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Carpet: Feedstock for the Future

Annual Conference • April 25-26, 2023 • Orlando, Florida
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 campaign to return astronauts, including the first woman and first person of color, to the lunar surface.

Gateway is a foundational element of NASA’s planned infrastructure at the Moon and for deep space travel, along with the Orion spacecraft, Space Launch System rocket, Human Landing System, and the Extra Vehicular Activity & Human Surface Mobility Programs.
Gateway is a multi-element space station in cis-lunar orbit. Gateway is central to advancing global human space exploration goals.

It will serve as a unifying catalyst for international partners to establish deep space scientific investigations, sustained lunar surface access, and missions to Mars.
Logistics Vehicle

- CARGO
- ELEMENTS
- FUEL
- SERVICE MODULE
- LOGISTICS MODULE
Logistics Mission Concept of Operations
Kennedy Space Center is home to the Gateway Deep Space Logistics (DSL) project, leading NASA’s commercial supply chain for deep space

DSL leverages specialized expertise and capability at KSC:

- Launch Services Program (LSP) provides commercial launch vehicle expertise as well as commercial business, contract management, and legal support
- Exploration Research & Technology (ER&T) provides commercial spacecraft expertise as well as cargo processing integration support
- KSC Technical Authorities provided by Engineering and Safety & Mission Assurance teams with expertise in supporting KSC commercial service Programs (LSP & CCP)
ARTEMIS: LANDING HUMANS ON THE MOON

Lunar Reconnaissance Orbiter: Continued surface and landing site investigation

Artemis I: First human spacecraft to the Moon in the 21st century
Artemis II: First humans to orbit the Moon and rendezvous in deep space in the 21st century
Gateway begins science operations with launch of Power and Propulsion Element and Habitation and Logistics Outpost
Artemis III-V: Deep space crew missions; cislunar buildup and initial crew demonstration landing with Human Landing System

Early South Pole Robotic Landings
Science and technology payloads delivered by Commercial Lunar Payload Services providers

Volatiles Investigating Polar Exploration Rover
First mobility-enhanced lunar volatiles survey

Uncrewed HLS Demonstration

Humans on the Moon - 21st Century
First crew expedition to the lunar surface

LUNAR SOUTH POLE TARGET SITE
ARTEMIS: LANDING HUMANS ON THE MOON

First lunar surface expedition through Gateway; external robotic system added to Gateway; Lunar Terrain Vehicle delivered to the surface.

Sustainable operations with crew landing services; Gateway enhancements with refueling capability, additional communications, and viewing capabilities.

Pressurized rover delivered for greater exploration range on the surface; Gateway enables longer missions.

Surface habitat delivered, allowing up to four crew on the surface for longer periods of time leveraging extracted resources. Mars mission simulations continue with orbital and surface assets.

SUSTAINABLE LUNAR ORBIT STAGING CAPABILITY AND SURFACE EXPLORATION

MATERIAL SCIENCE AND CARGO PAYLOADS | U.S. GOVERNMENT, INDUSTRY, AND INTERNATIONAL PARTNERSHIP OPPORTUNITIES | TECHNOLOGY AND OPERATIONS DEMONSTRATIONS FOR MARS
GATEWAY INITIAL COMPONENTS: TOGETHER IS BETTER!

- NASA will launch Gateway's Power and Propulsion Element (PPE) and Habitation and Logistics Outpost (HALO) on a single commercial launch vehicle.
- The two modules will be integrated on the ground at Kennedy Space Center and launched together on a Falcon Heavy rocket to reduce the risk associated with separate launches and enhance mission success.
- To reach the destination Near-Rectilinear Halo Orbit (NRHO), the co-manifested vehicle will perform a low-thrust electric propulsion spiral and a final transfer maneuver that will include a low altitude flyby of the lunar surface.
- Destined to be the most powerful electric propulsion spacecraft ever flown, the Solar Electric Propulsion (SEP) subsystem within PPE will enable new technology and allow for further exploration on the lunar surface than ever before.
POWER & PROPULSION ELEMENT (PPE)

- High-power 60-kilowatt solar electric propulsion spacecraft that will provide Gateway with electrical power, propulsion, thermal control and communication capabilities
- Accommodates science and technology demonstration payloads
- Maxar Technologies developing and building the PPE
WHY SOLAR ELECTRIC PROPULSION?

