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NASA

Human Space Exploration Programs Face Challenges

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GAO Highlights

Highlights of GAO-15-248T, a testimony before the Subcommittee on Space, 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: the SLS vehicle; the Orion capsule, which will launch atop the SLS and carry astronauts; and GSDO, the supporting ground systems. As a whole, the efforts represent NASA's largest exploration investment over the next decade, approaching $23 billion, to demonstrate initial capabilities.

In May 2014, GAO found that NASA's preliminary life-cycle cost estimates for human exploration were incomplete and recommended that NASA establish life-cycle cost and schedule baselines for each upgraded block of SLS, Orion, and GSDO; NASA partially concurred. In July 2014, GAO issued a report on SLS's progress toward its first test flight and recommended that NASA match SLS's resources to its requirements and define specific missions beyond the second test flight, among other actions. NASA concurred with these recommendations.

This testimony is based on GAO's May 2014 report (GAO-14-385), July 2014 report (GAO-14-631), and ongoing audit work related to SLS and Orion. It discusses NASA's efforts to match resources to requirements for the SLS program and developmental challenges facing the SLS and Orion programs. To conduct this work, GAO reviewed relevant design, development, cost, and schedule documents and interviewed program officials.

View GAO-15-248T. For more information, contact Cristina T. Chaplain at (202) 512-4841 or chaplainc@gao.gov.

What GAO Found

In 2014, GAO reported on a number of issues related to the National Aeronautics and Space Administration's (NASA) human exploration programs: the Space Launch System (SLS) vehicle, the Orion Multi-Purpose Crew Vehicle (Orion), and the Ground Systems Development and Operations (GSDO). For example, in July 2014, GAO found that NASA had not matched resources to requirements for the SLS program and was pursuing an aggressive development schedule—a situation compounded by the agency's reluctance to request funding commensurate with the program's needs. In August 2014, NASA established formal cost and schedule baselines for the SLS program at the agency-required 70 percent joint cost and schedule confidence level (JCL), which satisfied one recommendation from GAO's July 2014 report. The JCL is a calculation NASA uses to estimate the probable success of a program meeting its cost and schedule targets. To satisfy the 70 percent JCL requirement, the SLS program delayed its committed launch readiness date for its first test flight from December 2017 to November 2018. The program is still pursuing December 2017 as an internal goal, or target date, for the test flight, even though NASA calculated the JCL associated with launching SLS on this date at 30 percent. Moreover, neither the Orion nor GSDO program expects to be ready for the December 2017 launch date. With these programs likely unable to meet the December 2017 date, NASA risks exhausting limited human exploration resources to achieve an accelerated SLS program schedule when those resources may be needed to resolve challenges on other human exploration programs.

NASA's Target and Baseline Launch Readiness Dates and Associated Confidence Levels for Human Space Exploration Programs

	Target date	Confidence level for target date	Committed date	Confidence level for committed date
Space Launch System	December 2017	30%	November 2018	70%
Ground Systems Development and Operations	June 2018	30%	November 2018	80%
Orion Multi-Purpose Crew Vehicle[a]	TBD	TBD	TBD	TBD

Source: GAO analysis of NASA data. | GAO-15-248T

[a]Orion has yet to establish formal cost and schedule baseline commitments.

In addition, GAO's ongoing work has found that the Orion program is facing significant technical and funding issues. Orion just completed its first test flight, and data from this flight is required to address several risks that must be resolved before the second test flight in 2021 because they represent risks to crew safety. For example, during parachute testing, NASA discovered that when only two of the three main parachutes are deployed, they begin to swing past each other creating a "pendulum" effect. This effect could cause the capsule to increase speed and to hit the water at an angle that may damage the capsule, thereby endangering the crew. In addition, data from the test is necessary to inform NASA's design solution to address heat shield cracking issues, which NASA has been working to resolve since August 2013. The heat shield is integral to crew safety during re-entry.

