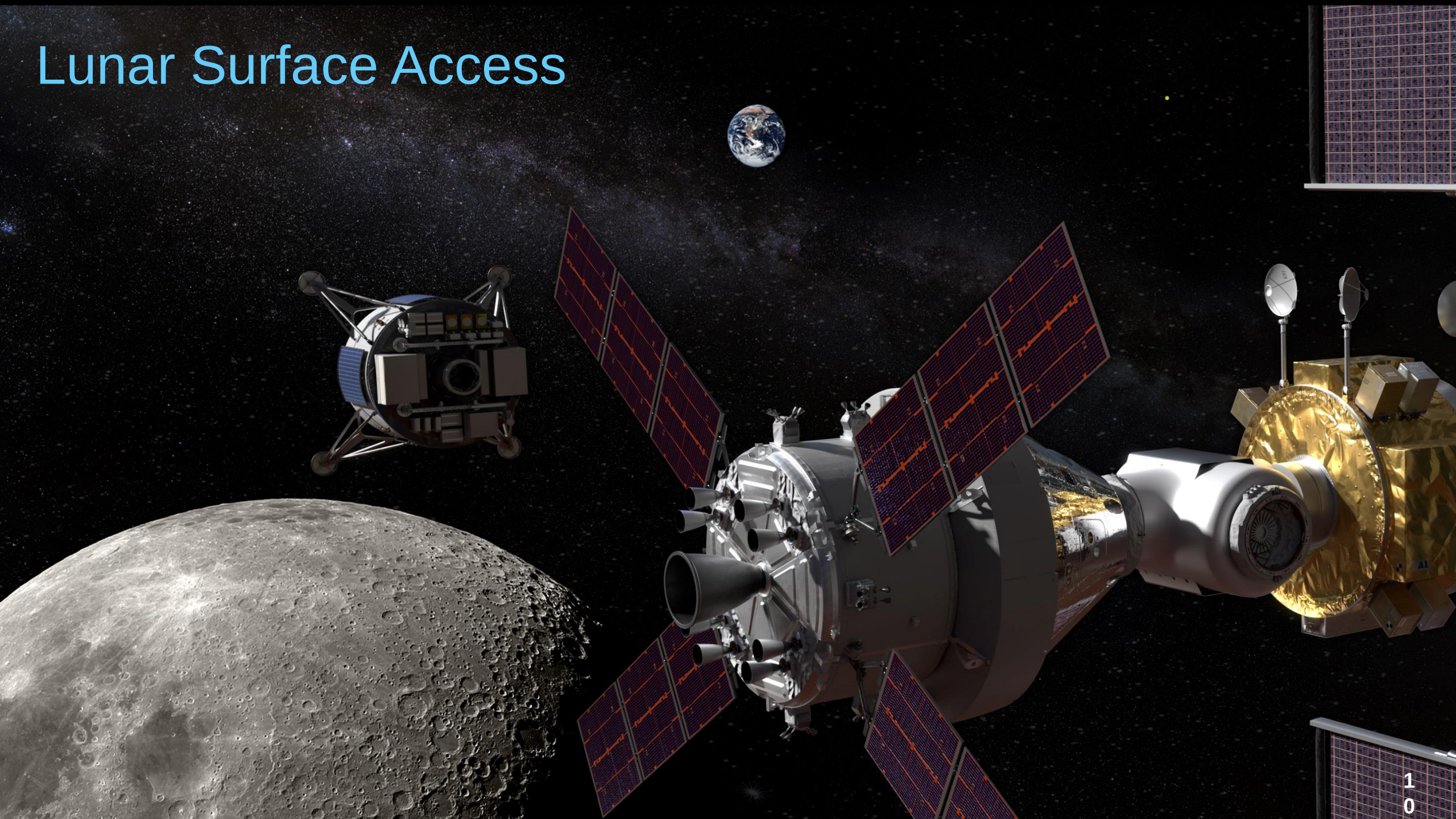
Science on Gateway

- **Gateway, in a NRHO, offers unique opportunities across all science disciplines.**
- **With the addition of additional transportation infrastructure (LLO transfer vehicle, surface access, sample return capability) gateway can enable additional important lunar science**
- **Externally mounted sample collection with controlled pointing can collect samples and provide important science about cometary material, solar composition, interstellar particles, and near Earth objects**
- **Radiation environment of the Gateway can provide important tests of the effects of radiation on biological organisms**
- ***Science utilization extremely constrained until the presence of an external robotic arm***
- ***2019 SMD Announcements of Opportunity (AO) require Gateway interface information for proposers if Gateway is to be included in AO***
- **The National Academies will conduct a workshop in April 2019 focusing on science research using Gateway.**
- **HEOMD to partner with CSA to conduct an engineering-focused Gateway payload workshop in Summer 2019**

Space Weather

- Dedicated session with 15 presentations
- Data to support Space Weather Forecasting
  - Possibly utilize smallsats released from the Gateway
- Observations of different phenomena
  - Solar Energetic Particle Events
  - X-ray Flares
  - Coronal Mass Ejections (CMEs)
  - Solar Wind Plasma
  - Interplanetary Magnetic Field
  - Galactic Cosmic Rays (GCRs)
  - GCR generated energetic particles from the lunar surface
  - Charged & neutral particle
- Spacecraft Charging & Space Environment Monitoring
  - Measure plasma/spacecraft interaction

Lunar Surface Access



Commercial Lunar Payload Services

Winning CLPS companies:

