COMMITTEE ON
SCIENCE, SPACE AND TECHNOLOGY
CHAIRMAN FRANK LUCAS

SPACE AND AERONAUTICS SUBCOMMITTEE

HEARING CHARTER

"Returning to the Moon: Keeping Artemis on Track"

Wednesday, January 17, 2024
10:00 AM
2318 Rayburn House Office Building

Purpose

The Artemis program is the National Aeronautics and Space Administration (NASA) effort to return United States astronauts to the lunar surface. The purpose of this hearing is to monitor progress on Artemis objectives, identify and understand challenges faced by NASA, and discuss the agency's path forward. This hearing also will provide the Committee with valuable insight on how NASA plans to ensure a successful American return to the Moon and enable future exploration of Mars and beyond.

Witnesses

- **Ms. Catherine Koerner,** Associate Administrator, Exploration Systems Development Mission Directorate, National Aeronautics and Space Administration
- **Mr. William Russell,** Director, Contracting and National Security Acquisitions, U.S. Government Accountability Office
- **Mr. George A. Scott,** Acting Inspector General, National Aeronautics and Space Administration
- **Dr. Michael D. Griffin,** Co-President, LogiQ, Inc

Overarching Questions

- What elements of the Artemis program are on the critical path to launching Artemis II and III? What is the status of these elements?
- NASA recently announced the delay of Artemis II and III from 2024 and 2025 respectively, to 2025 and 2026. What was the cause of this change in schedule? What is the anticipated impact of this delay on Artemis program costs?

- How has NASA adapted to mitigate future schedule and cost overruns?
- What are the most significant technical challenges NASA has faced so far? What impact have NASA management decisions had on program execution? How is NASA learning from these experiences to better execute the Artemis program moving forward?
- Among the existing risks and challenges to the Artemis program, which present the highest risks to program cost, schedule, and mission success?

Background

The Artemis program represents the next generation of United States human space exploration beyond Earth orbit. While the immediate goal of the program is to land humans on the lunar surface for the first time since the Apollo program, the Artemis program seeks to establish sustainable, long-term access to the Moon. Doing so will both advance exciting scientific research and serve as a proving ground for future human space missions to Mars and other deep space destinations.

Today's Artemis program is the result of almost two decades of evolution that started in 2004. President George W. Bush and then-Administrator Michael Griffin released a Vision for Space Exploration establishing goals for the United States space program and calling for a return to the Moon.[1] Congress incorporated the ambitious objectives of the Vision into the 2005 NASA Authorization, directing NASA to return to the moon by 2020 to promote exploration, science, and commerce, and also to serve as a stepping-stone to Mars and other deep space destinations.[2] Each phase of exploration (Earth orbit, the Moon, and ultimately Mars) would build on the experience and lessons learned from earlier missions. Constellation hardware included Ares launch vehicles, an Earth Departure Stage secondary booster, an Orion spacecraft, and an Altair lunar lander.

In 2009, President Obama ordered a review of the Constellation program and acting Administrator Christopher Scolese established the "Review of U.S. Human Spaceflight Plans Committee", commonly referred to as the Augustine Commission. The Commission found that "since Constellation's inception the program has faced a mismatch between funding and program content" and that the funding strategy for Constellation relied on NASA retiring the Space Shuttle by 2010 and decommissioning the ISS by 2016.[3] The Commission proposed five alternative approaches for human space exploration, only two of which aligned with the Obama Administration's FY2010 budget profile for Constellation. Neither option would "permit human exploration to continue in any meaningful way", and ultimately the Obama Administration's FY2011 budget proposed cancellation of the Constellation program, shifting instead to an approach that would land humans on the surface of an asteroid.[4] While many elements of the Constellation program were abandoned, Congress directed NASA to develop a Space Launch System using "existing vehicle development and associated contracts" (*i.e.,* efforts formerly dedicated to the development of the Ares launch vehicle) and the Orion spacecraft.[5]

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[1] https://georgewbush-whitehouse.archives.gov/news/releases/2004/01/20040114-3.html
[2] https://www.congress.gov/bill/109th-congress/senate-bill/1281
[3] https://www.nasa.gov/wp-content/uploads/2015/01/617036main_396093main_HSF_Cmte_FinalReport.pdf
[4] https://www.sciencedirect.com/science/article/pii/S0265964610001189
[5] https://www.congress.gov/bill/111th-congress/senate-bill/3729/text

In 2017, Congress reiterated its continued support for the stepping-stone approach in the NASA Transition Authorization Act.[6] The Trump Administration was aligned on this position and issued Space Policy Directive-1 (SPD-1) directing NASA to "lead the return of humans to the Moon for long-term exploration and utilization."[7] This time, however, NASA would not go alone; per SPD-1, the revived effort would involve a team of commercial and international partners.

In September of 2018, NASA issued its National Space Exploration Campaign Report describing NASA's efforts to plan a human lunar landing in the late 2020s.[8] This objective was confirmed six months later in NASA's FY2020 budget request, which announced NASA's intent to return humans to the Moon by 2028. Vice President Michael Pence further accelerated this deadline, directing NASA to land humans on the south pole of the Moon by 2024. NASA's FY2021 budget request reflected both the Artemis program and the 2024 landing date set by the Vice President. NASA also published its Lunar Exploration Program Overview in 2020, which provided an overview of the agency's planned lunar exploration activities.[9]

The Biden Administration has continued progress on the Artemis program's return to the Moon.[10] In 2022, Congress also required that NASA establish a new Moon to Mars Program Office within ESDMD, charged with ensuring that Artemis missions fit within the human exploration roadmap and facilitate a human mission to Mars.[11]

Artemis Elements

Artemis-related activities can be found in multiple NASA mission directorates. The primary branch responsible for Artemis elements is the Exploration System Development Mission Directorate (ESDMD), but the Space Technology Mission Directorate (STMD) and the Science Mission Directorate (SMD) also play key roles. The major elements of the Artemis program are set forth below.

