

NASA

National Aeronautics and Space Administration

Office of Inspector General

Office of Audits

NASA'S COST ESTIMATING AND REPORTING PRACTICES FOR MULTI-MISSION PROGRAMS

April 7, 2022

Report No. IG-22-011





Office of Inspector General

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RESULTS IN BRIEF

NASA's Cost Estimating and Reporting Practices for Multi-Mission Programs

April 7, 2022

IG-22-011 (A-20-016-00)

WHY WE PERFORMED THIS AUDIT

NASA has a long history of groundbreaking accomplishments but has struggled to establish credible cost estimates for some major acquisitions; particularly, human space flight missions, which are comprised of multiple programs with numerous deliverables—like rockets and spacecraft—stretching over many years. As a result, Congress and other stakeholders lack meaningful visibility into the complete costs of NASA's major acquisitions. Without adequate transparency, it is difficult for stakeholders to hold the Agency accountable for these large, years-long expenditures of taxpayer funds. To its credit, NASA has acknowledged the need for increased transparency of cost and schedule in its deep space exploration missions.

We initiated this audit to assess NASA's life-cycle cost estimating and reporting practices and policies for major programs with multiple deliverables. Specifically, we examined whether NASA's program management approach provides the necessary transparency and accountability for performance to the Agency's external stakeholders, and whether NASA's processes for estimating, tracking, and reporting life-cycle cost and schedule are adequate for these major program acquisitions. To complete our work, we assessed NASA's cost and schedule estimating and reporting practices for compliance with federal law and NASA policy; examined the estimates and commitments of certain major human exploration programs; and interviewed numerous Agency officials.

WHAT WE FOUND

Congress is not receiving the federally mandated cost and schedule information it needs to make fully informed funding decisions for NASA's multi-mission programs. Specifically, for the programs supporting Artemis, the Agency's return-to-the-Moon and ultimately to Mars effort, NASA is circumventing required cost and schedule controls by categorizing certain production costs as operations costs when, in our opinion, they should be categorized as development costs. When the Constellation Program was cancelled in 2010, Congress directed NASA to continue development of several major components, including the rocket, crew capsule, and ground launch infrastructure. Without clearly defined missions for these major items, NASA only made cost and schedule commitments to Congress to demonstrate the initial capability of each system. The three separately-managed programs—the Space Launch System (SLS), the Orion Multi-Purpose Crew Vehicle (Orion), and Exploration Ground Systems (EGS)—will provide the primary components for Artemis missions, the first of which is scheduled to launch no earlier than May 2022. Even though NASA has multiple Artemis missions planned, it has not adjusted the three programs' life-cycle cost estimates or commitments to account for future missions. The result is incomplete cost estimates and commitments for these programs and missions.

We raised questions with the Agency's recent update to NASA Procedural Requirements (NPR) 7120.5F, NASA Space Flight Program and Project Management Requirements, which establishes the requirements, life-cycle processes, and procedures by which NASA formulates and implements space flight programs and projects. Rather than resolving the major shortcomings with the Agency's cost estimating and reporting practices, the recent policy amendments formalized known deficiencies as acceptable management practices. NASA had previously stated that it intended to establish new policies and procedures that would provide additional transparency for major programs with multiple deliverables and unspecified end points. Instead, it codified its poor cost estimating and reporting practices in a new policy that fails to

comply with Title 51 of the United States Code, which requires the Agency to annually provide an estimate of the life-cycle cost for major programs, with a detailed breakout of the development cost and program reserves as well as an estimate of the annual costs until development is completed. The policy also weakens NASA's ability to account for some risks in programs consisting of multiple projects, a situation that may affect cost and schedule if risks are unidentified in the estimates. Furthermore, the revised policy will not adequately address several open NASA Office of Inspector General (OIG) and Government Accountability Office (GAO) recommendations regarding incomplete and missing cost estimates and the corresponding baseline commitments for programs supporting Artemis missions.

Congress, NASA OIG, and GAO have identified longstanding problems with the completeness and credibility of NASA's life-cycle cost estimates for major acquisitions. Ultimately, NASA is not providing full visibility into its investments as it begins a multi-decade initiative to transport humans to Mars at a cost that could easily reach into the hundreds of billions of dollars. Because the programs that support these exploration missions are still in their early development stages, it is critical that NASA establish credible and complete cost and schedule estimates.

WHAT WE RECOMMENDED

In order to ensure that all major programs and activities are reported to Congress in accordance with Title 51 of the United States Code, "National and Commercial Space Programs," we recommended the Chief Financial Officer, in coordination with the Associate Administrators for the Exploration Systems Development and Space Operations Mission Directorates (1) estimate, track, and report ongoing production costs for all major programs, such as SLS and Orion, as development costs and not as operations costs; (2) include in the next Major Program Annual Report (MPAR) to Congress the estimated baseline life-cycle cost and schedule for each Artemis mission; (3) should NASA elect to estimate, track, and report life-cycle costs for major programs or activities by component rather than by mission, include estimates for each component in the MPAR and provide Congress a cost estimate, outside of the MPAR, for each Artemis mission currently planned; and (4) develop a formal process by which a risk-based probabilistic analysis is conducted to cover the global and interdependency risks of major programs and projects when those individual programs and projects are required for the successful implementation of a mission. Furthermore, in order to ensure that all major programs or activities are reported to Congress in accordance with Title 51, we recommended the Chief Engineer (5) establish procedural requirements to report full life-cycle cost and schedule for all major programs should NASA elect to estimate, track, and report baseline costs for major programs or activities by component rather than by mission; (6) review NPR 7120.5F and update it as necessary to ensure compliance with laws and regulations and recommendations 1 through 5, as well as ensuring definitions of terms, such as "capability" and "life cycle," are consistent with those established in federal statutes and other NASA policy documents; and (7) establish procedural requirements for a risk posture analysis to ensure that major programs supporting multiple missions identify and estimate the cost and schedule impact of global and major interdependency risks.

We provided a draft of this report to NASA management, who concurred with Recommendations 3 and 4 and partially concurred with Recommendation 7 and described planned actions to address them. We consider the proposed actions for these three recommendations responsive and will close them upon completion and verification. The Agency did not concur with Recommendations 1, 2, 5, and 6, stating that it is meeting the statutory requirements of Title 51 regarding the reporting of major program life-cycle and development costs. We disagree and believe changes NASA has recently incorporated into NPR 7120.5F do not comply with statutory requirements and will further limit transparency and tracking of the costs associated with multi-billion dollar programs and missions. Therefore, these four recommendations remain unresolved pending further discussions with the Agency.

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Acronyms

ABC	Agency Baseline Commitment
AES	Advanced Exploration Systems
CADRe	Cost Analysis Data Requirement
EGS	Exploration Ground Systems
EM	Exploration Mission
ESD	Exploration Systems Development
EUS	Exploration Upper Stage
FY	fiscal year
GAO	Government Accountability Office
HEOMD	Human Exploration and Operations Mission Directorate
HLS	Human Landing System
ISS	International Space Station
JCL	Joint Cost and Schedule Confidence Level
JWST	James Webb Space Telescope
KDP	Key Decision Point
ML	Mobile Launcher
MPAR	Major Program Annual Report
NPR	NASA Procedural Requirements
OIG	Office of Inspector General
OMB	Office of Management and Budget
SLS	Space Launch System
VIPER	Volatiles Investigating Polar Exploration Rover

INTRODUCTION

NASA has a proud record of history-making accomplishments, from the Apollo Moon landings to the groundbreaking deep-space discoveries of the Hubble Space Telescope. As an agency that has tackled ambitious, first-of-a-kind projects, NASA has also at times seen expensive missions started but never completed (e.g., the Constellation Program), and has had others significantly exceed cost and schedule estimates, for example, the James Webb Space Telescope (JWST).¹ In both of these cases, the actual costs far exceeded what decision-makers initially expected to pay for the missions. In order to function, cost estimates and the process used to develop them need to provide decision-makers with reliable information about cost, schedule, and scope before missions are funded.

Historically, NASA has underestimated the cost of many of its major programs. Because of the significance of this problem, Congress established specific oversight and reporting requirements for NASA's major acquisitions that, if breached, trigger Agency notifications to Congress for exceeding cost and schedule thresholds.² In turn, NASA has worked to improve its estimating practices by implementing a variety of cost estimating and management tools. Over the years, the Agency has updated its estimating policies and procedures for major programs—most recently in August 2021—to improve its ability to provide accurate cost estimates.³

Congress, the NASA Office of Inspector General (OIG), and the Government Accountability Office

Constellation Flight Test



Shown here on the launch pad at Kennedy Space Center, the Ares rocket underwent one flight test, in October 2009, before the Constellation program was shuttered.

Source: NASA.

¹ The Constellation Program was NASA's Moon-to-Mars program from 2005 to 2009 and was centered on development of the Ares rocket and the Orion crew vehicle. Although Constellation was cancelled in 2010, its component launch vehicle, capsule, and ground systems continued to be individually developed. The Ares rocket series was redesigned and redesignated as the Space Launch System Program, while the Orion crew vehicle development continued as a separate program. The total cost NASA incurred in these transitions cannot readily be determined. With respect to JWST, NASA established a cost estimate of \$2.6 billion in 2009 and planned to launch in 2014. JWST launched on December 25, 2021 and carried a price tag of \$9.7 billion as of May 2021.

² National and Commercial Space Programs, 51 U.S.C. § 30104 - Baselines and cost controls.

³ NASA Procedural Requirements (NPR) 7120.5F, *NASA Space Flight Program and Project Management Requirements* (August 3, 2021) revised and cancelled NPR 7120.5E, *NASA Space Flight Program and Project Management Requirements* (August 14, 2012).

(GAO) continue to report on longstanding issues with incomplete, unreliable, and missing life-cycle cost estimates for some major acquisitions, particularly human space flight missions and programs. NASA has struggled to establish credible estimates for these missions, which are comprised of multiple programs with multiple deliverables stretching over many years. As a result, policymakers and stakeholders lack meaningful visibility into the Agency's major acquisitions. Without adequate transparency, stakeholders have more difficulty holding NASA accountable for these large expenditures of taxpayer funds. To its credit, the Agency has acknowledged the need for increased transparency of cost and schedule in its deep space exploration missions.⁴ With projected costs of \$93 billion from fiscal year (FY) 2012 to FY 2025 alone, NASA's current human exploration initiative known as Artemis, which aims to return humans to the Moon, has the potential to cost hundreds of billions of dollars over the next two decades. Recently, we reported that the average cost per launch for at least the first four of these missions is over \$4 billion.⁵ It is therefore critical that NASA provide high-quality cost estimates to inform future investment decisions and assess the long-term sustainability of its exciting but extremely expensive programs. Moreover, accurate cost estimates are important beyond NASA's current lunar programs. As the Agency pursues increasingly ambitious space exploration goals, it is imperative that stakeholders have a clear understanding of the financial commitments required.

Given the history of challenges with providing reliable life-cycle cost estimates for many major programs and the tremendous financial commitment NASA is making with the Artemis missions, we initiated this audit to assess NASA's life-cycle cost estimating and reporting practices and policies for major programs with multiple deliverables. Specifically, we examined whether NASA's program management approach provides the necessary transparency and accountability for performance to the Agency's external stakeholders, and whether NASA's processes for estimating, tracking, and reporting life-cycle cost and schedule are adequate for these major program acquisitions. Due to the complexity and uniqueness of NASA's multi-mission programs with multiple deliverables, we examined life-cycle cost development and reporting processes for major human space flight programs—currently the only NASA programs that use a single life-cycle cost estimate for the initial development but no life-cycle cost estimate for future iterations of the same major deliverable. Please see Appendix A for a full explanation of our scope and methodology.

Background

NASA has long faced challenges when attempting to provide policymakers and other stakeholders credible cost and schedule estimates for its major programs. In 1989, President George H.W. Bush announced a Moon to Mars campaign that became known as the Space Exploration Initiative. In response, NASA conducted a "90-Day Study of Human Exploration of the Moon and Mars" that produced a rough cost estimate of \$500 billion across 20 to 30 years.⁶ The size of the estimate, along with the lack of detail for many of the component costs, drew criticism from both the White House and Congress. A space policy group subsequently convened by the National Space Council to review the nation's human space flight program, known as the Augustine Commission, recommended that NASA

⁴ NASA, *2020 High Risk Corrective Action Plan* (August 2020). Available at https://www.nasa.gov/sites/default/files/atoms/files/nasa_high_risk_corrective_action_plan_2020.pdf (last accessed March 7, 2022).

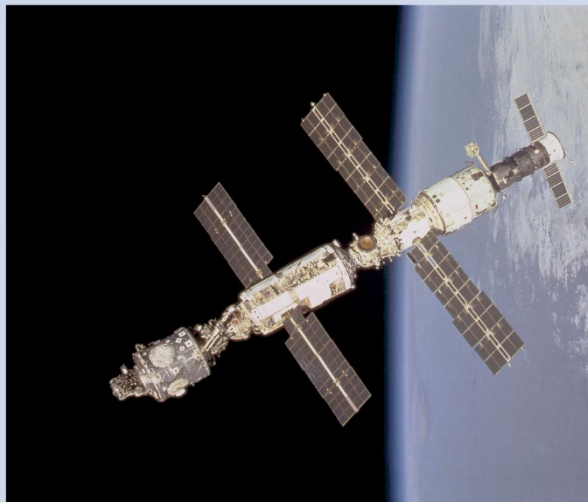
⁵ NASA OIG, *NASA's Management of the Artemis Missions* (IG-22-003, November 15, 2021).

