NASA

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NASA's Transition of the Space Launch System to a Commercial Services Contract

October 12, 2023

IG-24-001

Office of Inspector General

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RESULTS IN BRIEF

NASA's Transition of the Space Launch System to a Commercial Services Contract

October 12, 2023 IG-24-001 (A-23-08-00-HED)

WHY WE PERFORMED THIS AUDIT

The Artemis campaign seeks to return humans to the Moon's surface in 2025 before sending crewed missions to Mars in the 2030s. Key to this effort is development of the Space Launch System (SLS)—a two-stage, heavy-lift rocket that launches the Orion Multi-Purpose Crew Vehicle into space. In December 2022, Artemis I completed its 25-day uncrewed test mission after launch delays of nearly 4 years and billions of dollars in cost increases. NASA's total Artemis campaign costs are projected to reach $93 billion from fiscal year 2012 through 2025, with SLS Program costs representing 26 percent ($23.8 billion) of that total. NASA's development of space flight systems for Artemis IV includes the Gateway outpost, a Human Landing System, and a more powerful variant of the SLS rocket—known as the Block 1B—that will make the Artemis campaign more complicated and expensive.

In an effort to increase the affordability of Artemis, NASA is preparing to award a sole-sourced services contract, known as the Exploration Production and Operations Contract (EPOC), to Deep Space Transport, LLC (DST)—a newly formed joint venture of The Boeing Company and Northrop Grumman Systems Corporation—for the production, systems integration, and launch of at least 5 and up to 10 SLS flights beginning with Artemis V scheduled for 2029. Boeing and Northrop Grumman currently supply the SLS core and upper stages and boosters, respectively, that power the SLS. Before entering into EPOC, NASA intends to use a 3-year Pre-EPOC contract to evaluate DST's readiness to assume the new contract's tasks. Our audit projections estimate a single SLS rocket produced under EPOC will cost $2.5 billion, a figure NASA hopes to reduce by 50 percent through workforce reductions, manufacturing and contracting efficiencies, and expanding the SLS's user base. Given the enormous costs of the Artemis campaign, failure to achieve substantial savings will significantly hinder the sustainability of NASA's deep space human exploration efforts.

This report is another in a series of audits examining NASA's development of space flight systems for its Artemis IV and future missions. In this audit, we assessed the extent to which EPOC is positioned to achieve the Artemis campaign's performance and affordability goals. To complete this work, we interviewed officials with NASA, Boeing, The Aerospace Corporation, and the Defense Contract Management Agency (DCMA), as well as surveyed SLS Program and procurement officials. We also visited the Michoud Assembly Facility and reviewed contract files and other documentation related to SLS Program acquisitions, solicitations, costs, contract modifications, contractors, and production quality control.

WHAT WE FOUND

After reassessing NASA's planned strategy to shift SLS production, systems integration, and launch services to DST under a services rather than the current sole-source contract structure, the Exploration Systems Development Mission Directorate added 3 years to the timeline for transitioning these responsibilities and consolidating existing SLS-related contracts under DST. During this 3-year evaluation and readiness period, NASA will continue to manage the individual SLS contracts until DST is ready to fully assume that role. We believe this Pre-EPOC transition contract is a positive step as it will include an insight/oversight team to monitor and evaluate DST's ability to manage the full scope of SLS production and integration. For example, the transition period provides Boeing more time to improve its quality control efforts for core and upper stage production at NASA's Michoud Assembly Facility, a concern raised by DCMA since 2019.

Our analysis shows a single SLS Block 1B will cost at least $2.5 billion to produce—not including Systems Engineering and Integration costs—and NASA's aspirational goal to achieve a cost savings of 50 percent is highly unrealistic. Specifically, our review determined that cost saving initiatives in several SLS production contracts such as reducing workforce within Boeing's Stages contract and gaining manufacturing efficiencies with Aerojet Rocketdyne's RS-25 Restart and Production Contract were not significant and, as a result, a single SLS will cost more than $2 billion through the first 10 SLS rockets produced under EPOC.

That said, moving SLS production from separate cost-reimbursable contracts to a combined commercial services approach may potentially reduce SLS production costs in the long term if a fixed-price contract is used to codify a reduced price. However, the Agency has yet to determine the extent to which fixed-price contracts will be used with DST. Considering the $4.3 billion cost increase the Agency incurred with cost-reimbursable contracts used to build the space flight systems for the first Artemis mission, continuing to use this type of contract under EPOC calls into question the suitability, affordability, and effectiveness of NASA's contracting approach to SLS production. Moreover, a contractor's ability to manage costs has typically accounted for only 25 percent of its evaluation under the SLS's current cost-reimbursable contracts, so the SLS Program's significant past cost overruns have had little impact on the award fees NASA provided to Boeing and Northop Grumman.

Moreover, NASA's ability to reduce SLS costs and negotiate a fixed-price contract with DST will be impeded by a lack of competition for heavy-lift launch services, a characteristic that historically has helped drive down costs. Further, NASA has permitted current SLS contractors to incorporate limited rights data into the design of the core stage and Exploration Upper Stage, effectively blocking other contractors from competing to build the SLS system. That said, inclusion of several Federal Acquisition Regulation provisions in EPOC such as incentive fees may assist NASA in contract negotiations, mitigate the impact to schedule and cost overruns, and ensure remaining data rights are retained to the fullest extent possible by the government. Finally, while DST intends to reduce costs by increasing economies of scale by building more SLSs, its efforts to find customers outside of NASA have been unsuccessful to date. Although the SLS is the only launch vehicle currently available that meets Artemis mission needs, in the next 3 to 5 years other human-rated commercial alternatives that are lighter, cheaper, and reusable may become available. Therefore, NASA may want to consider whether other commercial options should be a part of its mid- to long-term plans to support its ambitious space exploration goals.

