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# NASA

# Actions Needed to Improve the Management of Human Spaceflight Programs

## Accessible Version

Statement of Cristina T. Chaplain, Director, Contracting and National Security Acquisitions

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# Actions Needed to Improve the Management of Human Spaceflight Programs

Highlights of GAO-19-716T, a testimony before the Subcommittee on Space and Aeronautics, Committee on Science, Space, and Technology, House of Representatives

## Why GAO Did This Study

NASA is undertaking a trio of closely related programs to continue human space exploration beyond low-Earth orbit. These three programs include a launch vehicle, a crew capsule, and the associated ground systems at Kennedy Space Center. All three programs are working towards a launch readiness date of June 2020 for the first mission. NASA then plans for these systems to support future human space exploration goals, which include seeking to land two astronauts on the lunar surface. GAO has a body of work highlighting concerns over NASA's management and oversight of these programs.

This statement discusses (1) the cost and schedule status of NASA's human spaceflight programs and (2) lessons that NASA can apply to improve its management of its human spaceflight programs. This statement is based on eight reports issued from 2014 to 2019 and selected updates as of September 2019. For the updates, GAO analyzed recent program status reports on program progress.

## What GAO Recommends

GAO has made 19 recommendations in these eight prior reports to strengthen NASA's acquisition management of SLS, Orion, and EGS. NASA generally agreed with GAO's recommendations, and has implemented seven recommendations. Further action is needed to fully implement the remaining recommendations.

View GAO-19-716T. For more information, contact Cristina T. Chaplain at (202) 512-4841 or chaplainc@gao.gov.

## What GAO Found

The National Aeronautics and Space Administration's (NASA) three related human spaceflight programs are in the integration and test phase of development, a phase of the acquisition process that often reveals unforeseen challenges leading to cost growth and schedule delays. Since GAO last reported on the status of these programs in June 2019, each program has made progress. For example, the Orion program conducted a key test to demonstrate the ability to abort a mission should a life-threatening failure occur during launch. As GAO found in June 2019, however, the programs continue to face significant schedule delays. In November 2018, within one year of announcing an up to 19-month delay for the three programs—the Space Launch System (SLS) vehicle, the Orion crew spacecraft, and Exploration Ground Systems (EGS)—NASA senior leaders acknowledged the revised launch date of June 2020 is unlikely. In addition, any issues uncovered during integration and testing may push the date as late as June 2021. Moreover, GAO found that NASA's calculations of cost growth for the SLS program is understated by more than 750 million dollars.

**Artist Rendering of Space Launch System**

Source: National Aeronautics and Space Administration. | GAO-19-716T

GAO's past work has identified a number of lessons that NASA can apply to improve its management of its human spaceflight programs. For example, NASA should enhance contract management and oversight to improve program outcomes. NASA's past approach in this area has left it ill-positioned to identify early warning signs of impending schedule delays and cost growth or reap the benefits of competition. In addition, NASA's approach to incentivizing contractors through contract award fees did not result in desired outcomes for the SLS and Orion programs. Further, NASA should minimize risky programmatic decisions to better position programs for successful execution. This includes providing sufficient cost and schedule reserves to, among other things, address unforseen risk. Finally, realistic cost estimates and assessments of technical risk are particularly important at the start of an acquisition program. But NASA has historically provided little insight into the future cost of these human spaceflight programs, limiting the information useful to decision makers.

Chairwoman Horn, Ranking Member Babin, and Members of the Subcommittee:

I am pleased to be here today to discuss the National Aeronautics and Space Administration's (NASA) management of its human space exploration programs. These programs are developing the systems that will enable the agency to achieve its human space exploration goals, which include seeking to land two astronauts on the lunar surface as soon as 2024. The focus of my statement today is on three programs that will contribute to achieving this goal:

- The Space Launch System (SLS) program is developing a vehicle to launch a crew capsule and cargo beyond low-Earth orbit.
- The Orion Multi-Purpose Crew Vehicle (Orion) program is developing a crew capsule to transport humans beyond low-Earth orbit.
- The Exploration Ground Systems (EGS) program is developing systems and infrastructure to support assembly, test, and launch of the SLS and Orion crew capsule, and recovery of the Orion crew capsule.

Each of these programs represents a large, complex technical and programmatic endeavor and is currently in the integration and test phase of development. Our prior work has shown this phase of the acquisition process often reveals unforeseen challenges leading to cost growth and schedule delays.[1]

GAO has designated NASA's management of acquisitions as a high-risk area for almost three decades. In our March 2019 high-risk report, we reported there was a lack of transparency in NASA's major project cost

[1]GAO, *Space Launch System: Resources Need to be Matched to Requirements to Decrease Risk and Support Long Term Affordability,* GAO-14-631 (Washington, D.C.: Jul. 23, 2014); *Space Launch System: Management Tools Should Better Track to Cost and Schedule Commitments to Adequately Monitor Increasing Risk,* GAO-15-596 (Washington, D.C.: Jul. 16, 2015); and *James Webb Space Telescope: Project on Track but May Benefit from Improved Contractor Data to Better Understand Costs,* GAO-16-112 (Washington, D.C.: Dec. 17, 2015).

and schedules, especially for its human spaceflight programs.[2] We reported that the agency has not taken action on several recommendations related to understanding the long-term costs of its human exploration programs. For example, EGS and SLS do not have a cost and schedule baseline that covers activities beyond the first planned flight, and Orion does not have a baseline beyond the second planned flight. We have previously reported that without transparency into these estimates, NASA does not have the data to assess long-term affordability and it may be difficult for Congress to make informed budgetary decisions.[3] Moreover, while human spaceflight programs have inherent technical, design, and integration risks, we have consistently found that management and oversight problems are the real drivers behind program cost and schedule growth.