⁶ NASA, *Report of the 90-Day Study on Human Exploration of the Moon and Mars* (November 20, 1989). Available at https://history.nasa.gov/90_day_study.pdf (last accessed March 7, 2022).

move away from human exploration to less expensive Earth science programs and focus on low earth orbit missions in what would later become the International Space Station (ISS) Program.⁷

When building the ISS in the late 1990s and early 2000s, NASA exceeded its original cost estimate of \$17.4 billion by over \$4 billion. Several members of Congress criticized NASA's management practices at the time, with one representative stating that the ISS program had not "maintained the mandatory annual independent audits, nor the recommended life-cycle cost projections."⁸ Other members pointed to "weakness" in the Agency's internal controls as a major factor in the cost overruns.⁹ GAO later determined that the Agency failed to detect cost growth because of its "deeply rooted culture of managing programs based on current year budgets rather than total costs."¹⁰ NASA subsequently underwent an Agency-wide financial reorganization intended to consolidate and modernize its financial management and institute stricter internal controls to monitor and control program cost and schedule.

ISS Under Construction



This photo, taken from the Space Shuttle Endeavour in 2000, shows the ISS in an early stage of construction, with the first three modules connected.

Source: NASA.

The 2005 NASA Authorization Act established the Constellation Program in response to President George W. Bush's "Vision for Space Exploration."¹¹ The program planned to develop new rockets (Ares I and Ares V), a crew vehicle (Orion Crew Exploration Vehicle), and lunar surface exploration capabilities. However, the program experienced significant management issues and cost and schedule overruns. Five years later Congress cancelled Constellation and mandated that its successor use the Space Launch System (SLS)—NASA's next large-scale rocket; the Orion Multi-Purpose Crew Vehicle (Orion); and the

⁷ *Summary of Space Exploration Initiatives*, Steve Dick, NASA Chief Historian. Available at <https://history.nasa.gov/seisummary.htm> (last accessed March 7, 2022).

⁸ Statement of Rep. Gary Miller, California, *Space Station Cost Overruns*, Hearing Before the Committee on Science, House of Representatives, April 4, 2001.

⁹ *Mission Impossible? Fixing NASA's Financial Management*, Hearing Before the Subcommittee on Government Efficiency and Financial Management of the Committee on Government Reform, House of Representatives, May 19, 2004.

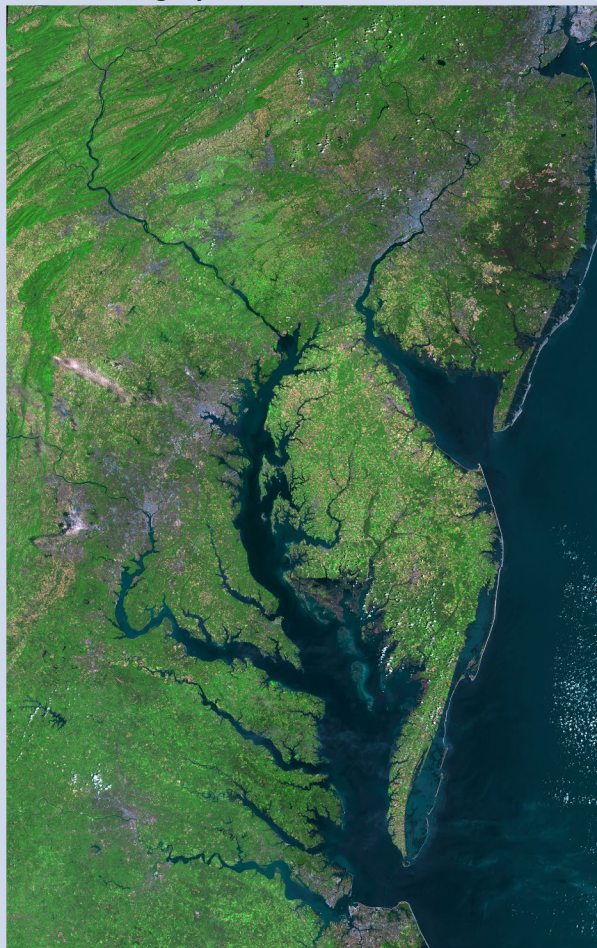
¹⁰ GAO, *Business Modernization: NASA's Integrated Financial Management Program Does Not Fully Address Agency's External Reporting Issues* ([GAO-04-151](#)), November 21, 2003).

¹¹ *NASA Authorization Act of 2005*, Pub. L. No. 109–155, December 30, 2005. President George W. Bush, "New Vision for Space Exploration Program," Remarks on U.S. Space Policy, NASA Headquarters, January 14, 2004.

ground systems for launch, known as the Exploration Ground Systems (EGS), building off development work begun under Constellation.¹² NASA initially hoped to launch Exploration Mission-1 (EM-1) using SLS Block 1, Orion, and the EGS Mobile Launcher-1 by 2017, setting the stage for Artemis, the Agency’s current Moon to Mars campaign.¹³

Importantly, NASA has not formally designated Artemis as a major program or project, a categorization that would trigger a series of additional program management requirements. Like certain other programs at the Agency—for example, Landsat, NASA’s Earth observing satellite program—Artemis is a “program” in name only; it was not established as and is not managed as a “program” in accordance with NASA Space Flight Program and Project Management Requirements.¹⁴ However, unlike Landsat where the cost and schedule of each mission has been estimated and reported as an individual project (e.g., Landsat 9 launched in September 2021), NASA is neither estimating nor reporting the full life-cycle cost and schedule by Artemis mission nor estimating and reporting the cost and schedule by individual component programs—SLS, Orion, and EGS—for each Artemis mission.

Landsat Imagery



Landsat has been collecting information on Earth’s surface for more than 40 years. This mosaic of the Chesapeake Bay region was created from five separate images taken in 2009 and 2011.

Source: NASA.

¹² *NASA Authorization Act of 2010*, Pub. L. No. 111–267, October 11, 2010.

¹³ *Exploration Systems Development Status*, NASA Advisory Council, March 2012. A “block” is the SLS variant that will be used for a particular mission. Block 1, with 8.8 million pounds of thrust, will be followed by Block 1B, an upgraded variant of the Block 1. Block 2 is the final planned variant of SLS and will be the most powerful of the three variants. Exploration Ground Systems (EGS) is the program overseeing the development of NASA’s next generation launch facilities and associated equipment. See Appendix B for more details on Artemis missions, as well as the SLS, Orion, EGS programs and their respective components.

¹⁴ NPR 7120.5F. The Landsat program is a collaboration between NASA and the U.S. Geological Survey that provides satellites enabling the longest continuous space-based record of Earth’s land and providing data for making informed decisions about Earth’s resources and environment. Landsat 1 launched in July 1972 and Landsat Next is planned to launch in 2029.

The Importance of Credible Life-Cycle Estimates

The life-cycle cost estimate is a key component of the federal acquisition process and can assist decision makers by helping to:¹⁵

- prioritize disparate missions,
- develop annual budget requests,
- evaluate resource requirements at key decision points,
- develop performance measurement baselines,
- support effective resource allocation, and
- support effective project management processes by establishing scope, cost, and schedule parameters.

Life-cycle cost estimates provide vital information to NASA projects, programs, Centers, Mission Directorates, and the Agency; external stakeholders like Congress, the Office of Management and Budget (OMB), and the broader scientific community; oversight bodies like NASA OIG and GAO; and taxpayers.

Also, credible life-cycle cost estimates are an essential component of sound management. Early emphasis on cost estimating during the planning phase is critical to successful life-cycle management of a program. Federal agencies are required to develop a cost estimating methodology—for collecting, managing, and sharing cost data—that suits their mission needs, while also delivering high-quality information to decision-makers. Characteristics of highly credible estimates include a disciplined cost estimating process, accurate and timely estimates, and quality risk assessments.

Mission Selection. At NASA, comprehensive, accurate, timely information about potential science and exploration activities supports effective short and long-term planning. Ultimately, the Agency and Congress should collaborate in order to gain the best return on investment by selecting the right missions at the right time based on a wide range of criteria such as the state of technology development, budget environment, and stakeholder priorities. Reliable estimates of the likely cost and delivery schedule are essential components in this decision-making process.

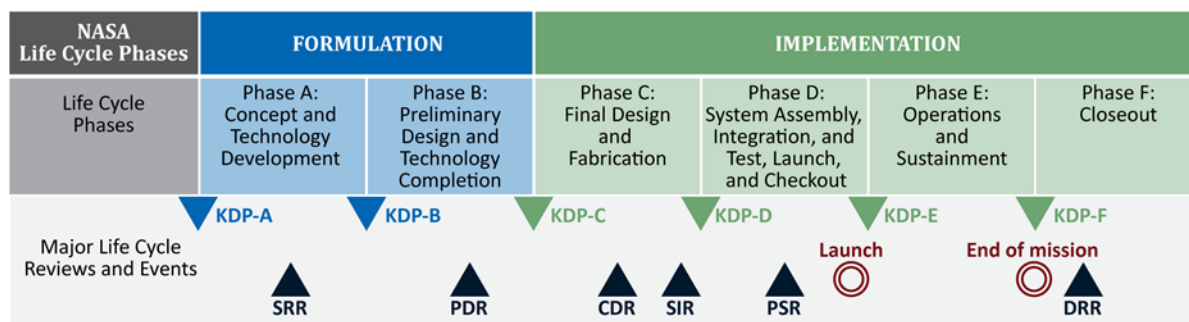
Budgets and Funding. Providing the right resources at the right time is essential to ensure efficient program development. Reliable life-cycle cost and schedule estimates allow programs to better plan their work tasks year by year and align Congressional appropriations with the annual, planned work effort. In our 2012 report on NASA’s project management challenges, we noted that project managers identified a lack of funding stability as a primary challenge in effectively managing a project’s cost and schedule.¹⁶ Accurate cost and schedule estimates are another way mission managers can better prepare for such instability.

¹⁵ Title 51 defines life-cycle cost as “the total of the direct, indirect, recurring, and nonrecurring costs, including the construction of facilities and civil servant costs, and other related expenses incurred or estimated to be incurred in the design, development, verification, production, operation, maintenance, support, and retirement of a program over its planned lifespan, without regard to funding source or management control.”

¹⁶ NASA OIG, *NASA’s Challenges to Meeting Cost, Schedule, and Performance Goals* ([IG-12-021](#), August 28, 2012).

Performance Monitoring. NASA Procedural Requirements (NPR) 7120.5F, *NASA Space Flight Program and Project Management Requirements*, establishes the requirements, and details the life-cycle processes and procedures, by which the Agency formulates and implements space flight programs and projects (see Figure 1). Under the policy, the Agency Baseline Commitment (ABC), established at KDP-C, documents an integrated set of project requirements including cost, schedule, technical content, and an agreed-to Joint Cost and Schedule Confidence Level (JCL) analysis that forms the basis for NASA’s commitments to Congress and OMB.¹⁷ Credible estimates and JCL analyses provide the basis for the ABC, the official baseline for each NASA program or project against which internal and external stakeholders measure cost and schedule performance.

Figure 1: NASA Project Life Cycle



A **Key Decision Point (KDP)** is an event where NASA determines whether a project is ready to move to the next phase of its life cycle and establishes content, cost, and schedule commitments for that phase.

System Requirements Review (SRR) evaluates whether the functional and performance requirements for the system meet the needs of the project and represent achievable capabilities.	Preliminary Design Review (PDR) evaluates completeness/consistency of the planning, technical, cost, and schedule baselines developed during Formulation.	Critical Design Review (CDR) evaluates the project design and its ability to meet mission requirements with appropriate margins and acceptable risk.	System Integration Review (SIR) evaluates whether the projects is ready for integration and test, can be completed with available resources, and is ready for Phase D.	Pre-Ship Review (PSR) ensures the completeness of any item of hardware or software before it is released to another facility for integration with a larger system or the spacecraft.	Disposal Readiness Review (DRR) evaluates the readiness of the project and system for a disposal event, such as deorbiting.
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Source: NASA FY 2022 Volume of Integrated Performance

Estimating Issues Reported by NASA OIG and GAO

To better understand its cost and schedule problems, in 2009 NASA performed an analysis and identified 15 core factors about why some of its missions, projects, and programs experience poor cost and schedule outcomes.¹⁸ We later noted that the Agency was making significant improvements in managing cost overruns and schedule delays because of improvements in its estimating practices, and that industry experts attributed the improvements to sound probabilistic estimating practices tied to 9 of the 15 factors NASA had identified.¹⁹ However, recent issues indicate that NASA has not effectively applied these improved estimating practices to its larger missions consisting of multiple programs with multiple deliverables, like the Artemis missions and the SLS and Orion programs. Since 2014, NASA OIG and GAO have reported issues with NASA’s cost and schedule estimating and reporting processes and made numerous recommendations to increase transparency and accountability for such programs,

¹⁷ A JCL is a probabilistic analysis intended to provide a risk-based estimate of cost and schedule to help predict the likelihood that a project or program will achieve its objectives within budget and on time. “KDP” stands for Key Decision Point.

¹⁸ NASA Advisory Council Meeting: Report of Audit and Finance Committee, Kennedy Space Center, February 5, 2009.

¹⁹ NASA OIG, *Audit of NASA’s Joint Cost and Schedule Confidence Level Process* ([IG-15-024](#), September 29, 2015).

including those supporting the Artemis missions. As of January 2022, 20 of those recommendations remain unimplemented. NASA has stated that it is actively working “to satisfy implementation requirements,” which could meet the intent of these recommendations. See Appendix C for details on open recommendations.

