



NASA ARTEMIS MISSIONS

Exploration Ground Systems Program Could Strengthen Schedule Decisions

Report to Congressional Committees

October 2024

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Accessible Version

GAO Highlights

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Highlights of [GAO-25-106943](#), a report to congressional committees

NASA Artemis Missions

Exploration Ground Systems Program Could Strengthen Schedule Decisions

Why GAO Did This Study

NASA plans to return astronauts to the moon to make new scientific discoveries, generate economic benefits, and inspire a new generation. NASA is planning to spend billions of dollars on the Artemis missions. This includes over \$3 billion specifically for EGS from fiscal years 2024 through 2028. The EGS program was a key contributor during the launch of Artemis I in November 2022. The program will support crewed Artemis launches in upcoming years. Since Artemis I, EGS continues to improve facilities and develop capabilities for future Artemis missions, such as the ML2, which will play a critical role for the Artemis IV launch.

A House report includes a provision for GAO to review NASA's human exploration programs, including EGS. GAO's report (1) evaluates the extent to which the EGS program has made progress toward upcoming Artemis missions, including on the ML2, and (2) assesses the extent to which NASA has established plans to measure EGS program costs. To do this work, GAO analyzed program documentation and cost data, conducted a site visit to Kennedy Space Center where EGS is located, and interviewed NASA, EGS, and ML2 officials and contractor representatives.

What GAO Recommends

GAO recommends that the EGS program and the ML2 project conduct at least one schedule risk analysis prior to beginning integration for Artemis IV. NASA partially concurred with this recommendation, which GAO maintains remains valid.

What GAO Found

The National Aeronautics and Space Administration (NASA) plans to build a sustained human lunar presence through a series of missions known as Artemis. The Exploration Ground Systems (EGS) program develops and operates the systems and facilities necessary to integrate and launch rockets and spacecraft and then recover crew for the Artemis missions.

Key Exploration Ground Systems Activities for Artemis Missions



Source: GAO presentation of NASA images. | GAO-25-106943

The program has made progress, but the Artemis schedule poses challenges.

- **Artemis II and III** launches (planned for September 2025 and 2026, respectively): EGS is making progress refurbishing the Mobile Launcher 1—the structure used to transport and launch key systems—and modifying elements to support crew during these missions. New capabilities are taking longer than planned, and the program has only limited time to address potential issues.
- **Artemis IV** launch (planned for September 2028): EGS has made some progress toward this mission, such as modifying facilities to accommodate processing and launching the larger Space Launch System (SLS) Block 1B launch vehicle. However, much work remains, some of which cannot start until after the Artemis III launch.

EGS's Mobile Launcher 2 (ML2) is the primary schedule driver for Artemis IV. While NASA has tools in place to help understand the ML2 contractor's schedule, there is substantial sequential work after the ML2 is delivered that will drive the Artemis IV mission schedule. NASA officials have not committed to conducting a future schedule risk analysis for EGS and ML2. Performing this analysis would provide insight into ML2's readiness for the mission and inform NASA management's resource decisions leading up to integration for Artemis IV.

NASA requires the EGS program to measure operations costs through annual 5-year cost estimates. EGS's most recent estimate from February 2024 stated that its operations will cost about \$3.7 billion through fiscal year 2029. Program officials said that they plan to refine their estimating processes based on lessons learned from the first annual update process and apply the lessons to future estimates or to updated guidance.

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Abbreviations

CDR	critical design review
EGS	Exploration Ground Systems
JCL	joint cost and schedule confidence level
KDP	key decision point
M2M	Moon to Mars
ML1	Mobile Launcher 1
ML2	Mobile Launcher 2
NASA	National Aeronautics and Space Administration
NPR	NASA Procedural Requirements
Orion	Orion Multi-Purpose Crew Vehicle
ORR	operational readiness review
Pad	Launch Pad 39B
PDR	preliminary design review
SLS	Space Launch System
SRA	schedule risk analysis

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October 17, 2024

The Honorable Jeanne Shaheen
Chair
The Honorable Jerry Moran
Ranking Member
Subcommittee on Commerce, Justice, Science, and Related Agencies
Committee on Appropriations
United States Senate

The Honorable Frank Lucas
Chairman
The Honorable Zoe Lofgren
Ranking Member
Committee on Science, Space and Technology
House of Representatives

The Honorable Hal Rogers
Chairman
The Honorable Matt Cartwright
Ranking Member
Subcommittee on Commerce, Justice, Science, and Related Agencies
Committee on Appropriations
House of Representatives

The National Aeronautics and Space Administration (NASA) plans to return astronauts to the moon, build a sustainable lunar presence over the next decade, and ultimately travel to Mars through a series of missions known collectively as Artemis. NASA requested over \$3 billion for fiscal years 2024 through 2028 for the Exploration Ground Systems (EGS) program. This program develops and operates the systems and facilities necessary to process and launch NASA's Space Launch System (SLS) rocket and Orion Multi-Purpose Crew Vehicle (Orion) spacecraft, and to recover the spacecraft and crew. The program demonstrated its initial capability in November 2022 during the launch of Artemis I, NASA's first uncrewed Artemis test flight, and will support future Artemis launches in upcoming years. EGS continues to improve facilities and develop capabilities for future Artemis missions. These capabilities include the Mobile Launcher 2 (ML2), which will provide support for and transport key systems to the launch pad.

We have designated NASA's acquisition management as a high-risk area for over 3 decades. In our April 2023 high-risk report, we found that NASA continues to face challenges with limiting cost growth and schedule delays for its most complex and expensive projects, including those for human spaceflight, such as EGS. We

further found that, to make human spaceflight programs more affordable, NASA needed to provide more information about long-term program costs and take actions to control those costs.¹

The House Report 117-395 accompanying the Commerce, Justice, Science, and Related Agencies Appropriations bill, 2023 contains a provision for us to continue conducting in-depth reviews of NASA's human exploration programs, including the EGS program and its mobile launch platforms. One of these platforms—ML2—is currently being built to support Artemis IV. This report (1) evaluates the extent to which the EGS program has made progress toward upcoming Artemis II through IV missions, including on ML2, and (2) assesses the extent to which NASA has established plans to measure EGS program costs after Artemis I launched.

To determine EGS's progress modifying and upgrading key elements for Artemis II through IV, we collected and analyzed EGS program documentation including program plans and schedule, technical, and risk data. We interviewed EGS program, ML2 project, and NASA officials to understand the status of work and any key challenges. We discussed the risks the program faces, plans for mitigating risks, and the extent to which EGS has accommodated and can continue to accommodate changes to Artemis missions. We conducted a site visit to Kennedy Space Center to observe the status of construction and modifications of key elements, including ML2. We also reviewed ML2 contract documentation to understand contractor progress and performance. We interviewed NASA officials and contractor representatives to understand the history and status of ML2 cost, schedule, and technical performance, including plans to review ML2 schedules after NASA establishes cost and schedule baselines for the project. We compared NASA's plans to conduct future schedule risk analyses against our best practices for schedule estimating and the *NASA Schedule Management Handbook*.²

To determine NASA's plans, guidance, and requirements to measure program costs after Artemis I launched, we reviewed NASA's policy for program management and its accompanying handbook, as well as NASA's cost estimating guide.³ These costs are also known as operations or Phase E cost estimates. We also collected and analyzed EGS cost data to understand the extent to which the program has followed requirements to create Phase E cost estimates. We interviewed EGS program officials to understand the methodology used to develop the Phase E cost estimates, including guidance that NASA had provided for preparation of the estimates. In addition, we interviewed officials from NASA's Moon to Mars (M2M) program office and its Office of the Chief Financial Officer to understand NASA's reviews of the Phase E cost estimate, these offices' access to supplemental information needed for the review, and lessons learned about the estimating process that could affect guidance or future cost estimate updates. We compared EGS's estimates against NASA's

¹GAO, *High-Risk Series: Efforts Made to Achieve Progress Need to Be Maintained and Expanded to Fully Address All Areas*, [GAO-23-106203](#) (Washington, D.C.: Apr. 20, 2023).

²GAO, *GAO Schedule Assessment Guide: Best Practices for Project Schedules*, [GAO-16-89G](#) (Washington, D.C.: Dec. 22, 2015). NASA, *NASA Schedule Management Handbook*, NASA/SP-2010-3403 (March 2024).

³NASA, *NASA Space Flight Program and Project Management Requirements*, NASA Procedural Requirements (NPR) 7120.5F (Aug. 3, 2021) (incorporating change 3, Oct. 27, 2023); *NASA Space Flight Program and Project Management Handbook*, NASA/SP-20220009501 (May 2022); and *NASA Cost Estimating Handbook Version 4.0* (February 2015).