My statement today discusses (1) the cost and schedule status of NASA's human spaceflight programs and (2) lessons that NASA can apply to improve its management of its human spaceflight programs. This statement is based primarily on work completed from eight GAO reports issued from May 2014 through June 2019.[4] To conduct our prior work on the cost and schedule performance of these programs, we compared cost and schedule estimates that were current as of the reporting timeframes in our June 2019 report to their original cost and schedule baselines, analyzed quarterly program status reports, interviewed NASA program and headquarters officials, and reviewed program documentation. To identify lessons that can be applied to NASA's management of human spaceflight programs, we reviewed issues and recommendations made in our prior reports such as those related to approaches to managing contractors and incentivizing contractor performance, the quality of the

[2]GAO, *High Risk Series: Substantial Efforts Needed to Achieve Greater Progress on High-Risk Areas*, GAO-19-157SP (Washington, D.C.: Mar. 6, 2019).

[3]GAO, *NASA Actions Needed to Improve Transparency and Assess Long-Term Affordability of Human Exploration Programs*, GAO-14-385 (Washington, D.C.: May 8, 2014).

[4]GAO, *NASA Human Space Exploration: Persistent Delays and Cost Growth Reinforce Concerns over Management of Programs, GAO-19-377 (Washington, D.C.: Jun.19, 2019); NASA Human Space Exploration: Delay Likely for First Exploration Mission*, GAO-17-414 (Washington, D.C.: Apr. 27, 2017); *NASA Human Space Exploration: Opportunity Nears to Reassess Launch Vehicle and Ground Systems Cost and Schedule,* GAO-16-612 (Washington, D.C.: July 27, 2016); *Orion Multi-Purpose Crew Vehicle: Action Needed to Improve Visibility into Cost, Schedule, and Capacity to Resolve Technical Challenges,* GAO-16-620 (Washington, D.C.: Jul. 27, 2016); GAO-14-385; GAO-14-631; GAO-15-596; GAO-19-157SP.

cost and schedule estimates, and long-term cost estimates. Detailed information on the objectives, scope, and methodologies for that work is included in each of the reports that are cited throughout this statement. We updated the progress the programs have made with information obtained from NASA programs' quarterly reports since June 2019, where available.

We conducted the work on which this statement is based 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.

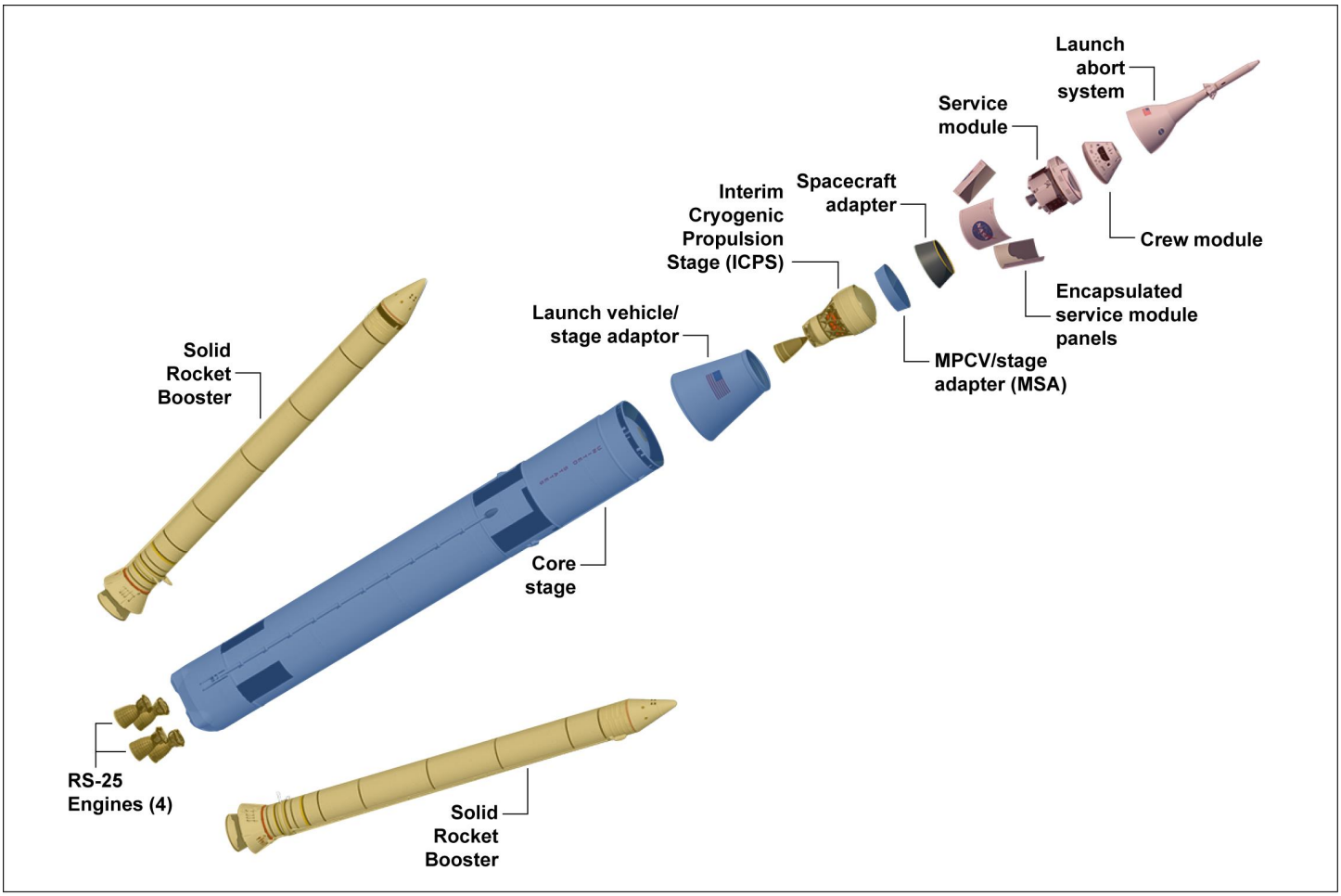
# Background

The NASA Authorization Act of 2010 directed NASA to develop SLS, to continue development of a crew vehicle, and to prepare infrastructure at Kennedy Space Center to enable processing and launch of the launch system.[5] To fulfill this direction, NASA formally established the SLS launch vehicle program in 2011. Then, in 2012, NASA aligned the requirements for the Orion program with those of the newly created SLS and EGS programs.[6] Figure 1 provides details about each SLS hardware element and its source as well as identifies the major portions of the Orion spacecraft.