- *Astrobotic*
- *Deep Space Systems*
- *Draper*
- *Firefly Aerospace*
- *Intuitive Machines*
- *Lockheed Martin Space*
- *Masten Space Systems*
- *Moon Express*
- *Orbit Beyond*

- Nine U.S. companies selected through CLPS Nov. 2018, developing landers to deliver NASA payloads to Moon surface; pre-authorized to compete on individual delivery orders
- Competition open to U.S. commercial providers of space transportation services, consistent with National Space Transportation Policy and Commercial Space Act
- Multi-vendor catalog, 10-year IDIQ contract, managed through task order competition for specific payload deliveries
- On ramps to the CLPS contracts will be used to provide additional capabilities as made available
- Structured for NASA as one of many customers of commercial service
- Building on NASA's model in low-Earth orbit, expands partnerships with industry and other nations to explore Moon and advance missions to farther destinations such as Mars, with America leading the way

International Partnerships

The SpaceIL lunar lander, Beresheet, successfully launched and deployed from a Space X Falcon 9 launch vehicle on Thursday, February 21. NASA provided a laser retroreflector assembly that is on board the lander. Beresheet is estimated to land on the surface of the Moon on April 11. The NASA DSN is providing support to the lander team as part of an NASA-Israel Space Agency cooperative agreement.

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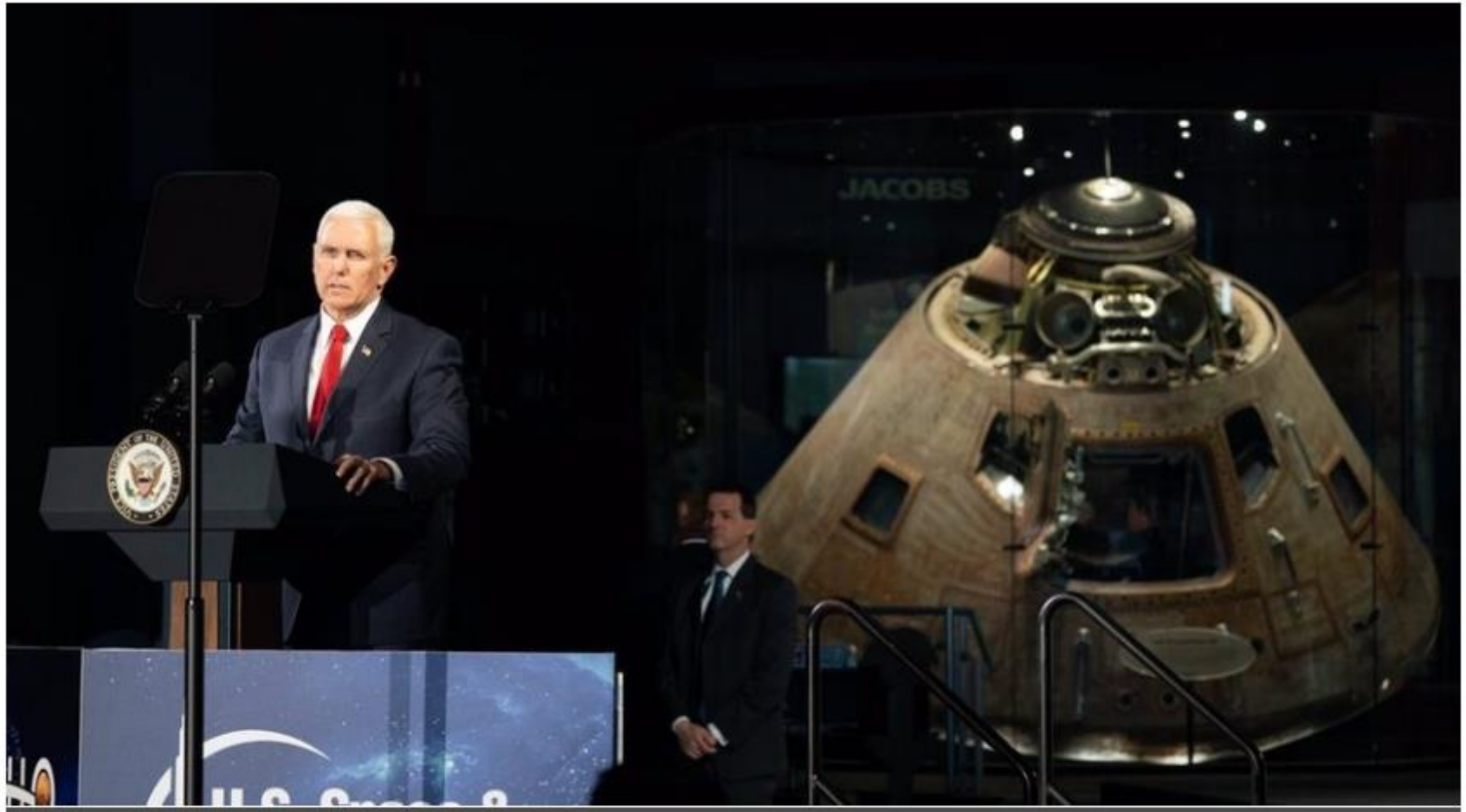
Pence calls for human return to the moon by 2024

by **Jeff Foust** — March 26, 2019



Vice President Mike Pence, speaking at the U.S. Space and Rocket Center in Huntsville, Alabama, March 26, directed NASA to land humans on the moon by 2024, four years earlier than the agency's current plans. Credit: White House

is creating a "Moon to
ition and execution of
the task of HEOMD...]