Chairman Palazzo, Ranking Member Edwards, and Members of the Subcommittee:

I am pleased to be here today to discuss our work on the Space Launch System (SLS) and National Aeronautics and Space Administration's (NASA) other human exploration programs. SLS is NASA's first exploration-class launch vehicle in over 40 years. It is being developed to launch astronauts and carry cargo into space, beyond low-Earth orbit. SLS progress cannot be fully discussed without considering the progress of the Orion Multi-Purpose Crew Vehicle (Orion) and Ground Systems Development and Operations (GSDO) programs. The Orion program is developing a capsule that will launch atop the SLS and carry the astronauts, and the GSDO program is developing systems and infrastructure to support such activities as assembly, test, and launch of the SLS and Orion. As a whole, these efforts may cost nearly $23 billion to demonstrate initial capabilities, including the first planned SLS flight in 2018, the ground systems for that effort, and the first two Orion flights currently planned for fiscal years 2018 and 2021. This amount represents a significant portion of NASA's planned budget for major projects during that period and also a significant portion of government-wide launch-related research and development funding. As we have reported, any cost or schedule overrun on NASA's largest, most complex projects—including SLS, Orion, and GSDO—could have a ripple effect on the portfolio and has the potential to postpone, or even cancel altogether, projects in earlier development stages.[1] Given the expensive nature of developing space systems for human exploration, in today's constrained government budget environment, it is essential that NASA manage the acquisition of these systems as efficiently and effectively as possible.

GAO has designated NASA's management of acquisitions as a high-risk area for more than two decades in view of persistent cost growth and schedule slippage in the majority of its major projects. NASA's attempts to develop systems capable of transporting humans to space since the development of the Space Shuttle have been unsuccessful. For example, prior development programs, the most recent being the Constellation program, were canceled in the face of acquisition problems and funding-related issues. While the agency has made progress in recent years in

[1]GAO, *NASA: Assessment of Large Scale Projects*, GAO-14-338SP (Washington, D.C.: Apr. 15, 2014).

reducing risk on smaller-scale, less complex projects, demonstrating that this progress can be translated to larger, more complex projects, such as SLS and Orion, is more challenging yet exceedingly important.

We recently issued two reports on NASA's current human exploration program.[2] In addition, we regularly review SLS and Orion as part of our annual review of major NASA programs and projects.[3] My remarks today are based on these reports and our ongoing work. Specifically, I will discuss NASA's efforts to establish baselines for the SLS program based on matching cost and schedule resources to requirements, developmental challenges facing the SLS and Orion programs, and shortcomings in NASA's planning and cost estimates for the SLS, Orion, and GSDO programs. To conduct this work, we reviewed relevant design, development, cost, and schedule documents; interviewed program officials; and evaluated SLS and Orion program actions using acquisition and cost estimating best practices. More information on our scope and methodology is available in our related GAO products.

The work that supports this statement was performed 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.

Summary

In 2014, we found that NASA had not matched cost and schedule resources to requirements for the SLS program and was pursuing an aggressive development schedule. This situation, in turn, was compounded by the agency's reluctance to request funding in line with

[2]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.; July 23, 2014); and *NASA: Actions Needed to Improve Transparency and Assess Long-Term Affordability of Human Exploration Programs*, GAO-14-385 (Washington, D.C.: May 8, 2014) .

[3]The explanatory statement of the House Committee on Appropriations accompanying the Omnibus Appropriations Act, 2009 required GAO to prepare project status reports on selected large-scale NASA programs, projects, or activities. 155 Cong. Rec. H1653, 1824-25 (daily ed., Feb. 23, 2009).

the program's needs. In addition, we found that the agency's preliminary life-cycle cost estimates for human exploration were incomplete. Based on these findings, in July 2014, we recommended, among other things, that NASA develop baselines for SLS that match cost and schedule resources to requirements and result in a level of risk in line with its policies as well as develop improved life-cycle cost estimates. NASA concurred with our findings and recommendations. In August 2014, NASA completed the review of the SLS program that sets formal cost and schedule baselines and, in doing so, delayed the first test flight to relieve schedule pressure and allow additional time to address design challenges. However, some of the concerns we raised about the cost estimates, mission requirements, and long-term affordability remain. In addition, our ongoing work has found that the three human exploration programs are pursuing inconsistent and unrealistic schedule goals and that the Orion program is facing significant technical and funding issues that may affect NASA's overall schedule for its human exploration programs.

