Human Exploration Operations
NASA’s Needs for Future Missions

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Manager, Exploration and Transportation Development Office
“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.”
# NASA Exploration Campaign

## Notional Launches

### Early Science & Technology Initiative
- **SMD**—Pristine Apollo Sample, Virtual Institute
- **HEO/SMD**—Lunar CubeSats
- **SMD/HEO**—Science & Technology Payloads

### Small Commercial Lander Initiative
- **HEO**—Lunar Catalyst & Tipping Point
- **SMD/HEO**—Small Commercial Landers/Payloads

### Mid to Large Lander Initiative Toward Human-Rated Lander
- **HEO/SMD**—Mid-sized Landers (~500kg–1000kg)
- **HEO/SMD**—Human Descent Module Lander (5-6000kg)
- **SMD/HEO**—Payloads & Technology/Mobility & Sample Return
- **SMD**—Mars Robotics

### Lunar Orbital Platform—Gateway
- **HEO**—Orion/SLS (Habitation Elements/Systems)
- **HEO/SMD**—Gateway Elements (PPE, Commercial Logistics)/Crew Support of Lunar Missions
- **HEO/SMD**—Lunar Sample Return Support

### Timelines

<table>
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<tr>
<th>Year</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
<th>2026</th>
<th>2027</th>
<th>2028</th>
<th>2029</th>
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Timelines are tentative and will be developed further in FY 2019
NASA LUNAR EXPLORATION

2018

LRO (2009)
ARTEMIS (2010)

2019

SMALL COMMERCIAL LANDERS
2019 ONWARD

2022

ORION SPACECRAFT
2019

POWER & PROPULSION ELEMENT
2022

ORION CREWED EXPLORATION

2024

GATEWAY IN LUNAR ORBIT

2026

ADVANCED EXPLORATION LANDER
GATEWAY DEVELOPMENT

Establishing leadership in deep space and preparing for exploration into the solar system

FOUNDATIONAL GATEWAY CAPABILITIES

<table>
<thead>
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<th>2022</th>
<th>2023</th>
<th>2024+</th>
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<tr>
<td>50 kW-class Power &amp; Propulsion Element</td>
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CAPABILITIES

- Supports exploration, science, and commercial activities in cislunar space and beyond
- Includes international and U.S. commercial development of elements and systems
- Provides options to transfer between cislunar orbits when uncrewed
- External robotic arm for berthing, science, exterior payloads, and inspections

OPPORTUNITIES

- Logistics flights and logistics providers
- Use of logistics modules for additional available volume
- Ability to support lunar surface missions

INITIAL SCOPE

- 4 Crew Members
- At least 55 m³ Habitable Volume
- 30 Day Crew Missions
- Up to 75mt with Orion docked

These foundational gateway capabilities can support multiple U.S. and international partner objectives in cislunar space and beyond.
Gateway Formulation Team Structure

**Power and Propulsion Element**
- Michele Gates, Director PPE
- Ron Ticker, Deputy Director PPE
- Michael Barrett, Element Manager
- Lead Center – GRC

**Gateway**
- Jason Crusan, Formulation Lead
- Marshall Smith, Director, Cross-Program Systems Integration, ESD/Gateway
- Nicole Herrmann, Integration
- Robert Smith, Project Coordination

**OSMA**
- George Gaika, CSO
- George Deckert, Deputy CSO

**OCHMO**
- Sharmila Watkins

**Systems Engineering and Integration (via CSI)**
- Marshall Smith, Director
- Joe Caram, Gateway SE&I Lead (Acting)

**Programmatic Integration & Strategic Analysis (PISA)**
- Doug Craig, Lead

**Gateway Utilization**
- John Guidi, Lead

**Other Elements as needed. i.e. (Habitation capabilities, logistics, node/airlock, etc…)**
- TBD Based on Acquisition/Partnership

**ESD/PSI**

**OIR**
- Meredith McKay

**AES RMO**
- Christine Solga

**OCE**
- Mcmanamen, CE
- Hanson, Deputy CE
Gateway Formulation Team Structure

**Gateway**
- **Formulation Lead**: Jason Crusan
- **Director**: Marshall Smith
- **Cross-Program Systems Integration, ESD/Gateway**: Nicole Herrmann
- **Project Coordination**: Robert Smith