[5]Pub. L. No. 111-267, §§ 302, 303, and 305.

[6]The Orion program began as part of NASA's Constellation program aimed at developing a human spaceflight system. The Constellation program was cancelled, however, in 2010 due to factors that included cost and schedule growth and funding gaps.

**Figure 1: Space Launch System and Orion Multi-Purpose Crew Vehicle Hardware**




Source: GAO analysis of National Aeronautics and Space Administration data (data and images). | GAO-19-716T

## History of Program Cost and Schedule Changes

In order to facilitate Congressional oversight and track program progress, NASA establishes an agency baseline commitment—the cost and schedule baselines against which the program may be measured—for all projects that have a total life cycle cost of $250 million or more. NASA refers to these projects as major projects or programs. When the NASA

Administrator determines that development cost growth within a major project or program is likely to exceed the development cost estimate by 15 percent or more, or a program milestone is likely to be delayed from the baseline's date by 6 months or more, NASA replans the project and submits a report to this committee—the Committee on Science, Space, and Technology of the House of Representatives—and the Committee on Commerce, Science, and Transportation of the Senate.[7] Should a major project or program exceed its development cost baseline by more than 30 percent, the program must be reauthorized by the Congress and rebaselined by NASA in order for the contractor to continue work beyond a specified time frame.[8] NASA tied the SLS and EGS program cost and schedule baselines to the uncrewed first mission—known now as Artemis-1—originally planned for November 2018. The Orion program's cost and schedule baselines are tied to a crewed second mission—known as Artemis-2—planned for April 2023.

In April 2017, we found that given combined effects of ongoing technical challenges in conjunction with limited cost and schedule reserves, it was unlikely that these three programs would achieve the originally committed November 2018 launch readiness date.[9] Cost reserves are for costs that are expected to be incurred—for instance, to address project risks—but are not yet allocated to a specific part of the project. Schedule reserves are extra time in project schedules that can be allocated to specific activities, elements, and major subsystems to mitigate delays or address unforeseen risks. We recommended that NASA confirm whether the November 2018 launch readiness date was achievable and, if warranted, propose a new, more realistic Artemis-1 date and report to Congress on the results of its schedule analysis. NASA agreed with both recommendations and stated that it was no longer in its best interest to pursue the November 2018 launch readiness date. Subsequently, NASA approved a new Artemis-1 schedule of December 2019, with 6 months of schedule reserve available to extend the date to June 2020, and revised the costs that it expects to incur (see table 1).

[7]51 U.S.C. § 30104.

[8]51 U.S.C. § 30104(e)(2), (f).

[9]GAO-17-414.

**Table 1: Human Space Exploration Program Baselines and Current Plans (costs in billions)**

| Category | Agency Baseline Commitment: Development Cost | Agency Baseline Commitment: Launch Date | Replan (December 2017): Development Cost | Replan (December 2017): Launch Date | Development percentage cost growth | Delay (Months) |
|---|---|---|---|---|---|---|
| Space Launch System | $7.021 | November 2018 Artemis-1 | $7.169 | December 2019–June 2020 Artemis-1 | 2.1% | 13-19 |
| Exploration Ground Systems | $1.843 | November 2018 Artemis-1 | $2.265 | December 2019-June 2020 Artemis-1 | 22.9% | 13-19 |
| Orion Multi-Purpose Crew Vehicle | $6.768 | April 2023 Artemis-2 | Not applicable because Orion's performance is measured to Artemis-2. | Not applicable because Orion's performance is measured to Artemis-2. | Not applicable because Orion's performance is measured to Artemis-2. | |

Source: GAO presentation of National Aeronautics and Space Administration data. | GAO-19-716T

# Cost and Schedule Status of NASA's Human Spaceflight Programs

In June 2019, we found that within 1 year of announcing a delay for the first human spaceflight mission, senior NASA officials acknowledged that the revised Artemis-1 launch date of December 2019 was unachievable and the June 2020 launch date (which takes into account schedule reserves) was unlikely.[10] These officials estimated that there were 6 to 12 months of schedule risk associated with this later date, which means the first launch may occur as late as June 2021 if all risks are realized. As we found in June 2019, this would be a 31-month delay from the schedule originally established in the programs' baselines. Officials attributed the additional schedule delay to continued production challenges with the SLS core stage and the Orion crew and service modules. NASA officials also stated that the 6 to 12 months of risk to the launch date accounts for the possibilities that SLS and Orion testing and final cross-program integration and testing at Kennedy Space Center may result in further delays. As we noted in our report, these 6 to 12 months of schedule risk do not include the effects, if any, of the federal government shutdown that occurred in December 2018 and January 2019.

[10]GAO-19-377.

In commenting on our June 2019 report, NASA stated that its Lunar 2024 planning activities would include an Artemis-1 schedule assessment.[11] However, in July 2019, NASA reassigned its senior leaders responsible for human spaceflight programs. The NASA Administrator stated in August 2019 that, as a result, the agency does not plan to finalize schedule plans for Artemis-1 until new leadership is in place at the agency. Additional details follow on the status of each program, including cost, schedule, and technical challenges.