Space Launch System (SLS): SLS is a two-stage, super heavy-lift launch vehicle operated at the Kennedy Space Center. Derived from the Constellation program's canceled Ares V launch vehicle, SLS uses RS-25 engines and solid rocket boosters adapted from the Shuttle program. NASA plans for three different SLS configurations:

- Block 1 (which includes a core stage, Interim Cryogenic Propulsion Stage (ICPS), and solid rocket boosters).
- Block 1B (which retains the core stage and solid rocket boosters, but replaces the ICPS with the Exploration Upper Stage (EUS)).
- Block 2 (retains the core stage and the EUS, but replaces the solid rocket boosters with an upgraded model).

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[6] https://www.congress.gov/bill/115th-congress/senate-bill/442/text
[7] https://www.govinfo.gov/content/pkg/FR-2017-12-14/pdf/2017-27160.pdf
[8] https://www.nasa.gov/wp-content/uploads/2015/01/nationalspaceexplorationcampaign.pdf
[9] https://www.nasa.gov/wp-content/uploads/2020/12/artemis_plan-20200921.pdf
[10] https://www.space.com/biden-administration-commits-to-artemis-moon-landings
[11] https://www.congress.gov/bill/117th-congress/house-bill/4346

Each configuration will result in greater SLS lift capacity, with the Block 2 capable of lifting 130 metric tons to Low Earth Orbit.

Orion Spacecraft (Orion): The Orion multipurpose spacecraft is a crew vehicle designed to carry astronauts between Earth and deep space. Orion can sustain a crew for up to 21 days of space exploration. For Artemis missions, Orion will carry crew from Earth to lunar orbit, and then from lunar orbit back to Earth (transport to the lunar surface and back will be provided by the Human Landing System discussed below). Orion consists of three main components: a crew module, a service module, and a launch abort system.

Exploration Ground Systems (EGS): EGS manages the development and operation of Kennedy Space Center systems and facilities that support modern and next generation launch vehicles and spacecraft. For Artemis, EGS is responsible for the capabilities used to assemble, launch, and recover SLS and Orion, which includes integration of the SLS and Orion systems in preparation for launch.

Gateway: Gateway is a small, multi-purpose space station that will be placed in lunar orbit to serve as both a staging point for lunar expeditions and deep space exploration, as well as a platform for scientific research and technology demonstrations. NASA intends for Gateway to be an international effort, and anticipates partners providing additional habitation modules, external robotics, refueling capabilities and other contributions. The first four elements of Gateway are as follows:

- **Power and Propulsion Element (PPE):** PPE will provide power, thrust, and communications capabilities for Gateway.
- **Habitation and Logistics Outpost (HALO):** HALO provides basic habitation support infrastructure for Gateway, as well as additional docking ports for Orion and other spacecraft. HALO also can store cargo and other logistics deliveries that will support crewed missions.
- **International Habitat (I-Hab):** Like HALO, the I-Hab will provide additional spacecraft docking parts and living quarters for visiting astronauts. The I-Hab will be supplied by the European Space Agency (ESA).
- **ESPRIT Refueling Module (ERM):** ERM, also developed by ESA, will supply Gateway's propulsion system with fuel and also will provide additional storage space for cargo.

Human Landing System (HLS): HLS will dock either with Gateway or Orion and will transport astronauts from lunar orbit to the surface of the Moon and back to lunar orbit. NASA awarded contracts to build landing systems to two United States commercial providers. SpaceX, selected in 2021, will develop an HLS based on its Starship spacecraft that will be used for Artemis III and IV.[12] Following direction from Congress, NASA opened another HLS solicitation[13] and picked Blue Origin as a secondary HLS provider in 2023.[14]

[12] https://www.nasa.gov/humans-in-space/nextstep-h-human-landing-system/
[13] https://www.nasa.gov/news-release/nasa-provides-update-to-astronaut-moon-lander-plans-under-artemis/
[14] https://www.nasa.gov/news-release/nasa-selects-blue-origin-as-second-artemis-lunar-lander-provider/

Space Suits: NASA requires new spacesuits that are suitable for deep space environments, including the lunar surface. While NASA initially planned to produce the suits internally, the agency shifted its acquisition approach and instead opted for a commercial procurement.[15] In June of 2022, NASA awarded contracts to Axiom Space and Collins Aerospace to produce new suits via the Exploration Extravehicular Activity Services (xEVAS) program.[16]

Artemis Missions

The Artemis missions use the elements described above to access deep space destinations, including lunar orbit, Gateway, and/or the lunar surface. Each Artemis mission is distinguished by a different number.

Artemis I launched from the Kennedy Space Center on November 16, 2022. This mission originally was scheduled to launch in November of 2018, but experienced years of delays caused by SLS and Orion manufacturing complications, technical issues (including hydrogen leaks found during SLS wet dress rehearsals), and other programmatic challenges.[17]

The mission was an uncrewed demonstration mission and the first test of the fully integrated SLS, Orion, and EGS systems. During the 25-day mission, NASA tested the Orion spacecraft by performing two lunar flybys before returning to Earth on December 11, 2022. Upon return, NASA conducted post-flight analysis indicating that the mission was successful and many systems performed better than expected.[18]

Artemis II will be the first crewed demonstration mission of the integrated SLS, Orion, and EGS systems. Over the course of ten days, astronauts onboard Orion will confirm that all spacecraft systems operate as designed and test performance of the crewed spacecraft in deep space. The Artemis II crew includes three NASA astronauts (Reid Wiseman, Victor Glover, and Christina Koch) as well as an astronaut from the Canadian Space Agency (Jeremy Hansen). NASA's original baseline commitment was to launch Artemis II in April 2023. NASA now estimates Artemis II will launch in September of 2025.

Artemis III will be a crewed lunar landing demonstration mission. After launch, the crew's Orion spacecraft will travel to lunar orbit where it will rendezvous with SpaceX's Starship HLS. Once docked, two astronauts will board the Starship HLS, which will disconnect from Orion and descend to the lunar surface. Astronauts will spend approximately one week on the Moon, performing a range of tasks including scientific experiments and technology demonstrations. The Starship HLS will then transport the two astronauts back to lunar orbit to join their colleagues on Orion for return to Earth. NASA estimates that Artemis III will launch in September of 2026.