Electric propulsion (EP) systems leverage power – in Gateway's case, the sun – to ionize inert gases and expel them from a spacecraft to produce efficient long-duration thrust. These systems reduce the amount of fuel required and lighten the load launched from Earth.

Solar Electric Propulsion (SEP) uses solar arrays to collect energy from sunlight and convert it into electrical power for Gateway's thrusters, which means Gateway can carry approximately 10 times less propellant.

SEP enables affordable and adaptable solutions for future human missions to the Moon, and eventually Mars.

The SEP's high fuel economy will allow Gateway to support lunar exploration for 15 years, and its ability to move while in orbit will allow explorers to land virtually anywhere on the Moon's surface – including the South Pole.
HABITATION AND LOGISTICS OUTPOST (HALO)

- The initial crew cabin for astronauts visiting Gateway
- Home of the command, control, and power distribution
- A building block for additional modules
- A hub of international cooperation:
  - High Rate Lunar Communication System for high data rate communication with lunar surface provided by the European Space Agency (ESA)
  - Batteries provided by Japan Aerospace Exploration Agency (JAXA) will power HALO until PPE solar arrays can be deployed and during eclipse periods
  - Robotic interfaces provided by Canadian Space Agency (CSA) will host payloads and provide base points for Canadarm3 robotic operations
INTERNATIONAL HABITATION MODULE (I-HAB)

I-HAB increases the Gateway habitation volume and capability enabling longer crewed missions. It includes:

- CO2 removal system
- Crew Quarters
- Internal and External Payloads
- Additional Heat Rejection
- Docking Ports

- Provides more room for scientific research
- Houses life support systems, crew living quarters and imagery components
- Includes additional docking ports
- To be launched with Orion on Space Launch System (SLS) as co-manifested payload on Artemis IV
EUROPEAN SYSTEM PROVIDING REFUELING INFRASTRUCTURE AND TELECOMMUNICATIONS (ESPRIT) REFUELING MODULE

- Docking port for future logistics and fuel resupply
- Windows for Moon and Earth observation
- Cargo storage for Gateway logistics
- Launching with Orion on the Space Launch System as co-manifested payload on Artemis V

Internal Volume of ESPRIT Refueling Module

ESPRIT windows provide crew views of Earth and the Moon

PPE/HALO/ESPRIT Refueling Breadboard
UTILIZING AND MAINTAINING

CANADARM3
• Next-generation robotic arm capable of moving end-over-end across Gateway’s exterior
• Enables robotic support for exterior maintenance and inspection
• Provides capability to transfer and install external hardware and science payloads between Gateway modules, visiting cargo vehicles and Gateway’s science airlock

CREW & SCIENCE AIRLOCK
• Enables crewed spacewalks
• Allows for transfer of science experiments and hardware between the pressurized cabin and the exterior of Gateway via the science airlock
• NASA exploring cooperation with a new partner for provision of Gateway airlock
Gateway will be a powerhouse for groundbreaking research of the deep space environment's impact on human body and vehicle systems that has not been possible from low-Earth orbit.

Initial science payloads include:

**ERSA:** ESA's radiation instrument package will help provide an understanding of how to keep astronauts safe by monitoring the radiation exposure in Gateway's unique orbit. It will also support the **JAXA Dust Monitor**, which will help characterize the lunar dust environment imparted on Gateway from vehicles returning from the lunar surface.