Background

The National Aeronautics and Space Administration Authorization Act of 2010 directed NASA to, among another things, develop a Space Launch System as a follow-on to the Space Shuttle and as a key component in expanding human presence beyond low-Earth orbit. To that end, NASA plans to incrementally develop three progressively more capable SLS launch vehicles—70-, 105-, and 130-metric ton (mt) variants. When complete, the 130-mt vehicle is expected to have more launch capability than the Saturn V vehicle, which was used for Apollo missions, and be significantly more capable than any recent or current launch vehicle. The act also directed NASA to prioritize the core elements of SLS with the goal of operational capability not later than December 2016.[4] NASA negotiated an extension of that date, to December 2017, based on the agency's initial assessment of the tasks associated with developing the new launch vehicle, and has subsequently committed to a launch readiness date of November 2018.

In 2011, NASA formally established the SLS program. To fulfill the direction of the 2010 act, the agency plans to develop the three SLS launch vehicle capabilities, complemented by Orion, to transport humans

[4]Pub. L. No. 111-267, §§ 302(c)(2), 303(a)(2) (codified at 42 U.S.C. §§ 18322, 18323).

and cargo into space. The first version of the SLS that NASA is developing is a 70-mt launch vehicle known as Block I. NASA has committed to conduct two test flights of the Block I vehicle—the first in 2018 and the second in 2021. The vehicle is scheduled to fly an uncrewed Orion some 70,000 kilometers beyond the moon during the first test flight, known as Exploration Mission-1 (EM-1), and to fly a second mission known as Exploration Mission-2 (EM-2) beyond the moon to further test performance with a crewed Orion vehicle. After 2021, NASA intends to build 105- and 130-mt launch vehicles, known respectively as Block IA/B and Block II, which it expects to use as the backbone of manned spaceflight for decades.[5] NASA anticipates using the Block IA/B vehicles for destinations such as near-Earth asteroids and LaGrange points and the Block II vehicles for eventual Mars missions.[6]

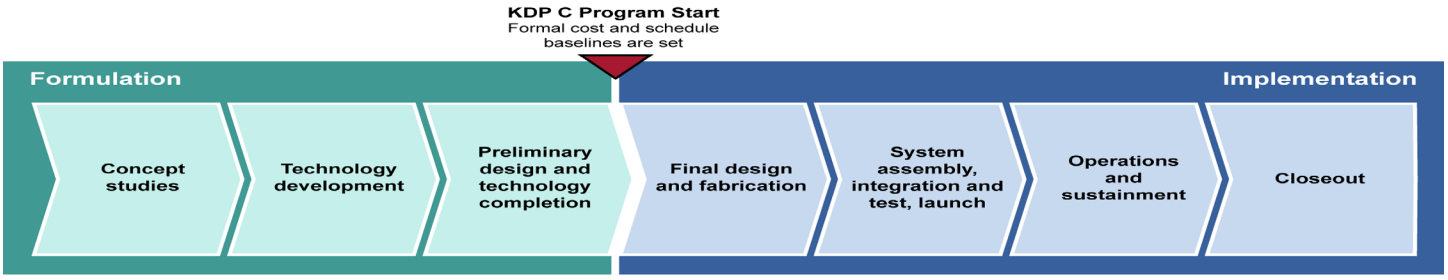
Space launch vehicle development efforts are high risk from technical, programmatic, and oversight perspectives. The technical risk is inherent for a variety of reasons including the environment in which they must operate, complexity of technologies and designs, and limited room for error in the fabrication and integration process. Managing the development process is complex for reasons that go well beyond technology and design. For instance, at the strategic level, because launch vehicle programs can span many years and be very costly, programs often face difficulties securing and sustaining funding commitments and support. At the program level, if the lines of communication between engineers, managers, and senior leaders are not clear, risks that pose significant threats could go unrecognized and unmitigated. If there are pressures to deliver a capability within a short period of time, programs may be incentivized to overlap development and production activities or delete tests, which could result in late discovery of significant technical problems that require more money and ultimately much more time to address. For these reasons, it is imperative that launch vehicle development efforts adopt disciplined practices and lessons learned from past programs.

[5]NASA plans for SLS Block IA to utilize advanced boosters, Block IB an exploration upper stage, and Block II the advanced boosters and exploration upper stage. The agency has not yet determined whether it will first develop the Block IA or Block IB variant.