WHAT WE RECOMMENDED

To improve the sustainability of the SLS system as the EPOC strategy is finalized, we recommended the Associate Administrator for Exploration Systems Development Mission Directorate (1) establish achievable cost saving metrics beginning with Artemis IV SLS elements and production contracts; (2) transition the core stage and Exploration Upper Stage contracts to fixed price with a per mission price to codify actual costs; (3) if keeping contracts as cost-plus-award-fee, increase the percentage of cost as a factor when conducting contractor evaluations for award fee purposes; (4) conduct a detailed review of all contractor-submitted documents to ensure the government's rights to data and processes are not unnecessarily transferred to the contractor; (5) include contract flexibility on future SLS acquisitions that will allow NASA to pivot to other commercial alternatives; (6) for each Artemis SLS rocket under EPOC, add compensation to the DST contract such as incentive fees for when the contractor achieves specific cost saving goals; and (7) ensure Government Mandatory Inspection Points and government oversight teams remain throughout the EPOC transition period.

We provided a draft of this report to NASA management who concurred or partially concurred with the recommendations and described planned actions to address them. We consider management's comments responsive; therefore, the recommendations are resolved and will be closed upon completion and verification of the proposed corrective actions.

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Acronyms

DCMA	Defense Contract Management Agency
DST	Deep Space Transport, LLC
EPOC	Exploration Production and Operations Contract
ESD	Exploration Systems Development
FAR	Federal Acquisition Regulation
ISS	International Space Station
JOFOC	justification for other than full and open competition
OIG	Office of Inspector General
RFI	Request for Information
SE&I	Systems Engineering and Integration
SLS	Space Launch System
STS	Space Transportation System
ULA	United Launch Alliance

INTRODUCTION

The Artemis campaign seeks to return humans to the surface of the Moon in 2025 before sending crewed missions to explore Mars in the 2030s. Key to this effort is development of the Space Launch System (SLS)—a two-stage, heavy-lift rocket that launches the Orion Multi-Purpose Crew Vehicle (Orion) into space. In December 2022, Artemis I—an uncrewed Orion spacecraft powered by the SLS rocket—successfully completed a 25-day mission that included an elliptical orbit of the Moon. The mission came after launch delays of nearly 4 years and significant cost increases in developing the SLS, Orion, and Mobile Launcher 1.[1] Specifically, NASA's total Artemis campaign costs are projected to reach $93 billion from fiscal year 2012 through 2025, with SLS Program costs representing 26 percent ($23.8 billion) of that overall Artemis investment. Starting with the development of Artemis IV space flight systems, NASA's Artemis campaign becomes more complicated and expensive as a more powerful variant of the SLS rocket—known as the Block 1B—takes flight and the Orion, the International Habitation Module, and an under-development Human Landing System dock with the pre-positioned Gateway outpost in lunar orbit.[2]

NASA has acknowledged the high costs of its Artemis goals—citing the SLS in particular—and is exploring ways to make the missions more affordable. To this end, NASA is preparing to award a services contract to Deep Space Transport, LLC (DST)—a newly formed joint venture of The Boeing Company (Boeing) and Northrop Grumman Systems Corporation (Northrop Grumman)—for the production, systems integration, and launch of at least 5 and up to 10 SLS flights beginning with Artemis V in 2029, potentially extending Artemis launches into 2037. Boeing and Northrop Grumman currently supply the SLS core and upper stages and boosters, respectively, that power the SLS.

Known as the Exploration Production and Operations Contract (EPOC), our cost projections show the total contract value for 10 launches could reach $25 billion over a 10-year period, making this NASA's most expensive Moon to Mars endeavor.[3] However, NASA is hoping to reduce these costs by 50 percent by undertaking workforce reductions, implementing manufacturing and contracting efficiencies, and expanding the SLS's user base to produce economies of scale. Given the enormous costs of the Artemis campaign, it is crucial that NASA achieve some significant measure of its affordability goals. Failure to do so will significantly hinder the sustainability of NASA's deep space human exploration efforts.

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[1] Mobile Launcher 1 will serve as the ground structure to assemble, process, transport, and launch the integrated SLS/Orion system for the first three Artemis mission launches.

[2] The Human Landing System will ferry crew from the Orion spacecraft to the lunar surface and back. Gateway is an orbiting lunar outpost that will be used throughout the Artemis missions as a way station for astronauts to live during lunar missions. The International Habitat is the Gateway's second habitation module and is being built by the European Space Agency in collaboration with the Japan Aerospace Exploration Agency.

[3] This projection is based on our analysis that determined an average production cost of $2.5 billion for each SLS Block 1B along with NASA's intention of reaching a launch cadence of at least once per year. While the original EPOC concept called for up to 20 launches, the forthcoming contract anticipates an initial 5 EPOC Artemis launches plus the option for an additional 5 launches. NASA Office of Inspector General (OIG), *NASA's Management of the Artemis Missions* (IG-22-003, November 15, 2021).

This report is one in a series of audits examining NASA's development of space flight systems for its Artemis IV and future missions, including the upgrade of the SLS to the Block 1B. In this audit, we assessed the extent to which EPOC is positioned to achieve the Artemis campaign's performance and affordability goals. See Appendix A for details of the audit's scope and methodology.

Background

The Artemis campaign is preparing to fly four astronauts in orbit around the Moon in 2024 in a mission known as Artemis II. NASA is seeking to partner with private industry to maximize the long-term feasibility of its Moon to Mars Program by developing an affordable and sustainable human Exploration Transportation System.[4] In July 2022 the Agency published a presolicitation notice for EPOC that would shift procurement of SLS launches from multiple NASA-managed individual contracts to one commercial services contract, thereby consolidating SLS production and operations into a single contract.[5] NASA would then purchase SLS launches "as a service" at a rate of one crewed flight per year and possibly one or more cargo flights per year starting with Artemis V. Under this approach, NASA will pay to use the contractor-built and contractor-owned systems instead of paying the contractors to build government-owned systems.[6]

According to its October 2021 Request for Information (RFI) on Exploration Production and Operations Long-Term Sustainability, NASA hopes to achieve "a substantial savings of 50 percent or more off of the current industry baseline per flight cost" under EPOC.[7] Under the contract, NASA would procure launch services for missions starting with Artemis V in the late 2020s. NASA maintains the EPOC approach will save money and make progress toward commercializing other uses of the SLS heavy-lift rocket. The contract initially covers Artemis V through IX missions, with an option for Artemis X through XIV missions. If NASA exercised all of the options, the contract would run through Artemis XIV, which is currently projected to launch in 2037.