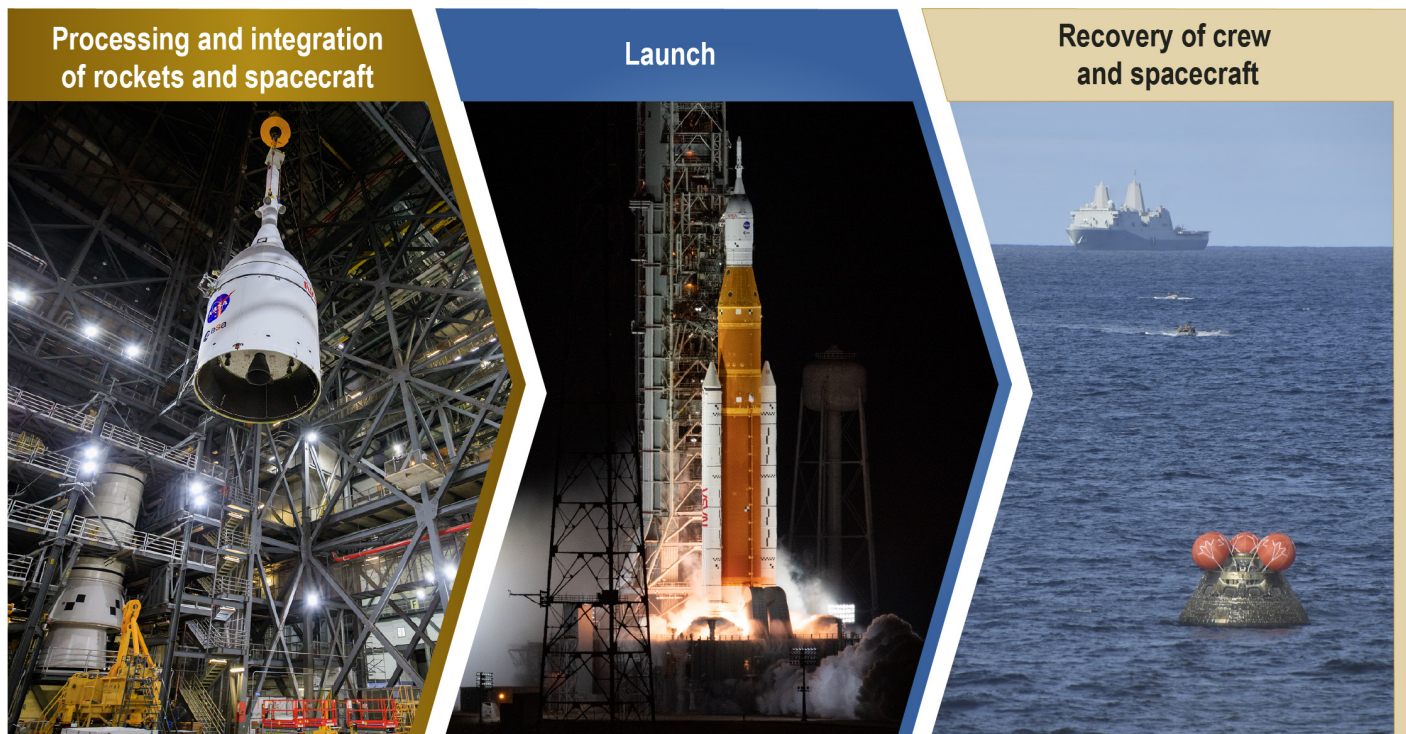
internal guidance for developing the Phase E cost estimates.⁴ We also reviewed NASA policies on budget execution and formulation to understand how the estimates may supplement that process.⁵

We conducted this performance audit from July 2023 to October 2024 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

The EGS program is composed of several elements, activities, and facilities at NASA's Kennedy Space Center that support the processing and integration, launch, and recovery for Artemis missions (see fig. 1).

Figure 1: Key Exploration Ground Systems Activities for Artemis Missions



Source: GAO presentation of NASA images. | GAO-25-106943

⁴NASA, NPR 7120.5F.

⁵NASA, *Budget Formulation (Revalidated on September 15, 2021 with Change 1)*, NPR 9420.1A (Sept. 7, 2016); and *Budget Execution*, NPR 9470.1 (Dec. 24, 2008).

EGS Elements

EGS elements are enduring capabilities and facilities that support multiple Artemis missions. These are necessary for EGS to manage and operate the safe connection of a spacecraft and rocket, the transportation of the integrated spacecraft and launch vehicle to the launch pad, the successful launch of the craft into space, and the recovery of the crew and spacecraft. Several EGS elements were upgraded to support Artemis I and currently do not have planned modifications. These elements include the crawler-transporter, which moves the mobile launcher, rocket, and spacecraft to the launch pad; the Launch Control Center; and other processing facilities.

However, EGS is modifying other elements to support future Artemis missions, including mobile launchers, Launch Pad 39B (Pad), the Vehicle Assembly Building (VAB), environmental control systems, and software.

- **Mobile launchers.** The mobile launchers support the SLS and Orion vehicles during stacking in the VAB and transport the integrated vehicles to the Pad, as well as provide the platform from which they will launch. Additionally, the mobile launchers provide the fuel, electrical, cooling, and communications connectivity from ground systems to the vehicles until launch using umbilical arms. Mobile Launcher 1 (ML1) will be used for Artemis I through III, and ML2 will be used for Artemis IV and beyond. While ML1 and ML2 look similar and have the same role, ML2 will be a larger structure with a new Exploration Upper Stage umbilical arm to support the taller SLS Block 1B vehicle, among other differences.⁶
- **Launch Pad 39B.** The launch pad provides the electrical power, water system, flame trench, and safe launch area that are needed to support an Artemis launch. EGS is completing a new liquid hydrogen sphere at the Pad in advance of Artemis II, which officials said will enable faster turnaround times between launch attempts. The EGS program is also adding an emergency egress system to transport astronauts and personnel from atop the mobile launcher to the ground in an emergency.⁷ The egress system is similar to an aerial tram with baskets that rapidly travel down a wire system away from the mobile launcher to the landing area. Each of the system's four baskets can hold up to five people. Upon landing, an armored vehicle that can withstand the blast conditions will evacuate the personnel from the Pad's vicinity to medical triage sites. Figure 2 depicts the integrated SLS and Orion atop the ML1 at Kennedy Space Center's Launch Pad 39B and one of the baskets for the egress system.

⁶The SLS Block 1B is a planned evolution of SLS with greater in-space thrust. It will use an Exploration Upper Stage and associated capabilities to increase the amount of mass that can be delivered to the moon and other deep space destinations.

⁷The egress system will connect to the mobile launcher on the same level as the crew access arm. EGS will modify the egress system's software between Artemis III and IV to calibrate the braking system with the extra cable length necessary for an emergency evacuation from the ML2's taller height. This is to ensure that personnel will safely travel the distance from the mobile launcher to the designated landing pad on the ground.

Figure 2: Photos of Launch Pad 39B and the Emergency Egress System



Source: NASA. | GAO-25-106943

- **Vehicle Assembly Building.** The VAB is where the various parts of SLS and Orion will be fully assembled, integrated with one another, and stacked on the mobile launcher in preparation for transport to the Pad. Inside the VAB are platforms with customized inserts to fit the curvature of the vehicles that allow workers to access parts of the vehicle. EGS will fabricate, install, and reconfigure platforms to support SLS Block 1B, which has new access points relative to SLS Block 1. Figure 3 depicts Kennedy Space Center's VAB.

Figure 3: Photo of the Vehicle Assembly Building



Source: NASA. | GAO-25-106943

- **Environmental control systems.** The environmental control systems regulate such things as the temperature, humidity, and flow rate for the conditioned air flowing from the Pad or VAB through the mobile launcher to the SLS rocket and Orion spacecraft. The EGS program is replacing the environmental control system in the VAB and upgrading the Pad's system. Officials explained that these upgrades are needed because the SLS Block 1B configuration uses the new Exploration Upper Stage. Therefore, the volumes

within the SLS requiring conditioned air are much larger for Block 1B than Block 1. In addition, the Block 1B requires additional air ducts.

- **Software.** The EGS program is responsible for development, activation, operations, and sustainment of command and control software. EGS has three primary software systems and is modifying these systems to improve their ability to execute multiple planned software development efforts at the same time.

EGS elements support multiple Artemis missions, but not every element is being modified for every mission. See table 1 for how different elements are supporting upcoming Artemis missions.

Table 1: Exploration Ground Systems Elements’ Statuses by Upcoming Artemis Missions They Support

	Artemis II	Artemis III	Artemis IV
Mobile Launcher 1	Refurbishment and Modifications	Refurbishment	Not used
Mobile Launcher 2	Not used	Not used	New development
Launch Pad 39B	Modifications	Operations	Operations
Vehicle Assembly Building	Modifications	Operations	Modifications
Software	New development	Operations	New development

Source: GAO analysis of NASA documentation. | GAO-25-106943

Note: Refurbishment is a type of modification that occurs only as needed, such as to repair damage from a prior launch. Modifications are any other type of upgrade or change to an existing element. Operations is use of the element, with no planned modifications beyond those necessary for continuing maintenance and operations or sustainment.

Key Aspects of NASA’s Planned Return to the Moon

The goal of NASA’s Artemis missions is to return U.S. astronauts to the moon, including a sustained lunar presence, and ultimately human exploration of Mars. The Moon to Mars (M2M) program office is responsible for supervising the development and operations of the individual M2M elements that will support Artemis missions, including the EGS program.⁸ It resides within NASA’s Exploration Systems Development Mission Directorate.