**SLS.** As we found in June 2019, ongoing development issues with the SLS core stage—which includes four main engines and the software necessary to command and control the vehicle—contributed to the SLS program not being able to meet the June 2020 launch date.[12] Officials from the SLS program and Boeing, the contractor responsible for building the core stage, provided several reasons for the delays. These reasons include the underestimation of the complexity of manufacturing and assembling the core stage engine section—where the RS-25 engines are mated to the core stage—and those activities have taken far longer than expected.

Since our June 2019 report, based on our review of the program's most recent status reports, NASA has reported progress across many parts of the SLS program. For example, NASA has delivered the four RS-25 engines to Michoud Assembly Facility. NASA has also completed qualification testing of all components of the boosters and reports that there is schedule margin remaining for the booster deliverables. In addition, NASA reports that Boeing has made continued progress and expects that the core stage will be complete and ready for testing in December 2019. Completion of the core stage will represent a significant milestone for the program.

In June 2019, we found that that SLS program has been underreporting its development cost growth since the December 2017 replan.[13] This underreporting is because of a decision to shift some costs to future missions while not adjusting the baseline costs downward to reflect this shift. The SLS development cost baseline established in August 2014 for

[11]GAO-19-377.

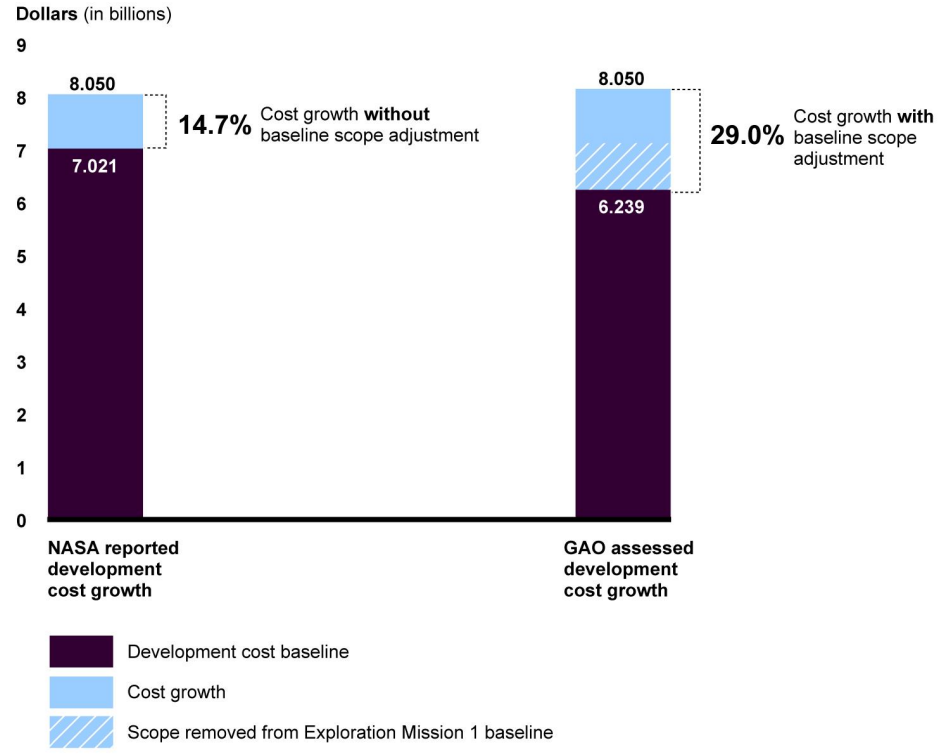
[12]GAO-19-377.

[13]GAO-19-377.

Artemis-1 includes cost estimates for the main vehicle elements—stages, liquid engines, boosters—and other areas. According to program officials, because of the December 2017 replan process, NASA decided that costs included as part of the SLS Artemis-1 baseline cost estimate would be more appropriately accounted for as costs for future flights. Thus, NASA decided not to include those costs, approximately $782 million, as part of the revised SLS Artemis-1 cost estimate. However, NASA did not lower the $7 billion SLS development cost baseline to account for this significant change in assumptions and shifting of costs to future flights.

This decision presents challenges in accurately reporting SLS cost growth over time. NASA's decision not to adjust the cost baseline downward to reflect the reduced mission scope obscures cost growth for Artemis-1. In June 2019, we found that NASA's cost estimate as of fourth quarter fiscal year 2018 for the SLS program indicated development cost growth had increased by $1 billion, or 14.7 percent. However, our analysis showed that development cost growth actually increased by $1.8 billion or 29.0 percent, when the development baseline is lowered to account for the reduced mission scope. Essentially, NASA is holding the baseline costs steady, while reducing the scope of work included in current cost estimates (see figure 2). As NASA determines its new schedule for the first mission, it is likely this cost growth will increase as additional time in the schedule leads to additional costs.

**Figure 2: NASA's Reported Development Cost Growth for Space Launch System Compared to GAO's Assessed Development Cost Growth, as of September 2018**




Source: GAO analysis of National Aeronautics and Space Administration data. | GAO-19-716T

**Accessible Data for Figure 2: NASA's Reported Development Cost Growth for Space Launch System Compared to GAO's Assessed Development Cost Growth, as of September 2018**

| Category | Development cost baseline (dollars, in billions) | Cost growth (in percent) | Scope removed from baseline |
|---|---|---|---|
| NASA reported development cost growth | 7.021 | 14.7 | |
| GAO assessed development cost growth | 6.239 | 29.0 | 1.029 |

In our June 2019 report, we recommended that the SLS program calculate its development cost growth using a baseline that is appropriately adjusted for scope and costs NASA has determined are not

associated with the first flight, and determine if the development cost growth has increased by 30 percent or more. NASA agreed with the recommendation and NASA officials stated that they plan to implement the recommendation when new leadership is in place for the human space exploration programs.

