SUBCOMMITTEE ON SPACE AND AERONAUTICS
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

HEARING CHARTER

Keeping Our Sights on Mars Part 3: A Status Update and Review of NASA's Artemis Initiative

Tuesday, March 1, 2022
11:00 a.m.
Online Via Zoom

PURPOSE

The purpose of the hearing is to examine the status of plans and progress on the National Aeronautics and Space Administration's Artemis initiative; to review challenges related to the implementation of those activities; and to understand the factors that contribute to overall success in the nation's Moon to Mars efforts, among other issues.

WITNESSES

- **Mr. James Free,** Associate Administrator, Exploration Systems Development Mission Directorate, National Aeronautics and Space Administration
- **Mr. William Russell,** Director, Contracting and National Security Acquisitions, Government Accountability Office
- **Dr. Patricia Sanders,** Chair, Aerospace Safety Advisory Panel
- **The Honorable Paul K. Martin,** Inspector General, National Aeronautics and Space Administration
- **Mr. Daniel Dumbacher,** Executive Director, American Institute of Aeronautics and Astronautics

OVERARCHING QUESTIONS

- *What is the plan, including goals and objectives, for NASA's Moon to Mars activity?*
- *What is the current status, including schedule, budget estimate, and technological readiness, of the development programs and other activities that are part of the Artemis initiative?*
- *What are the key challenges to implementing the Artemis initiative? How has NASA established a management, organizational, and oversight approach to address the challenges?*

BACKGROUND

NASA's Artemis initiative encompasses the programs and projects that relate to human exploration to destinations beyond low Earth orbit (LEO), primarily focused on the return of astronauts to the surface of the Moon in preparation for the future human exploration of Mars. The return of humans to the Moon was announced in 2017, under the Trump administration, and Artemis has continued under the Biden administration.[1] The table below summarizes key announcements and developments related to Artemis.

Timeline of Key Artemis Developments
December 11, 2017: President Trump signs Space Policy Directive-1 (SPD-1), which directs the NASA Administrator to partner with the private sector and the international community to return humans to the Moon, followed by missions to Mars and beyond. **March 11, 2019:** NASA announces, as part of the fiscal year 2020 (FY2020) budget request, an intention to return astronauts to the surface of the Moon in 2028. **March 26, 2019:** Then-Vice President Pence directs NASA to accelerate those plans by four years, and land astronauts on the south pole of the Moon in 2024. **May 13, 2019**: NASA submits to Congress a supplemental FY2020 budget request for an additional $1.6 billion to support the acceleration to 2024. **February 10, 2020:** NASA submits its FY2021 budget request, the first reflecting the Artemis initiative and the 2024 human landing date. **April 30, 2020:** NASA announces selections for the Human Landing System (HLS) "design contracts," which award three companies funding to design and develop human landing systems for Artemis, with the intent to downselect to one or more designs for the 2024 mission. **September 21, 2020:** NASA publishes the "Artemis Plan," which provides a high-level overview of the agency's lunar exploration activities.[2] **April 16, 2021:** NASA announces that it has selected SpaceX for the "option A" HLS award, a demonstration contract for the 2024 lunar landing. Shortly thereafter, the two other HLS design study contractors submit formal bid protests, after which work on the HLS contract pauses. **May 28, 2021:** The first budget request of the Biden administration, for FY2022, maintains Artemis and supports a human landing on the surface of the Moon in 2024. **November 9, 2021:** The legal protests to NASA's HLS award are resolved, with the original selection upheld. NASA and SpaceX resume work on the contract. NASA announces that the human landing has slipped to 2025.

[1] Some of the development programs now associated with Artemis were initiated under previous Administrations and in response to the NASA Authorization Act of 2010.
[2] https://www.nasa.gov/sites/default/files/atoms/files/artemis_plan-20200921.pdf

Artemis Elements

Many development programs and projects at NASA are associated with the Artemis initiative; most are managed within the Exploration Systems Development Mission Directorate (ESDMD),[3] though some activities are managed under the Space Technology Mission Directorate (STMD) or the Science Mission Directorate (SMD). Development projects and programs for core mission elements currently underway include:

Space Launch System (SLS): SLS is a two-stage, super heavy-lift rocket that will evolve over three configurations—Block 1, Block 1B, and Block 2—with incrementally increasing capacity. SLS is the only current capability that can carry the Orion crew vehicle to lunar orbit.

