FORWARD TO THE MOON:

NASA’s Strategic Plan for Lunar Exploration

Updated 5/22/2019
The NASA Charge to the Moon

In keeping with SPD-1, NASA is charged with landing the first American woman and next American man at the South Pole of the Moon by 2024, followed by a sustained presence on and around the Moon by 2028.

NASA will “use all means necessary” to ensure mission success in moving us forward to the Moon.

Vice President Mike Pence speaks about NASA’s mandate to return American astronauts to the Moon and on to Mars at the U.S. Space & Rocket Center in Huntsville, Alabama.
Why Go to the Moon?

- Establishes American leadership and strategic presence
- Proves technologies and capabilities for sending humans to Mars
- 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 & international partnerships in deep space
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.
American Leadership in Space Exploration

**EARTH ORBIT**
- Grow a robust commercial space industry with a constant human presence
- Expand our international partnerships through the ISS
- Conduct exploration science and technology demonstrations aboard ISS
- Continue critical earth science research
- New jobs through in-space manufacturing and assembly
- Low-Earth orbit launches us to farther destinations

**LUNAR ORBIT**
- The next step for commercial space development
- Conduct ground-breaking decadal science
- A new venue to strengthen international partnerships
- Stepping stone and training ground for extending human presence into deep space
- Sustainable and affordable human and robotic programs

**LUNAR SURFACE**
- Seed investments in commercial lunar landers
- Opportunities to develop technologies for long-term survival
- Explore and exploit space resources
- Create a foothold on a new frontier

**MARS & BEYOND**
- America’s next giant leap – reaching new worlds
- Push the boundaries of human knowledge
- Answer the question of ‘are we alone?’
- Unlock the mysteries of the universe
EXPLORE MOON to MARS

THE ARTEMIS PROGRAM

PHASE ONE: South Pole by 2024
## Strategic Changes to Achieve 2024

<table>
<thead>
<tr>
<th>Feature</th>
<th>Previous 2028 Target Features</th>
<th>Revised Target features for 2024 crew</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gateway</td>
<td>Significant platform; multi-element</td>
<td>Phase One; Absolute minimum configuration</td>
</tr>
<tr>
<td>Crew Size</td>
<td>Sizing for up to 4 crew to the lunar surface</td>
<td>2 to surface initially with up to 2 crew on-orbit</td>
</tr>
<tr>
<td>Access</td>
<td>Global</td>
<td>South Pole first. Access to Global locations.</td>
</tr>
<tr>
<td>Partners</td>
<td>Commercial and international opportunities; interoperability standards</td>
<td>Much stronger commercial engagement sooner, international opportunities remain; interoperability standards enable all partners</td>
</tr>
<tr>
<td>Launch Vehicles</td>
<td>SLS and commercial</td>
<td>SLS with increased number of commercial launches</td>
</tr>
<tr>
<td>Mission Duration</td>
<td>7 day lunar sorties</td>
<td>Trade lower number of mission days as needed</td>
</tr>
<tr>
<td>Schedule</td>
<td>2028 with a paced approach</td>
<td>Focused urgency and energy to accomplish 2024</td>
</tr>
<tr>
<td><strong>NASA Organizational Change</strong></td>
<td>Landing humans on the surface of the Moon in 2024 will require changes to established internal and external policies, procedures, and processes including: Legal/Procurement, Budget/Resources, Staffing/Workforce, Governance/Organization</td>
<td>Teams across the agency are working detailed recommendations in these, and other categories to support meeting the 2024 objective</td>
</tr>
</tbody>
</table>

*Current draft as of 5/21/2019*
A Budget Increase Towards 2024

- The FY2020 budget amendment provides an increase of $1.6 billion above the president’s initial $21 billion budget request with no money taken from existing NASA programs. This is the boost NASA needs.

- $1 billion to accelerate development of human lunar transportation systems to take astronauts to the surface and back to Gateway*.
- $651 million towards the completion of SLS and Orion to support a 2024 landing.
- $132 million for new technologies to help astronauts live and work on the lunar surface and in deep space.
- $90 million for Science to increase robotic exploration at the lunar South Pole in advance of astronauts.