Looking ahead, based on our review of the program's most recent status reports, completing core stage manufacturing and integration and green run testing will be the critical path—the path of longest duration through the sequence of activities in the schedule—for the SLS program. During green run testing, NASA will fuel the completed core stage with liquid hydrogen and liquid oxygen and fire the integrated four main engines for about 500 seconds. The green run test carries risks because it is the first time that several things are being done beyond just this initial fueling. For example, it is also the first time NASA will fire the four main engines together, test the integrated engine and core stage auxiliary power units in flight-like conditions, and use the SLS software in an integrated flight vehicle. In addition, NASA will conduct the test on the Artemis-1 flight vehicle hardware, which means the program would have to repair any damage from the test before flight.

**Orion.** While the Orion program's schedule performance is measured only to the Artemis-2 mission, we found in June 2019 that the program was not on schedule to support the June 2020 launch date for the first mission.[14] This was due to delays with the European Service Module and component issues for the avionics systems for the crew module, including issues discovered during testing. We found that these specific problems were resolved by the time of our report, but had already contributed to the inability of the program to meet the June 2020 launch date. Since we last reported, as of August 2019, the Orion program has completed significant events including completing the crew module and the service module prior to integration and conducting a test to demonstrate the ability to abort a mission should a life-threatening failure occur during launch. The program is tracking no earlier than October 2020 for an Artemis-1 launch date but that does not reflect the ongoing agency-wide schedule assessment noted above.

In June 2019, we found that the Orion program has reported development cost growth but is not measuring that growth using a complete cost

[14]GAO-19-377.

estimate.[15] In summer 2018, the Orion program reported development cost growth of $379 million, or 5.6 percent above its $6.768 billion development cost estimate. Program officials explained that the major drivers of this cost growth were the slip of the Artemis-1 launch date, which reflected delays in the delivery of the service module; Orion contractor underperformance; and NASA-directed scope increase.

However, during our review, Orion program officials originally stated that this cost estimate assumes an Artemis-2 launch date of September 2022, which is 7 months earlier than the program's agency baseline commitment date of April 2023 that forms the basis for commitments between NASA, the Congress, and Office of Management and Budget. Subsequently, during the review, program officials told us that its cost projections fund one of those 7 months. In either case, NASA's current cost estimate for the Orion program is not complete because it does not account for costs that NASA would incur through April 2023. As of September 2019, the program was targeting October 2022 for the Artemis-2 launch.

In June 2019, we recommended that the Orion program update its cost estimate to reflect its committed Artemis-2 baseline date of April 2023.[16] In its response, NASA partially agreed with our recommendation. NASA stated that providing the estimate to the forecasted launch date—September 2022—rather than to the committed baseline date of April 2023 is the most appropriate approach. However, by developing cost estimates only to the program's goals and not relative to the established baseline, the Orion program is not providing NASA or the Congress the means of measuring progress relative to the baseline. We continue to believe that NASA should fully implement this recommendation.

Looking ahead, based on our review of the program's most recent status reports, there is an emerging issue that may delay schedule further for the first mission. Namely, there is the risk of damage to the Orion capsule during travel to and from integrated testing at Plum Brook Station in Ohio. The program office is studying whether it will be able to safely transport the integrated crew and service modules via the Super Guppy airplane as planned or if it will have to use an alternate airplane. We will continue to monitor this effort.

[15]GAO-19-377.

[16]GAO-19-377.

Beyond Artemis-1, the Orion program must also complete development efforts for future missions. For example, the Artemis-2 crew module will need environmental control and life support systems, system updates from Artemis-1, and updated software to run these new elements.

**EGS.** At the time of our June 2019 report, the EGS program was expecting to have facilities and software ready by the planned June 2020 launch date.[17] We found that the program had overcome many challenging development hurdles that led to previous schedule delays. These hurdles included completing and moving the Mobile Launcher—a platform that carries the rocket to the launch pad and includes a number of connection lines that provide SLS and Orion with power, communications, coolant, fuel, and stabilization prior to launch—into the Vehicle Assembly Building for the multi-element verification and validation processes. Since our June 2019 report, the program is now targeting an Artemis-1 launch date of August 2020. According to NASA officials, the delay is primarily driven by challenges encountered installing ground support equipment on the Mobile Launcher and developing software, and does not reflect the ongoing agency-wide schedule assessment. The program has operated within the costs established for the June 2020 launch date, $3.2 billion, but officials stated that NASA is reevaluating the program's development cost performance and will establish an updated baseline when new leadership is in place.

Moving forward, based on our review of the program's most recent status reports, the program has to complete the multi-element verification and validation process for the Mobile Launcher and Vehicle Assembly Building and complete its two software development efforts. Additionally, the EGS program is responsible for the final integration of the three programs. NASA officials stated that the 6 to 12 months of risk to the June 2020 launch date includes risk associated with EGS completing this integration that includes test and checkout procedures after SLS and Orion components arrive. Officials explained that the EGS risk is based on a schedule risk analysis that considered factors such as historical pre-launch integrated test and check out delays and the learning curve associated with a new vehicle. As previously stated, our prior work has shown that the integration and test phase often reveals unforeseen challenges leading to cost growth and schedule delays.

[17]GAO-19-377.

# Lessons that NASA Can Apply to Better Manage its Human Spaceflight Acquisitions

NASA is currently embarking on an aggressive goal to return humans to the lunar surface in 2024. To achieve this goal, NASA not only needs SLS, Orion, and EGS to have completed their first two test missions, but is also developing several new systems. These new systems include a Lunar Gateway that will orbit the moon, landers that will transport astronauts from the Gateway to the lunar surface, and new space suits.