Ongoing Congressional Concerns

Since 2010, Congress has repeatedly raised concerns over transparency into NASA’s decision-making for Human Exploration and Operations Mission Directorate’s (HEOMD) Exploration Systems Development (ESD) programs (SLS, Orion, and EGS), along with the Agency’s long-term Moon to Mars planning.²⁰ For example:

- NASA repeatedly missed deadlines for submitting long-term plans for a Moon to Mars Campaign including the Human Exploration Roadmap mandated by the 2017 NASA Authorization Act.²¹
- Congress has repeatedly raised questions about NASA’s stewardship of investments in the Space Shuttle and Constellation programs.²²
- Congressional oversight committee members have expressed concerns during multiple hearings about cost and schedule deterioration and transparency into NASA’s long-term planning since at least 2014.²³

As detailed in Figure 2, we identified the following recurring congressional concerns about cost and schedule issues on NASA programs: (1) the relevant oversight and appropriations committees do not have enough insight into NASA’s decision-making process on its programs; and (2) NASA did not develop a detailed plan to use the technology and capabilities produced by taxpayer investments to get humans to the Moon and then to Mars. Numerous hearings listed on the timeline also detail more specific issues raised by various committees.

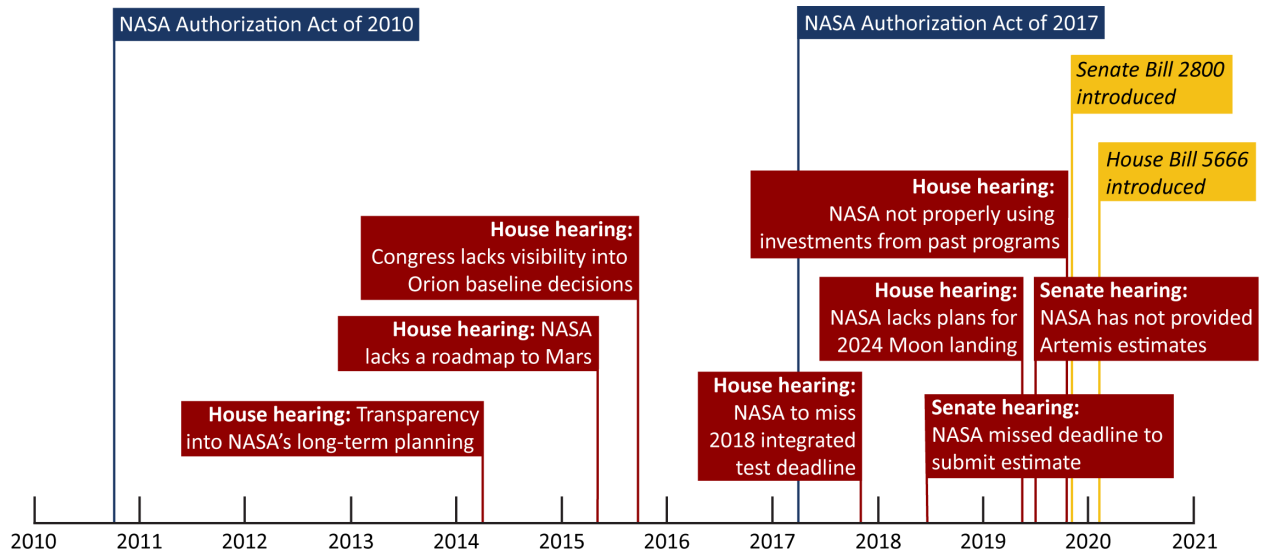
²⁰ In September 2021, the NASA Administrator announced that the Agency planned to split HEOMD into two separate mission directorates—the Exploration Systems Development Mission Directorate responsible for integrating the early Artemis missions, defining and managing systems development for programs critical to NASA’s Artemis missions, and planning for NASA’s Moon to Mars exploration approach in an integrated manner and the Space Operations Mission Directorate that will focus on launch and space operations, including the International Space Station, commercialization of low Earth orbit, and eventually operations around the Moon. Implementation of this organizational change will take several months. For purposes of this report, we refer to the organization using pre-transition terminology.

²¹ *Destination Mars – Putting American Boots on the Surface of the Red Planet*, Hearing before the Senate Subcommittee on Space, Science, and Competitiveness, July 25, 2018. NASA Transition Authorization Act of 2017, Pub. L. No. 115–10, March 21, 2017.

²² *An Overview of the Budget Proposal for the National Aeronautics and Space Administration for Fiscal Year 2016*, Hearing before the House Subcommittee on Space, April 16, 2015.

²³ House Subcommittee on Space; Senate Committee on Commerce, Science, and Transportation; and House Subcommittee on Space and Aeronautics.

Figure 2: Timeline of Congressional Concerns with NASA Cost and Schedule Estimates Since 2010



Source: OIG summary of selected Congressional hearings and Authorization Acts.

Federal Rules and Regulations Require that NASA Estimate, Commit, and Report the Life-Cycle Cost of Major Programs and Activities

Federal requirements for transparency and accountability in major activities are a critical control that require credible estimates; these requirements can be traced through law to NPRs. NASA defines a mission as a major activity required to accomplish an Agency goal or to pursue a scientific, technological, or engineering opportunity directly related to an Agency goal.²⁴

Title 51 of the United States Code (Title 51), “National and Commercial Space Programs.” Congress has established specific controls in Title 51 for NASA programs with life-cycle costs over \$250 million. For these programs, NASA is required to provide Congress a Major Program Annual Report (MPAR). For new major programs, the MPAR must include a Baseline Report that, at a minimum, gives an estimate of the life-cycle cost for the program, with a detailed breakout of the development cost and program reserves as well as an estimate of the annual costs until development is completed.

What NASA chooses to categorize as “development” (Phase C-D) is particularly important to MPAR development cost and schedule reporting, as the regulation also establishes additional reporting and re-authorization requirements for programs that exceed their development cost and schedule baselines. Specifically, the Agency must notify Congress if there is reasonable cause to believe that the development cost of the program is likely to exceed the MPAR estimate by 15 percent or more, or that a milestone is likely to be delayed by 6 months or more. Within this notification, the Agency must provide a detailed explanation for the increase or delay, a description of actions taken or proposed, and a description of impacts on other Agency programs. If the Agency intends to continue the program, it

²⁴ NPR 7120.5F.

must initiate an analysis of the program that includes the projected cost and schedule for completing the program and a description of—and the projected cost and schedule for—a broad range of alternatives to the program.

If the NASA Administrator determines that the development cost of a program will exceed the estimate provided in the Baseline Report by more than 30 percent, then, beginning 18 months after a report is transmitted, the Administrator is not permitted to expend any additional funds on the program, other than termination costs, unless Congress has authorized continuation of the program. If the program is continued, the Administrator must submit a new Baseline Report for the program.

OMB Circular A-11 Capital Programming Guide. As an executive branch agency, NASA must also follow the federal budget process described in OMB Circular A-11.²⁵ The Circular requires agencies to perform risk management and develop cost estimates to improve the accuracy of cost, schedule, and performance management to help mitigate challenges associated with asset management and acquisition.²⁶ In addition, the Circular encourages agencies to develop a baseline assessment for each major asset it plans to acquire. This baseline should include a full accounting of life-cycle costs, including all direct and indirect costs for planning, procurement, operations and maintenance, and disposal.²⁷ The life-cycle cost estimate must provide the total cost to the government of acquisition and ownership of the system over its entire life to help management make decisions.

²⁵ OMB, Circular No. A-11, *Preparation, Submission, and Execution of the Budget* (August 6, 2021).

²⁶ The Capital Programming Guide, V 3.1, is included as a supplement to OMB Circular No. A-11 (August 6, 2021).

²⁷ Effective capital programming uses long-range planning and a disciplined, integrated budget process as the basis for managing a portfolio of capital assets to achieve performance goals with the lowest life-cycle costs and least risk. Agencies are expected to comply with existing statutes and guidance for planning and funding new assets; achieving cost, schedule, and performance goals; and managing the operation of assets to achieve the asset's performance and life-cycle cost goals.

NASA'S PROGRAM MANAGEMENT APPROACH FOR MULTI-MISSION PROGRAMS LIMITS TRANSPARENCY OF COSTS AND ACCOUNTABILITY FOR PERFORMANCE

Congress is not receiving all of the federally mandated cost and schedule performance information it needs to make fully informed funding decisions for NASA's multi-mission programs supporting Artemis, the Agency's return-to-the-Moon effort. Additionally, for these programs NASA is circumventing required cost and schedule performance measurements and controls by categorizing production costs for ongoing and future developments that do not directly support their respective initial capability demonstrations as *operations costs* when, in our opinion, they should be categorized as *development costs*. When the Constellation Program was cancelled in 2010, Congress directed NASA to continue development of Constellation's major components: SLS, Orion, and EGS. Without clearly defined missions for these activities, NASA elected to manage them as separate "capability demonstrations" and made cost and schedule commitments to Congress only to demonstrate the capability of each system.²⁸ These three separately-managed programs will provide the primary components for Artemis missions, the first of which is scheduled to launch no earlier than May 2022. Even though NASA has multiple Artemis missions planned, it has not adjusted the programs' life-cycle cost estimates or commitments to account for these future missions. The result has been incomplete cost estimates and commitments for these programs and missions.

Baseline Commitments for SLS and Orion Are Incomplete

After the cancellation of the Constellation program and congressional direction to pursue similar goals through SLS, Orion, and EGS, NASA adopted a program management approach to demonstrate capabilities with the Exploration Missions, EM-1 and EM-2 (now known as Artemis I and II). In its 2012 budget request, NASA introduced the Human Exploration Capabilities Theme, a major element of which was shifting design and development efforts away from management of an overarching program of integrated major project components (as had been the case under Constellation with the Ares I rocket and Orion crew vehicle) to separate development programs for the launch vehicle and crew vehicle (SLS and Orion). This new approach shifted NASA's focus toward development of capabilities permitting flexible missions to multiple destinations beyond low Earth orbit. Consequently, the Agency made baseline commitments to OMB and Congress for only the demonstration of these initial capabilities—examples of an "initial capability" would be the first flight of SLS or the first crewed flight of Orion. NASA's initial decision to categorize the SLS, Orion, and EGS programs as capability demonstrations is

²⁸ Examples of capability demonstrations would be the first flight of an SLS rocket or the first crewed flight of an Orion vehicle. The ABC for Orion covers Phase A through the first crew capability at Artemis II launch readiness (end of Phase D) and excludes post-Artemis II costs such as production to support subsequent missions.

important because it impacts how the Agency continues to classify the production costs of the programs' deliverables that do not directly support their respective initial capability demonstrations.

NASA's current position is that for programs that are likely to operate for decades, such as human space flight programs, it is difficult to establish the duration of the life-cycle scope for the purposes of determining the life-cycle cost. As such, the Agency has allowed these programs and projects that have unspecified end points—as well as plans for on-going production—to establish cost estimates and commitments for only the initial capability and to classify costs that do not directly support these early demonstrations as Operations and Sustainment (Phase E) costs (see Figure 1 above). We agree that it may be difficult to define a life cycle for programs with no defined end point. We also acknowledge that NASA's decision to not specify a life cycle beyond these early capability demonstrations may have been suitable in 2012, as the Agency did not have clearly defined mission objectives for the programs. However, now that NASA has clearly established near-term objectives and estimated timelines for the Artemis missions—to include landing the first woman and the first person of color on the Moon—it is no longer appropriate and does not provide decision makers the required transparency to continue managing these major long-term programs as capability demonstrations with indefinite Phase E costs and schedules.

For these programs, the Agency plans to maintain ABCs for the initial capability and major capability upgrades but not for all other ongoing and future major development efforts. We disagree with equating initial capability with the life cycle of these programs, as all ongoing and future production efforts (i.e., launch and crew vehicle iterations) that do not support the initial capability demonstration will not be included in any Agency commitments or external cost and schedule performance reports to Congress and OMB. As a result, the Agency is evading the cost and schedule performance controls of Title 51, particularly the requirement to notify Congress when a program exceeds specified cost and schedule thresholds. NASA has taken the position that it will only make additional commitments to Congress for "major capability upgrades," such as the Exploration Upper Stage (EUS) and associated capabilities of SLS Block 1B and EGS' Mobile Launcher-2 (ML-2).²⁹

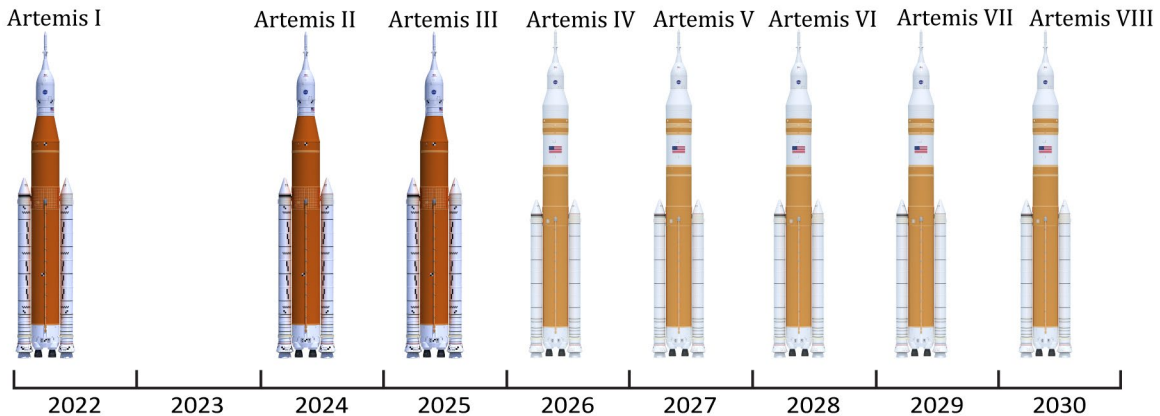
In our opinion, NASA should redefine the life cycles of these programs so they more accurately align with the Agency's strategic goals and objectives. Defining program life cycles that reflect the strategic commitments made to external stakeholders and the public, such as those published in the current NASA Strategic Plan and Artemis Plan, would provide greater transparency and accountability.³⁰ For example, NASA has stated that it plans to fly one Artemis mission per year through the end of FY 2030—a total of eight missions—each of which would require building and launching an SLS rocket (see Figure 3). Yet, the Agency's cost and schedule commitment and MPARs to Congress only include development of the Artemis I launch vehicle.