* Focusing Gateway on just the capabilities needed for Phase 1 allowed for a $321M scope
Artemis Phase 1: To the Lunar Surface by 2024

**Artemis 1:** First Human Spacecraft to the Moon in the 21st Century

**Artemis 2:** First Humans to the Moon in the 21st Century

**First High Power Solar Electric Propulsion (SEP) System**

**First Pressurized Crew Module Delivered to Gateway**

**Artemis 3:** Crewed Mission to Gateway and Lunar Surface

**Commercial Lunar Payload Services** - CLPS delivered science and technology payloads

**Early South Pole Crater Rim Mission(s)**
- First robotic landing on eventual human lunar return and ISRU site
- First ground truth of polar crater volatiles

**Large-Scale Cargo Lander**
- Increased capabilities for science and technology payloads

**Humans on the Moon - 21st Century**
First crew leverages infrastructure left behind by previous missions

**Lunar South Pole Crater Target Site**

**2019**

**2024**
Achieving 2024 – A Parallel Path to Success

Artemis will see government and commercial systems moving in parallel to complete the architecture and deliver crew

**NASA Programs SLS and Orion**

**Artemis 1**
First flight test of SLS and Orion as an integrated system

**Artemis 2**
First flight of crew to the Moon aboard SLS and Orion

**Artemis 3**
First crew to the lunar surface; Logistics delivered for 2024 surface mission

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Between now and 2024, U.S. industry delivers the launches and human landing system necessary for a faster return to the Moon and sustainability through Gateway.

**Commercially Provided Elements**

**PPE**
Power Propulsion Element arrives at NRHO via commercial rocket

**Crew Module**
Small pressurized crew module launches to Gateway on a commercial rocket

**Human Landing System**

**Transfer**
Transfers lander from Gateway to low lunar orbit

**Descent**
Descends from Transfer vehicle to lunar surface

**Ascent**
Ascends from lunar surface to Gateway

Up to three commercial rocket launches, depending on distribution of the Transfer, Descent, and Ascent functions.

Current draft as of 5/21/2019
The Power of SLS and Orion

**ORION**
The only spacecraft capable of carrying and sustaining crew on missions to deep space, providing emergency abort capability, and safe re-entry from lunar return velocities.

**SLS**
The only rocket with the power and capability required to carry astronauts to deep space onboard the Orion spacecraft.

**NATIONAL CAPABILITY**
The SLS and Orion programs (including Exploration Ground Support at Kennedy Space Center) leverages over 3,800 suppliers and over 60,000 workers across all 50 states.
# Integrated Artemis Manifest: 2019-2024

<table>
<thead>
<tr>
<th>Year</th>
<th>Sustainable Low-Earth Capability</th>
<th>Sustainable Lunar Orbit Staging Capability</th>
<th>Sustainable Lunar Surface Exploration</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>ISS MCB (transition)</td>
<td>NextSTEP Hab ground prototypes complete</td>
<td>CLPS opportunity</td>
</tr>
<tr>
<td>2020</td>
<td>Commercial Crew Test Flights and Certification</td>
<td>Artemis 1 crew - test flight 13 Cubesats, 7 lunar lander reviewed</td>
<td>NDL, ISRU</td>
</tr>
<tr>
<td>2021</td>
<td>Commercial Crew Test Flights and Certification</td>
<td>Artemis 2 crew - test flight 13 Cubesats, 7 lunar lander reviewed</td>
<td>NDL, ISRU, &amp; HPSC</td>
</tr>
<tr>
<td>2022</td>
<td>Commercial Crew Test Flights and Certification</td>
<td>CLV with testing missions</td>
<td>CLPS opportunity</td>
</tr>
<tr>
<td>2023</td>
<td>Commercial Crew Test Flights and Certification</td>
<td>Artemis 3 crew + Surface Logistics</td>
<td>Human Lunar Landing</td>
</tr>
<tr>
<td>2024</td>
<td>Other LEO Commercialization Activities (in work):</td>
<td>3 CLVs TV, Declass, and Ascend Modules</td>
<td>HPSC, NDL, ISRU, haz. detection, CFM, &amp; TRN</td>
</tr>
<tr>
<td>2025</td>
<td>• Multi-Agency Working Group (through NspC)</td>
<td>3 CLVs TV, Declass, and Ascend Nodes</td>
<td>ISRU &amp; Nuclear Surface Power</td>
</tr>
<tr>
<td>2026</td>
<td>• ISU Capabilities Pricing Policy</td>
<td>3 CLVs TV, Declass, and Ascend Nodes</td>
<td>ISRU &amp; Nuclear Surface Power</td>
</tr>
<tr>
<td>2027</td>
<td>• Government LEO Research Policy (through NspC)</td>
<td>3 CLVs TV, Declass, and Ascend Nodes</td>
<td>ISRU &amp; Nuclear Surface Power</td>
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<tr>
<td>2028</td>
<td>• LEO Commercial Capabilities Solicitation</td>
<td>3 CLVs TV, Declass, and Ascend Nodes</td>
<td>ISRU &amp; Nuclear Surface Power</td>
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**Current draft as of 5/21/2019**
Gateway is Essential for 2024 Landing

