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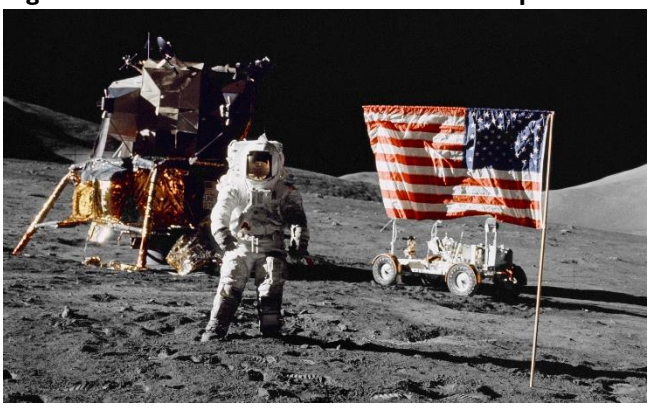
Artemis: NASA's Program to Return Humans to the Moon

Between 1969 and 1972, the Apollo program of the National Aeronautics and Space Administration (NASA) landed 12 American men on the Moon and returned them safely to Earth (see **Figure 1**). Since then, no human has been farther from Earth than low Earth orbit, a few hundred miles up; the distance to the Moon is about 240,000 miles. Artemis, named for Apollo's twin sister in ancient Greek mythology, is NASA's program for a return to the Moon by American astronauts—one of them a woman—in 2024.

Figure 1. The Last Human Lunar Mission: Apollo 17



Source: NASA, https://spaceflight.nasa.gov/gallery/images/apollo/apollo17/html/as17-134-20382.html.

Note: This image shows Apollo 17 astronaut Harrison Schmitt standing on the surface of the Moon on December 13, 1972. Behind him are the Lunar Module lander and the Lunar Roving Vehicle rover.

Orion and the Space Launch System

Artemis has evolved from plans initiated in the NASA Authorization Act of 2010 (P.L. 111-267). The act established a statutory goal of "expand[ing] permanent human presence beyond low-Earth orbit" and mandated the development of a crew capsule and a heavy-lift rocket to accomplish that goal. The capsule, now known as Orion, and the rocket, known as the Space Launch System (SLS), have been in development since then (see **Figure 2**).

Each Orion capsule consists of a crew module with room for four to six astronauts as well as storage space and a docking port; a service module (contributed by the European Space Agency) to provide power and propulsion; and a launch abort system. The crew module is the only portion intended to return to Earth at the end of a mission; it is designed to be reusable.

The SLS is an expendable rocket designed to carry Orion into space and set it on its initial trajectory. The SLS could also potentially be used for other missions involving heavy payloads or requiring very high thrust. It is designed to be upgraded in stages (known as Block 1, Block 1B, and Block 2) by substituting improved versions of its major elements. For example, for Block 1B, NASA is developing the Exploration Upper Stage to replace the Block 1 upper stage, which is known as the Interim Cryogenic Propulsion Stage.

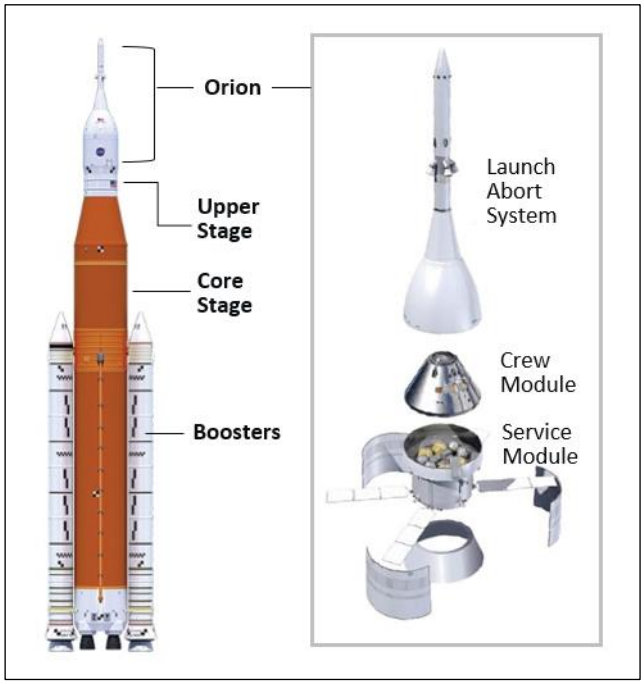
In December 2014, a partially complete Orion was launched on a Delta IV Heavy rocket and orbited Earth twice before splashing down in the Pacific Ocean. This uncrewed mission tested the crew module's heat shield and parachutes, as well as other systems.

The first flight of Orion on an SLS is expected in November 2021. During this mission, known as Artemis I, a complete but uncrewed Orion is to orbit the Moon before returning to Earth. The mission is intended to provide the data NASA needs to certify safety for crewed flights.

Artemis II, the first crewed test of Orion and the SLS, is expected in August 2023. During this 10-day mission, Orion and its crew of four are to fly around the Moon at an altitude of about 4,000 miles before returning to Earth.

The Artemis III mission, planned for 2024, is to include the first human Moon landing since 1972. Achieving that goal would require the development of other systems, such as a lunar lander. Detailed plans for Artemis III are not yet finalized.