We disagree with equating initial capability with the life cycle of these programs, as all ongoing and future production efforts (i.e., launch and crew vehicle iterations) that do not support the initial capability demonstration will not be included in any cost commitments or reports to Congress and OMB.

²⁹ See Appendix B for more details on SLS and EGS components.

³⁰ NASA 2018 Strategic Plan and Artemis Plan: NASA's Lunar Exploration Program Overview (September 2020).

Figure 3: Artemis Mission Planning Timeline



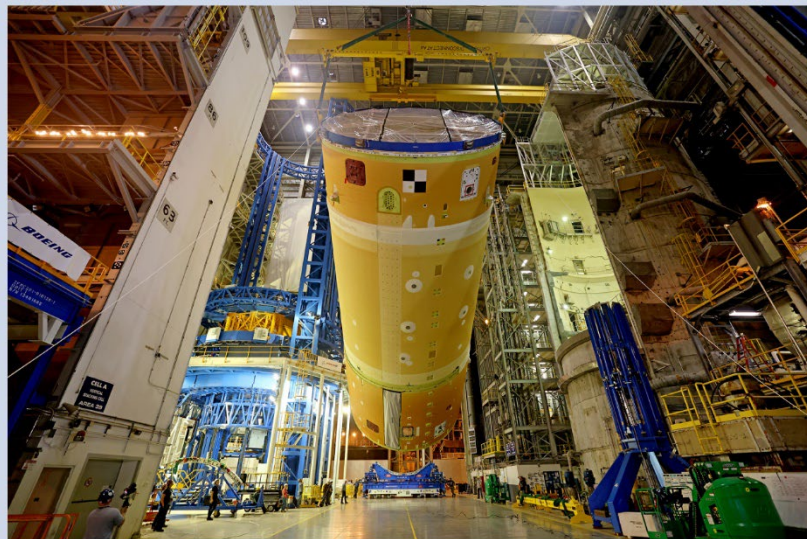
Source: OIG presentation of NASA information.

Note: Placement for Artemis IV through VIII are only representative of NASA’s plans for an annual rate of missions.

NASA Inappropriately Categorizes SLS and Orion Production as Operations and Sustainment

NASA has categorized production of the second SLS rocket and all SLS Block 1 rockets after that as Operations and Sustainment (Phase E) activities instead of Development (Phase C-D) activities. The Agency has done the same for all Orion capsules beyond Artemis II. As a result, future deliverables (iterations of SLS and Orion that do not support the initial capability demonstrations) are being included in the Operations and Sustainment phase of the programs’ life cycles instead of their Development phase. The consequence of that decision is that NASA does not establish a baseline cost or schedule commitment for these builds; the Agency is therefore reducing accountability and transparency of the cost for future iterations. For these programs, NASA considers future builds that do not include a major capability upgrade to be Phase E activities instead of categorizing those builds as additional developments. To put that into context, NASA has taken the position that the SLS rockets being built at Michoud Assembly Facility in New Orleans, Louisiana, for Artemis II and III missions (originally planned to launch in late 2023 and late 2024, respectively) are Operations and Sustainment activities of the SLS rocket for Artemis I—a

Building SLS for Artemis II

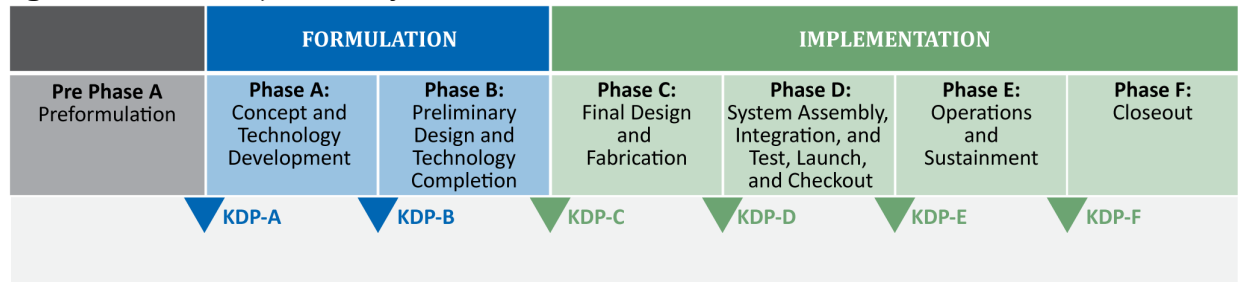


NASA completed assembly of Space Launch System (SLS) upper core stage in December at Michoud Assembly Facility.

Source: NASA.

launch vehicle now at Kennedy Space Center that is planned to launch no earlier than May 2022 for a brief, 8-minute flight before it is fully expended and plunges into the ocean. Unlike SLS, which is an expendable launch vehicle, we agree that the costs to refurbish Orion crew vehicles upon their return to Earth could be appropriately categorized as a Phase E cost.³¹ In contrast to these practices, Figure 4 shows that NASA policy categorizes the system assembly, integration, test, and launch activities of space flight projects as Phase D, or development, activities.

Figure 4: NASA Project Life Cycle



Source: NPR 7120.5F.

Title 51 defines development cost as “the total of all costs, including construction of facilities and civil servant costs, from the period beginning with the approval to proceed to implementation through the achievement of operational readiness, without regard to funding source or management control, for the life of the program.” Title 51 requires NASA to notify Congress if there is reasonable cause to believe that the **development** (Phases C & D) costs of the programs are likely to exceed the MPAR estimates by 15 percent or more. Because NASA is not including production of all SLS vehicles or subsequent Orion capsules as development costs in the estimates reported to Congress in the MPAR, the Agency will not be held fully accountable to the Title 51 cost and schedule thresholds and Congressional notification requirements for cost growth and schedule delays. More broadly, Congress will have reduced insight into the full development costs to inform its oversight and appropriations decisions.

Additionally, placing production activities under “Operations and Sustainment” does not align with NASA’s NPR-defined Expected Level of Maturity at the end of Phase D and start of Phase E (KDP-E).³² Specifically, at this phase in a project’s life cycle, the project and all supporting systems are required to be “ready for safe, successful launch and early operations with acceptable risk within ABC.” Future iterations of SLS and Orion, to include those currently being built, have not achieved this level of maturity, yet their costs are not being defined, tracked, or reported as development costs. Interestingly, while NASA has internally decided that ongoing and future SLS production is not a development activity, the Agency continues to submit Presidential budget requests for all SLS launch vehicles, to include those after Artemis I, as “Launch Vehicle Development” (discussed further below under the heading, *Lack of Transparency*).

³¹ NASA has a contract with Lockheed Martin for six Orion spacecraft intended to cover flights through Artemis VIII and an option for six more Orion spacecraft to be ordered through September 2030.

³² NPR 7120.5F.

NASA Is Not Reporting Baseline Commitments for the Artemis Missions

NASA has decided not to provide cost and schedule estimates for each Artemis mission to Congress and other stakeholders. This creates gaps in reliable and timely information for a series of missions that may cost hundreds of billions of dollars over several decades. As a result, multi-mission major acquisitions will lack cost and schedule baseline commitments in the Agency’s MPAR. NASA OIG and GAO have disagreed with the Agency on this approach in previous reports and have made recommendations on improving cost estimates and commitments by mission (see Appendix C).

To illustrate: each Artemis mission will require contributions from several projects and programs. As each mission progresses in complexity, the number of components will increase. For example, in addition to the ESD-managed SLS, Orion, and EGS programs, NASA’s Advanced Exploration Systems (AES) Division will contribute the Gateway outpost orbiting the Moon, the Human Landing System (HLS) to land crew on the Moon, Deep Space Logistics commercial cargo and supplies, next-generation spacesuits, and exploration tools such as the lunar terrain vehicle.³³ As shown in Table 1, NASA has no baseline costs documented for these missions. As the programs supporting Artemis missions progress there will likely be fewer baseline commitments among the individual components—and, beyond Artemis IV, possibly none at all when all components have transitioned to only “Operations and Sustainment” activities. These major activities, represented in gray below, will not be tracked externally beyond what can be inferred from budget requests. Even if NASA were to report mission-level costs in its annual budget request, these estimates would not be subject to the controls established via the MPAR.

Table 1: Baseline Commitment by Component for Artemis Missions as of December 2021

Component	Artemis Mission				
	I	II	III	IV	Beyond
SLS	GREEN	GRAY	GRAY	YELLOW	GRAY
Orion	GREEN	GREEN	GRAY	GRAY	GRAY
EGS	GREEN	GRAY	GRAY	GREEN	GRAY
Gateway	GRAY	GRAY	GRAY	GREEN	YELLOW
HLS	GRAY	GRAY	GREEN	GRAY	GRAY
Spacesuits and Exploration EVA	GRAY	GRAY	GRAY	GRAY	GRAY
Deep Space Logistics	GRAY	GRAY	GRAY	GRAY	GRAY
Lunar Terrain Vehicle	GRAY	GRAY	GRAY	GRAY	GRAY
Total Mission	GRAY	GRAY	GRAY	GRAY	GRAY
<p><i>GREEN: Baseline estimate provided via MPAR.</i> <i>GRAY: No baseline estimate provided via MPAR.</i> <i>YELLOW: A development project within a program, e.g., the Exportation Upper Stage (EUS) within SLS.</i> EVA = Extravehicular Activity</p>					

Source: NASA OIG presentation of Agency data. In February 2022, Office of the Chief Financial Officer officials stated that they intend on establishing commitments for Exploration Extravehicular Activity, Deep Space Logistics, and Lunar Terrain Vehicle.

³³ The Deep Space Logistics project is responsible for commercial services that will provide Gateway with cargo and supplies prior to crew arrival. The lunar terrain vehicle is proposed as a rover astronauts can drive on the Moon during multiple Artemis missions.

Fundamentally, NASA does not consider missions to be an “activity” that falls within the requirement to develop an Agency Baseline Commitment. However, Title 51 defines a major program as “an activity approved to proceed to implementation.” Even though NASA chose to develop and manage its human exploration programs and projects separately, they still must come together to accomplish the Artemis missions. In our opinion, the components of those Artemis missions collectively fit the definition of an “activity” as described in Title 51. While component programs such as SLS, Orion, and EGS are individually funded and managed, the ultimate goal of the individual programs is to further science and exploration through the Artemis missions. For example, NASA’s Mars 2020 mission, managed as a project, developed the Perseverance Rover and its associated instruments to gather scientific data regarding the potential for past life on Mars, not to continue rover technology production. Ultimately NASA is not primarily funded to produce SLS launch vehicles or Orion capsules—rather, it is funded to explore the Moon and Mars. Consequently, we believe Artemis mission costs should be captured in the Agency’s MPAR.³⁴

NASA’s Program Management Practices Have Resulted in Limited Transparency of Costs and Reduced Accountability for Performance

NASA’s lack of transparency of and accountability for the full life-cycle costs of these major multi-mission programs results in stakeholders not receiving the full cost and schedule performance information needed to make informed decisions on the allocation of resources. Moreover, cost overruns may not be detected by congressional performance monitoring controls because of insufficient life-cycle cost baselines and commitments. Finally, the Agency’s current policy and practices for estimating the cost of major programs with multiple deliverables has led to unaccounted mission costs.

Lack of Transparency

OMB Circular A-11 states that program or project acquisition life cycles start with concept analysis and then progress through technology definition, requirements planning, acquisition, and finally arrive at the operations and maintenance phase. OMB A-11 further states that it is critical that life-cycle cost estimates are realistic estimates of the final costs adjusted to consider risk. Congress and OMB scrutinize the credibility of the cost estimates each year when the Agency seeks funds during the budget process, and then seek to hold agencies accountable for meeting schedule and performance goals within those cost estimates.

Of the \$30.8 billion in NASA’s FY 2022 budget request for “SLS Launch Vehicle Development” through FY 2026 (see Table 2), less than \$11.8 billion is accounted for and measured in the FY 2022 MPAR life-cycle cost estimate and documented as a development cost in the budget request. This means that over \$19 billion, or 62 percent, of SLS development costs are not included in NASA’s MPAR or ABC, which is the only official baseline that NASA is accountable for when measuring cost and schedule performance and serves as the only basis for the Agency’s external commitment to Congress and OMB. Considering the magnitude of these unaccounted costs, external stakeholders lack visibility into how requested funds are being used or how many launch vehicles will ultimately be produced using appropriated funds.

³⁴ NASA launched the Mars 2020 mission in July 2020, and in February 2021 the Perseverance Rover landed in Jezero Crater to study the geology of Mars, identify evidence of ancient life, collect Martian surface samples, and test new technologies.