[6]In a two-body system, such as Earth and the sun, there are points nearby where a third object can be positioned and remain in place relative to the other two objects. These are known as Lagrange points.

Best practices for acquisition programs indicate that establishing baselines that match cost and schedule resources to requirements and rationally balancing cost, schedule, and performance is a key step in establishing a successful acquisition program.[7] Our work has also shown that validating this match before committing resources to development helps to mitigate the risks inherent in NASA's programs.[8] We have reported that within NASA's acquisition life cycle, resources should be matched to requirements at key decision point (KDP)-C, the review that commits the program to formal cost and schedule baselines and marks the transition from the formulation phase into the implementation phase, as seen in figure 1 below.[9] The SLS program completed its KDP-C review in August 2014, GSDO completed its KDP-C review in September 2014, and the KDP-C review for Orion is currently scheduled for May 2015.

Figure 1: Key Decision Point (KDP)-C in NASA Development Life Cycle



Source: NASA data and GAO analysis. | GAO-15-248T

[7]GAO-04-386SP and GAO-01-288.

[8]GAO, *Defense Acquisitions: Key Decisions to Be Made on Future Combat System*, GAO-07-376 (Washington, D.C.: Mar. 15, 2007); *Defense Acquisitions: Improved Business Case Key for Future Combat System's Success*, GAO-06-564T (Washington, D.C.: Apr. 4, 2006); *NASA: Implementing a Knowledge-Based Acquisition Framework Could Lead to Better Investment Decisions and Project Outcomes*, GAO-06-218 (Washington, D.C.: Dec. 21, 2005); and *NASA's Space Vision: Business Case for Prometheus 1 Needed to Ensure Requirements Match Available Resources*, GAO-05-242 (Washington, D.C.: Feb. 28, 2005).

[9]GAO, GAO-06-218 and *NASA: Agency Has Taken Steps Toward Making Sound Investment Decisions for Ares I but Still Faces Challenging Knowledge Gaps*, GAO-08-51 (Washington, D.C.: Oct. 31, 2007).

NASA Delayed SLS Launch Date to Better Match Resources to Requirements

NASA has taken positive steps to address specific concerns we raised in July 2014 regarding aggressive schedules and insufficient funding by establishing the SLS program's committed launch readiness date as November 2018—almost a year later than originally planned. Specifically, we reported in July 2014 that NASA had yet to establish baselines that matched the SLS program's cost and schedule resources with the requirement to develop the SLS and launch the first flight test in December 2017 at the required confidence level of 70 percent.[10] NASA policy generally requires a 70 percent joint confidence level—a calculation NASA uses to estimate the probable success of a program meeting its cost and schedule targets—for a program to proceed with final design and fabrication. At the time of our July 2014 report, NASA had delayed its review to formally commit the agency to cost and schedule baselines for SLS from October 2013, as the agency considered future funding plans for the program. At that time, the agency's funding plan for SLS was insufficient to match requirements to resources for the December 2017 flight test at the 70 percent joint confidence level and the agency's options for matching resources to requirements were largely limited to increasing program funding, delaying the schedule, or accepting a reduced confidence level for the initial flight test. We have previously reported that it is important for NASA to budget projects to appropriate confidence levels, as past studies have linked cost growth to insufficient reserves, poorly phased funding profiles, and more generally, optimistic estimating practices.

We found that NASA's proposed funding levels had affected the SLS program's ability to match requirements to resources since its inception. NASA has requested relatively consistent amounts of funding of about $1.4 billion each year since 2012. According to agency officials, the program has taken steps to operate within that flat funding profile, including streamlining program office operations and asking each contractor to identify efficiencies in its production processes. Even so,

[10]NASA's procedural requirements require Mission Directorates to plan and budget programs and projects with an estimated life-cycle cost greater than $250 million based on a 70 percent Joint Cost and Schedule Confidence Level (JCL), or at a different level as approved by the Decision Authority, which for SLS is the NASA Associate Administrator. Any JCL approved by the Decision Authority at less than 70 percent must be justified and documented. The JCL is a quantitative probability analysis that requires the project to combine its cost, schedule, and risks into a complete quantitative picture to help assess whether the project will be successfully completed within cost and on schedule. NPR 7120.5E, §§2.4.4, 2.4.4.1, 2.4.3.2 (Aug. 14, 2012).