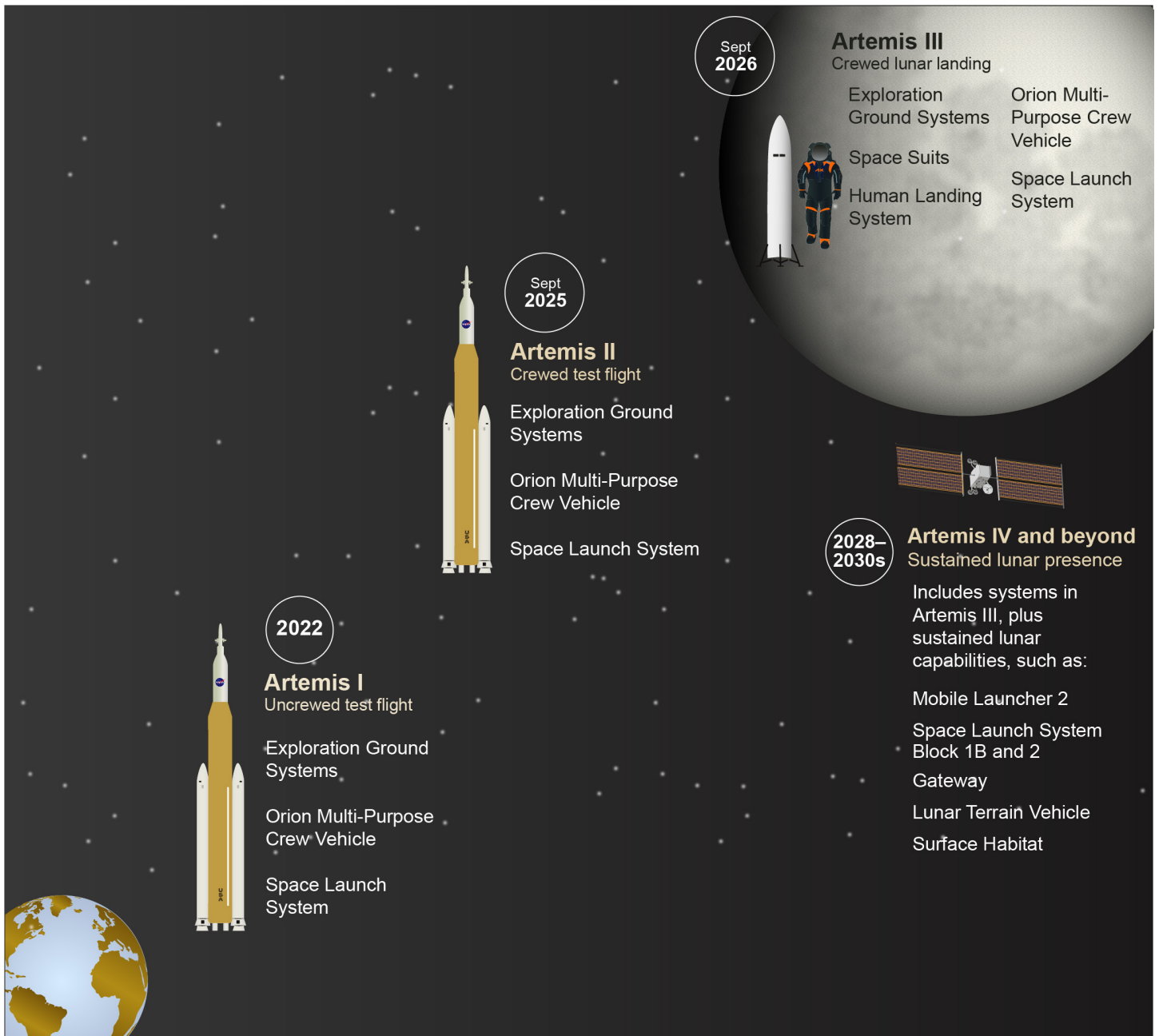
Executing Artemis missions requires extensive coordination across several NASA programs to ensure that systems integrate and operate together seamlessly and safely.

- Artemis I and II are the first uncrewed and planned crewed demonstration missions, respectively, of the SLS, Orion, and EGS.
- Artemis III is the first planned lunar landing since the 1972 Apollo 17 mission. This mission will begin to incorporate additional programs, such as those developing space suits and a landing system to put humans on the surface of the moon.
- Artemis IV is the first planned mission for astronauts to live and work in humanity’s first lunar space station. This mission will be complex, as NASA will need to coordinate across seven NASA programs, multiple contractors that support those programs, and international partners to execute the mission. Artemis IV will also be the first launch to use ML2.

⁸The M2M program office manages risks for exploration efforts; integrates the design, engineering, operations, and budget formulation for the elements; and oversees Artemis mission preparation, training, operations, and execution.

Figure 4 illustrates the missions and programs needed to accomplish each Artemis mission.

Figure 4: Artemis Missions and the Programs Needed to Accomplish Each Mission

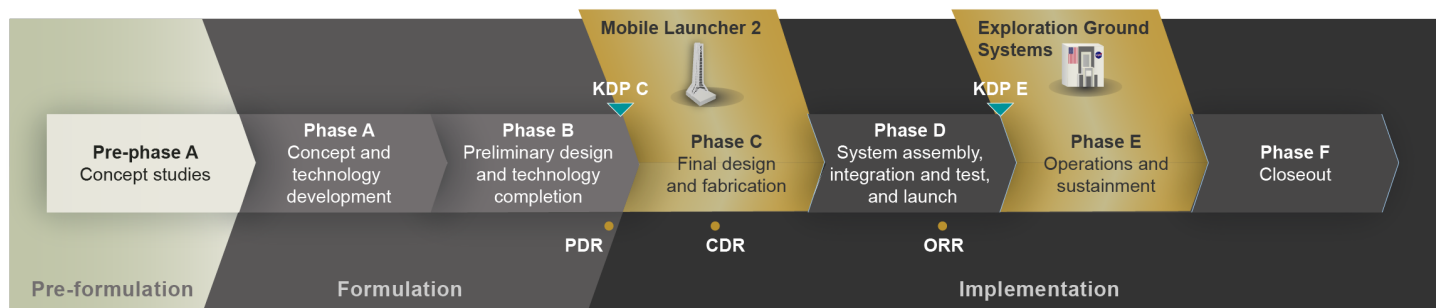


Source: GAO presentation of NASA documentation. | GAO-25-106943

NASA Acquisition Life Cycle

The life cycle for NASA space flight projects consists of two phases—(1) formulation, which takes a project from concept development to preliminary design; and (2) implementation, which includes activities like building, launching, and operating the system. NASA further divides formulation and implementation into phases A through F. Figure 5 depicts NASA’s life cycle for space flight projects, including where ML2 and EGS notionally fall in this process.

Figure 5: Acquisition Phases and Milestones for the Exploration Ground Systems and Mobile Launcher 2



KDP = key decision point
 PDR = preliminary design review
 CDR = critical design review
 ORR = operational readiness review

Source: GAO presentation of NASA images and information. | GAO-25-106943

Major projects must get approval from senior NASA officials at key decision points before they can enter each new phase.

- EGS is considered a single-project program with an unspecified Phase E endpoint. The program has moved through most of the life-cycle phases and NASA approved it to enter Phase E in May 2022. In Phase E, the program will continue to conduct development and operations to support future Artemis missions.
- ML2 is considered a launch capability upgrade project within the EGS program and is currently in development. NASA approved ML2’s agency baseline cost and schedule commitments in June 2024.

The *NASA Space Flight Program and Project Management Requirements* policy requires all major projects that have a total life-cycle cost of \$250 million or more to establish agency baseline commitments—cost and schedule baselines against which the program may be measured throughout its life cycle.⁹ A joint cost and schedule confidence level (JCL) is an analysis that provides the probability of a program’s success of meeting cost and schedule targets. The JCL incorporates and quantifies known risks, assesses the effects of cost and schedule to date on the estimate, and addresses available annual resources.

NASA programs conduct a JCL to inform their cost and schedule baselines. Programs such as EGS that have unspecified Phase E endpoints establish cost estimates and baseline commitments for their initial capability and for any capability upgrade that will cost more than \$250 million, such as ML2. EGS’s initial capability was

⁹NASA, NPR 7120.5F.

ties to the launch of Artemis I. EGS's costs for Artemis I were \$3.7 billion, which was \$892.2 million above the program's 2014 baseline cost commitment and \$292 million above the program's 2020 approved rebaseline. Once the initial capability has been demonstrated, NASA requires programs with an unspecified Phase E endpoint to develop an annual 5-year cost estimate beginning with key decision point E. NASA does not require that programs with an unspecified Phase E endpoint have life-cycle cost estimates.¹⁰

In addition to JCLs, the *NASA Schedule Management Handbook* states that programs should conduct a schedule risk analysis (SRA) sometime between the program's concept and preliminary design and then update it as needed.¹¹ An SRA is an analysis that uses statistical techniques to predict the likelihood of a project's completion date and provides numerous benefits to agency decision-makers.¹² For example, an SRA can predict the level of confidence in meeting a program's completion date, determine the reserve of time needed for a level of confidence, and identify high-priority risks. Unlike a JCL or integrated cost and schedule analysis, an SRA does not measure the adequacy of phased budgets to cover cost estimates and discrete, risk-related costs. SRAs assess the adequacy of required schedule margin.

Prior GAO Reports

NASA acquisition management has been on our high-risk list since 1990.¹³ As we noted in our January 2024 testimony on Artemis programs, NASA has made improvements to its acquisition management policies and practices in recent years.¹⁴ However, it still faces challenges in its ability to manage its costliest and most complex programs, such as those that are critical to support the Artemis missions. We previously found that when the agency's most expensive projects exceed their cost baselines and require cost reserves to meet their funding needs, it has a cascading effect on other projects.¹⁵ NASA officials continue to explore ways to better manage this project cost and schedule growth.