NASA originally expected to forgo the competitive bidding process and award a sole-source contract for EPOC to DST by late 2023, but the Agency is adding a 3-year evaluation and readiness period called Pre-EPOC that will start in spring 2024.[8] During this audit, the Agency was still finalizing its strategy for establishing a Pre-EPOC contract for transitioning work currently performed by NASA to DST during this

[4] The Moon to Mars Program focuses on hardware development, mission integration, and risk management for programs critical to NASA's exploration approach that uses Artemis missions at the Moon to prepare for human missions to Mars. This includes the SLS rocket, Orion spacecraft, supporting ground systems, human landing systems, spacesuits, and the lunar orbiting Gateway outpost. NASA's Exploration Transportation System consists of the SLS, Exploration Ground Systems at Kennedy Space Center, and Cross-Program Systems Integration including Orion/payload integration.

[5] A presolicitation notice is an official communication issued by NASA to provide advanced notification to potential vendors or stakeholders about an upcoming procurement opportunity. It serves to inform interested parties of the Agency's intent to release a formal solicitation in the near future, allowing them to prepare and align their resources accordingly.

[6] NASA is leaning into the commercial services approach in other aspects of its human exploration program through current contracts with Axiom Space and Collins Aerospace for spacesuit services and Space Exploration Technologies Corporation (SpaceX), Northrop Grumman, and Boeing for crew and cargo transport services to the International Space Station (ISS or Station).

[7] RFI refers to a formal document used by NASA to gather information, data, or proposals from potential vendors, suppliers, and stakeholders in support of the Agency's procurement activities. Due to ongoing price negotiations, we have not listed the actual cost baseline of an SLS rocket that NASA is using to measure potential savings under EPOC.

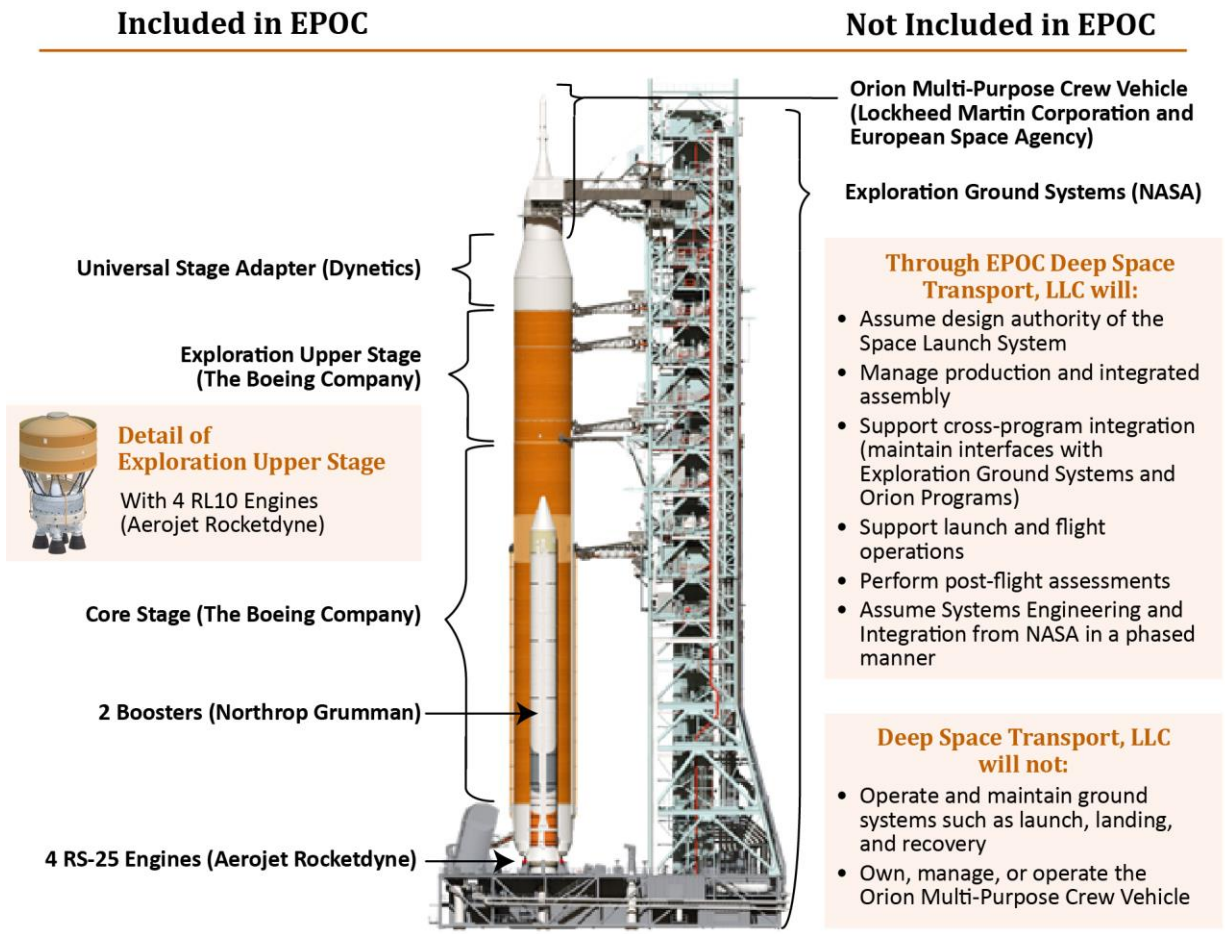
[8] Sole-source contracts are issued without a competitive bidding process. These contracts are solicited and negotiated with a single company for the purchase of supplies or services when it is determined only that company can fulfill the requirements of the contract.

evaluation period. DST consists of Boeing, the current prime contractor for the SLS core stage and Exploration Upper Stage that will be used on SLS missions starting with Artemis IV, and Northrop Grumman, the current prime contractor for the SLS solid rocket boosters.[9] NASA's use of a justification for other than full and open competition (JOFOC) is predicated on DST contracting with the SLS's other original equipment manufacturers including Aerojet Rocketdyne (Aerojet), which produces the RS-25 and RL10 liquid propellant engines, and Dynetics, which is building the Universal Stage Adapter that will be used to connect the SLS rocket's upper stage to the Orion capsule.[10] Like other major SLS contracts awarded since 2011, EPOC continues NASA's trend to sole source rather than compete its major SLS contracts. In its sole-source justification, NASA reasoned that competition was impracticable due to the high costs that would be incurred by a different contractor tasked with developing its own manufacturing processes and systems to produce the SLS. Figure 1 identifies the SLS elements and responsibilities that are included in EPOC.