according to the program's own analysis, going into the agency review to formally set baselines, SLS's top risk was that the current planned budget through 2017 would be insufficient to allow the SLS as designed to meet the EM-1 flight date. The SLS program office calculated the risk associated with insufficient funding through 2017 as 90 percent likely to occur; furthermore, it indicated the insufficient budget could push the December 2017 launch date out 6 months and add some $400 million to the overall cost of SLS development. The cost risk was considerably greater than $400 million in the past, but according to program officials they were able to reduce the affect due to receiving more funding than requested in fiscal years 2013 and 2014. Similarly, our ongoing work on human exploration programs has found that the Orion program is currently tracking a funding risk that the program could require an additional $560 to $840 million to meet the December 2017 EM-1 flight date. However, the agency has yet to complete the review that sets formal cost or schedule baselines for the Orion program. At this time, we have not conducted enough in-depth work on the GSDO program to comment on any specific risks the program is tracking.

In our July 2014 report we recommended, among other things, that NASA develop baselines for SLS based on matching cost and schedule resources to requirements that would result in a level of risk commensurate with its policies. NASA concurred with our findings and recommendations. In August 2014, NASA established formal cost and schedule baselines for the SLS program at the 70 percent joint confidence level for a committed launch readiness date of November 2018. Nevertheless, the program plans to continue to pursue an initial capability of SLS by December 2017 as an internal goal and has calculated a joint cost and schedule confidence level of 30 percent associated with that date.

As illustrated by table 1 below, the SLS and GSDO programs are pursuing ambitious and varying target dates for the EM-1 test flight. In addition, the Orion program is currently tracking and reporting to December 2017. The agency acknowledges differences in the target dates the programs are pursuing and has indicated that it will develop an integrated target launch date after all three systems hold their individual critical design reviews.

Table 1: NASA's Target and Baseline Launch Readiness Dates and Associated Confidence Levels for Human Spaceflight Programs

	Target date	Confidence level for target date	Committed date	Confidence level for committed date
Space Launch System	December 2017	30%	November 2018	70%
Ground Systems Development and Operations	June 2018	30%	November 2018	80%
Orion Multi-Purpose Crew Vehicle[a]	TBD	TBD	TBD	TBD

Source: GAO analysis of NASA data. | GAO-15-248T

[a]Orion has not yet established formal cost and schedule baseline commitments.

The SLS program has assigned a low confidence level—30 percent—associated with meeting the program's internal target date of December 2017. Even if SLS does meet that goal, however, it is unlikely that both Orion and GSDO will achieve launch readiness by that point. For example, the GSDO program only has a 30 percent confidence level associated with a later June 2018 date. Additionally, the Orion program is currently behind its planned schedule and is facing significant technical risks and officials indicated that the program will not achieve launch readiness by December 2017. The Orion program has submitted a schedule to NASA headquarters that indicates the program is now developing plans for a September 2018 EM-1 launch, though that date is preliminary until the program establishes official cost and schedule baselines now planned for May 2015. With the Orion and GSDO programs likely unable to meet the December 2017 date, NASA risks exhausting limited human exploration resources to achieve an aggressive SLS program schedule when those resources may be needed to resolve other issues within the human exploration effort. In other work, we have reported that in pursuing internal schedule goals, some programs have exhausted cost reserves, which has resulted in the need for additional funding to support the agency baseline commitment date once the target date is not achieved.[11]

NASA's urgency to complete development and demonstrate a human launch capability as soon as possible is understandable. The United States has lacked the ability to launch humans into space since the last flight of the Space Shuttle in July 2011 and the initial goal from Congress was that NASA demonstrate a new human launch capability by 2016. Also, the SLS and GSDO programs have already slipped their committed

[11]GAO-14-338SP

launch readiness dates to November 2018, and Orion appears likely to follow suit. While these delays were appropriate actions on the agency's part to reduce risk, their compounding effect could have impacts on the first crewed flight—EM-2—currently scheduled for 2021.