We also previously found that SRAs are key to informing realistic launch dates. In September 2022, we found that while NASA was beginning to take steps to create Artemis mission-level schedules, NASA had not performed an SRA for Artemis II.¹⁶ We found that ensuring SRAs are conducted early, updated frequently, and based on high-quality schedules is necessary to ensure that senior NASA leaders have quality, risk-informed information for decision-making. We recommended that NASA conduct an SRA for the Artemis II mission and update it as needed to incorporate schedule updates and new risks. NASA agreed with the recommendation, but as of August 2024, had not yet taken action to respond to it.

¹⁰A life-cycle cost estimate is a structured accounting of all labor, material, and other efforts required to develop, produce, operate and maintain, and dispose of a program.

¹¹NASA, *NASA Schedule Management Handbook*, NASA/SP-2010-3403 (March 2024).

¹²[GAO-16-89G](#).

¹³[GAO-23-106203](#).

¹⁴GAO, *NASA Artemis Programs: Lunar Landing Plans Are Progressing but Challenges Remain*, [GAO-24-107249](#) (Washington, D.C.: Jan. 17, 2024).

¹⁵[GAO-24-107249](#).

¹⁶GAO, *NASA Lunar Programs: Improved Mission Guidance Needed as Artemis Complexity Grows*, [GAO-22-105323](#) (Washington, D.C.: Sept. 8, 2022).

EGS Is Making Progress for Future Missions, but Artemis Schedule Presents Challenges

EGS is making progress upgrading and modifying elements that will support crewed Artemis missions II through IV. Modifications to those elements needed to support the Artemis II mission are nearing completion, and the program anticipates minimal changes for Artemis III. However, both missions' schedules allow only limited time for EGS to address unforeseen technical challenges. Further, while EGS has made progress toward Artemis IV, there is a significant amount of work left to complete the ML2 and reconfigure the VAB to be ready for integrated operations. Most of the remaining work must be done sequentially, and some work cannot start until after Artemis III launches. Completion of ML2 is the primary schedule driver for Artemis IV, but NASA has not committed to conducting a schedule risk analysis for EGS and ML2 moving forward.

Modifications for Near-Term Missions Are Close to Completion, but Schedule Risks Remain

EGS is making progress upgrading and modifying facilities and software to support Artemis II and III, the next missions in NASA's campaign to return humans to the lunar surface. However, the program has little schedule margin in the current Artemis II and III mission dates to address potential technical issues, or possible delays on the SLS and Orion programs.¹⁷ Should any of these occur, then delays to the planned Artemis launches are possible.

Artemis II

The Artemis II mission, scheduled for September 2025, will be the first crewed test flight of SLS and Orion. To support the Artemis II launch, EGS needed to make certain modifications to the Kennedy Space Center, such as adding an emergency egress system. In addition, EGS needs to refurbish the ML1 due to damage sustained during the Artemis I launch.

EGS is currently working to finish developing and modifying elements supporting Artemis II so it can be ready to begin integration with SLS and Orion. As of June 2024, EGS planned to be ready for integration by September 2024. After EGS certifies its new or modified elements, the program is responsible for stacking the SLS launch vehicle components and Orion and conducting the testing and check out of the integrated SLS and Orion flight vehicle to ensure they are prepared for launch in September 2025.

EGS has completed a large amount of work to get to this point. As of June 2024, the remaining pre-integration work included completing software system upgrades and work on the egress system, ML1 and crew access arm, and environmental control systems.

- **Software.** EGS software controls communication across Kennedy Space Center, as well as the functionality of hardware elements like the environmental control systems at the Pad and in the VAB. Officials explained that as EGS develops and modifies hardware, it needs to also develop, modify, and sustain the corresponding software. They said that software changes being made specifically to support an

¹⁷Margin, or a reserve of extra time also referred to as contingency, accounts for known and unknown risks and uncertainty in the schedule. See [GAO-16-89G](#).

individual mission must be complete by 1 month prior to beginning operations—such as integrated testing and checkout—in the mission’s launch flow.

EGS is monitoring a risk that some software will not be ready for Orion offline processing due to the interdependencies with the Orion program.¹⁸ Officials told us that delayed Orion data pushes out the time frame for when EGS can complete the software development. Officials also stated that the programs are working closely together to prioritize software needs to minimize potential impacts.

- **Emergency egress system.** The egress system’s baskets have been built, the cabling that carries the baskets to a landing area has been installed, and testing is underway at the Pad. As of September 2024, officials said EGS had completed certification testing of the system—indicating the system is safe to transport humans.
- **ML1.** EGS has been refurbishing the ML1 after it experienced more damage than anticipated during the Artemis I launch. According to officials, EGS has been working to strengthen the elevator shaft and repair damage in the tower, while also providing protective barriers to damaged systems. They said these barriers are intended to reduce the risk that the ML1 will need extensive refurbishment following Artemis II.

In addition to refurbishment, EGS is certifying the ML1 crew access arm, which crew will use to board the Orion spacecraft. According to officials, the arm was modified after Artemis I to be able to extend quickly in an emergency should crew need to evacuate. Officials said that as of September 2024, the arm is going through testing and certification and is the primary schedule driver for the ML1’s roll to the VAB and for the Artemis II mission overall. The arm’s testing takes place at the launch pad and must be complete before the ML1 can roll back to the VAB for the next stage of testing. The crew access arm is at risk of delay due to challenges experienced during testing.

- **Environmental control systems.** EGS is modifying its two environmental control systems by (1) upgrading the Pad’s system, and (2) replacing the VAB’s system. As of June 2024, the Pad system had been built and tested and is no longer a constraint to the ML1 moving to the VAB.

As of June 2024, the VAB’s system had started its initial phase of testing. This portion of testing will verify the functionality of the VAB’s system. Once verified, the system will be used to support multi-element verification and validation testing with the ML1. This testing is expected to verify that the ML1 and VAB work together. Officials said the multi-element testing is required before EGS can power up the SLS core stage, which is planned for December 2024. They said that integration activities can begin in September 2024 and occur in parallel with the final verification and validation activities.

While EGS elements are close to completion, the program has no schedule margin for these remaining activities. In January 2024, NASA delayed Artemis II by 9 months, but officials said that the delay only provided the EGS program about 3 months of margin to the September 2025 launch readiness date. As of June 2024, officials said all this margin has been applied to technical issues already experienced at the Pad during ML1 and Pad testing. Earlier in 2024, the program was reserving that time for technical issues that may arise during testing of the integrated SLS and Orion vehicle or if weather interferes with planned activities, among other things. Officials said it is likely that issues will arise because this is the first time testing many of these systems. Given the lack of margin, if further issues arise during testing or integration, there will likely be delays to the September 2025 Artemis II launch date.

¹⁸During Orion offline processing, the spacecraft is prepared for the mission prior to installation on the rocket.

Artemis III

NASA plans for 1 year between the Artemis II and III launches, which officials said is a very tight turnaround. As a result, EGS will have only limited time to react to and implement information gained from the Artemis II mission and address challenges, which could lead to schedule delays for future missions. Further, officials said if the Artemis II launch is delayed, it would threaten the Artemis III schedule. EGS officials stated that they are looking at requirements to determine if any can be eliminated to create schedule margin. For example, they said that since Artemis II and III will use the same hardware, there may be opportunities to reduce some testing. At the same time, however, officials noted there could be some additional hardware development activities, depending on lessons learned from Artemis II and how SLS and Orion requirements evolve.

EGS's Artemis III work focuses on ML1 refurbishment and software sustainment, and there are no planned modifications to other program elements.

- **ML1.** EGS's primary schedule driver for Artemis III is post-Artemis II ML1 refurbishment. After Artemis I, EGS spent over a year refurbishing the ML1, though officials explained that this also included time to modify the tower to reduce the risk of future damage. According to program documentation, EGS plans for the post-Artemis II ML1 refurbishment work to take 1 month. However, the program is tracking a risk that if the damage from Artemis II is more significant, the work may take a total of 4 months and officials said that could delay the Artemis III launch readiness date.
- **Software sustainment.** Program officials noted that because EGS does not plan to develop new hardware for Artemis III, the program does not anticipate software changes beyond normal sustainment activities. Given the narrow, 1-year window between Artemis II and III, however, there is limited margin should any major software development efforts be needed to respond to lessons learned from Artemis II. According to officials, one of the challenges in the overall Artemis enterprise is that the nature of concurrent development means requirements may change as new information becomes available, which is an inherent schedule risk. Officials noted that the mission schedule allocates some time for addressing unexpected changes based on current knowledge.

Final System Integration and Launch

As mission integrator, EGS is dependent on hardware and data from SLS and Orion to effectively integrate the ground systems, launch vehicle, and spacecraft to support a successful launch. In addition to potential technical challenges with EGS development activities, the program also faces external challenges due to interdependencies with SLS and Orion. For example, as of August 2024, Orion was scheduled to be delivered to EGS in October 2024 to support Artemis II; however, that date was being reassessed by NASA. According to NASA officials, given the potential delay, M2M is evaluating whether to conduct a key test in the launch flow without Orion. While officials said that doing so may conserve schedule and would enable other integration challenges to be addressed, they also acknowledged that it may also introduce other risks.

