Update on Gateway with Science and Technology (Utilization) Discussion

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Space Policy Directive 1

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.

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LEADING FUTURE EXPLORATION - STRATEGIC PRINCIPLES

Fiscal Realism  |  Commercial & International Partnerships  |  Scientific Exploration
Technology Pull and Push  |  Gradual Buildup of Capability
Architecture Openness and Resilience  |  Continuity of Human Spaceflight

Global Collaboration and Leadership
Gateway Objectives

NASA shall establish a Gateway to enable a sustained presence around and on the Moon and to develop and deploy critical infrastructure required for operations on the lunar surface and at other deep space destinations.

– The Gateway shall be utilized to enable human crewed missions to cislunar space including capabilities that enable surface missions. *(Crewed Missions)*

– The Gateway shall provide capabilities to meet scientific requirements for lunar discovery and exploration, as well as other science objectives. *(Science Requirements)*

– The Gateway shall be utilized to enable, demonstrate and prove technologies that are enabling for Lunar missions and that feed forward to Mars as well as other deep space destinations. *(Proving Ground & Technology Demonstration)*

– NASA shall establish industry and international partnerships to develop and operate the Gateway. *(Partnerships)*
GATEWAY
An exploration and science outpost in orbit around the Moon

- **Power and Propulsion Element:** Power, communications, attitude control, and orbit control and transfer capabilities for the Gateway.

- **ESPRIT:** Science airlock, additional propellant storage with refueling, and advanced lunar telecommunications capabilities.

- **U.S. Utilization Module:** Small pressurized volume for additional habitation capability.

- **Habitation Module:** Pressurized volumes with environmental control and life support, fire detection and suppression, water storage and distribution.

- **Robotic Arm:** Mechanical arm to berth and inspect vehicles, install science payloads.

- **Logistics and Utilization:** Cargo deliveries of consumables and equipment. Modules may double as additional utilization volume.

- **Airlock:** Enables spacewalks, potential to accommodate docking elements.

- **Sample Return Vehicle:** A robotic vehicle capable of delivering small samples or payloads from the lunar surface to the Gateway.

- **Orion:** U.S. crew module with ESA service module that will take humans farther into deep space than ever before.

**Gateway Compared to the International Space Station**

- The International Space Station is a permanently crewed research platform that has 11 modules and is the size of a football field.

- The Gateway is a much smaller, more focused platform for extending initial human activities into the area around the Moon.
Gateway Modules

**ADVANCED SEP**

**Power and Propulsion Element: 2022**

*Power, in-space transportation, and initial lunar communications*

- One or more competitive awards to U.S. industry
- Launching 2022 on partner-provided commercial launch vehicle.
- Acquisition time: 3 years

**EARLY OPERATIONAL CAPABILITY**

**ESPRIT:**

- International partner provided
- Launching NET 2023 on SLS
- Acquisition time: 3-4 years

**U.S. Utilization Module:**

- Provided by NASA
- Launching NET 2023 on SLS
- Acquisition time: 3-4 years

**EVA CAPABILITY**

- Airlock: Enables EVAs and additional docking
- Acquisition approach deferred until 2020
- Acquisition time: 3-6 years

**ENHANCED HABITATION**

International partner and U.S. habitat modules: 2024 and 2025

*Two habitats provide increased volume for crew operations and science.*

- **International Partner Habitat***:
  - Launching NET 2024 on SLS
  - Acquisition time: 5 years

- **U.S. Habitat***:
  - U.S. provided by competitive award to industry
  - Launching NET 2025 on SLS
  - Acquisition time: 5-6 years

*Habitation functional allocations are currently under review

**ENHANCED SCIENCE & OPERATIONS**

Launch package: Provides logistics and utilization payloads, external robotic capabilities

- **Logistics:**
  - U.S. and international partner provided
  - Earliest delivery 2024
  - Acquisition time: 3-4 years

- **Robotic Arm:**
  - International partner provided
  - Earliest delivery on first logistics flight (2024)

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**Power and Propulsion Element: First Module in Lunar Orbit for Gateway**