- Initial Gateway focuses on the minimum systems required to support a 2024 human lunar landing while also supporting Phase 2

- Provides command center and aggregation point for 2024 human landing

- Establishes strategic presence around the Moon – US in the leadership role

- Creates resilience and robustness in the lunar architecture

- Provides building block for the future, expanded capabilities on and around the Moon
Lunar Science by 2024

Polar Landers and Rovers
- First direct measurement of polar volatiles, improving our understanding of their lateral and vertical distribution, as well as their physical state and chemical composition
- Information on the geology of the South-Pole Aitken basin, the largest impact in the solar system

Non-Polar Landers and Rovers
- Ability to explore scientifically valuable terrains not explored by Apollo.
  Examples include:
  - Land at a lunar swirl and make the first surface magnetic measurement
  - Visit young volcanic features such as Ina to understand volcanic evolution
  - PI-led instruments - Discovery-class science such as geophysical network and visiting lunar volcanic region

Artemis 1 – CubeSat Program
- Over a dozen satellites will be launch as part of Artemis 1

Orbital Data
- Cubesats delivered by CLPS providers, or comm/relay spacecraft could acquire new scientifically valuable datasets
- Global mineral mapping (including resource identification), global elemental maps, improved volatile mapping

In-Situ Resource Initial Research
- What is the composition and ability to use lunar ice for sustainment and fuel
Space Technology for 2024 and Beyond

- High Performance Spaceflight Computing
- Precision Landing
- Solar Electric Propulsion
- Cryofluid Management
- Lunar Dust Mitigation
- Surface Excavation/Construction
- In Situ Resource Utilization
- Lunar Surface Power
- Extreme Environments
- Extreme Access

Lunar Surface Innovation Initiative
THE ARTEMIS PROGRAM

PHASE 2: Sustainability at the Moon and on to Mars
Sustainability at the Moon and on to Mars

- The U.S. leading in exploration and setting the standards for the Moon
- Unbound potential for partnerships and collaboration
- Meaningful, long-duration human missions
- Testing impacts on human performance and exploration operations to be used for Mars
- Repeatable operations traveling from Earth to the Gateway to the surface with reusable systems
- Unprecedented science outside of Earth’s influence
- Maintains strategic presence as a deep space port and refueling depot around the Moon
- Increases international and commercial partnership opportunities, fostering healthy competition
Lunar Science After 2024
Human and Robotic Missions Provide Unique Science Opportunities

On Gateway
- Deep space testing of Mars-forward systems
- Hosts groundbreaking science for space weather forecasting, full-disc Earth observation, astrophysics, heliophysics, and lunar and planetary science
- Mars transit testbed for reducing risk to the human body

Surface Exploration
- Understanding of how to use in-situ resources for fuel and life
- Geophysical measurements and carefully selected samples of rock types returned to Earth will revolutionize our understanding of the origin and evolution of the Moon
- Samples from different geologic areas will provide important information about the inner solar system
- In-situ study of lunar impact craters will help us understand the physics of impact cratering, the most prevalent geologic process in the solar system
- Humans have the ability to set up complex surface instrumentation; these instruments will cover astrophysics, heliophysics and Earth observation
- Partial gravity research in physical and life sciences ranging from combustion to plant growth will inform and support sustained human presence.

Surface Telerobotics to Provide Constant Science
- Sending rovers into areas that are too difficult for the crew to explore; rovers can be teleoperated from Earth to maximize the scientific return
Let’s go! *The time is now.*

We have the capability

We have the purpose

We have the charge

We have the responsibility