Significant Work Remains to Support September 2028 Artemis IV Schedule

EGS has made some progress toward Artemis IV, but a significant amount of work remains. In terms of work underway, EGS has:

- Begun modifying facilities to accommodate the larger SLS Block 1B launch vehicle for Artemis IV. This includes upgrades to environmental control systems at the Pad and in the VAB in advance of Artemis II.
- Awarded a cost-plus-award-fee contract to Bechtel National, Inc. for the design and build of the ML2.¹⁹ As of June 2024, the ML2's design is nearly complete and construction has begun. For example, the steel skeleton of the structure's base is complete and assembly of portions of the ML2 tower on the ground are underway.
- Started construction of new platforms that will be used to access SLS Block 1B in the VAB. This effort is expected to be complete by April 2025.

However, EGS has a lot of work left to complete. For example, EGS needs to complete construction and assembly of the ML2 base and tower and install ML2 umbilicals—the arms that connect the tower to the rocket and spacecraft to provide electrical support and propellant—among other things. NASA and Bechtel will then inspect and test the ML2 prior to Bechtel's handover to NASA. Figure 6 shows the status of ML2 base and tower construction as of July 2024.

Figure 6: Photos of Mobile Launcher 2 Base and Tower Construction Sites as of July 2024



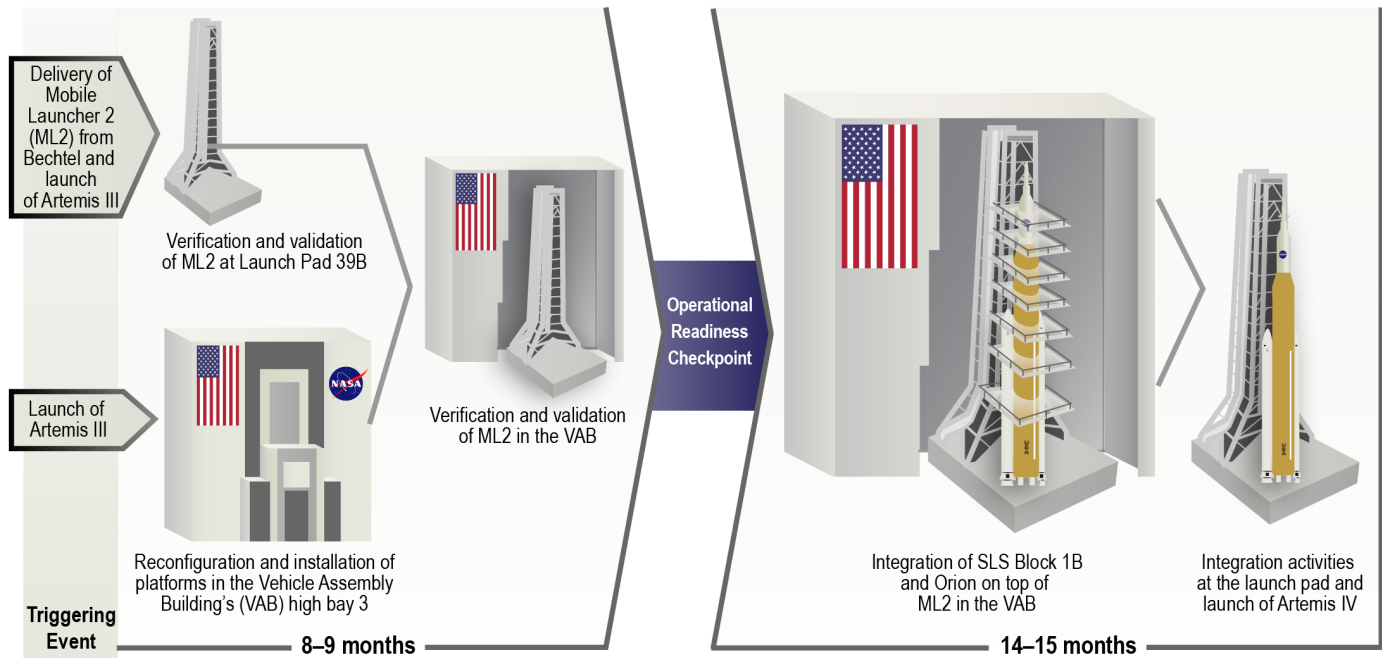
Source: NASA. | GAO-25-106943

Much of EGS's remaining work for Artemis IV must be done sequentially, and some cannot start until after the Artemis III launch. After Bechtel hands over the ML2 to NASA and after Artemis III launches, EGS will need to complete deferred work and verification and validation at the Pad and in the VAB. The verification and validation activities will culminate in an operational readiness checkpoint. During this review, officials said EGS will ensure that the ML2 meets requirements before NASA stacks SLS Block 1B on it to begin integration activities. EGS will also need to reconfigure existing platforms and install new platforms in the VAB. This work cannot begin until after Artemis III because NASA needs the current configuration to support the smaller SLS and ML1. NASA currently plans for 2 years between Artemis III and IV—September 2026 to September 2028.

¹⁹Under a cost-plus-award-fee contract, the majority of the cost and performance risk is to the government. Award fee contracts are intended to motivate contractor performance in areas that are susceptible to judgmental and qualitative measurement and evaluation (e.g. technical, cost, and schedule).

However, as of July 2024, Bechtel’s risk-informed delivery date is November 2026, which would leave approximately 22 months to complete this series of activities (see fig. 7).²⁰

Figure 7: Notional Depiction of Exploration Ground Systems Activities Between Artemis III and IV



Source: GAO presentation of NASA documentation. | GAO-25-106943

Note: As of June 2024, EGS retains schedule flexibility to conduct verification and validation of ML2 in the VAB before the program conducts verification and validation activities of ML2 at the launch pad. These activities need to be completed before NASA can hold the operational readiness checkpoint.

The ML2 is the primary schedule driver for the Artemis IV mission. According to program documentation, EGS’s schedule has limited margin and significant risk. Further, the sequential nature of remaining work provides limited schedule flexibility to mitigate risk. EGS’s ability to support the Artemis IV date hinges on Bechtel’s timely delivery and EGS’s completion of multi-element verification and validation, both of which have schedule risk.

- Bechtel’s delivery and challenges.** Bechtel has encountered some significant technical challenges, numerous schedule delays, and a large increase in contract value since the project’s start. For example, according to NASA, in 2021 and 2022, Bechtel’s design for the ML2 measured 1 million pounds over its weight limit, which led to a redesign of the ML2 structure. NASA officials said the project completely stopped steel fabrication to resolve the weight issues. According to NASA documentation, these issues also delayed drawings needed to fabricate steel, which contributed to steel delivery delays that prevented a timely start of construction. In addition, the contract value has increased from \$383 million in June 2019 to approximately \$1.1 billion as of June 2024.

²⁰November 2026 is the NASA-approved over-target schedule. According to the NASA earned value management handbook, an over-target schedule is an established schedule that extends beyond the contractual milestones or delivery dates. NASA often refers to this as Bechtel’s “risk-informed” delivery date.

NASA officials said schedule performance has improved now that Bechtel has started construction, which they highlighted is one of the contractor's strengths. Moreover, in the most recent contractor performance period, Bechtel met all areas of emphasis in the award fee evaluation plan, including the early completion of parts of the base's steel skeleton, which NASA officials found encouraging. NASA also changed the contract award fee structure to add schedule incentives to the contract. Officials said they hope this change will motivate the contractor to deliver as early as possible. Overall, NASA has increased the possible maximum award fee available to Bechtel from \$23.3 million as of June 2019 to a possible maximum of \$81.3 million as of June 2024. Bechtel had earned \$20 million in award fees as of June 2024.

NASA and Bechtel are monitoring schedule risks for ML2. For example, government-driven design changes may present additional schedule risk as the project proceeds. At NASA's request, Bechtel is currently assessing whether the ML2 requires design changes due to new loads data.²¹ According to officials, the SLS launch-induced loads put on the ML1 structure during the Artemis I launch were higher than anticipated and may require adding steel reinforcements within the ML2 base and tower. Officials said that the analysis and changes stemming from it could increase the ML2's weight, increase project costs, and delay the project's schedule.

- **Post-delivery multi-element verification and validation.** NASA currently has approximately 8 months allocated specifically for EGS to conduct ML2 multi-element verification and validation activities. EGS is tracking this issue as one of its top risks. According to NASA documentation, experiences and lessons learned from the ML1 test campaign suggest that the allocated duration may not be sufficient. ML2 officials said the same first-time through testing for the ML1 took 16 months, and there is no margin in the EGS schedule and limited options to mitigate the risk. Further, delays in ML2 construction or contractor testing, availability of personnel, and VAB readiness could further threaten the verification and validation schedule.

At the same time EGS is conducting these verification and validation activities, the program will be completing tasks that NASA deferred to after Bechtel has delivered the ML2. This introduces additional complexity into the planned work during this already compressed schedule.

The bulk of the work NASA needs to do with the ML2 at the Pad and in the VAB can only be accomplished after the launch of Artemis III. As a result, even if Bechtel delivers earlier than November 2026, EGS will not be able to start many ML2 activities. For example, EGS officials said that they would have to balance launch operations at the Pad with ML2 activities if Bechtel delivers the ML2 ahead of schedule. The ML2 would not be able to start VAB activities earlier than planned because the VAB reconfiguration would not yet be complete.