Human spaceflight projects face inherent technical, design, and integration risks because they are complex, specialized, and are pushing the state of the art in space technology. Moreover, these programs can be very costly and span many years, which means they may also face changes in direction from Administrations and the Congress. Meeting the 2024 goal will also be challenging given the effort needed to better manage SLS, Orion, and EGS, coupled with the addition of the new programs, which are likely to compete for management attention and resources. Nevertheless, our past work has identified a range of actions that NASA can take to better position its human spaceflight programs for success.

Today I would like to highlight three lessons from the SLS, Orion, and EGS programs that NASA can apply to improve the management of its human spaceflight programs.

**Enhance Contract Management and Oversight to Improve Program Outcomes.** Over the past several years, we and the NASA Office of the Inspector General have identified shortcomings related to NASA's management and oversight of its human spaceflight contracts. These shortcomings have left NASA ill-positioned to identify early warning signs of impending schedule delays and cost growth, reap the potential benefits of competition, and achieve desired results through contractor incentives.

- In July 2014, we found that NASA allowed high-value modifications to the SLS contracts to remain undefinitized for extended periods—in one instance a modification remained undefinitized for 30 months.[18] Undefinitized contract actions such as these authorize contractors to

[18]GAO-14-631.

begin work before reaching a final agreement with the government on terms and conditions. We have previously found that while undefinitized contract actions may be necessary under certain circumstances, they are considered risky in part because the government may incur unnecessary costs if requirements change before the contract action is definitized.[19] Because lack of agreement on terms of the modification prolonged NASA's timeframes for definitizing, the establishment of contractor cost and schedule baselines necessary to monitor performance was delayed. Specifically, we found in July 2014 that, in most cases, the SLS program did not receive complete earned value management data derived from approved baselines on these SLS contracts. Earned value, or the planned cost of completed work and work in progress, can provide accurate assessments of project progress, produce early warning signs of impending schedule delays and cost overruns, and provide unbiased estimates of anticipated costs at completion.[20]

- In July 2014, we also found the SLS program could be in a favorable position to compete contracts for the exploration upper stage, the upper stage engine, and advanced boosters that it expected to use on future variants of the launch vehicle.[21] At that time, except for the RS-25 engines, NASA's contracting approach for the SLS program did not commit the program beyond the hardware needed for the second mission, and we found that moving forward the agency would be in a position to take advantage of the evolving launch vehicle market. We found that an updated assessment of the launch vehicle market could better position NASA to sustain competition, control costs, and better inform the Congress about the long-term affordability of the program. We recommended that before finalizing acquisition plans for future capability variants, NASA should assess the full range of competition opportunities and provide to the Congress the agency's assessment of the extent to which development and production of future elements of the SLS could be competitively procured. NASA agreed with the

[19]GAO, *Missile Defense: The Warfighter and Decision Makers Would Benefit from Better Communication About the System's Capabilities and Limitations,* GAO-18-324 (Washington, D.C.: May 30, 2018).

[20]GAO-14-631.

[21]GA-14-631.

recommendation, which we have identified as among those that warrant priority attention.[22]

Since we made that recommendation, NASA has awarded a sole-source contract for the upper stage engine and agency officials told us in July 2018 that they planned to incorporate additional booster development under the existing contract. This further limits an opportunity for competition for the program. Our body of work on contracting has shown that competition in contracting is a key element for achieving the best return on investment for taxpayers.[23] We have found that promoting competition increases the potential for acquiring quality goods and services at a lower price and that noncompetitive contracts carry the risk of overspending because, among other reasons, they have been negotiated without the benefit of competition to help establish pricing.

- In July 2016, we found that the lack of earned value management data for the SLS Boeing core stage contract persisted.[24] Without this information, some 4.5 years after contract award, the program continued to be in a poor position to understand the extent to which technical challenges with the core stage were having schedule implications or the extent to which they may have required reaching into the program's cost reserves.
- In October 2018, the NASA Office of Inspector General reported that NASA does not require Boeing to report detailed information on development costs for the two core stages and exploration upper stage, making it difficult for the agency to determine if the contractor is

[22]We send letters each year to the heads of key departments and agencies, including NASA, that give the overall status of the department's or agency's implementation of our recommendations and identify open recommendations that should be a priority for implementation. In April 2019, we sent the Administrator of NASA this year's letter, which identified nine recommendations as being a priority for implementation. See GAO, *Priority Open Recommendations: National Aeronautics and Space Administration*, GAO-19-424SP (Washington, D.C.: Apr. 12, 2019).

[23]See, for example, GAO, *Federal Contracting: Noncompetitive Contracts Based on Urgency Need Additional Oversight*, GAO-14-304 (Washington, D.C.: Mar. 26, 2014); *Defense Contracting: Actions Needed to Increase Competition*, GAO-13-325 (Washington, D.C.: Mar. 28, 2013); and *Federal Contracting: Opportunities Exist to Increase Competition and Assess Reasons When Only One Offer Is Received*, GAO-10-833 (Washington, D.C.: Jul. 26, 2010).

[24]GAO-16-612.

meeting cost and schedule commitments for each deliverable.[25] The NASA Office of Inspector General found that given the cost-reporting structure, the agency is unable to determine the cost of a single core stage. Internally, Boeing tracks all individual costs but submits a combined statement of labor hours and material costs through the one contract line item for all its development activities. NASA approximates costs based on numerous monthly and quarterly reviews with the contractor to track the progress of each individual deliverable. The NASA Office of Inspector General made a number of recommendations aimed at improving reporting relative to the core stage contract. Among these was a specific recommendation to separate each deliverable into its own contract line item number for tracking performance, cost, and award fees. NASA concurred with this recommendation and is currently renegotiating the core stage contract with Boeing.