**HERMES:** NASA's space weather instrument suite will observe radiation in the form of solar particles and solar wind created by the Sun.

**Internal Dosimeter Array:** Complementing the external suit, ESA's IDA will study radiation shielding effects inside of Gateway, while also improving radiation physics models for cancer, cardiovascular, and central nervous system effects. Additional instruments will be provided by JAXA.

Small Orbital Replacement Unit Robotics Interface, or SORI, allows external payloads and other hardware to be mounted on external sides on Gateway modules. The robotics interface allows the CSA-provided robotic arm to exchange payloads after research objects are complete.
Supply missions are planned for each crewed Artemis mission. Cargo spacecraft will stay at the Gateway for 6-12 months at a time, and support research after Gateway departure.

**SpaceX Logistics Module:**
- > 5 metric ton delivered cargo capability
- Power to support powered payloads
- Trash removal
- Automated docking/undocking

**JAXA's HTV-XG:**
- Derived from HTV-X, which serviced the International Space Station
- 4 metric ton pressurized cargo capability (initially)
- Power to support powered payloads
- Fast transit (<30 days launch to arrival at Gateway)
GATEWAY’S UNIQUE ORBIT

There are many ways to orbit the Moon. Gateway will travel in a near-rectilinear halo orbit to support missions to the lunar surface and serve as a staging point for exploration farther into the solar system, including Mars.

NEAR-RECTILINEAR HALO ORBIT (NRHO)

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

ENVIRONMENT
The deep space environment is useful for radiation testing and experiments in preparation for missions to the lunar surface and Mars

NRHO

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

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 the lunar surface
» Orbit period: 2 weeks

HALO ORBITS
Fuel-efficient orbits revolving around Earth-Moon neutral-gravity points
» Orbit period: 1-2 weeks
# GATEWAY AND THE INTERNATIONAL SPACE STATION

<table>
<thead>
<tr>
<th></th>
<th>Size</th>
<th>Vehicle Life</th>
<th>Crewed</th>
<th>Uncrewed</th>
<th>Logistics</th>
<th>Refueling</th>
<th>EVA Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gateway</strong></td>
<td>1-bedroom condo</td>
<td>Minimum 15 years</td>
<td>30+ days/year</td>
<td>330 days per year up to three years</td>
<td>1 logistics resupply per crewed mission</td>
<td>1 refueler for 15-year lifespan</td>
<td>With airlock arrival</td>
</tr>
<tr>
<td><strong>ISS</strong></td>
<td>6-bedroom house</td>
<td>Initially 15, extended to 30</td>
<td>365 days/year</td>
<td>0 days in 22 years and counting</td>
<td>Approx. 7 logistics re-supply per year</td>
<td>3 refuelers per year</td>
<td>Continuous</td>
</tr>
</tbody>
</table>

**International Space Station (ISS)**

- Length: 111 m (365 ft)
- Width: 108.5 m (356 ft)
- Height: 71.8 m (235 ft)

**Gateway**

- Length: 26.4 m (87 ft)
- Width: 18.9 m (62 ft)
- Height: 5.5 m (14 ft)
On and around the Moon, we can take reasonable risks, perform groundbreaking science, and prove technologies and mature systems necessary while astronauts are just days away from home.

Gateway will serve as a steppingstone for visiting spacecraft to deep space, equipping NASA and its international partners with knowledge and experiences that will feed forward to successful missions to Mars.
Additional Slides
SPEAKER RESOURCES

- Gateway Frequently Asked Questions
- Publicly Approved Images on Flickr
ARTEMIS I
ARTEMIS I
The First Uncrewed Integrated Flight Test of NASA’s Orion Spacecraft and Space Launch System Rocket