In June 2024, NASA approved the ML2 cost and schedule baseline commitment. NASA's cost baseline is \$1.87 billion and the schedule baseline is September 2027, which is marked by the ML2 turnover from Bechtel to NASA. This date is based on a 70 percent joint cost and schedule confidence level (JCL), as required by NASA policy. The schedule baseline of September 2027 is approximately 10 months later than Bechtel's risk-informed November 2026 delivery date. Should Bechtel deliver the ML2 in September 2027, EGS would only have 1 year, rather than the planned approximately 2 years, to conduct multi-element verification and validation activities—as well as integration with SLS Block 1B and Orion—to support a September 2028 Artemis IV launch.

According to officials, NASA does not plan to update the JCL in the future. NASA policy requires programs to update their JCL analysis at the critical design review. EGS and the ML2 project did so in late 2023, and again

²¹Loads are the forces put on the ML2 during launch.

in early 2024 for the key decision point C milestone review.²² According to policy, if there is a certain amount of cost growth against the baseline at the key decision point D milestone, projects would be required to update the JCL.²³ According to officials, the ML2 project will not have this milestone because it is a capability upgrade. There are no additional policy triggers to update the project's JCL in the future. Further, as of spring 2024, NASA officials had not committed to conducting an SRA for EGS and ML2, but doing so could provide better insights into the risks of not being able to support the current September 2028 Artemis IV launch date.

An SRA covering both the period leading up to Bechtel's delivery of the ML2 and the EGS-led ML2 activities through the operational readiness checkpoint preceding stacking, when integrated operations begin, would provide insight to help NASA understand the likelihood of the ML2 being ready for the Artemis IV mission. An SRA goes beyond monitoring individual activities. For example, according to our *Schedule Assessment Guide*, SRAs incorporate uncertainty, account for schedule underestimation and bias stemming from merging paths in a schedule, incorporate the effects of correlation between schedule activity durations, and prioritize risks by probability and magnitude of their effect.²⁴ Based on where the EGS program and ML2 project are in their life cycles, the *NASA Space Flight Program and Project Management Requirements* policy does not require either to conduct an SRA at an upcoming milestone.²⁵ However, the *NASA Schedule Management Handbook* states that SRAs inform management of the adequacy of margin to accommodate expected risk effects and help management prioritize risk mitigations.²⁶

With approximately 4 years until Artemis IV and a significant amount of work ahead for Bechtel and EGS, regularly assessing EGS and ML2 schedule risks—including those following Bechtel's delivery—is critical to understanding if EGS and the ML2 will be ready for the planned Artemis IV launch date. EGS has struggled to meet time frames in the past. For example, the program identified issues during final integrated testing that contributed to Artemis I mission delays. M2M officials, who oversee the EGS program and ML2 project, stated they are currently assessing how to best manage and oversee the Artemis mission schedule. For example, they said that they are considering whether to conduct an Artemis mission-level SRA, but did not provide a time frame for making the decision. The officials said they are not planning on requiring or requesting an ML2 project SRA in the future.

NASA has tools in place, such as weekly status briefings, contractor schedules, and steel delivery trackers, to help it understand Bechtel's schedule. NASA officials also said they monitor schedules and risks as well as contractor cost and schedule performance on a regular basis. However, these tools do not consider what our best practices identified as one of the most important reasons for performing a schedule risk analysis—that the overall program schedule duration may be greater than the sum of the durations of lower-level activities.²⁷ Further, the contractor's schedule is not the only ML2-related schedule driver affecting the Artemis IV mission.

²²Key decision point C is when senior NASA officials approve the project to move into implementation.

²³Key decision point D is when officials approve the project to move into the system assembly, integration and test, launch and checkout phase.

²⁴[GAO-16-89G](#).

²⁵The EGS program is in Phase E, and the ML2 project is past the critical design review and does not plan to conduct a key decision point D milestone.

²⁶NASA, NPR 7120.5F; and *NASA Schedule Management Handbook*, NASA/SP-2010-3403 (March 2024).

²⁷[GAO-16-89G](#).

As discussed above, EGS multi-element verification and validation will likely also drive EGS and ML2 readiness for Artemis IV. The current suite of tools to monitor the contractor's cost and schedule performance provides insight into lower-level activities and may not be enough, given the EGS program's and ML2 project's issues to date. Additional tools, like an SRA, could provide new insights on the overall program schedule to M2M and other NASA decision-makers.

Given the criticality of the ML2 to the Artemis IV mission, the project's history of schedule delays, and the ongoing schedule risk, performing an EGS and ML2 SRA would provide better insight into the EGS program and the ML2 project's ability to support the Artemis IV mission schedule. The *NASA Schedule Management Handbook* states that SRAs may be routinely performed to support management decisions regarding schedule and schedule performance trends throughout the life cycle.²⁸ Further, our *Schedule Assessment Guide* also states that an SRA should be performed periodically as the schedule is updated to reflect progress on activity durations and sequences.²⁹ For example, an SRA may be updated more regularly if schedule challenges with a contractor begin to emerge. Conducting an SRA at least once before beginning Artemis IV integrated operations activities would provide additional insight into Artemis IV mission readiness. For example, it could provide additional information on the cumulative effects of the schedule risks associated with Bechtel's delivery and the EGS activities leading up to integrated operations. Without an updated understanding of the schedule impact of uncertainty and risk, NASA risks making resource decisions that are not fully informed by ML2 project readiness and the Artemis mission manifest.

NASA Estimates EGS Operations Will Cost \$3.7 Billion through Fiscal Year 2029

As required by the *NASA Space Flight Program and Project Management Requirements* policy, EGS established its initial 5-year cost estimate in May 2022, and subsequently updated it in February 2024. This policy requires single-project programs and projects that plan continuing operations and production with an unspecified Phase E end point, such as the EGS program, to produce an initial 5-year cost estimate for the continuing operations and production phase.³⁰ This initial estimate is approved when the project is authorized to proceed to Phase E of its life cycle and then is required to be updated annually for the next 5-year period. These estimates are the primary means by which NASA intends to measure and report on the EGS program's operations costs.

NASA does not consider the Phase E cost estimates to be an official program baseline commitment or a life-cycle cost estimate. A NASA official said that the agency does not intend to develop a life-cycle cost estimate for these projects. The official stated that there is too much uncertainty in projecting costs into the future because NASA does not know how long Artemis missions will be executed. For example, an official explained that attempting to estimate costs for a program to support an Artemis mission in 2050 would not be informative. Instead, NASA officials said that the agency considered how far out it could project EGS costs while still providing meaningful estimates and decided on a 5-year rolling cost estimate. This approach is reflected in the

²⁸NASA, *NASA Schedule Management Handbook*, NASA/SP-2010-3403 (March 2024).

²⁹[GAO-16-89G](#).

³⁰NASA, NPR 7120.5F.

NASA Space Flight Program and Project Management Requirements policy, which was updated in August 2021.

Further, the *NASA Space Flight Program and Project Management Handbook*—the management policy’s companion guidance—provides a high-level overview of the process that projects should follow in developing the cost estimates.³¹ For example, it states that the scope of the estimate is defined by NASA’s direction for the President’s Budget Request. Officials said the rationale for this guidance was so that the programs can use the budget request cycle to generate the estimate. Program officials said that they used NASA’s Planning, Programming, Budgeting, and Execution (budget) process as the primary methodology to develop the cost estimates. As part of the budget process, officials said that the M2M program office communicates the Artemis mission manifest and requirements that EGS uses to develop budget estimates. Typically, NASA budget estimates capture the current year and 5 future years. Program officials said they work with EGS technical managers to coordinate what funding is required to support the manifest, the time required for any necessary upgrades, and the scheduling availability to complete necessary work. Officials said this information informs EGS’s estimated costs for upcoming years.

Like the program’s budget estimate, the EGS Phase E annual cost estimate captures the current year and 5 future years. Program officials said they plan for the annual cost estimate updates to consider many factors, including the actual performance from the previous year, new activities they need to complete, new site conditions, inflation, and the actual appropriations received. According to the *NASA Space Flight Program and Project Management Handbook*, the mission directorate and the Office of the Chief Financial Officer may need to coordinate with programs to ensure there are not disconnects in the estimates. For example, an M2M official said that they review the Phase E cost estimate to ensure that the process used to develop the estimate is using the same assumptions used to develop the budget estimate. While the assumptions should align, NASA officials said that the costs included in a program’s Phase E cost estimate may not fully align with what is reported in the President’s Budget Request. They explained that the Phase E cost estimate is from a point in time that may precede the finalization of the budget, and the budget is meant to serve a different purpose as it balances resources across agency programs.

EGS has produced two Phase E cost estimates—an initial estimate and one annual update.

- In May 2022, NASA’s Associate Administrator approved the initial EGS Phase E cost estimate for \$2.5 billion (total for 5 years) for fiscal years 2022 through 2026.³²
- In February 2024, the EGS program released its first annual updated cost estimate, estimating costs of \$3.7 billion (total for 7 years) for fiscal years 2023 through 2029. See appendix I for detailed information on the cost estimates.

The cost estimates cover different time periods and support the evolving timelines of the Artemis missions. For example, the initial estimate assumed Artemis I would launch in November 2021. But the launch occurred a year later, which is reflected in the February 2024 estimate. The initial estimate included costs to support three Artemis missions following the launch of Artemis I that demonstrated EGS’s initial capability. The updated estimate includes an additional \$734 million to support the same three missions.

³¹NASA, *NASA Space Flight Program and Project Management Handbook*, NASA/SP-20220009501 (May 2022).