- 2022 launch on partner-provided commercial rocket
- 50 kW class spacecraft with 40 kW class EP system
- Power transfer to other gateway elements
- Passive docking using IDSS compliant interface
- Capability to move gateway to multiple lunar orbits
- Orbit control for gateway stack
- Communications with Earth, visiting vehicles, and initial communications support for lunar surface systems
- 2t class xenon EP propellant capacity, refuelable for both chemical and xenon propellants
- Accommodations for utilization payloads
- 15 year life

Five full-sized ground prototypes will be delivered for testing in 2019. In final negotiations with NanoRacks for sixth habitat prototype demonstrator.
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 RETROGRADE 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 (932 miles) at its closest to the lunar surface, 70,000 km (43,495 miles) 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.
GATEWAY - A spaceport for human and robotic exploration to 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 Moon or Mars samples robotically delivered to the Gateway for safe processing and return to Earth.

**COMMUNICATIONS RELAY**
Data transfer for surface and orbital robotic missions and high-rate communications to and from 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.

**GATEWAY SPECS**
- 4 Crew Members
- 30-90 Day Crew Missions
- 125 m³ Pressurized Volume
- Up to 75mt with Orion docked

**ACCESS**
- 384,000 km from Earth
- Accessible via NASA’s SLS as well as international and commercial ships.

**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.
Workshop sponsored by NASA HQ (HEOMD & SMD), JSC, MSFC & GSFC

• All elements will have external payload accommodations

• All pressurized volumes may have internal payload accommodations

Driving Rationale:

• Engage the science community with respect to the scientific potential of a lunar Gateway

• Discuss potential scientific investigations leveraging the Gateway
  – Including the scope of possible instruments
  – Using the Gateway infrastructure

• Discuss what resources the Gateway would have to provide to facilitate different types of scientific investigations
Science Workshop Format

• Introductory briefings on NASA plans, ISS lessons learned, Gateway orbit options

• ~180 Talks, ~300 Attendees
  • Government, academia, industry, international

• One day of discipline-focused sessions in five venues – 5-20 minutes per abstract
  • Heliophysics
  • Earth Science
  • Astrophysics & Fundamental Physics
  • Lunar & Planetary
  • Life Sciences and Space Biology

• Cross-cutting discussions
  • Orbits, Human exploration, Potential future capabilities, Space Weather
  • External Instruments
  • Samples
  • Telerobotics & Leveraging Infrastructure
  • Internal Instruments
Key ISS Lessons Learned for Gateway
(Presented by Robinson at the Workshop)

1. **Target obtaining science support from key science stakeholder communities**
   - Engage SMD and science communities early
   - Build stakeholder support to aid funding and long term sustainability
   - Align Gateway capabilities with key stakeholder needs (e.g. sample/sample return, astrophysics, heliophysics, human research, Earth/Moon observations)

2. **Consider Utilization location within Program Office**
   - Goal of Gateway operations - touches all systems and needs all systems
   - Systems view of Utilization sets up competition with other Gateway systems resources rather than supported by other resources

3. **Consider new accommodation of internal experiments (i.e. different than Express Racks)**
   - Incorporate modern improvements – software upgrades, plug and play, standard interfaces, automation, structural improvements
   - Legacy experiment considerations
   - Balance between crew and automation/robotics

4. **Prioritizing science among Gateway users and partners**
   - ISS evolved to current prioritization processes
   - Start defining processes now
Near Term Utilization Activities

• **Providing GPS/Navigation on the Gateway**
  – Precision timing/location for physics experiments, facility capability for instruments or cis/lunar/surface assets

• **Utilization during uncrewed periods**
  – Defining Gateway internal environmental conditions for experiments - requirements
  – Developing ConOps to optimize automation planning, robotic system potential designs
    • Established Software/Autonomy working group

• **External location of experiments**
  – Field of View studies, vent location designs, shadowing, exosphere analysis (includes NRHO)

• **Logistics**
  – Advocating for dual use logistics vehicles (supply, secondary missions/tugs, experiments)

• **External arm delivery**
  – Protecting earlier delivery in Gateway assembly sequence

• **Internal science accomodations**
  – Detailed studies on potential internal science experiments and identifying common facility lab systems