[9] The SLS rocket delivers propulsion in stages to send the Orion spacecraft and its cargo to the Moon for the Artemis missions. At liftoff, the core stage—which stores liquid hydrogen and liquid oxygen and the systems that feed the stage's four RS-25 engines—and twin solid rocket boosters fire to propel the SLS off the launch pad into low Earth orbit. Once in orbit, the upper stage provides the in-space propulsion to set the spacecraft on a precise trajectory to the Moon. While the SLS rocket's core stage design remains the same, for the upper stage the first three Artemis missions will utilize an Interim Cryogenic Propulsion Stage with one RL10 engine to send Orion to the Moon. Later missions with the evolved SLS Block 1B rocket configuration will use an Exploration Upper Stage with larger fuel tanks and four RL10 engines to send a crewed Orion and larger payloads to the Moon.

[10] A JOFOC refers to a formal document required by the Federal Acquisition Regulation (FAR) for situations where a procurement is conducted through a non-competitive process. The JOFOC provides a detailed justification, supported by specific criteria outlined in FAR Subpart 6.3, for why a full and open competition is not feasible or practical in a given acquisition.

Figure 1: NASA's Major Deep Space Transport, LLC Elements and Responsibilities (as of September 2023)



Source: NASA Office of Inspector General (OIG) presentation of Agency information.

EPOC Evolved from NASA's Affordability Initiatives

NASA has been evaluating the affordability of its Exploration Systems Development (ESD) programs—SLS, Orion, and Exploration Ground Systems—as far back as 2016 when the Agency began transitioning the programs from design and development to long-term production.[11] In November 2016, the Agency submitted an RFI focused on maximizing the long-term efficiency and sustainability of the SLS, Orion, and Exploration Ground Systems by minimizing production, operations, and maintenance costs. Among the potential approaches NASA solicited in the RFI were new contractual arrangements (e.g., firm-fixed-price and hybrid contracts) for producing and operating exploration systems, establishing public-private partnerships that may utilize ESD production facilities, and expanding the user base to reduce costs

[11] The Exploration Ground Systems Program develops and operates the facilities and ground support equipment necessary to assemble, transport, launch, and recover rockets and spacecraft.

borne solely by the Agency.[12] Over the past several years, NASA has also solicited information about competing exploration services subject to reliable commercial alternatives being available. NASA is employing several strategies including adapting heritage hardware from the Space Shuttle era—16 RS-25 engines for Artemis I through IV—and streamlining manufacturing and management practices in the hopes of reducing both developmental and long-term production and operations costs.[13]

Moreover, in 2021 ESD Mission Directorate officials directed program managers to include a roadmap for potential cost saving initiatives as part of the fiscal year 2023 budget development process. Suggestions included implementing firm-fixed-price contracts where feasible, reducing production cycle times, and using an integration prime contractor to perform Systems Engineering and Integration (SE&I).[14] Taken together, this work, along with the 2016 RFI and other ESD affordability initiatives, led NASA to develop EPOC as a way to maximize the long-term efficiency and sustainability of the SLS by procuring launch services from a single contractor.

With a focus on building an affordable ESD enterprise, the EPOC RFI—issued in October 2021—also solicited information on launch and mission milestones to incentivize affordability. Prior to NASA's EPOC presolicitation in July 2022, an informal partnership consisting of Boeing, Northrop Grumman, Aerojet, and others known as Project Eta that responded to the EPOC RFI was informed that a formal structure was necessary to move forward with the procurement process. As a result, Boeing and Northrop Grumman formed a joint venture known as Deep Space Transport, LLC or DST.

The Agency is planning on using a Pre-EPOC Evaluation and Readiness contract of a shorter duration and significantly less value before awarding the larger EPOC to provide NASA more time to evaluate DST's ability to assume all SLS-related production and launch responsibilities including design authority, supply chain management, avionics software, and SE&I. NASA intends to include a measurable performance plan in the Pre-EPOC contract that, should DST fail to achieve, would allow the Agency to reassess its commitment to EPOC which could include reducing the scope of EPOC or reverting back to individual contracts.

Multiple Contracts Are Required to Produce the SLS Block 1B Configuration

NASA contracted with three companies—Boeing, Northrop Grumman, and Aerojet—to develop the major elements of the SLS for the Artemis missions. Boeing/United Launch Alliance (ULA) provides the upper stage, known as the Interim Cryogenic Propulsion Stage, for the first three Artemis missions. Under a separate contract—Stages—Boeing provides the core stage for the first two Artemis missions as well as the more powerful Exploration Upper Stage for Artemis IV (the start of the SLS Block 1B). For Artemis III and future missions, the core stage is provided under the subsequent Stages Production and Evolution Contract, which will also provide the Exploration Upper Stage beginning with Artemis V.

[12] A firm-fixed-price contract is where the price is predetermined and remains fixed throughout the performance of the contract. A hybrid contract can include fixed-price portions along with other types of arrangements.

[13] The Space Shuttle Program flew from 1981 to 2011 and consisted of reusable shuttles that could carry crew and cargo to space and back to Earth.

[14] SE&I is a methodical approach for the definition, implementation, integration, and operations of a system (product or service).