**Power and Propulsion Element**
- **Director**: Michele Gates
- **Deputy Director**: Ron Ticker
- **Element Manager**: Michael Barrett

**Other Elements as needed**
- Habitation capabilities, logistics, node/airlock, etc...
- TBD Based on Acquisition/Partnership

**Systems Engineering and Integration (via CSI)**
- **Director**: Marshall Smith
- **Gateway SE&I Lead (Acting)**: Joe Caram

**Programmatic Integration & Strategic Analysis (PISA)**
- **Lead**: Doug Craig

**Gateway Utilization**
- **Lead**: John Guidi

**OCHMO**
- **CSO**: George Gafka
- **Deputy CSO**: George Deckert

**OSMA**
- **CSO**: George Gafka
- **Deputy CSO**: George Deckert

**OCE**
- **CE**: Mcmanamen
- **Deputy CE**: Hanson

**AES RMO**
- **Lead**: Christine Solga

**OIR**
- **Lead**: Meredith McKay

**ESD/PSI**
- **Lead**: Doug Craig

**Indicates MSFC Engagement**
Gateway Formulation Team Structure

MSFC:
- Requirements Development
  - Deputy Lead
  - Product Development (SE&I)
- Design Integration
  - Habitat Definition & Integration
  - Subject Matter Experts
    - Structures
    - Avionics
    - ECLSS
    - Payload accommodations
    - Environments
- Cross Program Integration
  - Interface Definition
  - Verification
  - Structures, Loads and Environments
  - Mission definition

Key Support and Engagement
- IAC1 – Post Analysis Sync Review (April 2018)
  - Initial Requirements
  - Ground Rules and Assumption
  - Document Development
  - International Partner initial engagement
- Habitat Acquisition Planning
- Risk Identification and Mitigation Development

Gateway
Jason Crusan, Formulation Lead
Marshall Smith, Director, Cross Program Systems Integration, ESD/Gateway
Nicole Herrmann, Integration
Robert Smith, Project Coordination

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Gateway Utilization
John Guidi, Lead

Other Elements as needed. i.e. (Habitation capabilities, logistics, node/airlock, etc…)
TBD Based on Acquisition/Partnership

MSFC:
- Mars Study Team
- Potential Lunar studies

MSFC:
John Hanson
Deputy Chief Engineer responsible for Gateway

MSFC:
• Support to Science Utilization including Workshop planning, conduct, and participation
• Input to technology demonstration requirements

MSFC:
• IAC1 – Post Analysis Sync Review (April 2018)
  - Initial Requirements
  - Ground Rules and Assumption
  - Document Development
  - International Partner initial engagement
- Habitat Acquisition Planning
- Risk Identification and Mitigation Development

Indicates MSFC Engagement
MSFC SEI Support - Requirements Development Team

• Key Products and Tasks
  – Deputy Requirements Team Lead (Rhodes/EE)
  – Teams’ Key SEI products (Bold=MSFC Developed):
    • ConOps (Greene/HP)
    • Functional Analysis/Allocations (Foster/ES)
    • System Requirements
    • Architecture Definition
    • SE Management Plan (Rhodes/EE)
    • Interface Development (Hicks/HP)
    • Verification Planning
  – Future wok Areas (M&S Planning, Requirements (HAB))
Habitat Status

Boeing (MSFC)

Lockheed Martin (KSC)

SierraNevada (LaRC)

Orbital ATK (JSC)

Bigelow

NanoRacks (MSFC)
Agency Gateway Formulation

MSFC and JSC ECLSS Collaboration

JSC and Agency-Designated Center Roles

Readying Capabilities & Leaning Forward:

- Carbon Dioxide Removal
- Trace Contaminate Control
- ECLSS Architecture
- Requirements, Common Standards, Trade Studies

ECLSS Test Area

Trace Contaminant Control
Catalytic Oxidizer

4BCO2 Design
Marshall – Gateway Ready