Artemis IV will be the first Artemis mission to utilize the SLS Block 1B configuration, which includes the EUS. Astronauts will travel onboard the Orion to lunar orbit, where they will deliver

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[15] https://www.gao.gov/products/gao-22-105533
[16] https://www.space.com/nasa-selects-companies-build-spacesuits-moon-space-station
[17] https://www.smithsonianmag.com/science-nature/what-you-need-to-know-about-nasas-artemis-i-launch-180980654/
[18] https://www.nasa.gov/humans-in-space/analysis-confirms-successful-artemis-i-moon-mission-reviews-continue-2/

the I-Hab module to the Gateway. Then, two astronauts will board a Starship HLS and descend to the lunar service for a week of tasks, including collection of samples to bring back to Earth.

Artemis V, also using an SLS Block 1B, will deliver crew to lunar orbit and the ESPRIT module to Gateway. Two astronauts will again travel to the lunar surface to collect additional samples for return to Earth.

By the end of the 2020s, NASA intends to establish an SLS launch cadence of roughly one mission per year. NASA already is working to establish long-lead contracts to achieve this goal. For example, NASA has awarded a contract for the SLS solid rocket boosters that extends through Artemis XII.[19]

Key Issues

The Artemis program has already seen both cost and schedule growth from its established baseline commitments. Despite forward progress on Artemis program initiatives, there are a number of risks that NASA must mitigate moving forward. Establishing an improved understanding of project cost and schedule, finalizing design and technical requirements, and resolving contract and personnel management concerns will all be important matters to consider moving forward. Artemis also faces difficulties stemming from the maturity of technologies critical to future missions. Below is a summary of key issues identified in recent reports, reviews, and audits of the Artemis program.

Government Accountability Office (GAO)

NASA Artemis Programs: Crewed Moon Landing Faces Multiple Challenges

GAO released a November 2023 report evaluating NASA's plan to complete a lunar landing on the Artemis III mission.[20] The report highlighted multiple challenges, including delays in the development of the lunar lander and spacesuits needed for the mission. The report concluded that a variety of factors, particularly the readiness of HLS, made a 2025 lunar landing unlikely. The challenges GAO identified include:

- An overly ambitious development schedule for the HLS program: GAO estimated that NASA's launch date was 13 months too short when compared to NASA's usual rate of production. If HLS development follows the average speed for major NASA projects, GAO estimated that HLS would not be ready for launch until early 2027.
- Delays in critical milestones: GAO found that 8 of 13 key events for the HLS program had been delayed by at least 6 months. SpaceX attempted a Starship Orbital Test Flight in April of 2023, but the flight was terminated early by the FTS system. Many subsequent tests are contingent on a successful Orbital Flight Test, causing strain on the already-compressed development timeline.
- Multiple novel and complex technical capabilities critical to the HLS design have yet to be matured: SpaceX must complete a large volume of complex technical work for HLS, especially in the areas of on-orbit propellant transfer and storage.

[19] NASA's Artemis Moon Missions: all you need to know (rmg.co.uk)
[20] https://www.gao.gov/products/gao-24-106256

NASA Lunar Programs: Improved Mission Guidance Needed as Artemis Complexity Grows

GAO released a September 2022 report assessing NASA's mission-level management for the Artemis program, including its development of mission schedules and mission-level reviews.[21] The report identified the following concerns:

- NASA lacks "agency-wide, mission-level schedule management guidance to inform realistic integration schedules and launch dates for Artemis missions." NASA instead adapts guidance that was developed for program-level schedule management rather than mission-level.
- NASA has yet to conduct a Schedule Risk Analysis (SRA) for Artemis II.
- NASA has not developed a mission-level schedule for Artemis III.
- While NASA conducts workforce planning, it does not perform any advance workforce planning beyond five budget years. NASA already has committed billions of dollars for Artemis contracts that extend well beyond this five-year window. NASA risks facing a shortage of skilled laborers needed for future Artemis activities.

GAO recommended that NASA:

- Direct the NASA Chief Financial Officer to coordinate with mission directorates for development of mission-level schedule management guidance for Artemis.
- Conduct a schedule risk analysis for the Artemis II mission and update it as needed to incorporate schedule updates and new risks.
- Develop guidance for division-level schedule collaboration on Artemis III and subsequent missions.
- Ensure that the NASA Office of the Chief Human Capital Officer develops guidance identifying a regular and recurring process for long-term Artemis workforce scenario planning at least 5 years beyond the existing 5-year workforce plans.

Other Reports

GAO has released several reports regarding the Artemis program. In an analysis of SLS cost transparency, GAO stated:

> "NASA does not plan to measure production costs to monitor the affordability of the SLS program. After SLS's first launch, Artemis I in November 2022, NASA plans to spend billions of dollars to continue producing multiple SLS components, such as core stages and rocket engines, needed for future Artemis missions. These ongoing production costs to support the SLS program for Artemis missions are not captured in a cost baseline, which limits transparency and efforts to monitor the program's long-term affordability."[22]

When reviewing programmatic challenges of Artemis I through III, GAO noted that, due to the sequential links between each of the first three missions, delays to one mission will have cascading

[21] https://www.gao.gov/products/gao-22-105323
[22] https://www.gao.gov/products/gao-23-105609

cost and schedule impacts for the other missions.[23] Further, the minimum time required between Artimis I and II, and Artemis II and III limits NASA's ability to mitigate the effects of these delays. GAO also highlighted a noticeable lack of cost and schedule baselines for many Artemis projects, which creates challenges in assessing the progress and affordability of the program. For example, Orion does not have a cost and schedule baseline past Artemis II.

NASA Inspector General

NASA's Management of the Artemis Supply Chain

NASA OIG issued a report in October of reviewing NASA's management of the Artemis supply chain and analyzing problems.[24] NASA IG noted that, while many of the challenges it identified were outside of NASA's control, "the Agency lacks visibility into its critical suppliers with many Artemis programs and projects not tracking their prime contractors' supply chain impacts." Additionally, the IG found that Artemis programs and projects were not taking advantage of NASA's Logistics Management Division (LMD) when addressing supply chain issues. More generally, the report noted that NASA's project management practices fell short of other government agencies conducting major projects. It also concluded that NASA's efforts to improve supply chain visibility thus far have been ineffective.