- Launch: SLS and Orion lift off from pad 39B at Kennedy Space Center.
- Jettison Rocket Boosters, Fairings, and Launch Abort System
- Core Stage Main Engines Cut Off
- Perigee Raise Maneuver
- Earth Orbit: Systems check with solar panel adjustments.
- Trans Lunar Injection (TLI) Burn: Manoeuver lasts for approximately 20 minutes.
- Interim Cryogenic Propulsion Stage (ICPS) Separation and Disposal: ICPS commits Orion to moon at TLI.
- Outbound Powered Flyby (OPF): 60 km from the Moon; targets DRO insertion.
- Outbound Trajectory Correction (OTC) Burn: As necessary adjust trajectory for lunar flyby to distant retrograde orbit (DRO).
- Lunar Orbit Insertion: Enter distant retrograde orbit.
- DRO Departure: Leave DRO and start return to Earth.
- Return Powered Flyby (RPF): RPF burn prep and return coast to Earth initiated.
- Return Transit: Return Trajectory Correction (RTC) aims as necessary to aim for Earth’s atmosphere.
- Crew Module Separation from Service Module
- Entry Interface (EI): Enter Earth’s atmosphere.
- Splashdown: Pacific Ocean landing within view of the U.S. Navy recovery ship.

Mission Durations:
- Total: 26-42 days
- Outbound Transfers: 5-6 days
- DRO Stay: 6-10 days
- Return Transit: 9-19 days
With the Artemis Program, NASA will leverage capabilities and international partnerships to emplace infrastructure that will enable humanity to go to the Moon and prepare missions to Mars.

10 CubeSats, or small satellites, hitched a ride on Orion when NASA's Space Launch System launched during Artemis 1, and play a key role in gaining knowledge and demonstrating potential technologies that reduce risk, increase effectiveness, and improve design.
EXPLORATION EXTRAVEHICULAR ACTIVITY (xEVA) SYSTEM
SPACESUITS, TOOLS, VEHICLE INTERFACES

- Provides all life support functions for up to 8 hours
- Supports multiple suit pressures (up to 8.2 psi) to enable reduced pre-breathe time required
- Single exploration EVA architecture to support destinations from LEO to lunar vicinity and surface to deep space
- xEVA services contracts with U.S. industry upcoming missions
THE ARTEMIS ACCORDS
Principles for a Safe, Peaceful, and Prosperous Future

PEACEFUL PURPOSES
Conduct activities for peaceful purposes, per the tenets of the Outer Space Treaty

TRANSPARENCY
Publicly describe space polices and plans in a transparent manner

INTEROPERABILITY
Use open international standards and support interoperability

EMERGENCY ASSISTANCE
Provide emergency assistance to those in need

REGISTRATION OF SPACE OBJECTS
Join the Registration Convention and register public and private activities in space to avoid harmful interference

RELEASE OF SCIENTIFIC DATA
Release scientific data publicly to ensure the entire world can benefit from space exploration and discovery

SPACE RESOURCES
Extract and use space resources under the auspices of the Outer Space Treaty

DECONFLICTION OF ACTIVITIES
Provide public information about the location and general operations of activities on the Moon to inform scale and scope of ‘safety zones’

ORBITAL DEBRIS AND SPACECRAFT DISPOSAL
Plan for the mitigation of orbital debris
INTERNATIONAL DEEP SPACE INTEROPERABILITY STANDARDS

Gateway is being built by utilizing and meeting the following the Interoperability Standards, which facilitates future collaborative deep space exploration endeavors.

**AVIONICS STANDARD**
Basic design parameters for developers to independently design compatible Avionics systems.

**ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS STANDARD**
Basic common design performance parameters for development of compatible life support systems.

**COMMUNICATIONS STANDARD**
Functional, interface and performance standards necessary to support Interoperable and compatible communications between space craft, around infrastructure, and other surface vehicles.

**DOCKING STANDARD**
Standard docking interface to enable collaborative endeavors.

**POWER STANDARD**
Bus voltage, power quality, and grounding approaches to ensure commonality, reliability, interchangeability and interoperability for electric load applications between space application power systems.