³²At the same time, the EGS program was authorized to enter Phase E.

EGS's Phase E cost estimates are used in conjunction with budget information. EGS officials said that internally, when they share the estimate with M2M for review, they submit additional information that documents assumptions and ground rules, as well as what is included in a given year's costs. They said this information, as well as other data available via the budget process, can help M2M officials understand how the estimates have changed over time.

The February 2024 EGS Phase E cost estimate is the first time NASA has implemented the annual update process. Officials told us they are in the process of collecting lessons learned to apply to either NASA guidance or future Phase E cost estimate updates. For example, the current guidance states that the annual updates should be released at the end of the first full quarter following the release of the President's Budget Request. According to NASA documentation, this is to ensure the scope is defined by the most recent budget request. Officials told us they now believe that the more appropriate cycle is for the annual updates to be released at the end of the first quarter of the fiscal year to capture the prior fiscal year-end data. They said this could be an example of the type of changes they will make after completing their lessons learned process. A NASA official said they will likely wait until another cycle of estimates has occurred before making any updates to NASA's guidance.

Conclusions

Artemis mission success depends on the successful implementation of the EGS program. The program has made progress modifying facilities for future missions, but a significant amount of work remains, particularly for the ML2 in advance of Artemis IV. The ML2 is a necessary component for the Artemis IV mission. The project has had numerous delays since its inception and continues to track several schedule risks, both with contractor-led construction and NASA-led verification and validation activities. An SRA prior to the start of Artemis IV integrated operations would provide NASA valuable information about the ML2's ability to support the mission on time and help inform Artemis mission-level trade-off decisions.

Recommendation for Executive Action

The NASA Administrator, in coordination with the Exploration Systems Development Mission Directorate, should ensure that Exploration Ground Systems program and Mobile Launcher 2 project officials perform at least one schedule risk analysis prior to beginning integrated operation activities to support the Artemis IV launch. (Recommendation 1)

Agency Comments and Our Evaluation

We provided a copy of this report to NASA for review and comment. NASA provided written comments that are reprinted in appendix II, and technical comments that we incorporated as appropriate.

In responding to a draft of our report, NASA partially concurred with our recommendation for the EGS program and ML2 project to perform at least one SRA prior to beginning integrated operation activities to support the Artemis IV launch. NASA recognized our concern with the overall Artemis mission schedule risk and that EGS is an integral piece of that integrated schedule, but does not plan to conduct an SRA. Instead, NASA explained that the agency will monitor schedule risk using several tools such as annual budget requests, baseline

performance reviews, and frequent meetings between EGS and the Moon to Mars office. Further, NASA stated that schedule management and analysis, including risk aspects, is a fundamental part of EGS's ongoing program and project management approach. NASA said that in addition to regular reporting on ML2's progress to Congress, the Office of Management and Budget, and us, it plans to report on the integration schedule prior to commencement of vehicle stacking. NASA plans to complete these activities by September 30, 2027.

While the ongoing and planned activities cited by NASA are useful to manage schedule risks, an SRA would provide additional needed insight to help NASA understand the likelihood of the ML2 being ready for the Artemis IV mission. In particular, the SRA would cover both the period leading up to Bechtel's delivery of the ML2 and the EGS-led ML2 activities through the start of integrated operations. NASA has tools in place to help it understand ML2's schedule, but these tools do not consider that the overall program schedule duration may be greater than the sum of the durations of lower-level activities, which our best practices identified as one of the most important reasons for performing an SRA. While NASA policy does not require EGS and ML2 to conduct a future SRA, NASA's *Schedule Management Handbook* and our best practices tout the benefits of an SRA, such as its ability to help management prioritize risk mitigations. Given the criticality of the ML2 to the Artemis IV mission, the project's history of schedule delays, and the ongoing schedule risk, performing an EGS and ML2 SRA would provide better insight into the EGS program's and the ML2 project's ability to support the Artemis IV mission schedule. For example, it could provide additional information on the cumulative effects of the schedule risks associated with Bechtel's delivery and the EGS activities leading up to integrated operations. Without an updated understanding of the schedule impact of uncertainty and risk, NASA risks making resource decisions that are not fully informed by ML2 project readiness and the Artemis mission manifest.

We are sending copies of this report to the NASA Administrator and interested congressional committees. In addition, the report is available at no charge on the GAO website at <https://www.gao.gov>.

If you or your staff have any questions about this report, please contact me at (202) 512-4841 or russellw@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix III.



William Russell
Director, Contracting and National Security Acquisitions

Appendix I: Exploration Ground Systems Phase E Cost Estimates

The *National Aeronautics and Space Administration (NASA) Space Flight Program and Project Management Requirements* policy requires single-project programs that plan continuing operations and production with an unspecified Phase E end point, such as the Exploration Ground Systems (EGS) program, to annually update Phase E cost estimates for the next 5-year period.¹ Phase E is the operations and sustainment phase of a NASA project’s life cycle. = EGS established initial and first annual Phase E cost estimates in 2022 and 2024, respectively. In May 2022, the initial EGS Phase E cost estimate for \$2.5 billion over 5 years was approved. In February 2024, the EGS program released its first recurring cost estimate for \$3.7 billion over 7 years, which includes \$532.7 million in actuals for fiscal year 2023. Both the 2022 and 2024 estimates include construction of facilities funding, which are reported in a separate budget line to Congress.²

EGS Phase E cost estimates identify funds as general operations or construction of facilities, and further classify if funds are for (1) post-Artemis I development, (2) processing and operations, or (3) project-managed reserves. An EGS official said that the post-Artemis I development category includes software development, work in the Vehicle Assembly Building high bays, and communications work with camera upgrades, trackers, and recorders. The processing and operations category includes everything required to keep the program up and running including personnel and training costs. See table 2.

Table 2: Comparison of EGS Program’s 2022 and 2024 Phase E Cost Estimates

Fiscal years	2022	2023	2024	2025	2026	2027	2028	2029	Total
May 2022 estimates	\$510.2	\$534.3	\$518.1	\$479.7	\$459.6	n/a	n/a	n/a	\$2,501.8
General operations	446.4	496.9	507.6	466.0	449.6	n/a	n/a	n/a	2366.4
Post-Artemis I development	99.7	88.7	103.3	71.7	3.4	n/a	n/a	n/a	366.9
EGS processing and operations	336.7	388.1	384.2	374.3	426.2	n/a	n/a	n/a	1909.6
Project-managed reserves	10.0	20.0	20.0	20.0	20.0	n/a	n/a	n/a	90.0
Construction of facilities	63.8	37.4	10.5	13.7	10.0	n/a	n/a	n/a	135.4
Post-Artemis I development	30.5	8.5	Details not available	Details not available	Details not available	Details not available	Details not available	Details not available	Details not available
EGS processing and operations	33.3	28.9	Details not available	Details not available	Details not available	Details not available	Details not available	Details not available	Details not available

¹NASA, *NASA Space Flight Program and Project Management Requirements*, NASA Procedural Requirements (NPR) 7120.5F (Aug. 3, 2021) (incorporating change 3, Oct. 27, 2023).

²NASA’s construction of facilities program funds capital repairs and improvements to NASA’s infrastructure to support NASA missions. Construction of real property infrastructure or the modification of existing infrastructure above a defined dollar amount must go through the construction of facilities account. For example, construction of facilities funds are being used for EGS’s fabrication of new platforms for the Vehicle Assembly Building and new liquid nitrogen equipment at Launch Pad 39B.

Appendix I: Exploration Ground Systems Phase E Cost Estimates

Fiscal years	2022	2023	2024	2025	2026	2027	2028	2029	Total
February 2024 estimates	0a	\$532.7 ^a	\$536.6	\$569.2	\$536.7	\$551.4	509.4	499.7	\$3,735.7
General operations	0	463.2	526.0	536.8	526.7	541.4	499.4	489.7	3,583.2
Post-Artemis I development	0	98.4	82.3	77.4	49.0	79.6	3.1	2.8	392.6
EGS processing and operations	0	364.8	423.7	439.4	457.6	441.8	476.3	467.0	3,070.6
Project-managed reserves	0	0	20.0	20.0	20.0	20.0	20.0	20.0	120.0
Construction of facilities	0	69.5	10.5	32.4	10.0	10.0	10.0	10.0	152.4
Post-Artemis I development	0	30.2	10.5	11.7	0	0	0	0	52.4
EGS processing and operations	0	39.3	0	20.7	10.0	10.0	10.0	10.0	100.0

n/a = not applicable

Source: GAO analysis of NASA documentation. | GAO-25-106943

Note: Phase E is the operations and sustainment phase of a NASA project's life cycle. Costs presented are dollars in millions. Exploration Ground Systems (EGS) had additional actuals for 2022 that are not included here because they are considered development costs. The EGS program's estimates exclude Mobile Launcher 2 costs because it is a separate project that is in development and tracked separately.

^aFebruary 2024 estimates for fiscal years 2022 and 2023 represent actual costs.

Appendix II: Comments from the National Aeronautics and Space Administration

National Aeronautics and Space Administration

Mary W. Jackson NASA Headquarters
Washington, DC 20546-0001



Reply to Attn of: Exploration Systems Development Mission Directorate

Mr. W. William Russell
Director
Contracting and National Security Acquisitions
United States Government Accountability Office
Washington, DC 20548

Dear Mr. Russell:

The National Aeronautics and Space Administration (NASA) appreciates the opportunity to review and comment on the Government Accountability Office (GAO) draft report entitled, "NASA Artemis Missions: Exploration Ground Systems Program Could Strengthen Schedule Decisions" (GAO-24-106943), dated August 21, 2024.