NASA's SLS and Orion Programs Are Making Progress, but the Orion Program Is Facing Technical Challenges

We reported in July 2014 that NASA's metrics indicated the SLS program was on track to meet many of its design goals for demonstrating the initial capability of SLS. However, we found that the development of the core stage—SLS's fuel tank and structural backbone—represents the critical path of activities that must be completed to maintain the program's schedule as a whole. The core stage development had an aggressive schedule in order to meet the planned December 2017 first test flight. For example, the core stage had threats of nearly 5 months to its schedule due to difficulty acquiring liquid oxygen fuel lines capable of meeting SLS operational requirements. The aggressiveness of, and therefore the risk associated with the core stage schedule was reduced when the agency delayed its commitment for initial capability of SLS until November 2018. With SLS continuing to pursue a target date of December 2017, however, the aggressive core stage schedule remains a risk. Further, we reported that the program faced challenges integrating heritage hardware, which was designed for less stressful operational environments, into the SLS design. We found that these issues were not significant schedule drivers for the program as each had, and continues to have, significant amounts of schedule reserve to both the target and agency baseline commitment dates for launch readiness.

The Orion program just completed its first experimental test flight—EFT-1. This flight tested Orion systems critical to crew safety, such as heat shield performance, separation events, avionics and software performance, attitude control and guidance, parachute deployment, and recovery operations. According to NASA, the data gathered during the flight will influence design decisions and validate existing computer models. Data from this flight are required to address several significant risks that the Orion program is currently tracking that must be addressed before humans can be flown on Orion. Specifically, our ongoing work indicates that the Orion program passed its preliminary design review—a review that evaluates the adequacy of cost schedule and technical baselines and whether the program is ready to move forward—in August 2014 by meeting the minimum standards for all 10 success criteria. For 7 of the 10 success criteria, however, review officials highlighted known issues that could compromise Orion's success. Specifically, the review officials noted concerns about several unresolved design risks, including technical

challenges with the parachute system and heat shield. For example, during parachute testing, NASA discovered that when only two of the three main parachutes are deployed, they begin to swing past each other creating a "pendulum" effect. This effect could cause the capsule to increase speed and to hit the water at an angle that may damage the capsule thereby endangering the crew. Further, NASA faces choices between differing design solutions to resolve cracking issues discovered during manufacturing of the heat shield that protects the capsule during re-entry. Program officials plan to make a decision prior to the program's critical design review, based on additional testing and analysis, about how to resolve these risks with a goal of limiting design changes to the capsule's structure. Both the parachute and heat shield challenges must be resolved before EM-2 because each represents a significant risk to crew safety. Significant cost and schedule impacts could result if a redesign is required to address any of these unresolved design risks.

NASA's Human Exploration Programs' Long-Term Missions and Affordability Are Uncertain

NASA has yet to address our concerns regarding mission planning or life-cycle cost estimates. NASA has not yet defined specific mission requirements for any variant of the SLS. The two currently scheduled flights are developmental test flights designed to demonstrate and test the capabilities of the 70-mt launch vehicle and the capability of the core stage in particular. Office of Management and Budget guidance indicates that agencies should develop long-range objectives, supported by detailed budgets and plans that identify the agency's performance gaps and the resources needed to close them.[12] With mission requirements unspecified, NASA has not yet finalized plans for the next step in evolving the SLS and risks investing limited available resources in systems and designs that are not yet needed and missing opportunities to make early investments in developing systems that may be needed in the future. According to agency officials, beyond the two scheduled test flights, future mission destinations remain uncertain. In the absence of specific mission requirements, officials indicated the SLS program is developing current and future variants based on top-level requirements derived from NASA's Design Reference Architectures for conducting missions in line with the agency's strategic plan. NASA's 2014 strategic plan, for example, identifies sending humans to Mars as one of the agency's long-term

[12]Office of Management and Budget, *OMB Circular A-11, Supplement for Part 7: Capital Programming Guide* (Washington, D.C.: July 2013).

goals; in turn, the agency's Mars Design Reference Architecture indicates that multiple missions using a vehicle with a lift capability of about 130-mt will be necessary to support that goal. We recommended based on these findings that NASA define a range of possible missions beyond the second test flight and introduce increased competition in the acquisition of hardware needed for future variants to reduce long-term costs.[13] The agency concurred with our recommendations, but has not yet taken specific actions to address our concerns