The NASA IG provided many recommendations for NASA, including suggestions that NASA:

- Provide training and resources to ensure that contracting officers utilize available supplier data.
- Centralize supply chain management for the Artemis campaign within the Moon to Mars Program Office.
- Incorporate a representative from LMD into each Artemis-related program.
- Ensure an Artemis-specific industrial base and supply chain study is completed on a recurring basis.

NASA's Partnerships with International Space Agencies for the Artemis Campaign

In January of 2023, NASA OIG issued a report assessing NASA's plans for international cooperation and identifying impediments to execution of international partnerships.[25] The report found:

- NASA lacks a comprehensive, overarching strategy to coordinate international contributions for the Artemis program.
- NASA lacks comprehensive forums (e.g., boards, panels, and working groups) to facilitate Artemis-related discussions with international partners.
- U.S. export control regulations present an obstacle, as such regulations "can be overly complex and restrictive, and their implementation in international agreements, policies, and how space flight systems are classified routinely limit NASA's international

[23] https://www.gao.gov/products/gao-22-105533
[24] https://oig.nasa.gov/docs/IG-24-003.pdf
[25] https://oig.nasa.gov/docs/IG-23-004.pdf

collaborations on Artemis." Further, "the Artemis campaign lacks a unique EAR classification of specific space flight items or consistent jurisdiction and classification of Artemis elements, such as the Orion spacecraft, that would simplify the timely exchange of space flight items and technical information with international partners."

Select recommendations from the report suggest that NASA leadership:

- Establish NASA-led Artemis campaign boards and working groups for partners with agreed-upon commitments and provide opportunities for liaison representation from international partner agencies.
- Perform a detailed gap analysis and cost estimate for Artemis missions beyond Artemis IV that will help inform a cost-sharing strategy with international partners.
- Review export control requirements and consider additional roles for partner astronauts to increase their utilization in NASA space flight operations.
- Execute Artemis agreements with key international space agency partners to ensure partner roles and responsibilities are clearly understood and allow for efficient and timely partnerships in support of Artemis.

NASA's Management of the Space Launch System Booster and Engine Contracts

Issued in May of 2023, this NASA OIG report explored performance of the Boosters and Adaptation contracts and reviewed the impact of Booster Production and Operations Contract (BPOC) and R-25 Restart and Production efforts to improve Artemis program cost management.[26] The IG found the following:

- NASA continues to face substantial cost growth, and schedule delays in the Artemis program that could impact technology design. Despite this, NASA concurrently is developing and producing engines and boosters. This conflicts with the established best practice of completing development before moving to production.
- Marshall Space Flight Center (MSFC) procurement officials charged with overseeing all four Artemis program contracts "are challenged by inadequate staff, their lack of experience, and limited opportunities to review contract documentation."
- NASA opted to use cost-plus contracts for projects where fixed-price contracts could potentially have reduced costs, including for added production engines under the RS-25 Restart and Production contract and acquisition of long-lead materials under the BPOC letter contract.

Select recommendations from the report suggest that NASA leadership:

- Assess whether the 18 new production engines under the RS-25 Restart and Production contract can be acquired through a fixed-price contract.
- Identify procurement needs and resources available to address MSFC staff shortages, and ensure that MSFC officials comply with best practices for establishing and maintaining

[26] https://oig.nasa.gov/docs/IG-23-015.pdf

internal controls related to requests for equitable adjustment of award fee payments, fiscal law, and appropriate internal and external engagement.

- Update the cost-per-engine estimate for RS-25 engines to include investments made in production restart.
- Develop a separate non-fee bearing contract line item for completion of the unfinished adaptation of heritage RS-25 engines.

Figures

The following figures provide additional information on the Artemis program, including budget estimates, program elements, and mission profiles.

Budget Charts

Artemis Campaign Development

Budget Authority (in $ millions)	Op Plan FY 2022	Enacted FY 2023	Request FY 2024	FY 2025	FY 2026	FY 2027	FY 2028
Gateway	742.5	--	**914.2**	853.0	744.2	768.8	777.3
Adv Cislunar and Surface Capabilities	70.1	--	**60.3**	102.0	433.0	563.8	969.9
Human Landing System	1,195.0	1,485.6	**1,880.5**	2,224.7	2,286.7	2,748.3	2,526.6
xEVA and Human Surface Mobility Program	0.0	275.9	**379.9**	494.8	605.0	605.3	605.7
Total Budget	**2,007.6**	**2,600.3**	**3,234.8**	**3,674.4**	**4,068.9**	**4,686.2**	**4,879.6**

Figure 1: NASA budget request for Artemis Campaign Development for FY2024 to FY2028 (source: NASA FY2024 budget request)

Artemis Program Components

Budget Authority (in $ millions)	Op Plan FY 2022	Enacted FY 2023	Request FY 2024	FY 2025	FY 2026	FY 2027	FY 2028
Orion Program	1,401.7	1,338.7	**1,225.0**	1,093.7	1,093.7	1,094.2	1,115.1
Crew Vehicle Development	1,388.8	1,320.3	**1,212.6**	1,058.7	1,058.7	1,058.5	1,062.5
Orion Program Integration and Support	12.9	--	**12.5**	34.9	35.0	35.7	52.7
Space Launch System	2,600.0	2,600.0	**2,506.1**	2,483.3	2,322.4	1,917.1	1,969.1
Launch Vehicle Development	2,526.9	2,361.4	**2,427.2**	2,365.8	2,206.7	1,804.6	1,798.8
SLS Program Integration and Support	73.1	--	**78.9**	117.5	115.7	112.5	170.3
Exploration Ground Systems	589.0	799.2	**794.2**	664.7	593.2	546.0	445.5
Exploration Ground Systems Development	398.1	330.6	**273.2**	143.5	81.8	15.6	0.0
EGS Program Integration and Support	190.9	--	**521.0**	521.2	511.4	530.4	445.5
Construction & Envrmtl Compl Restoration	90.3	--	**10.5**	0.0	0.0	0.0	0.0
Exploration CoF	90.3	--	**10.5**	0.0	0.0	0.0	0.0
Total Budget	**4,681.0**	**4,824.1**	**4,535.9**	**4,241.7**	**4,009.3**	**3,557.3**	**3,529.7**