Table 2: NASA’s FY 2022 Budget Request for SLS Launch Vehicle Development

Budget Authority (in \$ millions)	Op Plan			Request					BTC	Total
	Prior	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026		
Formulation	2,673.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,673.9
Development/Implementation	7,980.0	511.1	462.5	153.7	0.0	0.0	0.0	0.0	0.0	9,107.3
Operations/Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2021 MPAR LCC Estimate	10,653.9	511.1	462.5	153.7	0.0	0.0	0.0	0.0	0.0	11,781.2
Total Budget	14,208.5	2,468.0	2,494.3	2,413.6	2,413.3	2,408.9	2,202.9	2,182.9	0.0	30,792.4

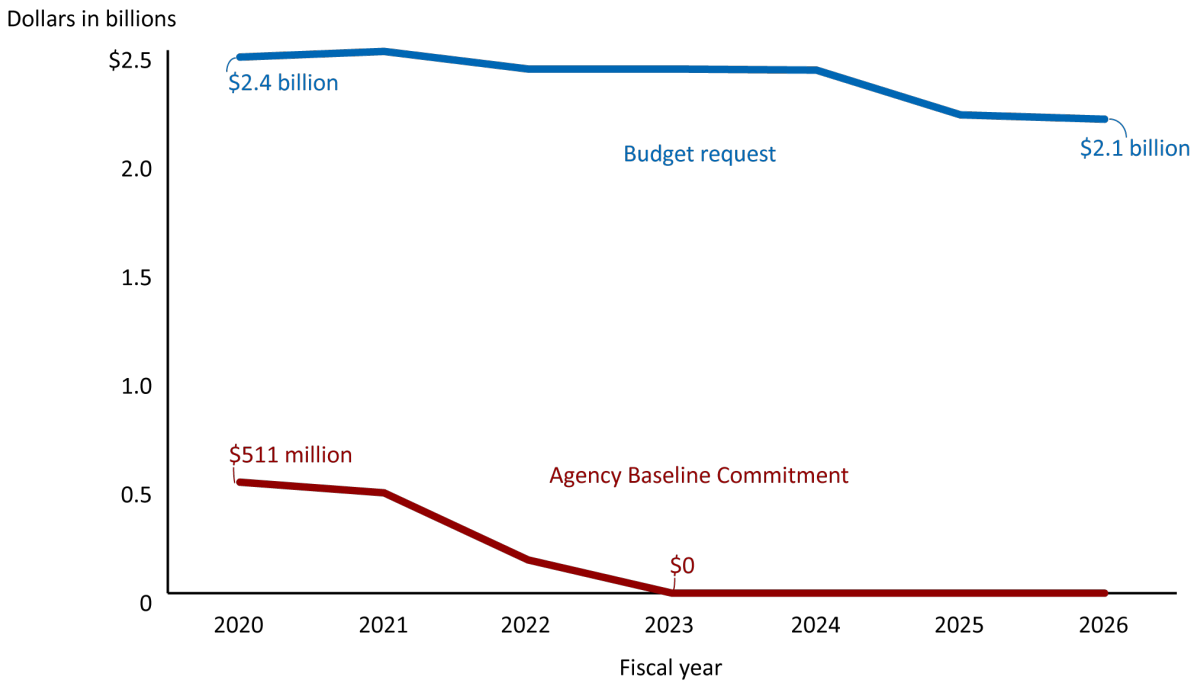
Source: President’s FY 2022 Budget Request.

Lack of Accountability

NASA continues to exclude required, reliable cost information for major production activities supporting future Artemis missions from its reports to Congress and OMB. The Agency does not consider production activities that are not supporting the initial capability demonstrations to be development activities. Specifically, the Agency has not developed or provided Congress and OMB a baseline cost commitment, supported by a Joint Cost and Schedule Confidence Level (JCL) analysis, which would include the life-cycle cost for current and future major development activities that will support future Artemis missions. Providing a “life-cycle cost” that excludes significant categories of costs beyond an “initial capability demonstration” limits congressional insight into the true costs of the programs supporting Artemis missions and NASA’s long-term budget needs to sustain these programs. As an example, Figure 5 illustrates the disconnect between NASA’s budget request and MPAR cost commitment for SLS Launch Vehicle Development.

This means that over \$19 billion, or 62 percent, of NASA’s FY 2022 request for SLS development funds is not included in NASA’s MPAR or ABC, which is the only official baseline on which to measure cost and schedule performance and serves as the only basis for the Agency’s external commitment to Congress and OMB.

Figure 5: SLS Annual Budget Requests and ABC (Fiscal Years 2020 to 2026)



Source: OIG presentation of NASA data.

As noted in our recent SLS report, this reduced transparency and accountability is a result of NASA’s deviation from statutory cost reporting requirements and what, until recently, had been Agency policy—both of which require a life-cycle cost estimate for every major program and direct that the ABC be based on all formulation and development costs.³⁵ As a result, NASA has not established a cost commitment for Artemis II and beyond and is not tracking these costs as part of the SLS ABC. Therefore, SLS cost increases for the launch vehicles supporting Artemis II and beyond (the Agency has documented plans through Artemis VIII) will not be reported through the ABC process.

³⁵ NASA OIG, *NASA’s Management of Space Launch System Program Costs and Contracts* ([IG-20-012](#), March 10, 2020).

NASA'S UPDATED COST ESTIMATING AND REPORTING POLICY DOES NOT COMPLY WITH FEDERAL LAW OR ADDRESS CRITICAL OUTSTANDING RECOMMENDATIONS

The development of human space flight programs to support Artemis missions has further highlighted major shortcomings with NASA's cost estimating and reporting practices. The Agency's August 2021 updates to its program and project management policy do not resolve these deficiencies, but rather formalize them as acceptable management practices.³⁶ NASA stated that it intended to establish new policies and procedures that would provide additional transparency for major programs with multiple deliverables and unspecified end points. Instead, the Agency exacerbated the situation by codifying its poor cost estimating and reporting practices in a policy that fails to comply with federal statute. The policy also weakens NASA's ability to account for risks in programs consisting of multiple projects, a situation that may affect cost and schedule if risks are unidentified in the estimates. Furthermore, the revised policy will not adequately address several open recommendations from NASA OIG and GAO regarding incomplete and missing cost estimates and the corresponding baseline commitments for programs supporting Artemis missions.

NASA Policy Does Not Comply with Federal Law for Estimating and Reporting Life-Cycle Costs for Programs and Activities

We compared NASA's recent revisions of NPR 7120.5 to requirements of Title 51 and OMB Circular A-11 and found that the Agency's revised program and project management procedural requirements for multi-mission programs do not comply with statutory requirements to estimate and report the life-cycle costs of major programs and activities, nor do they comply with OMB's requirement to provide the total cost to the government of acquisition and ownership of the system over its lifetime. Contrary to Title 51 requirements for estimating and reporting major program life-cycle costs with a breakdown of total development costs by year, NASA's revised policy only requires a 5-year rolling budget projection for projects and single-project programs with an unspecified end point.³⁷

Title 51 requires NASA to establish "a Baseline Report that shall, at a minimum, include an estimate of the life-cycle cost for the program." However, NASA's updated policy allows single-project programs and projects that have an unspecified end point and that plan for on-going production and operations (for example, SLS, Orion, and EGS) to establish cost estimates and commitments for only the individual

³⁶ NPR 7120.5F.

³⁷ Per NPR 7120.5F, "For single-project programs and projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point, the Phase E cost estimate for the continuing operations and production phase is established as part of the Operational Readiness Review and KDP E for the five years after initial capability and subsequently updated and documented annually for the next 5-year period."

program’s initial capability and any major capability upgrades. The Agency has determined that ongoing and future SLS and Orion developments for missions after capability demonstration will not be included in MPAR cost estimates and commitments, with only “major capability upgrades” reflected in future cost commitments for these programs. In our view, NASA’s substitution of “initial capability” for the statutory “life cycle” violates the statute and can potentially result in artificially low estimates of life-cycle costs for multi-mission programs.

Instead of adhering to statutory and OMB requirements, as shown in Table 3, NASA has revised its policy to equate the terms “life-cycle cost estimate” with “initial capability cost estimate.” Furthermore, the new NPR 7120.5F states that all single-project programs and projects are required to document the Agency’s life-cycle cost estimate, or initial capability cost estimate, at KDP-C, and this becomes the Agency Baseline Commitment. The exception to full life-cycle reporting violates Title 51. In February 2021, during NASA’s formal review of the draft NPR 7120.5F, NASA OIG provided the Agency with comments to this effect regarding the proposed changes and suggested finalization of the policy be delayed pending this audit. The Agency responded, stating it planned to complete the update to the NPR and address any potential changes to the document pending completion of the audit. The Agency finalized the NPR on August 3, 2021.

Table 3: OIG Analysis of NASA’s 2021 Revision to NPR 7120.5

Definition of “Life-Cycle Cost”			
NPR 7120.5E (August 2012 through August 2021)	NPR 7120.5F (effective as of August 2021)	U.S.C. Title 51 (December 2010)	OMB Circular A-11 (August 2021)
The total of the direct, indirect, recurring, nonrecurring, and other related expenses both incurred and estimated to be incurred in the design, development, verification, production, deployment, prime mission operation, maintenance, support, and disposal of a project, including closeout, but not extended operations. The LCC of a project or system can also be defined as the total cost of ownership over the project or system’s planned life cycle from Formulation (excluding Pre-Phase A) through Implementation (excluding extended operations). The LCC includes the cost of the launch vehicle.	The total of the direct, indirect, recurring, nonrecurring, and other related expenses both incurred and estimated to be incurred in the design, development, verification, production, deployment, prime mission operation, maintenance, support, and disposal of a project, including closeout, but not extended operations. The LCC of a project or system can also be defined as the total cost of ownership over the project or system’s planned life cycle from Formulation (excluding Pre-Phase A) through Implementation (excluding extended operations). The LCC includes the cost of the launch vehicle. <i>A key policy change includes “using initial capability cost estimates instead of LCC estimates in specific, identified instances for single-project programs and projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point.”</i>	The term “life-cycle cost” means the total of the direct, indirect, recurring, and nonrecurring costs, including the construction of facilities and civil servant costs, and other related expenses incurred or estimated to be incurred in the design, development, verification, production, operation, maintenance, support, and retirement of a program over its planned lifespan, without regard to funding source or management control.	Life-cycle costs of an asset are all direct and indirect initial costs, including planning, procurement, development, construction, and other costs; all periodic or continuing costs of operation and maintenance; and costs of decommissioning and disposal. The life-cycle cost estimate provides the total cost to the Government of acquisition and ownership of the system over its full lifetime. The project’s Life-Cycle Cost helps management to make the right decision.

Source: NASA OIG analysis.

Note: LCC = life-cycle cost.

Additionally, NASA’s use of the term “capability” in NPR 7120.5F is inconsistent with NASA Policy Directive 8600.1, *Capability Portfolio Management*, which defines a capability as “the ability of a system comprising workforce, competencies, assets, equipment, processes, and technologies to provide products and services to achieve objectives or meet requirements.”³⁸ Examples within NASA’s capability portfolio include wind tunnels, test stands, laboratories, and thermal vacuum chambers. NPD 8600.1 further states that procurement line items are separate from the capability to build them; for example, the Agency may have the capability to build a rocket, but the rocket itself would be considered a product, not a capability. In our opinion, and consistent with NPD 8600.1, the first SLS (an expendable launch vehicle) does not provide NASA with an established capability to provide products and services. Instead, and consistent with NPD 8600.1, we believe that the workforce, assets, equipment, and processes established for SLS development and production more accurately represent the capability of the SLS program to provide launch vehicles. Moreover, defining the first SLS rocket—the product of a development effort—as a capability is inconsistent with the Agency’s own definition of the term.

Instead of establishing and reporting realistic, transparent development costs for launch and crew vehicles needed for planned Artemis missions, NASA intends to provide future costs solely as a 5-year, rolling budget request in line with the Agency’s annual Planning, Programming, Budgeting, and Execution process. In essence, the Agency plans to report costs for numerous, major exploration programs via the annual budget process rather than estimate and commit to the total cost for ongoing developments and report performance relative to those commitments in the MPAR. In 2003, GAO attributed ISS cost overruns to this very same practice.³⁹ And, as we have found in our review of the Volatiles Investigating Polar Exploration Rover (VIPER) mission, the practice of justifying the exclusion of selected costs from commitments (such as landing and launch vehicles) appears to be taking root in other programs supporting Artemis missions.⁴⁰

Policy Reduces Ability to Identify Significant Risks Across Programs and Projects

NASA’s process outlined in NPR 7120.5F to identify and estimate the cost and schedule impact of global and major interdependency risks across Artemis components is insufficient.⁴¹ Formerly, tightly coupled programs, such as Constellation, and underlying component projects with an estimated life-cycle cost greater than \$250 million were required to develop a probabilistic analysis of cost and schedule estimates with a JCL.⁴² Performing a high-level, tightly coupled program JCL, which combines cost, schedule, and risk, can help identify global and major interdependency risks. This integrated assessment

³⁸ NASA Policy Directive 8600.1, *Capability Portfolio Management* (November 30, 2018). NASA added the term “Initial Capability” and the following definition to NPR 7120.5F: “For single-project programs and projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point, the initial capability is the first operational mission flight or as defined as part of the KDP B review plan. The scope of the initial capability is documented in the KDP B Decision Memorandum.”

³⁹ [GAO-04-151](#).

⁴⁰ NASA OIG, *NASA’s Volatiles Investigating Polar Exploration Rover (VIPER) Mission*, ([IG-22-010](#), April 6, 2022).

⁴¹ Global program risks affect many or all tasks within the program such as available workforce with the right skills. Major interdependency risks affect connection between major elements such as software compatibility.