Orion Crew Vehicle: The Orion multipurpose crew vehicle is a spacecraft capable of supporting crew exploration in deep space for up to 21 days. For Artemis, Orion will carry the crew to lunar orbit and return them safely to Earth. The European Space Agency is providing the Orion service module, which will provide propulsion, air, water, and power to the crew module.

Exploration Ground Systems (EGS): EGS is a development and operations program for the systems and facilities that Kennedy Space Center (KSC) will use to process and launch modern and next-generation vehicles and spacecraft, including SLS and Orion. The EGS integrates the SLS and Orion systems in preparation for launch.

Human Landing System (HLS): The HLS will transport astronaut crew from lunar orbit—docking to either the Gateway or Orion—to the lunar surface, and back to lunar orbit.

Gateway: Gateway is a small, space-station-like-outpost orbiting the Moon that will provide a staging point for lunar expeditions and deep space exploration, as well as a platform for scientific research and technology demonstrations. The Gateway will involve international contributions including additional habitation, external robotics, and refueling capability. The first two modules of Gateway will be:

- **Power and Propulsion Element (PPE):** The PPE will provide initial power capability to the Gateway.
- **Habitation and Logistics Outpost (HALO):** The HALO will provide docking ports and basic habitation support infrastructure to supplement the Orion crew vehicle whenever it docks to the Gateway. HALO can also host and store cargo and logistics deliveries in support of crewed missions.

Spacesuits: Spacesuits are required for extravehicular activities, or EVAs (e.g., spacewalks) on the lunar surface, on Gateway, and on the International Space Station (ISS).

[3] In September 2021, NASA announced a reorganization of its Human Exploration and Operations Mission Directorate (HEOMD), into two mission directorates: Exploration Systems Development Mission Directorate (ESDMD) and Space Operations Mission Directorate (SOMD).

Commercial Lunar Payload Services (CLPS): NASA's CLPS program procures commercial services for delivery of small and medium NASA science and technology payloads to the lunar surface. The first three CLPS missions are all landers scheduled to launch in 2022. CLPS is managed by SMD, with some payloads provided by STMD and ESDMD.

Volatiles Investigating Polar Exploration Rover (VIPER): NASA's SMD is developing the VIPER robotic rover to investigate the presence and accessibility of water ice and other potential resources on the south pole of the Moon. VIPER is scheduled to be delivered to the Moon as a CLPS delivery in late 2023.

Artemis Missions

NASA designates missions of the combined deep space human exploration systems—to destinations including lunar orbit, the Gateway, and/or the lunar surface—as numerical Artemis missions. The first three, Artemis I, II, and III, are demonstration missions to prove out key capabilities.

Artemis I will be an uncrewed demonstration mission and the first fully integrated test of the SLS, Orion, and EGS systems. The mission will last approximately three weeks and Orion will orbit the Moon for six days before returning to Earth.[4] NASA's original baseline commitment for Artemis I was for a November 2018 launch date. As of February 2022, NASA was anticipating an Artemis I launch no earlier than May 2022.[5]

Artemis II will be the first crewed demonstration mission of the integrated SLS, Orion, and EGS systems, carrying up to four astronauts to orbit the Moon. NASA's original baseline commitment was to launch Artemis II in April 2023. As of November 2021, NASA is estimating that Artemis II will launch no later than May 2024.[6]

Artemis III will demonstrate a human lunar landing. SLS will launch a crew of four astronauts aboard Orion to rendezvous in lunar orbit with the HLS Starship. Two of the four crew will descend to the lunar surface, where they will stay for approximately one week. Crew activities on the lunar surface may include scientific experiments, technology demonstrations, and/or sample collection of lunar surface material.[7] As of November 2021, NASA is estimating that Artemis III will launch no earlier than 2025.[8]

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[4] NASA, "Around the Moon with NASA's First Launch of SLS with Orion." Available at: https://www.nasa.gov/feature/around-the-moon-with-nasa-s-first-launch-of-sls-with-orion

[5] Smith, Marcia, "Artemis I Still on Track for Major Test in March," SpacePolicyOnline, February 24, 2022. Available at: https://spacepolicyonline.com/news/artemis-i-still-on-track-for-major-test-in-march/

[6] One constraint on the Artemis II launch date is that NASA needs a minimum gap of twenty months between Artemis I and Artemis II to refurbish and reinstall reused components between the two missions.