Figure 2: NASA budget request for Orion, SLS, and EGS for FY2024 to FY2028 (source: NASA FY2024 budget request)

Budget Authority (in $ millions)	Op Plan FY 2022	Enacted FY 2023	Request FY 2024	FY 2025	FY 2026	FY 2027	FY 2028
Total Budget	**0.0**	**--**	**49.1**	**50.0**	**50.5**	**51.0**	**51.1**

Figure 3: NASA budget request for Moon to Mars Architecture for FY2024 to FY2028 (source: NASA FY2024 budget request)

Budget Authority (in $ millions)	Op Plan FY 2022	Enacted FY 2023	Request FY 2024	FY 2025	FY 2026	FY 2027	FY 2028
Total Budget	**187.4**	**--**	**161.8**	**164.4**	**164.4**	**164.5**	**167.8**

Figure 4: NASA budget request for Mars Campaign Development for FY2024 to FY2028 (source: NASA FY2024 budget request)

Artemis Operational Costs

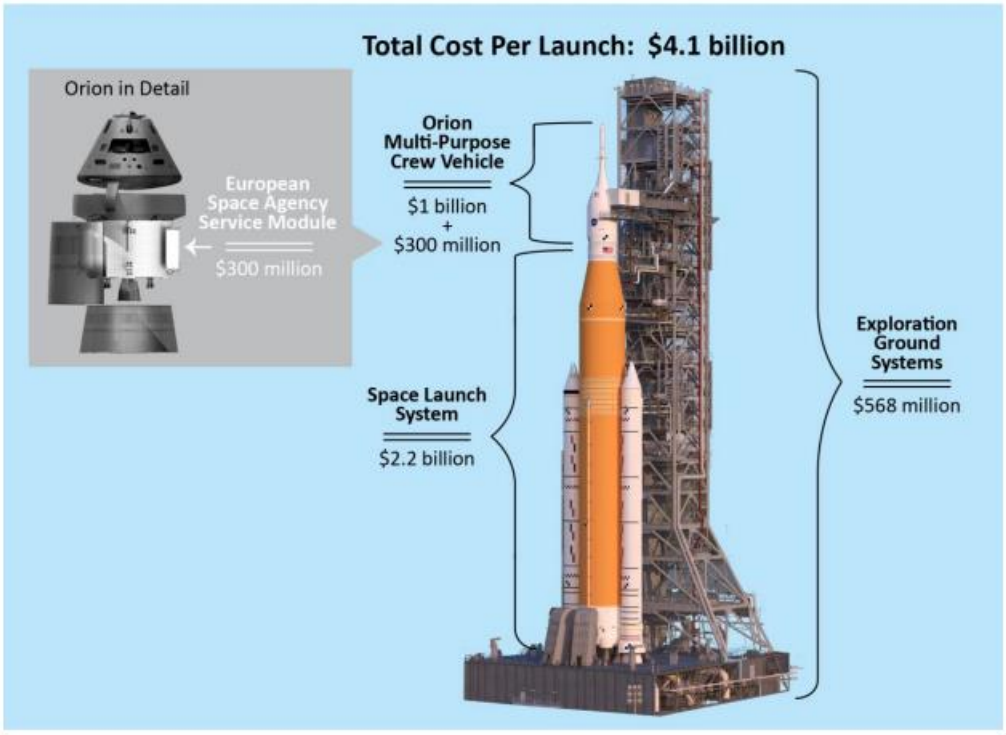


Figure 5: NASA estimate of SLS and Orion Operating Costs Per Launch (Source: NASA OIG)

Artemis Schedule

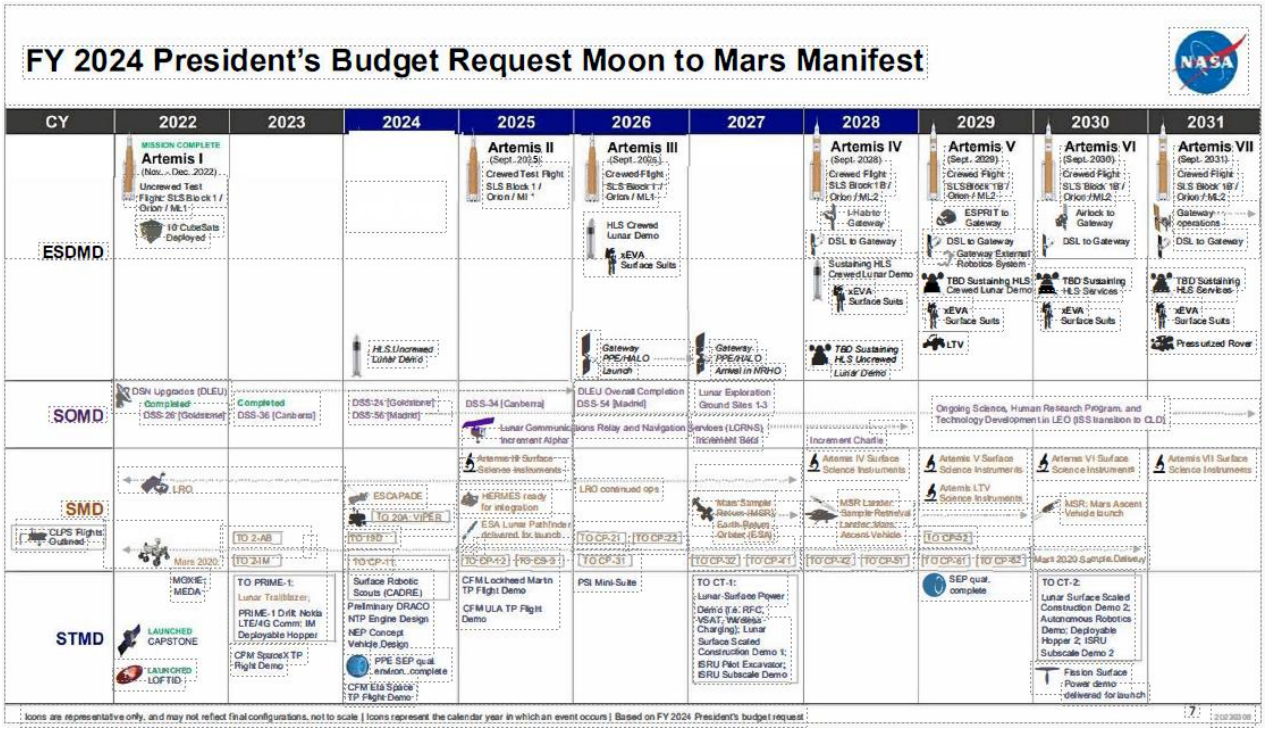


Figure 6: NASA schedule for Artemis and associated missions (Source: NASA)