⁴² Tightly coupled programs consist of multiple programs and projects that execute portions of a mission where no single project is capable of implementing a complete mission. Per NPR 7120.5E, which was cancelled by NPR 7120.5F on August 3, 2021, tightly coupled programs were required to perform a JCL analysis and fund the program at a 70 percent confidence. The Constellation Program—with its Ares rockets, Orion Exploration Crew Vehicle, and Lunar Lander—was an example of a tightly coupled program.

and risk identification process is particularly important because, as NASA has observed, when program size increases the number of interconnections increases exponentially, thereby raising the potential for schedule errors, missed connections, and omissions—all of which can lead to escalating costs. NASA is setting a precedent for multi-mission programs by removing the JCL requirements for all tightly coupled programs in the NPR 7120.5F revision.⁴³ The Agency failed to replace those requirements with a substantial alternative. The revised policy requires only a “risk posture” analysis, which, in our opinion, is not sufficiently defined to be an effective requirement.

A lesson learned from NASA’s review of its Constellation Program was that flagship missions should decouple programs and projects as much as possible in strategic, programmatic, and technical aspects.⁴⁴ One of the recommendations from Constellation Program Lessons Learned Volume II was to modify the nature of how NASA should conduct a JCL in these large, multi-mission circumstances. However, the Agency then also recommended that managers encourage or require JCLs for programs like Constellation; there was no suggestion in the review that the program-level JCL should be eliminated as the Agency has elected to do in NPR 7120.5F. NASA has not conducted a JCL for the Artemis missions, nor will they for the underlying components when they proceed to “Operations and Sustainment.” HEOMD management stated that comparable global and major interdependency risk identification processes exist for the Artemis missions using the ESD Risk Management Plan and ESD Implementation Plan. Much like “risk posture” now required by NPR 7120.5F, these ESD Plans are not equivalent to formal policies and procedures to ensure comparable risk identification processes take place for future Artemis or other similar NASA missions. Without a robust process like JCL that combines a project’s cost, schedule, and risk into a complete picture, managers and stakeholders will not have the information needed to make informed decisions on these large multi-mission programs.

In essence, the Agency plans to report costs for numerous, major exploration programs via the annual budget process rather than estimate and commit to the total cost for ongoing developments and report performance relative to those commitments in the MPAR. In 2003, GAO attributed ISS cost overruns to this very same practice.

Without JCL data, NASA will also miss an opportunity to improve the utility of its Cost Analysis

Data Requirement (CADRe) database. CADRe is an NPR 7120.5 requirement that provides a historical record of cost, schedule, and technical project attributes intended to help develop better estimates. According to NASA, CADRe satisfies a foundational cost estimating need by capturing data across all major flight projects at NASA, which is vital to performing estimates for future missions. Therefore, JCL data in CADRe from Artemis missions could support estimating cost and schedule for future large space flight efforts. NASA has stated that CADRe is a vital component for NASA to develop its early cost and schedule estimates for new NASA projects and is needed to provide a common description of a project

⁴³ NASA removed the JCL requirements for all tightly coupled programs in the NPR 7120.5F revision. The Agency now requires JCL analyses to be performed only on projects individually within a tightly coupled program.

⁴⁴ “Flagship” missions are generally large-scale, strategic missions of national importance and usually assigned directly to NASA Centers or other organizations. An executive summary of Constellation lessons learned can be found at <https://history.nasa.gov/SP-6127.pdf> (last accessed March 7, 2022).

at a point in time when information is needed to support various cost and schedule analysis activities.⁴⁵ Without a requirement for JCL-based commitments, there is no assurance NASA programs and projects will generate mission-based JCL cost and schedule data. Consequently, CADRe data quality will be reduced for subsequent missions.

NASA Has Not Addressed Critical NASA OIG and GAO Audit Recommendations

NASA’s program management practices for multi-mission programs and recent revisions to NPR 7120.5 do not align with the intent of high-priority open recommendations from NASA OIG and GAO. Currently 10 open NASA OIG recommendations to NASA’s HEOMD focus on issues with the Agency’s cost and schedule estimating, tracking, and reporting for HEOMD programs with multiple deliverables (specifically, SLS, Orion, EGS, and Gateway). Seven of these recommendations remain open due to a lack of full life-cycle cost and schedule estimates and Agency Baseline Commitments for HEOMD programs or projects. In response to our March 2020 recommendations on the SLS program aimed at increasing accountability and transparency of SLS cost and schedule beyond Artemis I, NASA indicated that the then-pending NPR 7120.5 changes and redefining formal reporting requirements were intended to resolve the associated issues.⁴⁶ However, NASA’s current and planned corrective actions are not sufficient to close our recommendation that the Agency “review HEOMD and NASA program management policies, procedures, and ABC reporting processes to provide greater visibility into current, future, and overall cost and schedule estimates for the SLS Program and other human space flight programs.” Specifically, NASA’s corrective actions and policy changes do not require the Agency to provide longer-term estimates or provide a transparent baseline of total program estimated costs to measure actual costs against. In our judgment, NASA needs to establish longer term estimates—beyond Artemis I for SLS and Artemis II for Orion—to comply with the life-cycle cost requirement under Title 51.

Similarly, GAO has 10 open recommendations that focus primarily on HEOMD’s lack of full life-cycle cost and schedule estimates for the programs supporting Artemis missions. Four of these recommendations that seek to “provide the Congress with the necessary insight into program affordability,” and to “decrease the risk of cost and schedule overruns,” remain open after more than 7 years.⁴⁷ Recently, GAO recommended that NASA establish cost and schedule baselines and begin quarterly status reviews for SLS Block 1B, SLS Block 2, Mobile Launcher 2, and the Orion Docking System as soon as practicable. GAO has also recommended that NASA conduct a JCL at the program level for Gateway and create a life-cycle cost estimate for the Artemis III mission. In response, NASA said it plans to conduct a JCL for Gateway’s initial capability in 2022 and establish cost and schedule commitments for some of the projects that compose the Artemis III lunar mission. GAO stated that NASA needs to complete the efforts in a timely manner or risks rendering them useless.

⁴⁵ NASA, *2020 High Risk Corrective Action Plan* (August 2020). NASA developed the Corrective Action Plan in response to NASA’s designation on GAO’s High Risk List. The Plan can be accessed at, https://www.nasa.gov/sites/default/files/atoms/files/nasa_high_risk_corrective_action_plan_2020.pdf (last accessed November 9, 2021).

⁴⁶ [IG-20-012](#).

⁴⁷ [GAO-14-631](#) and [GAO-14-385](#).

In its 2021 “High Risk Series” report, GAO maintains that NASA acquisition management remains a high-risk area and that NASA needs to continue implementing its corrective action plan with a focus on improving visibility into human space flight long-term costs and building capacity to reduce acquisition risk.⁴⁸ GAO stated that NASA should take action in the following areas, among others, to reduce acquisition risk to its portfolio of major projects and demonstrate progress:

- Establish cost and schedule baselines for additional human space flight capabilities in a timely manner to ensure the baselines are a useful programmatic tool and to demonstrate a commitment to improving transparency into long-term human space flight costs.
- Implement recommendations related to lunar missions, including developing a life-cycle cost estimate for the Artemis III mission, and defining and determining a schedule to ensure requirements are aligned across programs.

If the Agency were to fully implement these open OIG and GAO recommendations, external stakeholders would have greater visibility into the life-cycle costs of critical NASA programs. However, NASA’s recent revisions to NPR 7120.5 are not consistent with its High-Risk Corrective Action Plan and raise further questions about the Agency’s actual commitment to developing and reporting more accurate and transparent long-term cost and schedule estimates for major programs and projects.

⁴⁸ GAO, *High-Risk Series: Dedicated Leadership Needed to Address Limited Progress in Most High-Risk Areas* ([GAO-21-119SP](#), March 2, 2021).

CONCLUSION

NASA has a long history of cost growth and schedule delays for its major programs and projects. Such outcomes have, in part, been attributed to the Agency's poor management of these projects but also to issues regarding the credibility of the Agency's life-cycle cost estimates used to support major acquisition decisions. NASA has made improvements but continues to struggle with estimating and external reporting, in particular with large programs and missions comprised of multiple programs and projects that have multiple deliverables.

Congress, NASA OIG, and GAO have identified longstanding problems with the completeness and credibility of life-cycle cost estimates for the Artemis missions and their component programs. Without accurate cost estimates, Congress and other policymakers cannot make informed decisions on how to best invest taxpayer funds in NASA's missions.

NASA's decision to manage the development of SLS launch vehicles and Orion capsules within the initial capability program and classify those expenditures as "operations costs" rather than "development costs" has created a gap in cost estimates for Artemis missions. The Agency is currently expending funds for SLS and Orion developments that are not fully estimated and reported in accordance with requirements of Title 51. As a result, Congress does not have adequate transparency into the potential ongoing costs of these space exploration programs, rendering informed decision-making more difficult. In its recent revisions to NPR 7120.5, NASA modified its policy to continue this practice of reducing transparency of and accountability for major, multi-mission programs. In so doing, the Agency is setting a troublesome precedent for future programs and projects by providing stakeholders and decision-makers less insight into the complete development costs of multi-mission programs, projects, and initiatives.

Ultimately, NASA is not providing full visibility into its investments as it begins a multi-decade initiative to transport humans to Mars at a cost that could easily reach into the hundreds of billions of dollars. Accordingly, because some of the programs that support these exploration missions are still in their early development stages, it is critical that NASA establish credible and complete cost and schedule estimates. By adhering to sound cost estimating and reporting practices, NASA and its stakeholders can better assess the affordability and sustainability of its long-term programs and goals.

RECOMMENDATIONS, MANAGEMENT'S RESPONSE, AND OUR EVALUATION

In order to ensure that all major programs and activities are reported to Congress in accordance with Title 51, we recommend the Chief Financial Officer, in coordination with the Associate Administrators for Exploration Systems Development and Space Operations Mission Directorates:

1. Estimate, track, and report ongoing production costs for all major programs, such as SLS and Orion, as development costs (Phase C and D) and not as Operations and Sustainment (Phase E) costs.
2. Include in the next MPAR to Congress the estimated baseline life-cycle cost and schedule for each Artemis mission (starting no later than Artemis III) for which NASA proposes to expend funds in the subsequent fiscal year.
3. Should NASA elect to estimate, track, and report life-cycle costs for major programs or activities that exceed \$250 million by component rather than by mission, include estimates for each component in the MPAR and provide Congress a cost estimate, outside of the MPAR, for each Artemis mission currently planned, starting no later than Artemis III.
4. Develop a formal process by which a risk-based probabilistic analysis is conducted to cover the global and interdependency risks of major programs and projects when those individual programs and projects are required for the successful implementation of a mission; regardless of how those programs and projects are categorized (i.e., tightly coupled, single-project program, etc.).

In order to ensure that all major programs or activities are reported to Congress in accordance with Title 51, we recommend the Chief Engineer:

5. Establish procedural requirements to ensure compliance with the Title 51 requirement to report full life-cycle cost and schedule for all major programs should NASA elect to estimate, track, and report baseline costs for major programs or activities that exceed \$250 million by component rather than by mission.
6. Review NPR 7120.5F and update it as necessary to ensure compliance with laws and regulations and recommendations 1 through 5 above. Ensure the use and definitions of terms, such as "capability" and "life cycle," are consistent with those established in federal statutes and other NASA procedural requirements and policy directives.
7. Establish procedural requirements for a risk posture analysis to ensure that major programs supporting multiple missions identify and estimate the cost and schedule impact of global and major interdependency risks.

We provided a draft of this report to NASA management, who concurred with Recommendations 3 and 4; partially concurred with Recommendation 7; and non-concurred with Recommendations 1, 2, 5, and 6. We consider management's comments responsive to Recommendations 3, 4, and 7 and therefore those recommendations are resolved and will be closed upon completion and verification of the

proposed corrective actions. However, we found the Agency's response to Recommendations 1, 2, 5, and 6 unresponsive. Consequently, those recommendations will remain unresolved pending further discussions with the Agency.

NASA did not concur with Recommendation 1, stating that it does not consider on-going production activities beyond the initial capability commitment (e.g., the first SLS rocket) to be development activities. However, including on-going production of major development activities in Phase E is an approach that NASA only recently implemented for subsequent builds of SLS and Orion vehicle iterations. This exception for additional major program production units did not exist until recent changes incorporated in NPR 7120.5F. It is the OIG's position that the cost of additional production units in the operations phase conflicts with Title 51 and NPR 7120.5F, both of which define "development cost" as all costs from the beginning of implementation through the achievement of operational readiness. Since an SLS launch vehicle in production, whether it is the first or tenth unit, has not yet reached operational readiness, we believe that those costs fit within the definition of—and must be considered—development costs. NASA's new categorization of costs allows the Agency to circumvent the established cost and schedule requirement in Title 51 for all ongoing and future production units.

NASA did not concur with Recommendations 2 and 5, stating that the Agency is committed to providing transparent and accountable communication to Congress and that its reporting is compliant with Title 51. Management highlighted the new methodology implemented in NPR 7120.5F whereby NASA has decided to commit to only initial capability and major upgrade costs in the MPAR for programs with "unspecified Phase E end points." According to NASA officials, the Agency intends to report—but not commit to—all future production costs as Phase E operations costs in future MPARs; this has not yet been implemented. We do not agree that this new methodology meets statutory requirements. As specified in Title 51, the first MPAR for each major program shall at a minimum include "an estimate of the life-cycle cost for the program," which Title 51 defines as "the total of the direct, indirect, recurring, and nonrecurring costs, including the construction of facilities and civil servant costs, and other related expenses incurred or estimated to be incurred in the design, development, verification, production, operation, maintenance, support, and retirement of a program over its planned lifespan, without regard to funding source or management control." Title 51 does not provide a waiver for programs with an "unspecified Phase E end point," nor does it exclude production or operations activities from its definition of "life-cycle cost," as NASA has recently inserted in NPR 7120.5F. Therefore, we do not believe NASA is complying with the statutory requirements, nor do we believe this methodology will provide the necessary transparency of program or mission costs.