- In June 2019, we found that NASA's approach to incentivizing Boeing for the SLS stages and Lockheed Martin for the Orion crew spacecraft have not always achieved overall desired program outcomes.[26] NASA paid over $200 million in award fees from 2014-2018 related to contractor performance on the SLS stages and Orion spacecraft contracts, but the programs continue to fall behind schedule and incur cost overruns. For example, in its December 2018 award fee letter to Boeing in which the contractor earned over $17 million in award fees, NASA's fee determination official noted that the significant schedule delays on this contract have caused NASA to restructure the flight manifest for SLS. For the Lockheed Martin Orion contract, the contractor earned over $29 million for the award fee period ending April 2017. NASA noted that Lockheed Martin was not able to maintain its schedule for the crew service module and that the contractor's schedule performance had decreased significantly over the previous year.

  In June 2019, we reported that our past work shows that when incentive contracts are properly structured, the contractor has profit motive to keep costs low, deliver a product on time, and make decisions that help ensure the quality of the product. Our prior work also shows, however, that incentives are not always effective tools for achieving desired acquisition outcomes. We have found that, in some

[25]NASA Office of Inspector General, NASA's Management of the Space Launch System Stages Contract, IG-19-001 (Washington, D.C.: Oct. 10, 2018).

[26]GAO-19-377.

cases, there are significant disconnects between contractor performance for which the contractor was awarded the majority of award fees possible without achieving desired program results. Additionally, we have found that some agencies did not have methods, data, or performance measures to evaluate the effectiveness of award fees.[27]

As part of our June 2019 report, we recommended that NASA direct the SLS and Orion programs to reevaluate their strategies for incentivizing contractors and determine whether they could more effectively incentivize contractors to achieve the outcomes intended as part of ongoing and planned contract negotiations.[28] NASA agreed with the intent of this recommendation and stated that the SLS and Orion program offices reevaluate their strategies for incentivizing contract performance as part of contracting activities including contract restructures, contract baseline adjustments, and new contract actions. We will continue to follow-up on the actions the agency is taking to address this recommendation after its ongoing contract negotiations are complete.

**Minimize Risky Programmatic Decisions to Better Position Programs for Successful Execution.** Through our reviews of NASA's human spaceflight programs, we have found that NASA leadership has approved programmatic decisions that compound technical challenges. These decisions include approving cost and schedule baselines that do not follow best practices, establishing insufficient cost and schedule reserves, and operating under aggressive schedules.[29] As a result, these programs have been at risk of cost growth and schedule delays since NASA approved their baselines.

- In July 2015, we found that NASA generally followed best practices in preparing the SLS cost and schedule baseline estimates for the

[27]GAO, *Defense Acquisitions: DOD Has Paid Billions in Award and Incentive Fees Regardless of Acquisition Outcomes*, GAO-06-66 (Washington, D.C.: Dec. 19, 2005); *NASA Procurement: Use of Award Fees for Achieving Program Outcomes Should Be Improved*, GAO-07-58 (Washington, D.C.: Jan. 17, 2007); and *Federal Contracting: Guidance on Award Fees Has Led to Better Practices but Is Not Consistently Applied*, GAO-09-630 (Washington, D.C.: May 29, 2009).

[28]GAO-19-377.

[29]GAO-15-596; GAO-16-620; GAO-16-612.

limited portion of the program life cycle covered through launch readiness for the first test flight of SLS. However, we could not deem the cost estimate fully reliable because it did not fully meet the credibility best practice.[30] While an independent NASA office reviewed the cost estimate developed by the program and as a result the program made some adjustments, officials did not commission the development of a separate independent cost estimate to compare to the program cost estimate to identify areas of discrepancy or difference. In addition, the program did not cross-check its cost estimate using an alternative methodology. The purpose of developing a separate independent cost estimate and cross-checking the estimate is to test the program's cost estimate for reasonableness and, ultimately, to validate the cost estimate.

- In July 2016, we found that the Orion program's cost and schedule estimates were not reliable based on best practices for producing high-quality estimates.[31] For example, the cost estimate lacked necessary support and the schedule estimate did not include the level of detail required for high-quality estimates. Therefore, we recommended that NASA perform an updated joint cost and schedule confidence level analysis including updating cost and schedule estimates in adherence with cost and schedule estimating best practices, which we have identified as among those recommendations that warrant priority.[32] NASA officials have stated that they have no plans to implement our recommendation. In commenting on the July 2016 report, NASA stated that the agency reviewed, in detail, the Orion integrated cost/schedule and risk analysis methodology and determined the rigor to be a sufficient basis for the agency commitments. However, without sound cost and schedule estimates, decision makers do not have a clear understanding of the cost and schedule risk inherent in the program or important information needed to make programmatic decisions. We continue to believe that NASA should fully implement our recommendation.

[30]GAO-15-596. A credible cost estimate is one that discusses any limitations of the analysis from uncertainty or biases surrounding data or assumptions.

[31]GAO-16-620.

[32]A joint cost and schedule confidence level analysis produces a point-in-time estimate that includes, among other things, all cost and schedule elements from concept and technology development through launch, incorporates and quantifies known risks, assesses the effects of cost and schedule to date on the estimate, and addresses available annual resources.