Artemis Architecture

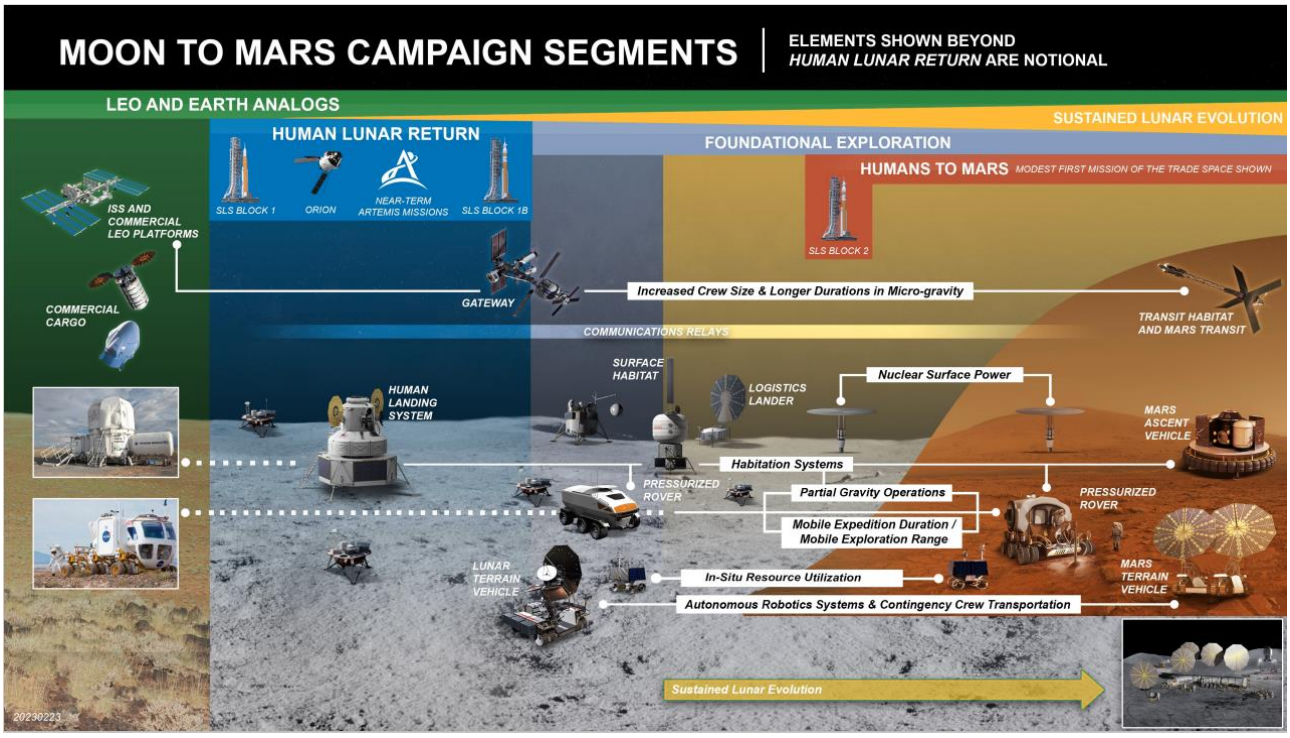
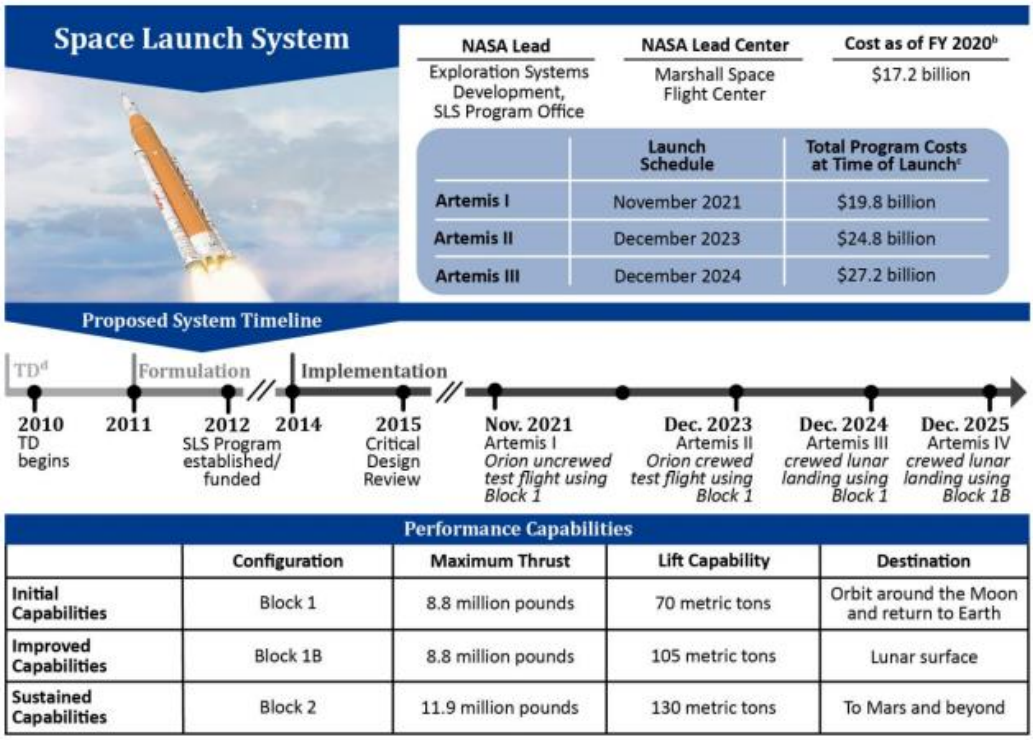