Figure 2. Major Elements of SLS and Orion



Source: CRS illustration based on NASA diagrams at https://www.nasa.gov/exploration/systems/sls/overview.html and https://oig.nasa.gov/docs/IG-20-018.pdf.

Human Landing System

The Orion capsule is not designed to land on the Moon. Instead, for Artemis III and subsequent lunar surface missions, astronauts will need to transfer to a separate spacecraft, known as the Human Landing System (HLS), for lunar descent and ascent. In April 2020, NASA awarded fixed-price contracts for the first phase of HLS design and development to three companies: Blue Origin, Dynetics, and SpaceX. Not all companies will necessarily be selected for subsequent development and demonstration contracts.

Gateway

To facilitate Artemis lunar landings and other missions, NASA is developing a modular platform, known as Gateway, to be placed in a permanent orbit around the Moon. The first two Gateway modules—the Power and Propulsion Element (PPE) and the Habitation and Logistics Outpost (HALO, a pressurized habitat for astronauts)—are currently in development, with launch planned in 2023.

Gateway is intended to serve as a depot for storing supplies, a platform for science experiments, a location where subsystems launched separately can be assembled and integrated, and a rendezvous point where astronauts can transfer between Orion and the HLS and potentially, at some point in the future, depart for other, more distant destinations, such as Mars. NASA initially planned for Gateway to be the Orion-HLS transfer point for the Artemis III lunar landing in 2024. In March 2020, it announced that Gateway will no longer be essential for that mission, to ensure that any unexpected delays in Gateway development do not jeopardize the planned 2024 lunar landing. It did not immediately announce an alternative mission architecture.

Other Elements

In addition to Orion, SLS, HLS, and Gateway, NASA is planning robotic precursor missions to explore potential landing sites, as well as developing technologies for lunar surface power, in-situ use of lunar resources such as water, and other lunar surface systems such as rovers and habitats for missions after Artemis III. The detailed profiles of those future missions are not yet fully developed.

Issues for Congress

As Congress oversees the progress of the Artemis program and acts on NASA authorization and appropriations legislation, it may address issues such as the 2024 target date for the first landing, cost and schedule concerns, the relative exploration priority of the Moon versus Mars, and the role of the commercial space sector.

Why 2024?

As recently as early 2019, NASA was planning the first post-Apollo human lunar landing for 2028. The acceleration to 2024 was announced by Vice President Pence in March 2019. Supporters of the 2024 goal argue that it instils a sense of urgency, focus, and motivation, and that the U.S. space program is in competition with Russia and China. Opponents argue that the 2024 date is driven by political goals rather than by technical or scientific considerations.

As Congress considers the schedule for Artemis, it may examine what geopolitical or other benefits a 2024 landing might bring; how providing the funding needed to achieve a 2024 landing might affect the availability of funding for other NASA programs; how schedule pressure might influence safety decisions; and how design choices made to meet the 2024 deadline might affect system reusability for subsequent NASA human exploration missions.

Cost and Schedule

Even among congressional supporters of the Artemis program and the 2024 goal, concerns remain about cost and schedule. For example, in its report on FY2020 NASA appropriations, the Senate Appropriations Committee wrote: "While there is support for the mission, it is difficult to weigh the impacts of the accelerated mission on the overall budget of NASA" (S.Rept. 116-127). For FY2021, NASA requested a budget increase of $2.6 billion (about 12%); FY2021 appropriations have not yet been enacted, but the House-passed bill (H.R. 7617) would provide none of the requested increase. NASA notified Congress in August 2020 that cost growth in the development of SLS will exceed 30%, triggering a reauthorization requirement. In addition, repeated slips in the launch dates for Artemis I and II—September 2018 and August 2021 in the baseline plan; currently November 2021 and August 2023—have made some policymakers doubt the credibility of the 2024 schedule for Artemis III.

Moon or Mars?

Is returning to the Moon the primary goal for human exploration of space, or is it an interim step to gain experience for future expeditions to Mars? While this distinction is to some extent a matter of emphasis, the debate continues. For example, the NASA Authorization Act of 2020 (H.R. 5666) states that "the Nation's human space exploration goal should be to send humans to the surface of Mars," although "reducing the risk and demonstrating the capabilities and operations needed to support a human mission to Mars may require human exploration of the cis-lunar vicinity [i.e., the region around the Moon and between Earth and the Moon] and lunar surface." This debate may drive how Artemis missions are planned, e.g., whether lunar habitats are designed to be permanent and whether potential reuse for Mars missions is a major factor in technology choices for lunar missions.

Role of the Commercial Space Sector

In recent years, NASA has placed growing emphasis on procuring services from the commercial space industry. For example, where it used to use NASA-owned space shuttles to carry cargo and crews to the International Space Station, it now buys cargo transport (and soon, also crew transport) as a commercial service on commercially owned spacecraft.

Orion and the SLS are being developed as NASA-owned systems under the traditional model, but NASA intends the HLS to be commercially owned and lunar surface descent and ascent to be a commercial service. Not all policymakers support this approach. For example, H.R. 5666 would direct that the U.S. government should retain "full ownership of the human landing system."

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