- In our 2017 High-Risk Report, we highlighted concerns that all three programs—SLS, Orion, and EGS—were operating with limited cost reserves, limiting each program's ability to address risks and unforeseen technical challenges.[33] For example, we found in July 2016 that the Orion program was planning to maintain low levels of cost reserves until later in the program.[34] The lack of cost reserves at that time had caused the program to defer work to address technical issues to stay within budget.
- Also in our 2017 High-Risk Report, we highlighted concerns regarding each program managing to an aggressive internal NASA launch readiness date. This approach creates an environment for programs to make decisions based on reduced knowledge to meet a date that is not realistic.[35] For example, the EGS program had consolidated future schedule activities to prepare the Mobile Launcher—the vehicle used to bring SLS to the launch pad—to meet its internal goal. The program acknowledged that consolidating activities—which included conducting verification and validation concurrent with installation activities—increased risk because of uncertainties about how systems not yet installed may affect the systems already installed. Officials added, however, that this concurrency is necessary to meet the internal schedule. Subsequently, as discussed above, NASA delayed its committed launch readiness date.

**Improve Transparency into Costs for Long-term Plans.** As we previously reported, a key best practice for development efforts is that requirements need to be matched to resources (for example, time, money, and people) at program start.[36] In the past, we have found that NASA programs, including the Constellation Program, did not have sufficient funding to match demanding requirements.[37] Funding gaps can cause programs to delay or delete important activities and thereby increase risks.

[33]GAO, *High-Risk Series: Progress on Many High-Risk Areas, While Substantial Efforts Needed on Others*, GAO-17-317 (Washington, D.C.: Feb. 15, 2017).

[34]GAO-16-612.

[35]GAO-17-317.

[36]GAO, *U.S. Launch Enterprise: Acquisition Best Practices Can Benefit Future Efforts*, GAO-14-776T (Washington, D.C: July 16, 2014).

[37]GAO, *NASA: Constellation Program Cost and Schedule Will Remain Uncertain Until a Sound Business Case Is Established,* GAO-09-844 (Washington, D.C.: Aug. 26, 2009) and GAO-14-385.

In addition, since May 2014, we have found there has been a lack of transparency into the long-term costs of these human spaceflight programs.[38] As discussed above, the EGS and SLS programs do not have a cost and schedule baseline that covers activities beyond the first planned flight. In addition, as previously noted, the Orion program does not have a baseline beyond the second planned flight. As a result, NASA is now committing to spend billions of taxpayer dollars for missions that do not have a cost and schedule baseline against which to assess progress.

To that end, we have made recommendations in the past on the need for NASA to baseline these programs' costs for capabilities beyond the first mission; however, a significant amount of time has passed without NASA taking steps to fully implement these recommendations. Specifically, among those recommendations that we have identified as warranting priority attention, in May 2014, we recommended that, to provide Congress with the necessary insight into program affordability, ensure its ability to effectively monitor total program costs and execution, and to facilitate investment decisions, NASA should:

- Establish a separate cost and schedule baseline for work required to support the SLS for the second mission and report this information to the Congress through NASA's annual budget submission. If NASA decides to fly the SLS configuration used in the second mission beyond that mission, we recommended that it establish separate life cycle cost and schedule baseline estimates for those efforts, to include funding for operations and sustainment, and report this information annually to Congress via the agency's budget submission.
- Establish separate cost and schedule baselines for each additional capability that encompass all life cycle costs, to include operations and sustainment. This is important because NASA intends to use the increased capabilities of the SLS, Orion, and EGS well into the future.

As part of the latter recommendation, we stated that, when NASA could not fully specify costs due to lack of well-defined missions or flight manifests, the agency instead should forecast a cost estimate range—including life cycle costs—having minimum and maximum boundaries and

[38]GAO-14-385.

report these baselines or ranges annually to Congress via the agency's budget submission.[39]

In its comments on our 2014 report, NASA partially concurred with these two recommendations, noting that much of what it had already done or expected to do would address them.[40] For example, the agency stated that establishing the three programs as separate efforts with individual cost and schedule commitments met the intent of our recommendation. NASA also stated that its plans to track and report development, operations, and sustainment costs in its budget to Congress as the capabilities evolved would also meet the intent of the recommendation. In our response, we stated that while NASA's prior establishment of three separate programs lends some insight into expected costs and schedule at the broader program level, it does not meet the intent of the two recommendations because cost and schedule identified at that level is unlikely to provide the detail necessary to monitor the progress of each block against a baseline. Further, we stated that reporting the costs via the budget process alone will not provide information about potential costs over the long term because budget requests neither offer all the same information as life-cycle cost estimates nor serve the same purpose. Life-cycle cost estimates establish a full accounting of all program costs for planning, procurement, operations and maintenance, and disposal and provide a long-term means to measure progress over a program's life span.[41] We continue to believe that NASA should fully implement these recommendations.

As NASA considers these lessons, it is important that the programs place a high priority on quality, for example, holding suppliers accountable to deliver high-quality parts for their products through such activities as regular supplier audits and performance evaluations of quality and delivery. As we found in June 2019, both the SLS and Orion programs have struggled at times with the quality of parts and components.[42] For example, the Orion contractor has had a number of issues with subcontractor-supplied avionics system components failing during testing

[39]GAO-14-385.

[40]GAO-14-385.

[41]GAO, *Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, GAO-09-3SP (Washington, D.C.: March 2009).

[42]GAO-19-377.

that have required time to address. NASA has highlighted concerns over the contractor's ability to manage its subcontractors and the resulting significant cost, schedule, and technical risk impacts to the program. And the SLS program faced setbacks after its contractor did not verify the processes that its vendors were using to clean the fuel lines, resulting in delays to resolve residue and debris issues.

Chairwoman Horn, Ranking Member Babin, and Members of the Subcommittee, this completes my prepared statement. I would be pleased to respond to any question that you may have at this time.

## GAO Contact and Staff Acknowledgments

If you or your staff have any questions about this testimony, please contact Cristina T. Chaplain, Director, Contracting and National Security Acquisitions at (202) 512-4841 or chaplainc@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this statement. GAO staff who made key contributions to this statement include Molly Traci, Assistant Director; John Warren; Sylvia Schatz; Ryan Stott; and Chad Johnson.

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