The long-term affordability of the human exploration programs are also uncertain, as we found in May 2014, because NASA's cost estimates for the programs do not provide any information about the longer-term, life-cycle costs of developing, manufacturing, and operating the launch vehicles.[14] For example, as illustrated in table 2 below, NASA's baseline estimate for SLS does not cover program costs after EM-1 or costs to design, develop, build, and produce the 105- or 130-mt variants. Though the subsequent variants will evolve from the first variant, they each represent substantial, challenging development efforts and will require billions of more dollars to complete. For example, the 105-mt vehicle will require development of a new upper stage and upper stage engine or the development of advanced boosters, either of which will be significant efforts for the program.

[13]GAO-14-631

[14]The Orion program has not yet established formal cost and schedule baseline commitments.

Table 2: Costs Included in the Scope of Baseline or Preliminary Cost Estimate

	Agency baseline commitment (costs)	System development (including establishing manufacturing and test facilities)	Exploration Mission 1 (including 3 months of post-flight data analysis)	Exploration Mission 2 (including 3 months of post-flight data analysis)	Development of future vehicles	Future manufacturing, operations, and support costs
Space Launch System (SLS)	$9.7 billion	Yes	Yes	No	No	No
Ground Systems Development and Operations	$2.8 billion	Yes	Yes	No	No	No
Orion Multi-Purpose Crew Vehicle	TBD Preliminary range estimate of $8.5 billion to $10.3 billion	Yes	Yes	Yes	No	No

Source: GAO analysis of NASA data. | GAO-15-248T

Based on the tenets of widely accepted best practices for cost estimation, as well as NASA's own requirements and guidance regarding life-cycle costs, in May 2014 we recommended that NASA establish a separate cost and schedule baseline for the SLS program for work required to support EM-2.[15] Additionally, we recommended that NASA establish life-cycle cost and schedule baselines, or at least provide minimum and maximum ranges, for each upgraded block of SLS, Orion, and associated ground support. NASA partially concurred with our recommendations, stating that their current approach for establishing separate baselines and estimates for the SLS, Orion, and GSDO programs met the intent of our recommendations and agreed to report cost estimates for the future SLS capabilities annually via the agency budget submission until key requirements are defined and baselines can be established. We disagreed and stated that establishing cost and schedule baselines at the program level was unlikely to provide the detail necessary to monitor the progress of future blocks of SLS, each of which will in essence constitute a separate development project within the SLS program, and that budget requests neither offer all the same information as life-cycle cost estimates nor are necessarily linked to an established baseline that indicates how

[15]GAO-14-385.

much NASA expects to invest to develop, operate, and sustain a capability over the long term.

In conclusion, by delaying the committed launch readiness date and establishing funding levels at a 70 percent confidence level, NASA has improved the SLS program's overall risk posture. We are concerned, however, that the program continues to pursue the overly ambitious goal of a December 2017 launch date. It is important to note at this point that the SLS, Orion, and GSDO programs are intrinsically linked. None of the three can satisfy NASA's human exploration goals on its own, and cost overruns or delays in any single program, such as the significant funding and technical issues now facing the Orion program, will directly affect the others. Without a realistic integrated flight date guiding the efforts of all three programs, and meaningful reporting of progress, insight into the progress of NASA's human exploration portfolio and the agency's ability to make informed management decisions regarding the allocation of resources across the three programs is limited. Further, NASA's plans for human exploration beyond SLS's second flight in 2021 remain unclear. Until long-term missions are finalized, the agency will lack clear definition in its plans to move forward. This will in turn affect the agency's acquisition planning and any efforts to incorporate increased competition. Furthermore, without complete life-cycle cost estimates for all three programs, and their planned variants, the agency's ability to make important decisions about the affordability of the program in the context of the agency's overall budget and competing priorities is limited.

Chairman Palazzo, Ranking Member Edwards, and Members of the Subcommittee, this completes my prepared statement. I would be pleased to respond to any questions that you may have at this time.

GAO Contact and Staff Acknowledgments

GAO Contact

If you or your staff have any questions about this testimony, please contact Cristina T. Chaplain, Director, Acquisition and Sourcing Management 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.

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