NASA did not concur with Recommendation 6 to review and update NPR 7120.5F, stating that the Agency is already fully compliant with applicable laws and Agency procedural requirements and policy directives, adding that there are no other applicable NASA procedural requirements or policy directives that dictate the term "capability." We disagree. NPD 8600.1 defines the term "capability," as "the ability of a system comprising workforce (Full-Time Equivalent (FTE)/Work-Year Equivalent (WYE)), competencies, assets, equipment, processes, and technologies to provide products and services to achieve objectives or meet requirements." We believe that this definition is sufficient to describe a capability for the purposes of developing policy requirements, including cost estimates for multi-mission programs. In its commitments to Congress, NASA is inappropriately using a definition of capability in NPR 7120.5F that does not apply to major acquisitions; the Agency is substituting the cost of only the first operational SLS and Orion vehicles (and capability upgrades) for the full life-cycle costs of the SLS and Orion programs.

Management's comments are reproduced in Appendix D. Technical comments provided by management and revisions to address them have been incorporated as appropriate.

Major contributors to this report include Raymond Tolomeo, Science and Aeronautics Research Director; Gerardo Saucedo, Project Manager; Matthew Anderson; Greg Lokey; John Schultz; and Matt Ward.

If you have questions about this report or wish to comment on the quality or usefulness of this report, contact Laurence Hawkins, Audit Operations and Quality Assurance Director, at 202-358-1543 or laurence.b.hawkins@nasa.gov.

Paul K. Martin
Inspector General

APPENDIX A: SCOPE AND METHODOLOGY

We performed this audit from October 2020 through February 2022 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.

In this report, we assessed NASA's cost and schedule estimating and reporting practices for major programs in order to determine if the policies and practices, as written, are both effective and in compliance with federal law and NASA policy. Due to the programmatic complexity and uniqueness of HEOMD's multi-mission programs with multiple deliverables, we examined the estimates and commitments of major HEOMD programs that included SLS, Orion, and EGS—currently the only NASA programs that use a single life-cycle cost estimate for the initial development but no life-cycle cost estimate for future iterations of the same major deliverable. Our assessment of the processes and practices included interviews with NASA officials from the Office of the Administrator, Program Management Improvement Office, Office of the Chief Financial Officer, Office of the Chief Engineer, HEOMD, and the Office of Legislative and Intergovernmental Affairs.

Our primary criteria for assessing the aforementioned practices and procedures were NPRs 7120.5E/F, U.S. Code Title 51, and the NASA Authorization Acts of 2005, 2010, and 2017. We reviewed NASA's MPARs since 2017 to determine if the Agency was in compliance with federal law and internal policies regulating external reporting and monitoring of performance for major programs. The MPAR, mandated by U.S. code Title 51, is contained in each annual budget requests and serves as NASA's primary tool for reporting major program baseline commitments and program performance to Congress. Additionally, we reviewed Department of Defense acquisition policies and compared them to NASA's acquisition policies to determine if the former offered a more efficient alternative to NASA's current policies. This comparison did not produce substantive results.

Our audit ran concurrently with the planned revision of NPR 7120.5E and the publication of NPR 7120.5F. We were able to assess whether the revisions complied with federal statute but were unable to fully gauge the impacts of the policy changes due to the timing of the NPR's publication.

Use of Computer-Processed Data

We did not use computer-processed data to perform this audit.

Review of Internal Controls

We assessed internal controls and compliance with laws and regulations as they relate to cost and schedule estimating, baseline commitments, tracking, and external reporting. We focused specifically on NPR 7120.5F, U.S. Code Title 51, and the NASA Authorization Acts of 2005, 2010, and 2017 in order to determine if NASA's estimating and reporting practices are in compliance with federal law. We identified control weaknesses with NASA's estimating and reporting policies and practices that are addressed in the findings. Our recommendations, if implemented, will ensure compliance with cited federal statutes and correct the control weaknesses identified in this report.

Prior Coverage

During the last 5 years, the NASA Office of Inspector General (OIG) and the Government Accountability Office (GAO) have issued 15 reports of significant relevance to the subject of this report. Reports can be accessed at <https://oig.nasa.gov/audits/auditReports.html> and <http://www.gao.gov>.

NASA Office of Inspector General

2021 Report on NASA's Top Management and Performance Challenges ([MC-2021](#), November 15, 2021)

NASA's Management of the Artemis Missions ([IG-22-003](#), November 15, 2021)

2020 Report on NASA's Top Management and Performance Challenges ([MC-2020](#), November 12, 2020)

NASA's Management of the Orion Multi-Purpose Crew Vehicle Program ([IG-20-018](#), July 16, 2020)

NASA's Development of Ground and Flight Application Software for the Artemis Program ([IG-20-014](#), March 19, 2020)

Audit of NASA's Development of Its Mobile Launchers ([IG-20-013](#), March 17, 2020)

NASA's Management of Space Launch System Program Costs and Contracts ([IG-20-012](#), March 10, 2020)

2019 Report on NASA's Top Management and Performance Challenges ([MC-2019](#), November 13, 2019)

NASA's Heliophysics Portfolio ([IG-19-018](#), May 7, 2019)

NASA's Management of the Space Launch System Stages Contract ([IG-19-001](#), October 10, 2018)

NASA Cost and Schedule Overruns: Acquisitions and Program Management Challenges ([CT-18-002](#), June 14, 2018)

NASA's Plans for Human Exploration Beyond Low Earth Orbit ([IG-17-017](#), April 13, 2017)

Government Accountability Office

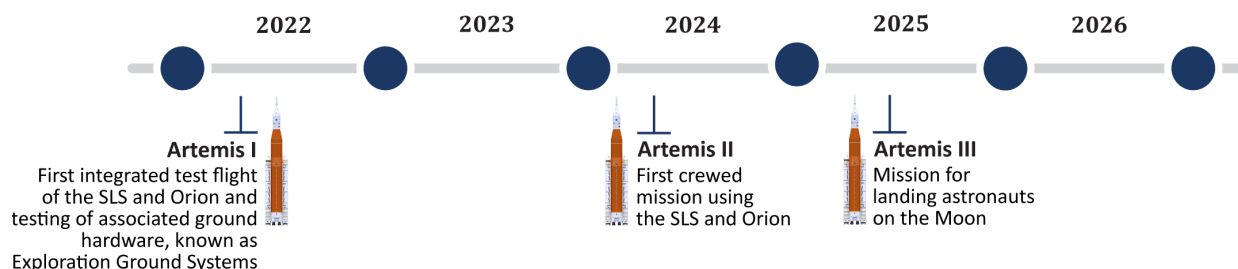
NASA Human Space Exploration: Significant Investments in Future Capabilities Require Strengthened Management Oversight ([GAO-21-105](#), December 15, 2020)

NASA Lunar Programs: Opportunities Exist to Strengthen Analyses and Plans for Moon Landing ([GAO-20-68](#), December 19, 2019)

NASA Human Space Exploration: Persistent Delays and Cost Growth Reinforce Concerns over Management of Programs ([GAO-19-377](#), June 19, 2019)

APPENDIX B: ARTEMIS COMPONENTS

Figure 6: Timeline for Artemis I, II, and III



Source: NASA.

Figure 7: Major Components of the Artemis Missions



Space Launch System (SLS). The SLS is being built to meet the Agency's long-term human exploration goal of landing humans on Mars. The first three Artemis missions will use the Block 1 configuration consisting of a core stage with four RS-25 engines, two solid rocket boosters, and an upper stage that includes an Interim Cryogenic Propulsion Stage (ICPS). For Artemis IV and beyond, NASA plans to use the Block 1B configuration, which will replace the ICPS with a more powerful Exploration Upper Stage (EUS), consisting of larger fuel tanks and four RL-10 engines.



Orion Multi-Purpose Crew Vehicle (Orion). As the crew vehicle for the Artemis missions, Orion will carry up to four astronauts during in-space operations and provide reentry, descent, and landing upon their return to Earth. The vehicle is composed of the Launch Abort System, Crew Module, Service Module, and the Spacecraft Adapter, which connects Orion to the SLS.



Exploration Ground Systems (EGS). EGS is the systems and facilities at Kennedy Space Center—such as the mobile launchers and the Vehicle Assembly Building—needed to process, integrate, and launch rockets and spacecraft.



Gateway. Gateway will be a small space station that will orbit the Moon to facilitate a long-term human presence there and serve as a staging point for deep space exploration. Initial Gateway elements consist of the Power and Propulsion Element (PPE) and the Habitation and Logistics Outpost (HALO), which provides a docking location for Orion, living and working spaces for crewmembers staying less than 30 days, and logistics capabilities.



Human Landing System (HLS). The HLS Program will design and develop the lunar lander to ferry astronauts from either the orbiting Orion or Gateway to the surface of the Moon.

Source: NASA.

APPENDIX C: RELATED OPEN NASA OIG AND GAO RECOMMENDATIONS

Report Number	Title	Recommendation	Agency Estimated Completion Date
IG-22-003	NASA's Management of the Artemis Missions	Expand upon the existing draft Artemis IMS to include Artemis programs outside AES and ESD to properly align dependencies across directorates.	9/30/22
IG-22-003	NASA's Management of the Artemis Missions	Develop an Artemis-wide cost estimate, in accordance with best practices, that is updated on an annual basis.	N/A (non-concur)
IG-22-003	NASA's Management of the Artemis Missions	Maintain an accounting of per-mission costs to increase transparency and establish a benchmark against which NASA can assess the outcome of initiatives to increase the affordability of ESD systems.	N/A (non-concur)
IG-20-018	Audit of the Orion Multi-Purpose Crew Vehicle Program	To the extent practicable, adjust the production schedules for Artemis IV and V to better align with the successful demonstration of Artemis II to reduce schedule delays associated with potential rework.	12/31/21
IG-20-013	Audit of NASA's Development of its Mobile Launchers	Ensure life-cycle and milestone reviews incorporate programmatic and technical risks and are conducted with the Associate Administrator for Human Exploration and Operations Directorate and other senior Agency officials.	4/22/22
IG-20-013	Audit of NASA's Development of its Mobile Launchers	Require the ML-2 project to develop an ABC separate from the EGS Program.	4/ 29/22
IG-20-012	NASA's Efforts to Manage Space Launch System Program Costs and Contracts	Review HEOMD and NASA program management policies, procedures, and ABC reporting processes to provide greater visibility into current, future, and overall cost and schedule estimate for the SLS Program and other human space flight programs.	4/29/22
IG-20-012	NASA's Efforts to Manage Space Launch System Program Costs and Contracts	Establish methodologies and processes to track and set cost commitments for Artemis II.	4/29/22
IG-20-012	NASA's Efforts to Manage Space Launch System Program Costs and Contracts	Determine reporting and tracking procedures for setting cost and schedule commitments, and monitoring progress throughout the entire life cycle of the SLS Program (through at least 2030).	4/29/22
IG-20-012	NASA's Efforts to Manage Space Launch System Program Costs and Contracts	Conduct a thorough review of each major SLS contract's scope of work and technical requirements needed to complete the period of performance to assist in eliminating incremental contract value increases to the contract.	1/31/22

Report Number	Title	Recommendation	Agency Estimated Completion Date
GAO-21-105	NASA Human Space Exploration: Significant Investments in Future Capabilities Require Strengthened Management Oversight	We recommend that the NASA Administrator ensure that the NASA Associate Administrator for Human Exploration and Operations Mission Directorate establish cost and schedule baselines for SLS Block 1B, SLS Block 2, Mobile Launcher 2, and Orion Docking System at their preliminary design reviews or as soon as practicable in advance of critical design reviews.	4/29/22
GAO-21-105	NASA Human Space Exploration: Significant Investments in Future Capabilities Require Strengthened Management Oversight	We recommend that the NASA Administrator ensure that the NASA Associate Administrator for Human Exploration and Operations Mission Directorate directs the Exploration Systems Development organization to include cost, schedule, and technical performance updates for SLS Block 1B, SLS Block 2, Mobile Launcher 2, and the Orion Docking System in its quarterly program status reviews in order to maintain oversight of these development projects.	3/31/21
GAO-20-68	NASA Lunar Programs: Opportunities Exist to Strengthen Analyses and Plans for Moon Landing	The NASA Administrator should ensure that the NASA Associate Administrator for Human Exploration and Operations directs the Gateway program to conduct a JCL at the program level for the Artemis III mission.	4/29/22
GAO-20-68	NASA Lunar Programs: Opportunities Exist to Strengthen Analyses and Plans for Moon Landing	The NASA Administrator should ensure that the NASA Associate Administrator for Human Exploration and Operations directs the Gateway program to update its overall schedule for 2024 to add a KDP II to occur before system integration.	4/29/22
GAO-20-68	NASA Lunar Programs: Opportunities Exist to Strengthen Analyses and Plans for Moon Landing	The NASA Administrator should ensure that the NASA Associate Administrator for Human Exploration and Operations creates a life-cycle cost estimate for the Artemis III mission.	11/30/21
GAO-16-620	Orion Multi-Purpose Crew Vehicle: Action Needed to Improve Visibility into Cost, Schedule, and Capacity to Resolve Technical Challenges	To provide the Congress and NASA a reliable estimate of program cost and schedule that are useful to support management and stakeholder decisions, the NASA Administrator should direct the Orion program to perform an updated JCL analysis including updating cost and schedule estimates in adherence with cost and schedule estimating best practices.	8/30/22
GAO-14-631	Space Launch System: Resources Need to be Matched to Requirements to Decrease Risk and Support Long Term Affordability	To provide the Congress with the necessary insight into program planning and affordability, and to decrease the risk of cost and schedule overruns, NASA's Administrator should direct the Human Exploration and Operations Mission Directorate to take the following action: To allow for a continued assessment of progress and affordability, NASA should structure each future increment of SLS capability with a total cost exceeding the \$250 million threshold for designation as a major project as a separate development effort within the SLS program. In doing so, NASA should require each increment to complete both the technical and programmatic reviews required of other major development projects, per the agency's acquisition and system engineering policies.	4/29/22