As NASA's first crewed Artemis mission draws near, the Exploration Systems Development Mission Directorate (ESDMD) is setting out on one of humanity's boldest adventures—venturing deep into space with astronauts. NASA's dedication to this mission is immense, highlighting the Agency's pivotal role in expanding the frontiers of human exploration. As such, the Exploration Ground Systems (EGS) Program plays a crucial role in the Artemis Campaign but also a critical piece of the NASA Government infrastructure that enables integration, processing, and launch of the Space Launch System (SLS) and Orion spacecraft.

ESDMD remains dedicated to working closely with the GAO. During this specific audit, ESDMD provided 537 products, attended 21 requested meetings, and participated in 43 hours of interviews. Altogether, this activity recorded an estimated 1,110 hours of work from our ESDMD team.

ESDMD recognizes the GAO's concern with the overall Artemis mission schedule risk and that EGS is an integral piece of that integrated schedule. ESDMD reiterates that concurrent management of development projects within a single enterprise presents several significant challenges and identifying, assessing, and mitigating risks for multiple projects simultaneously requires robust risk management processes. The EGS Program employs multiple programmatic and technical indicators to effectively manage schedule performance and monitor schedule risk. Examples of these programmatic and technical indicators include, but are not limited to, cost and schedule trends, integrated master schedule, production trackers, and reviews with the prime contractor.

NASA does not share the same opinion with GAO on the value of performing an EGS Mobile Launcher 2 (ML2) schedule risk analysis (SRA) prior to beginning integrated operations. NASA employs several strategies and tools to effectively monitor schedule risk, ensuring that projects are managed proactively and adjustments are made in response to emerging challenges. These tools include project-level cost and schedule joint confidence level informed development commitments (including for major developmental upgrades); independent reviews at major life-cycle reviews and associated key decision points; documented and configuration-controlled mission definition baselines; by-mission schedule risk assessments; life-cycle cost estimates in Phase E, Operations and Sustainment; five-year rolling estimates consistent with guidance provided in NASA Procedural Requirements 7120.5F, NASA Space Flight Program and Project Management Requirements; annual budget requests; and Agency-led baseline performance reviews. There are also independent reviews by the NASA Advisory Council and Aerospace Safety Advisory Panel, as well as ongoing audits from various Governmental oversight entities. Further, NASA emphasizes the following statement from GAO's report, "Based on where the EGS program and ML2 project are in their lifecycles, NASA's Space Flight Program and Project Management Requirements policy does not require either to conduct an SRA at an upcoming milestone."

NASA prioritizes contractor performance as a fundamental element of its mission success. By upholding rigorous standards and promoting a culture of accountability, NASA ensures that projects are executed with both excellence and efficiency. The ML2 Agency Baseline Commitment (ABC) was established in June 2024 and reflects ML2's transition from the design phase to construction phase. Earlier estimates had underestimated the full scope of ML2, but this is now accurately understood with associated risks factored into NASA's latest estimate. Additionally, NASA collaborated with Bechtel National, Inc. (Bechtel) to develop and negotiate an incentive plan aimed at driving superior cost and schedule performance. Recently, Bechtel completed an important integration milestone two weeks ahead of schedule, marking a critical advancement in its construction and assembly capabilities within the Artemis Campaign. The integration of the "Jack and Set" milestone, which allowed the entire base to be weighed and the project to be deemed within anticipated weight margins, demonstrated Bechtel's ability to meet stringent technical requirements and timelines set by NASA, as well as proved the utility of the new incentive fee process. The next major milestone, the "Rig and Set," is making excellent progress and is on plan to deliver well ahead of time to support the ABC. ESDMD continues to closely monitor Bechtel's progress and remains confident in NASA's ABC to complete the ML2 by 2027.

NASA's commitment to maintain EGS cost and schedule highlights its focus on accountability, transparency, and responsible resource management. The Agency strives to stay aligned with strategic goals, manage risks effectively, and fulfill its promises to stakeholders, including the American public. This commitment fuels ongoing improvement and innovation throughout NASA's operations, guaranteeing that projects are carried out efficiently and effectively to further exploration, scientific discovery, and space exploration capabilities.

GAO makes one recommendation addressed to the NASA Administrator.

Specifically, GAO recommends the following:

Recommendation 1: The NASA Administrator, in coordination with ESDMD, should ensure that EGS Program and ML2 Project officials perform at least one SRA prior to beginning integrated operation activities to support the Artemis IV launch.

Management's Response: NASA partially concurs. NASA does not plan to conduct an SRA as defined in the report. GAO has stated there is no agency requirement to perform an SRA. NASA and ESDMD utilize multiple risk and schedule analysis instruments and instead will employ the tools described above in this letter to ensure steady, measured progress toward completion. These analyses will be used to continuously monitor the risks associated with EGS ML2 integrated operation activities, supporting the launch of Artemis IV.

Schedule management and analysis (including risk aspects) is a fundamental part of EGS's ongoing program/project management approach. The Program relies on various schedule analysis tools and reports to continuously assess schedule performance and risk, including earned value management metrics, critical/near-critical path reports, and monthly financial reporting versus progress to date in accordance with the NASA Schedule Management Handbook. Schedule accountability is managed through biweekly meetings with both the EGS Program Manager and the Moon to Mars Program Office along with quarterly stakeholder reviews. Also, the EGS Program and the prime contractor conduct weekly and monthly project reviews that include detailed metrics and trackers with the primary focus on schedule performance and interdependencies. EGS and the Moon to Mars Program Office use these activities as part of a continuous risk management effort by leadership to assess the risks associated with ML2 delivery, EGS ML2 integration activities, and ultimately Artemis IV. NASA believes these efforts meet the intent of the GAO recommendation for the EGS Program to perform regular schedule analysis.

NASA will report ML2 progress, compared with the ABC, in our regular reporting to Congress, the Office of Management and Budget, and GAO (via Quick Look). Additionally, ESDMD will provide reporting on the integration schedule prior to commencement of vehicle stacking. Current schedule milestone to begin stacking is in the third quarter of fiscal year 2027.

Estimated Completion Date: September 30, 2027.

We have reviewed the draft report for information that should not be publicly released. As a result of this review, we have not identified any information that should not be publicly released.

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Once again, thank you for the opportunity to review and comment on the subject draft report. If you have any questions or require additional information regarding this response, please contact Christine Solga at (202) 358-1238.

Sincerely,

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Date: 2024.09.30
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Catherine A. Koerner
Associate Administrator for Exploration
Systems Development Mission Directorate

Accessible Text for Appendix II: Comments from the National Aeronautics and Space Administration

National Aeronautics and Space Administration
Mary W. Jackson NASA Headquarters
Washington, DC 20546-0001

Reply to Attn of: Exploration Systems Development Mission Directorate

Mr. W. William Russell
Director
Contracting and National Security Acquisitions
United States Government Accountability Office
Washington, DC 20548

Dear Mr. Russell:

The National Aeronautics and Space Administration (NASA) appreciates the opportunity to review and comment on the Government Accountability Office (GAO) draft report entitled, "NASA Artemis Missions: Exploration Ground Systems Program Could Strengthen Schedule Decisions" (GAO-24-106943), dated August 21, 2024.

As NASA's first crewed Artemis mission draws near, the Exploration Systems Development Mission Directorate (ESDMD) is setting out on one of humanity's boldest adventures— venturing deep into space with astronauts. NASA's dedication to this mission is immense, highlighting the Agency's pivotal role in expanding the frontiers of human exploration. As such, the Exploration Ground Systems (EGS) Program plays a crucial role in the Artemis Campaign but also a critical piece of the NASA Government infrastructure that enables integration, processing, and launch of the Space Launch System (SLS) and Orion spacecraft.

ESDMD remains dedicated to working closely with the GAO. During this specific audit, ESDMD provided 537 products, attended 21 requested meetings, and participated in 43 hours of interviews. Altogether, this activity recorded an estimated 1,110 hours of work from our ESDMD team.

ESDMD recognizes the GAO's concern with the overall Artemis mission schedule risk and that EGS is an integral piece of that integrated schedule. ESDMD reiterates that concurrent management of development projects within a single enterprise presents several significant challenges and identifying, assessing, and mitigating risks for multiple projects simultaneously requires robust risk management processes. The EGS Program employs multiple programmatic and technical indicators to effectively manage schedule performance and monitor schedule risk. Examples of these programmatic and technical indicators include, but are not limited to, cost and schedule trends, integrated master schedule, production trackers, and reviews with the prime contractor.

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Sincerely,

Digitally signed by
Catherine A. Koerner
Associate Administrator for Exploration Systems
Development Mission Directorate

Date: 2024.09.30
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Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

William Russell, (202) 512-4841 or RussellW@gao.gov

Staff Acknowledgments

In addition to the contacts named above, Kristin Van Wychen (Assistant Director), Juli Steinhouse (Analyst-in-Charge), Laura Greifner, Tonya Humiston, William Laing, Jason Lee, Adie Lewis, Connor Mason, Jose A. Ramos, Sylvia Schatz, Kate Sharkey, Alyssa Weir, and Adam Wolfe made significant contributions to this report.

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