Figure 6: NASA Architecture for human deep space exploration (Source: NASA)

Artemis Components



Space Launch System

NASA Lead	NASA Lead Center	Cost as of FY 2020[b]
Exploration Systems Development, SLS Program Office	Marshall Space Flight Center	$17.2 billion

	Launch Schedule	Total Program Costs at Time of Launch[c]
Artemis I	November 2021	$19.8 billion
Artemis II	December 2023	$24.8 billion
Artemis III	December 2024	$27.2 billion

Proposed System Timeline

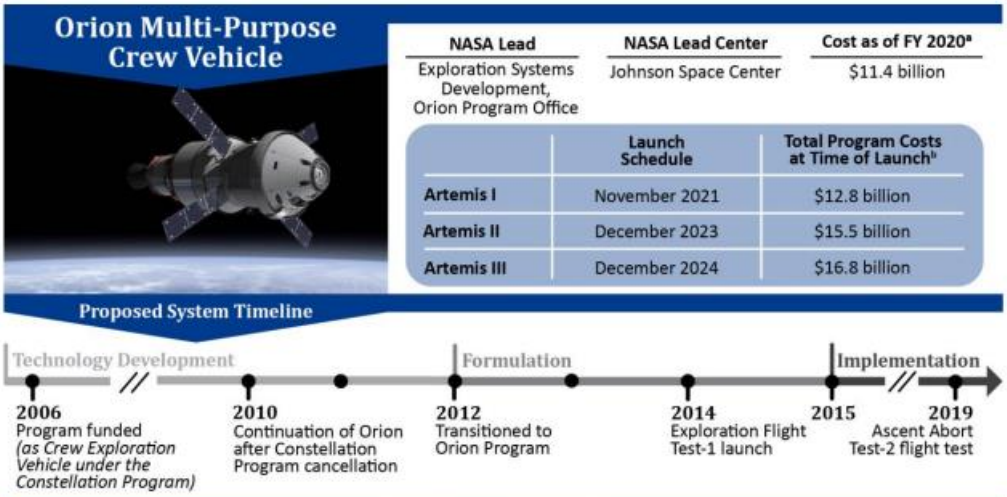
TD[d] | Formulation | Implementation

- **2010** TD begins
- **2011**
- **2012** SLS Program established/ funded
- **2014**
- **2015** Critical Design Review
- **Nov. 2021** Artemis I *Orion uncrewed test flight using Block 1*
- **Dec. 2023** Artemis II *Orion crewed test flight using Block 1*
- **Dec. 2024** Artemis III *crewed lunar landing using Block 1*
- **Dec. 2025** Artemis IV *crewed lunar landing using Block 1B*

Performance Capabilities

	Configuration	Maximum Thrust	Lift Capability	Destination
Initial Capabilities	Block 1	8.8 million pounds	70 metric tons	Orbit around the Moon and return to Earth
Improved Capabilities	Block 1B	8.8 million pounds	105 metric tons	Lunar surface
Sustained Capabilities	Block 2	11.9 million pounds	130 metric tons	To Mars and beyond

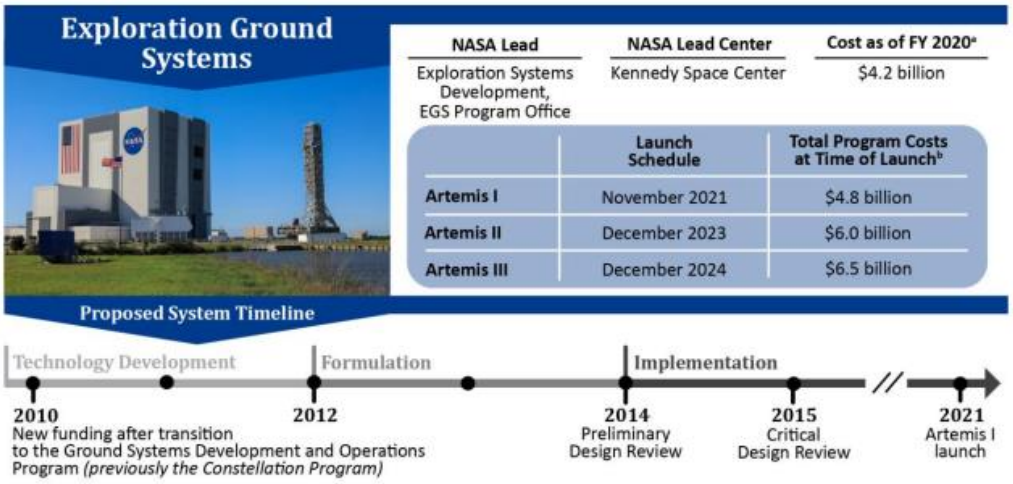
Figure 6: SLS overview and development plan (Source: NASA OIG)



Performance Capabilities

	Number of Crew	Mission Duration	Habitable Volume	Docking Capability	Abort Capability	Life Support	Return Entry Velocity
Initial Capabilities *(Artemis I)*	0	21 to 42 days	316 cubic feet	None	Limited	Limited	+36,000 feet per second
Sustained Capabilities *(Artemis III and beyond)*	4	21 days	316 cubic feet	Gateway or Human Landing System	Full	Full	+36,000 feet per second

Figure 7: Orion overview and development plan (Source: NASA OIG)



Performance Capabilities

	Launch Readiness Date	Mission	Type of Rocket/System	Launch Capacity
Initial Capabilities *(Mobile Launcher 1)*	November 2021	Artemis I, II, and III	SLS Block 1 configuration and Orion	Up to two per year
Sustained Capabilities *(Mobile Launcher 2)*	December 2025	Artemis IV and beyond	SLS Block 1B and 2 configuration and Orion	Up to two per year

Figure 8: EGS overview and development plan (Source: NASA OIG)