Northrop Grumman provides solid rocket boosters procured under the Boosters contract for Artemis I through III as well as production of boosters for use beginning with Artemis IV under their follow-on Boosters Production and Operations Contract.[15] For Artemis I through IV, Aerojet provides 16 RS-25 engines refurbished and updated from the Space Shuttle era under the Adaptation contract, and beginning with Artemis V they will produce new engines under the follow-on RS-25 Restart and Production contract.[16] Under other contracts, they will also provide RL10 engines for powering the SLS upper stage. In addition to these three contractors, Dynetics provides the Universal Stage Adapter that connects the Exploration Upper Stage to the Orion spacecraft.

When NASA canceled the precursor to the Artemis campaign known as Constellation in 2010, Congress directed that any follow-on human exploration program use, to the extent practical, components from the Constellation and Space Shuttle Programs.[17] Except for Dynetics, all three major SLS contracts were sole sourced and used cost-reimbursable contracts that included award fee provisions with companies who were responsible for major Constellation elements.[18] NASA's decision in 2019 to not compete the follow-on SLS stages contract—an action permissible under a JOFOC acquisition—was predicated on the Agency's belief that competition followed by an award to a company other than Boeing or Northrop Grumman, for example, would lead to significant cost and schedule delays. As a result, competitive follow-on awards for production contracts for these elements several years later were not practicable due to the high costs that would be incurred by any other contractors developing their own manufacturing processes and systems to produce the SLS core stage, boosters, and RS-25 engines. Specifically, NASA officials estimated that seeking a suitable contractor other than Boeing to duplicate a core stage would disrupt the current launch schedule by 10 years and cost the taxpayer billions more, with similar delays and cost increases for boosters and engines using different contractors.

To keep Boeing and Northrop Grumman working until the specifics of their new follow-on contract terms were finalized, NASA used what is known as letter contracts—undefinitized instruments where many of the contract terms including cost and fees remained under negotiation while work was ongoing—during the 2 to 3 years it took to finalize the contracts. Appendix B shows the time that elapsed for several SLS contracts to become definitized.

If EPOC is awarded after the 3-year transition period, DST would assume responsibility for the contractors that produce individual SLS elements that make up the SLS Block 1B—the upgraded version of SLS Block 1 with the addition of the Exploration Upper Stage—and later, the Block 2 configuration.

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[15] The SLS booster has five segments or sections—an upgrade from the four-segment Shuttle booster—that are packed with solid propellant and joined together with a forward assembly and aft skirt that house the systems and electronics to ignite, steer, and jettison the boosters.

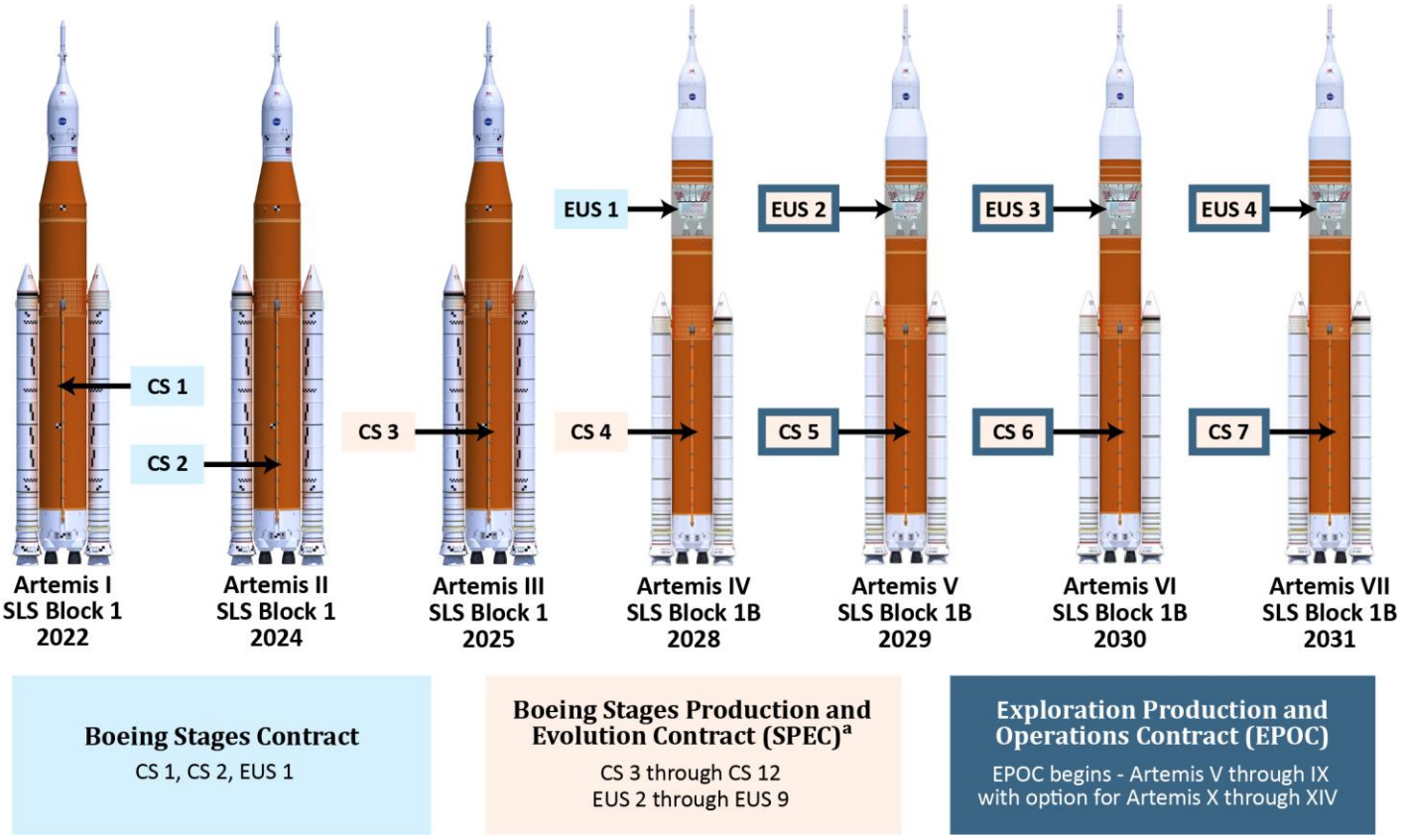
[16] Earlier this year we reported on the SLS's booster and engine contracts. See NASA OIG, *NASA's Management of the Space Launch System Booster and Engine Contracts* (IG-23-015, May 25, 2023).