[7] The "Artemis III Science Definition Team Report," issued in December 2020, describes candidate science programs and considerations for the mission. Available at: https://www.nasa.gov/sites/default/files/atoms/files/artemis-iii-science-definition-report-12042020c.pdf

[8] NASA, "NASA Outlines Challenges, Progress for Artemis Moon Missions," November 9, 2021. Available at: https://www.nasa.gov/press-release/nasa-outlines-challenges-progress-for-artemis-moon-missions

NASA has stated an intention to achieve a roughly annual cadence of one Artemis mission per year, starting in the late 2020s. Mission profiles for Artemis IV and beyond have not yet been released.

Artemis Budget

In September 2020, NASA estimated the direct costs associated with Artemis I-III and achieving the Artemis III human landing, from FY2021-FY2025, would be $27.9 billion.[9] The NASA Inspector General, in a report issued in November 2021,[10] found that, when accounting for all Artemis costs for FY2021-FY2025, including those related to Artemis IV and beyond and activities in the Science and Mission Support directorates, the initial $27.9 billion estimate would increase by $25 million. The OIG projected the total cost of Artemis, over the five-year period from FY2021 through FY2025 at $53 billion. The IG further found that NASA had already spent $40 billion on projects related to Artemis (such as SLS and Orion) previously, from FY2012 through FY2020, bringing the total estimated Artemis cost through FY2025 to $93 billion.

Key Issues Identified in Recent Reports, Reviews, and Audits

GAO: *NASA Lunar Programs* Report

In May 2021, the Government Accountability Office (GAO) issued a report reviewing NASA's lunar programs, which provided an assessment of NASA's progress, as well as challenges, with the Artemis lunar programs.[11]

GAO found that NASA's efforts to accomplish its Artemis missions contained significant risk in many areas. Programmatic and management challenges GAO identified include:

- NASA plans to complete development of human-rated space systems years faster than they have for similar systems in the past.
- There is difficulty determining the cost of each program and Artemis missions, because many of the systems required to execute Artemis missions are too early in development and before the point at which they are required to set cost and schedule baselines.
- NASA is not planning to develop a cost estimate for each Artemis mission individually.
- Projects and programs that will have to be integrated to support Artemis missions are split across NASA's mission directorates and divisions. While NASA established a systems engineering and integration office for Artemis missions within one mission directorate, this office is not fully responsible for work related to integrating systems across those directorates or divisions, nor does it appear to provide "true technical, production-level engineering integration."

[9] NASA, "Artemis Plan: Lunar Exploration Program Overview," September 2020. Available at: https://www.nasa.gov/sites/default/files/atoms/files/artemis_plan-20200921.pdf
[10] NASA OIG, "NASA's Management of the Artemis Missions," IG-22-003, November 15, 2021. Available at: https://oig.nasa.gov/docs/IG-22-003.pdf
[11] GAO, "NASA Lunar Programs: Significant Work Remains, Underscoring Challenges to Achieving Moon Landing in 2024," GAO-21-330, May 26, 2021. Available at: https://www.gao.gov/assets/gao-21-330.pdf

GAO also found significant technical risks for NASA's lunar programs, including:

- The Gateway program has seen multiple requirement changes, stemming from the decision to co-manifest the PPE and HALO on a single launch vehicle and eliminating the back-up solar electric propulsion technology that the program was planning to use.
- SpaceX, the selected HLS provider, included immature propulsion system technologies in its proposal despite NASA requesting that all providers propose only mature technologies.

Select GAO recommendations to the NASA Administrator include:

- Ensuring that the NASA Office of the Chief Engineer develop[s] guidance to mitigate risks associated with delaying the establishment of high-level requirements early in the acquisition process when using service-type contracts and incorporate the guidance in its reference guide or a similar document.
- Coordinating with the Associate Administrator for the Human Exploration and Operations Mission Directorate to ensure the Gateway program, in advance of the Power and Propulsion Element (PPE) project's confirmation review, assesses the solar electric propulsion thrusters' technical risks and determine whether off-ramps are needed or whether the project's schedule should be reassessed.
- Coordinating with the Associate Administrator for Human Exploration and Operations Mission Directorate to ensure the Advanced Exploration Systems Division documents the process used to determine the program and technical management practices and tools that it will apply to the Artemis III and later missions, in the absence of establishing a formal Artemis program.