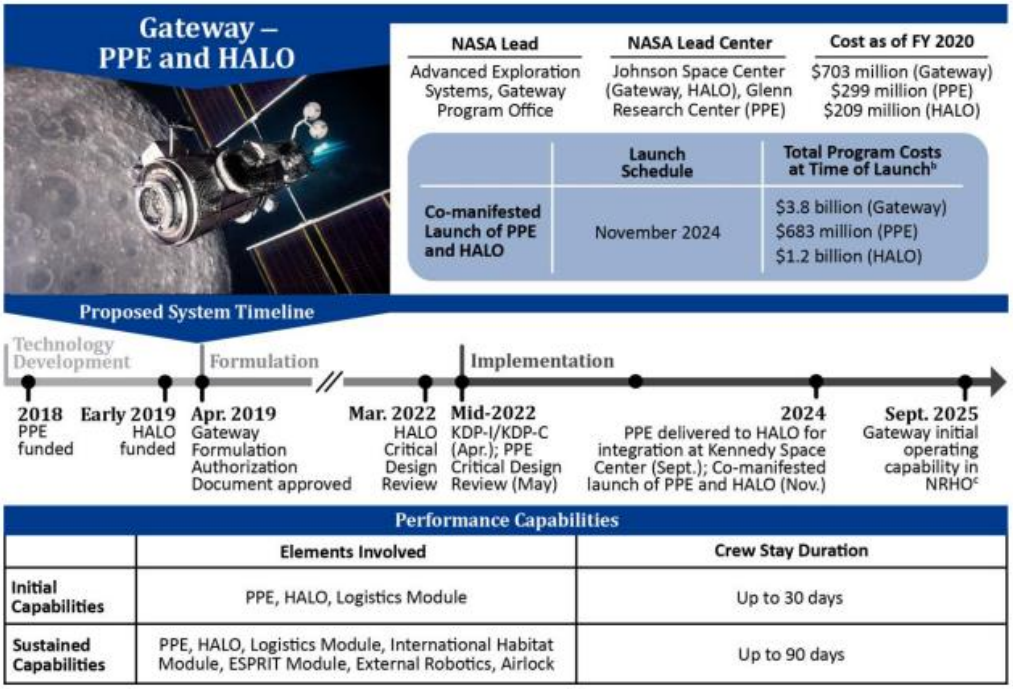


Figure 9: Gateway overview and development plan (Source: NASA OIG)

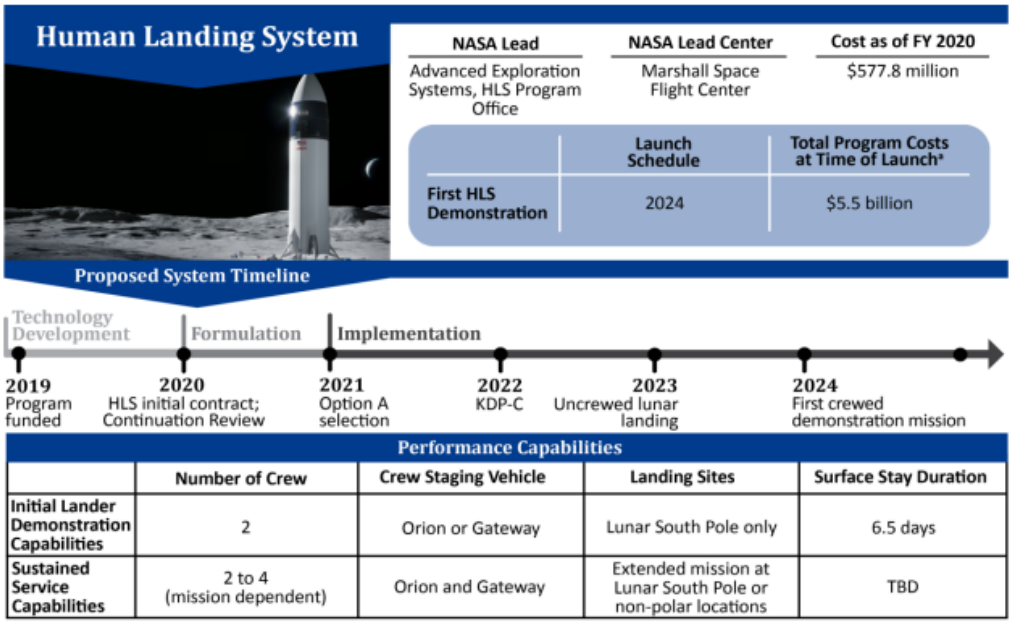


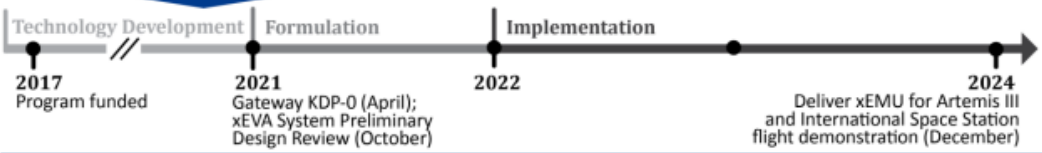
Figure 10: HLS overview and development plan (Source: NASA OIG)

Spacesuits

NASA Lead	NASA Lead Center	Costs between FYs 2016-2020
Advanced Exploration Systems, Gateway Program Office	Johnson Space Center	$197.2 million

	Launch Schedule	Total Program Costs at Time of Launch[a]
Artemis III	December 2024	$794 million

Proposed System Timeline



Performance Capabilities

	Flight Hardware	Suited Training Event *(supports NASA's training of crew on systems and development of EVA task content)*	Number of EVAs
Initial Capabilities *(ISS EVA Demonstration)*	Hardware for 4 crewmembers	60 events	TBD
Sustained Capabilities *(ISS EVA Service)*	Hardware for 10 crewmembers	80 events per mission plus 5 events per EVA	10 per year
Initial Capabilities *(Artemis EVA Demonstration)*	Hardware for 4 crewmembers	160 events	5 per mission
Sustained Capabilities *(Artemis EVA Service)*	Hardware for 4 to 8 crewmembers	160 events	5 per mission

Figure 11: Spacesuits overview and development plan (Source: NASA OIG)