[17] National Aeronautics and Space Administration Authorization Act of 2010, Pub. L. No. 111-267, 124 Stat. 2805 (2010). Established in 2006, the Constellation Program aimed to develop crew launch, heavy launch, and crew exploration vehicles to return humans to the Moon and for future exploration of Mars and other destinations.

[18] Using a cost-reimbursable approach, the majority of cost, schedule, and outcome risks are borne by the federal government. A cost-plus-award-fee contract provides a fee consisting of (a) a base amount fixed at inception of the contract and (b) an award amount based upon a judgmental evaluation by the government sufficient to provide motivation for excellence in contract performance. We have reported in several audits about excessive award fees provided to Boeing and Northrop Grumman under these contracts. See NASA OIG, *NASA's Management of Space Launch System Program Costs and Contracts* (IG-20-012, March 10, 2020) and IG-23-015.

However, the actual timing for the novation of the Stages Production and Evolution Contract from NASA to DST is yet to be determined.[19] Figure 2 shows which contracts are being used to build the core and upper stages of the SLS rocket by Artemis mission.

Figure 2: Artemis Mission Core and Upper Stage Contracts (as of September 2023)



Source: NASA OIG presentation of Agency information.

Note: Core Stage (CS) and Exploration Upper Stage (EUS). The upper stage for Artemis I through III uses the Interim Cryogenic Propulsion Stage which was awarded to Boeing under a separate contract and built by ULA, a joint venture between Boeing and Lockheed Martin Corporation.

[a] To date under the Stages Production and Evolution Contract, CS 3 and CS 4 have been definitized—meaning contract terms and specifications have been agreed upon—while critical long-lead materials purchases are being procured for CS 5, CS 6, EUS 2, and EUS 3.

[19] Novation is the replacement of one of the parties in an agreement between two parties, with the consent of all three parties involved.

ALTHOUGH NASA MADE IMPROVEMENTS TO ITS EPOC STRATEGY THE AGENCY WILL FALL SHORT OF ITS SLS COST SAVINGS GOAL

Despite NASA's noteworthy modifications to the current transition plan and its affordability initiatives, the $2.5 billion production cost of the SLS Block 1B rocket will not be significantly reduced through a sole-source services EPOC contract with DST, Boeing's and Northrop Grumman's new joint venture.[20] This is due to a variety of unrealistic assumptions associated with the impact of NASA's proposed efficiencies, the Agency's limited ability to negotiate lower launch costs with the current set of contractors, and the uncertainty of DST expanding the SLS user base. Failure to achieve NASA's hoped-for cost savings of 50 percent under EPOC will continue to threaten the long-term sustainability of the SLS rocket as the mainstay of the Artemis campaign, especially as less costly commercial heavy-lift alternatives become available.

NASA's Revised EPOC Strategy Has the Potential to Reduce Costs and Provides Additional Time to Improve Transition Plans

NASA's strategy of moving from separate component-based cost-reimbursable contracts to a combined commercial services approach has the potential to reduce the overall cost of SLS production if fixed-price contracts codify a reduced price from the $2.5 billion per launch under the current contracts. Fixed-price contracts coupled with a mature design and stable requirements afford NASA the potential to eliminate the significant cost increases the Agency has incurred under the current cost-type contracts used to build the first four SLS rockets. Under the planned strategy, DST hopes to increase its SLS production rate and build more rockets not just for NASA's ESD Mission Directorate but also for the Science Mission Directorate, NASA's international partner space agencies, other government agencies such as the U.S. Department of Defense, and commercial businesses. If successful, DST could benefit from increased economies of scale due to larger material purchases and efficiencies with its workforce that could lead to lower SLS per-unit prices.

When NASA assigned the ESD Mission Directorate oversight of EPOC in 2022, the Directorate reassessed the planned strategy for transitioning EPOC responsibilities—production, systems integration, and launch—to DST. This reassessment resulted in an extension of 3 years to the timeline for transitioning the full slate of contract responsibilities to DST, which the Directorate believed provided a better opportunity to evaluate the new entity's ability to manage the full scope of SLS development and

[20] Since our November 2021 audit (IG-22-003) that projected a $2.2 billion cost per SLS rocket, the price has increased to $2.5 billion, an amount that reflects only costs of the major SLS contracts and does not include anticipated SE&I costs. The $2.5 billion reflects only the production costs for the Artemis IV mission and not the billions spent in development costs.

integration. During this time, NASA will continue to manage the various individual SLS contracts until DST is ready to fully assume that role. In our judgment, this extended Pre-EPOC transition and evaluation period is a positive step for the Agency that is needed for three main reasons:

1. The short transition period of 3 to 6 months initially planned between the end of NASA's management of the separate SLS contracts and DST assuming full responsibility for SLS production was an insufficient amount of time for DST to coordinate with its subcontractors (Aerojet and Dynetics) and gain competency on all SLS-related tasks.[21] Almost 90 percent of the 48 SLS Program and procurement officials surveyed by our office envisioned challenges with the transition from individual contracts to a single entity under EPOC, with several citing ownership of intellectual property and proprietary data rights as key unresolved issues.
2. NASA requires an insight/oversight team to monitor DST coupled with sufficient time to evaluate DST's performance on SE&I and software development—new critical tasks that up to this point have been undertaken by NASA civil servants supported by multiple contractors.[22] Under EPOC, the SE&I task would include performing SLS engineering and technical management activities and integrating all SLS elements—stages, boosters, and adapters—along with integrating flight software.
3. The longer transition period of 3 years affords Boeing time to improve its quality control system for core stage production at NASA's Michoud Assembly Facility. We found in this audit and in previous SLS reviews that Boeing is not properly addressing corrective action requests prepared by the Defense Contract Management Agency (DCMA) and endorsed by the SLS Program's Safety and Mission Assurance team.[23] DCMA conducts Government Mandatory Inspection Points designed to ensure compliance with manufacturing standards, and since 2019 they have reported significant deficiencies in Boeing's quality control efforts at Michoud. Specifically, welding errors on several core stage fuel tanks were due in part to a lack of responsiveness by Boeing to corrective action requests, poor work instructions, the departure of experienced personnel, and errors of newly hired workers.