Report Number	Title	Recommendation	Agency Estimated Completion Date
GAO-14-631	Space Launch System: Resources Need to be Matched to Requirements to Decrease Risk and Support Long Term Affordability	To provide the Congress with the necessary insight into program planning and affordability, and to decrease the risk of cost and schedule overruns, NASA's Administrator should direct the Human Exploration and Operations Mission Directorate to take the following action: Provide decision makers with an informed basis for making investment decisions regarding the SLS program, NASA should identify a range of possible missions for each future SLS variant that includes cost and schedule estimates and plans for how those possible missions would fit within NASA's funding profile.	4/29/22
GAO-14-385	NASA: Actions Needed to Improve Transparency and Assess Long-Term Affordability of Human Exploration Programs	To provide the Congress with the necessary insight into program affordability, ensure its ability to effectively monitor total program costs and execution, and to facilitate investment decisions, the NASA's Administrator should direct the Human Exploration and Operations Mission Directorate to establish a separate cost and schedule baseline for work required to support the SLS Block I Exploration Mission-2 (EM-2) and report this information to the Congress through NASA's annual budget submission. If NASA decides to fly the SLS Block I beyond EM-2, 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.	4/29/22
GAO-14-385	NASA: Actions Needed to Improve Transparency and Assess Long-Term Affordability of Human Exploration Programs	To provide the Congress with the necessary insight into program affordability, ensure its ability to effectively monitor total program costs and execution, and to facilitate investment decisions, because NASA intends to use the increased capabilities of the SLS, Orion, and Ground Systems Development and Operations efforts well into the future and has chosen to estimate costs associated with achieving the capabilities, the NASA's Administrator should direct the Human Exploration and Operations Mission Directorate to establish separate cost and schedule baselines for each additional capability that encompass all life-cycle costs, to include operations and sustainment. When NASA cannot fully specify costs due to lack of well-defined missions or flight manifests, forecast a cost estimate range -- including life-cycle costs -- having minimum and maximum boundaries. These baselines or ranges should be reported to Congress annually via the agency's budget submission.	4/29/22

APPENDIX D: MANAGEMENT'S COMMENTS

National Aeronautics and
Space Administration

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



April 1, 2022

Reply to Attn of: Office of the Chief Financial Officer

TO: Assistant Inspector General for Audits

FROM: Chief Financial Officer
Associate Administrator for Exploration Systems Development Mission
Directorate
Associate Administrator for Space Operations Mission Directorate
Chief Engineer

SUBJECT: Agency Response to OIG Draft Report, "NASA's Cost Estimating and Reporting Practices for Multi-Mission Programs" (A-20-016-00)

The National Aeronautics and Space Administration (NASA) appreciates the opportunity to review and comment on the Office of Inspector General (OIG) draft report entitled, "NASA's Cost Estimating and Reporting Practices for Multi-Mission Programs" (A-20-016-00), dated February 25, 2022.

In the draft report, the OIG makes four recommendations to the Chief Financial Officer (CFO), in coordination with the Associate Administrators (AA) for Exploration Systems Development Mission Directorate (ESDMD) and Space Operations Mission Directorate (SOMD), and three recommendations to the Chief Engineer (CE):

Specifically, the OIG recommends the CFO, in coordination with the AA for ESDMD and SOMD:

Recommendation 1: Estimate, track, and report ongoing production costs for all major programs, such as SLS and Orion, as development costs (Phase C & D) and not as Operations and Sustainment (Phase E) costs.

Management's Response: Non-concur. NASA does not consider ongoing production activities beyond the initial capability commitment to be development activities. Title 51 clearly defines "development" within Section 103f (1) as the beginning of approval to proceed to implementation – "as defined in NASA's Procedural Requirements 7120.5." NASA Procedural Requirements (NPR) 7120.5F communicates that additional production units are considered part of Phase E Operations and Sustainment (Figures 2-4, 2-5; Sections 2.4.3, 2.4.4). The Agency has maintained and expanded expectations that any major development upgrades, as defined by the monetary threshold set forth in the

“major program” definition within Title 51, conducted in Phase E will be considered a development effort and be reported consistent with Title 51.

Estimated Completion Date: N/A

Recommendation 2: Include in the next Major Program Annual Report (MPAR) to Congress the estimated baseline life-cycle cost and schedule for each Artemis mission (starting no later Artemis III) for which NASA proposes to expend funds in the subsequent fiscal year.

Management’s Response: Non-concur. NASA is committed to providing transparent and accountable communication to Congress, and we currently provide such communication to them in accordance with our statutory obligations. Agency MPAR reporting will continue to be conducted consistent with the way the Agency is currently complying with Title 51 reporting requirements. For all projects subject to Title 51, the Agency provides the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate, as part of the Agency Congressional Justification submit, the MPAR that includes the information required by Title 51 section 103b. Consistent with Title 51, projects that have not been baselined are not included in that report. For projects that do not have a defined life cycle, NASA is reporting initial capability costs as part of the MPAR and subsequently providing additional Phase E operations cost in MPAR as the Agency solidifies operations scope (e.g., anticipated manifest). Additionally, the Agency provides major upgrade development efforts, as defined by the monetary threshold set forth in the “major program” definition within Title 51 in MPAR.

NASA will provide additional information concerning estimated per mission cost and schedule to Congress outside the MPAR (see Management Response to Recommendation 3).

Estimated Completion Date: N/A

Recommendation 3: Should NASA elect to estimate, track, and report life-cycle costs for major programs or activities that exceed \$250 million by component rather than by mission, include estimates for each component in the MPAR and provide Congress a cost estimate, outside of the MPAR, for each Artemis mission currently planned, starting no later than Artemis III.

Management’s Response: Concur. NASA is developing a methodology to provide Congress with a repeatable assessment of mission costs for each mission in its Artemis campaign. Costs of newly developed capabilities will be provided in addition to production and operations cost estimates for any hardware in the mission that has been previously produced and operated. These estimates will include the cost of hardware production, integration costs for each mission, operations costs, and separately the annual fixed basis of costs as captured by these programs. Costs expended by international partners will be excluded. Future missions and mission content are predicated on Presidential direction and Congressional appropriations and therefore estimates could

reflect changes in manifest, changes in contract strategies, and/or fluctuations due to obsolescence and production rate. Such an assessment will be provided as a report outside of MPAR. All cost data will be consistent with the established reporting restrictions associated with pre-decisional data.

Estimated Completion Date: Estimated completion will coincide with FY2024 President Budget Release – currently estimated no later than February 28, 2023.

Recommendation 4: Develop a formal process by which a risk-based probabilistic analysis is conducted to cover the global and interdependency risks of major programs and projects when those individual projects are required for the successful implementation of a mission; regardless of how those programs/ projects are categorized (i.e., tightly coupled, single-project program, etc.).

Management's Response: Concur. As discussed in Management's Response to Recommendation 7, NASA does have formal processes defined for accounting for global and interdependency risks for major programs and projects as it relates to their specific commitments; however, NASA does not have a formalized process for accounting for mission implementation specifically. As previously reported, NASA is in the process of formalizing an integrated mission schedule for the Artemis missions that will include development and production schedule details from each program included in the mission. ESDMD/Artemis Campaign Division (ACD) will work with and include programs, projects, and other efforts across Mission Directorates in the Artemis integrated mission schedule that have interdependencies with or constraints to defined Artemis mission content. NASA will use both internal and contractor schedules and data sources to run Schedule Risk Assessments (SRAs), which include probabilistic analyses, against mission schedules to identify margin and schedule risk to support management decisions. This process will be codified in the ACD schedule management plan and will be informed by the Joint Cost and Schedule Level Confidence Level (JCL) analyses performed at the program level for programs and upgrade commitments at Key Decision Points. Recommendation response closure will be demonstrated by approved ACD schedule management plan with inclusion of SRA process.

Estimated Completion Date: September 30, 2022.

Additionally, the OIG recommends the CE:

Recommendation 5: Establish procedural requirements to ensure compliance with the Title 51 requirement to report full life-cycle cost and schedule for all major programs should NASA elect to estimate, track, and report baseline costs for major programs or activities that exceed \$250 million by component rather than by mission.

Management's Response: Non-concur. NASA disagrees with the OIG's finding and this recommendation because NASA is already fully compliant with Title 51. NASA is conforming to Title 51 by having all major development activities, consistent with Title 51 specifications, be subject to Congressional reporting and performance thresholds. For programs and projects that plan continuing operations and production, including

integration of capability upgrades, with an unspecified Phase E end point, the initial capability cost estimate and other parameters become the Agency Baseline Commitment (ABC). In addition, NASA establishes ABCs for all future major development activities and communicates a five-year Phase E operation cost estimate prior to entering Phase E Operations and Sustainment. The Phase E operations cost estimate is updated annually. NASA's approach with respect to compliance with Title 51 ensures the Agency is consistently and effectively communicating estimates of Phase E operations as the mission cadence matures. For example, in FY22 Exploration Ground Systems (EGS) Mobile Launcher-2 and Space Launch System (SLS) Block 1B will establish ABCs; and SLS and EGS will communicate the 5-year operations costs that will be updated annually.

Estimated Completion Date: N/A

Recommendation 6: Review NPR 7120.5F and update it as necessary to ensure compliance with laws and regulations and recommendations 1 through 5 above. Ensure the use and definitions of terms, such as “capability” and “life cycle,” are consistent with those established in federal statutes and other NASA procedural requirements and policy directives.

Management's Response: Non-concur. NASA disagrees with the OIG's finding and this recommendation because NASA is already fully compliant with applicable laws and Agency procedural requirements and policy directives. Consistent with Management Responses for Recommendations 1 through 5, the Agency does not deem it necessary to update NPR 7120.5F.

The NPR 7120.5F definition for “life cycle” cost is consistent with the Title 51 definition.

- **NPR 7120.5F Life-cycle Cost Definition:** The total of the direct, indirect, recurring, nonrecurring, and other related expenses both incurred and estimated to be incurred in the design, development, verification, production, deployment, prime mission operation, maintenance, support, and disposal of a project, including closeout, but not extended operations. The LCC of a project or system can also be defined as the total cost of ownership over the project or system's planned life cycle from Formulation (excluding Pre-Phase A) through Implementation (excluding extended operations). The LCC includes the cost of the launch vehicle.
- **Title 51 Life-cycle Cost Definition:** The total of the direct, indirect, recurring, and nonrecurring costs, including the construction of facilities and civil servant costs, and other related expenses incurred or estimated to be incurred in the design, development, verification, production, operation, maintenance, support, and retirement of a program over its planned lifespan, without regard to funding source or management control.

There are no relevant Federal statutes that dictate the term “capability” as it is used in NPR 7120.5F, and there are no other applicable NASA procedural requirements or policy directives that dictate such a term. Within NPR 7120.5F, NASA does define initial

capability as “For single-project programs and projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point, the initial capability is the first operational mission flight or as defined as part of the KDP B review plan. The scope of the initial capability is documented in the KDP B Decision Memorandum.”

Estimated Completion Date: N/A

Recommendation 7: Establish procedural requirements for a risk posture analysis to ensure that major programs supporting multiple missions identify and estimate the cost and schedule impact of global and major interdependency risk.

Management’s Response: Partially concur. The Agency already states for major programs to identify and estimate the cost and schedule impacts as it relates to its commitment within NPR 7120.5F. Specifically, NPR 7120.5F addresses potential externality risks with regards to projects and programs as:


- **Projects:** For projects and single-project programs, a JCL analysis is required to support the ABC. As defined in NPR 7120.5F, JCL is the “probability that cost will be equal to or less than the targeted cost and schedule will be equal to or less than the targeted schedule date.” The JCL calculation includes consideration of the risk associated with all elements, regardless of whether or not they are funded from appropriations or managed outside of the project (e.g., risk impacts of a foreign contribution behind schedule, risk impacts of the Launch Vehicle). JCL calculations include content from the milestone at which the JCL is calculated through the completion of Phase D activities. (See the NASA Cost Estimating Handbook for more information on JCL.)
- **Programs:** NPR 7120.5F specifically states, in section 2.4.7 that “Tightly coupled, loosely coupled, and uncoupled programs are not required to develop program cost and schedule confidence levels. Tightly coupled, loosely coupled, and uncoupled programs shall provide analysis of the program’s risk posture to the governing PMC as each new project reaches KDP B and C or when a project’s ABC is rebaselined.”

Though current policy addresses the incorporation of major interdependency risks as it relates to a project or program commitment, the Agency does not currently have any formal procedural requirements that address specific mission communication. As such, NASA is currently piloting a formal process (as described in Management Response to Recommendation 4) for the Artemis missions to include a risk-based probabilistic analysis to cover the global and interdependency risks of the major programs included as it relates to specific missions. Best practices from that pilot effort will be added to the NASA Space Flight Program and Project Management (PM) Handbook as applicable.

Estimated Completion Date: Whitepaper for best practices will be complete by the end of calendar year 2023. Incorporation of best practices in the PM Handbook will be incorporated during the next major update.

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.

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 Aliza Margolies at (202) 358-1631.

A handwritten signature in black ink that reads "Margaret Vo Schaus". The signature is written in a cursive style with a large, stylized "M" and "V".

Margaret Vo Schaus

APPENDIX E: REPORT DISTRIBUTION

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(Assignment No. A-20-016-00)