Inspector General: NASA's Management of the Artemis Missions

In November 2021, NASA OIG released the report "NASA's Management of the Artemis Missions," assessing the schedule and costs of Artemis activities as well as NASA's acquisition and programmatic approaches to returning astronauts to the lunar surface.[12]

NASA OIG found that the first three Artemis missions are projected to be delayed months to years past NASA's goals, due to technical difficulties, COVID-19 impacts, and weather events:

- The uncrewed Artemis I mission will be ready to launch summer of 2022.
- The crewed Artemis II launch to orbit the Moon is projected to be delayed until at least mid-2024 due to the reuse of Orion components from Artemis I and addition of new Orion components.
- The Artemis III mission to land astronauts on the Moon is expected to exceed NASA timelines by "several years," due to the time needed to develop and test HLS and new spacesuits.

[12] NASA OIG, "NASA's Management of the Artemis Missions," IG-22-003, November 15, 2021. Available at: https://oig.nasa.gov/docs/IG-22-003.pdf

Select recommendations to NASA of the NASA OIG report include:

- Develop a realistic, risk-informed schedule that includes sufficient margin to better align Agency expectations with the development schedule.
- Develop an Artemis-wide cost estimate and update it on an annual basis.
- Maintain an accounting of per-mission costs and establish a benchmark against which NASA can assess the outcome of initiatives to increase the affordability of ESD systems.
- Develop a realistic funding profile and schedule given the underfunding of HLS in FY 2021, selection of one HLS award, and desire to compete a sustainability contract for future lunar missions.
- Codify the remaining governance structure for Artemis coordination, collaboration, and board processes, such as the Federated Boards and Joint Directorate Program Management Council.

As part of its Artemis work, NASA OIG also issued reports focusing on NASA's management of the Gateway Program[13] and spacesuit development.[14] On Gateway, the OIG report states that "the development schedules for both the PPE and HALO have been negatively impacted by the Agency's still-evolving Gateway requirements." In the report reviewing spacesuits, the OIG found that NASA's internal development of spacesuits was significantly behind schedule, and the suits would not be ready in time for a 2024 lunar landing.

Aerospace Safety Advisory Panel 2021 Annual Report

The Aerospace Safety Advisory Panel (ASAP) was established by Congress in 1968 to advise the NASA Administrator and Congress on matters of safety in NASA's programs, primarily human spaceflight programs.[15]

The recently released 2021 ASAP Annual Report[16] focuses on the strategic ways that NASA manages human space flight programs throughout the agency, because "the Panel believes that how NASA manages human space flight programs can have a significant impact on the risks associated with those programs." ASAP finds "an urgent need for NASA to strategically define its future role and articulate a vision and a set of guiding principles to direct its efforts." Concerns raised by ASAP include:

- NASA Centers are incentivized to "prioritize their own goals rather than those of the overall Agency."
- Establishing the Space Launch System (SLS), Orion Crew Vehicle, and Exploration Ground Systems (EGS) as individual programs, rather than managing them as an integrated program, "left a critical gap in the system-of-systems integration process that

[13] NASA OIG, "NASA's Management of the Gateway Program for Artemis Missions," IG-21-004, November 10, 2020. Available at: https://oig.nasa.gov/docs/IG-21-004.pdf
[14] NASA OIG, "NASA's Development of Next-Generation Spacesuits," IG-21-025, August 10, 2021. Available at: https://oig.nasa.gov/docs/IG-21-025.pdf
[15] P.L. 90-68, NASA Authorization Act of 1968. Available at: https://www.congress.gov/90/statute/STATUTE-81/STATUTE-81-Pg168.pdf
[16] ASAP, "Annual Report for 2021," January 11, 2022. Available at: https://oiir.hq.nasa.gov/asap/documents/2021_ASAP_Report-TAGGED.pdf

is usually filled by having a single overarching program umbrella with requisite program authorities and integration responsibilities."

- Unlike under Apollo, the Shuttle program, or the ISS program, "there is no similar unifying and comprehensively aligned program framework for the Artemis enterprise […] there is no clearly defined leader of the enterprise, transparently endowed with the ultimate authority, responsibility, and accountability to direct all Artemis-related programs and ensure full synchronization and integration of effort."

Specific to Artemis, the ASAP recommended:

- NASA should manage Artemis as an integrated program with top-down alignment, and designate a Program Manager endowed with authority, responsibility, and accountability, along with a robust bottom-up, collaborative feedback process for both systems engineering and integration (SE&I) and risk management.