[21] Once DST assumes responsibility for SLS production, current SLS prime contractors that are not a part of the DST joint venture—Aerojet and Dynetics—will become subcontractors under DST.

[22] Oversight is the process in which NASA approves and directly manages contractor activities while insight occurs when the Agency monitors contractor activities but does not require specific approvals for most decisions.

[23] IG-20-012. DCMA is responsible for contract management—ensuring contracts are fulfilled on time and at the correct cost—for NASA, the Department of Defense, and several other federal agencies. A DCMA team onsite at the Michoud Assembly Facility in New Orleans, Louisiana, supports the Agency's SLS Program by providing quality assurance, testing, and supply chain management oversight. The SLS Safety and Mission Assurance team seeks to help ensure the success of SLS activities through the development, implementation, and oversight of safety, reliability, assurance, and space environment sustainability policies and procedures.

NASA's EPOC Strategy for SLS Will Fall Far Short of Anticipated Cost Savings Goal Due to Unrealistic Assumptions

SLS Block 1B Production Costs Expected to Remain High in the Near Term under EPOC

Under EPOC, NASA's goal is to achieve a 50 percent cost savings in producing flight-ready SLS vehicles, which by our calculation would reduce the contract cost of a single SLS Block 1B rocket from a current production cost of at least $2.5 billion per launch vehicle to $1.25 billion. According to Agency officials, this goal is aspirational and not based on actual analysis, and in our estimation is highly unrealistic. Specifically, our review of current SLS contracts, affordability initiatives, and cost estimates for the DST Boeing-Northrop Grumman joint venture leads us to conclude that SLS production costs will remain at over $2 billion per rocket for at least the first 10 SLS launch vehicles under EPOC.

We examined current SLS contracts managed by NASA to project a baseline cost for a Block 1B rocket that will be built under EPOC. Table 1 provides a summary of the SLS Block 1B element contracts for Artemis IV and subsequent missions. We determined SLS contracts will collectively cost at least $2.5 billion for Artemis IV not including additional tasks such as SE&I, which will be added to EPOC and therefore increase this baseline cost.[24] Beyond the planned 3-year transition period, there will likely be an extended period of time before NASA fully transfers all SLS contracts to DST. In our estimation, the $2.5 billion in production costs per vehicle will likely apply through Artemis VIII, although DST will have the potential to start reducing costs beginning with the subsequent renegotiation of its newly acquired subcontracts.

[24] In addition to managing all SLS-related production contracts, DST will assume other functions that NASA currently performs, the most notable of which is SE&I. NASA is currently conducting SE&I in-house using a combination of federal employees and contractors—an arrangement that previous senior NASA officials believed would reduce costs. Turning SE&I efforts over entirely to a contractor will likely add nearly $100 million per year to EPOC as evidenced by previous NASA programs such as the Space Shuttle Program that had a similar contractor-led SE&I function.

Table 1: SLS Block 1B Contracts (as of May 2023)

Contract	Contractor	SLS Block 1B Deliverables	Cost of Deliverables per Block 1B Launch	Performance Period	Contract Type[a]	Contract Value
Stages Contract	Boeing	1 Exploration Upper Stage for Artemis IV	$482M	2007-2025	CPAF CPIF FFP	$9.7B
Stages Production and Evolution Contract	Boeing	Core stages for Artemis III and IV, long-lead materials for Artemis V and VI core stages, Exploration Upper Stages for Artemis V and VI	$1B	2019-2028	CPIF CPAF CPFF	$3.2B
Boosters Production and Operations Contract	Northrop Grumman	10 Shuttle-era steel-cased boosters for Artemis IV through VIII, new composite boosters for missions starting with Artemis IX	$336.2M	2020-2031	CPFF CPIF FPIF	$3.2B
Restart and Production RS-25 Engines[b]	Aerojet	Restart production and certification of 24 new RS-25 engines	$582.7M	2015-2029	CPAF CPIF	$3.6B
RL10 Engines	Aerojet	10 flight engines for Artemis II through IV	$68.9M	2016-2027	CPAF FFP	$257M
Universal Stage Adapter	Dynetics	Universal Stage Adapter for Artemis IV with options for Artemis V to X stage adapters	$19.9M	2017-2029	CPAF FFP	$406.2M
		Totals	**$2.5B**			**$20.4B**

Source: NASA OIG presentation of Agency information.

Note: Dollar amounts are rounded.

[a] Cost-plus-award-fee (CPAF), cost-plus-incentive-fee (CPIF), firm-fixed price (FFP), cost-plus-fixed-fee (CPFF), and fixed-price-incentive-fee (FPIF).
[b] This contract provides engines for Artemis V and future missions. Artemis IV engines are provided under the Adaptation contract.

As the Agency continues to finalize its strategy for EPOC, it has not yet determined the extent to which fixed price versus cost-reimbursable contracts will be used in the new services contract with DST. From our perspective, the possibility of DST's continued use of cost-reimbursable contracts under EPOC raises questions about the suitability, affordability, and effectiveness of what is touted as a new "services" approach to SLS production and integration. For example, the three key deep space exploration systems—SLS, Orion, and Exploration Ground Systems—have, up to this point, been developed under a cost-reimbursable contracting structure that experienced 4 years of delays leading up to the launch of Artemis I with cost increases of $4.3 billion.

In addition, the Office of Inspector General has previously reported on issues related to the proper evaluation of contractor performance and allocation of award fees under the cost-reimbursable structures of SLS contracts, highlighting inadequate scrutiny and overpayment of fees.[25] The SLS Program's significant cost overruns have had little impact on contractor award fees because the evaluation criteria focused more on technical performance and project management. Managing

[25] IG-20-012. Cost-plus-award-fee contracts provide contractors with an award fee based on their performance. The evaluation is subjective and determined by the Agency considering factors such as cost, technical competence, and adherence to schedule. These factors are weighted based on their significance to overall contract performance.

contract costs typically accounted for 25 percent of the evaluation in these development contracts. Alternatively, when technologies are mature and requirements are stable, fixed-price contracts offer a framework in which the contractor is responsible for managing costs and meeting agreed-upon requirements at a predetermined price. Such a contract structure incentivizes contractors to exercise efficient resource allocation and diligent project management while allowing NASA, in this case, to make payments based on predetermined milestones or deliverables. Notably, requirements should be stable by the time DST takes over SLS production beginning with Artemis V because the bulk of development work for the Block 1B rocket should be completed after its first launch during the Artemis IV mission.

NASA's SLS Cost Saving Initiatives Are Based on Unrealistic Assumptions

Ongoing Affordability Efforts to Reduce Costs Have Not Achieved Expected Savings

NASA expects to achieve cost savings through EPOC by lowering SLS production costs by using fixed-price contracts. This would require DST to renegotiate contracts with Aerojet and Dynetics. Moreover, DST's efforts to reduce production costs are based, in part, on reducing the size of its workforce and gaining efficiencies in manufacturing using 3D printing of parts. While Boeing officials told us they believe the 50 percent cost reduction goal under EPOC is achievable, based on our audit we find such a goal infeasible. Specifically, when we examined the SLS's cost saving initiatives we found the proposed reductions in several key production contracts not particularly significant and, as a result, the cost of a single SLS will remain at more than $2 billion through the first 10 SLS produced. Those contracts include:

- *Boeing's Stages Contract*. A major cost of producing the SLS's core stage is the large workforce required to build the system. Although Boeing's efforts to increase affordability include workforce reductions, bulk material purchases, and decreases of certain production lines from three shifts to two, we have not identified significant cost reductions that would result from these actions. For example, Boeing reported a 13 percent reduction in workforce for building a core stage between Core Stage 1 and Core Stage 2. Given the transition from the development of the time-intensive Core Stage 1 to additional core stages, we would have expected a greater workforce reduction. In addition, our analysis of the company's budget reporting and financial management documents indicate that Boeing will continue to employ a large workforce and therefore have minimal cost reductions.
- *Aerojet's RS-25 Restart and Production Contract*. Despite initiatives aimed at cutting costs by gaining manufacturing efficiencies utilizing 3D printing and using less costly materials for RS-25 engines beyond Artemis VII, we instead found cost increases for future engines. For example, while NASA continues to claim a 30 percent reduction in RS-25 engine costs compared to those produced during the Space Shuttle era, we estimated the per-engine cost for SLS will exceed the

$104.5 million cost per RS-25 Shuttle engine.[26] Moreover, our analysis identified a 13 percent increase in the RS-25 Restart and Production contract costs to date. NASA's cost savings calculation excluded overhead and other associated costs with recertification, industry base restart, and production efforts for 24 new engines.[27]

Despite these setbacks, NASA has had some limited success in identifying ways to make the SLS more affordable. Cost saving initiatives presented by SLS managers during their May 2022 budget presentations to senior NASA officials and our internal analysis noted reduced contract costs for the solid rocket boosters. For example, booster costs are projected to decrease by 29 percent from $470 million to $336 million by the time Artemis IV launches; however, the remaining high-cost elements—core and upper stages, engines, and Universal Stage Adapter—have yet to see any significant cost savings. In addition, with the Boosters Production and Operations Contract, we found that costs continued to increase even with these projected cost saving initiatives in the contract. Nonetheless, during the transition period that ultimately will transfer contract management to DST, NASA plans to adopt more cost-effective fixed-price contracts, which includes the implementation of fixed-price frameworks for the production of some, but not all, SLS elements.

Lack of Competition Will Make It Difficult to Negotiate Lower Prices with DST

At its core, NASA's procurement strategy seeks to move the SLS from solely a NASA-owned launch system to what it hopes will be a less costly commercial services contract with DST. In our judgment, however, this transformation will be impeded by the lack of competition in procuring NASA heavy-lift launch services. In our previous work examining NASA's space flight systems, we noted several examples of how a competitive approach to space flight can yield significant savings.[28] In particular, the positive effects of competition coupled with fixed-price contracts have been demonstrated through both NASA's Commercial Cargo and Commercial Crew Programs. In the case of space flight development for delivering cargo to the International Space Station (ISS or Station), we reported that using Space Exploration Technologies Corporation (SpaceX) alone has saved the Agency between $1.4 billion and $4 billion under its competitive commercial services approach.[29] Likewise, with regard to crew transportation to the ISS, NASA paid $55 million per seat to SpaceX versus the $80 million per seat for missions to and from the Station provided by Russia's space agency. Competing these contracts and choosing two companies not only drove down prices but ensured redundancy in these cargo and crew transportation systems.[30]

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[26] The $104.5 million was calculated by NASA as the manufacturing cost of a Shuttle engine.

[27] IG-23-015.

[28] As noted in IG-22-003, NASA's competitive bid environment surrounding the Human Landing System provided initial funding to three contractors to drive down costs and ensure redundancy but due to funding limitations only SpaceX was awarded a firm-fixed-price contract. NASA OIG, *NASA's Management of Crew Transportation to the International Space Station* (IG-20-005, November 14, 2019) noted that contracts awarded to SpaceX and Boeing for crewed missions to the ISS through NASA's Commercial Crew Program have provided cost savings over use of Russia's Soyuz rocket. NASA OIG, *NASA's Plans for Human Exploration Beyond Low Earth Orbit* (IG-17-017, April 13, 2017) found that NASA has also used cost-sharing arrangements with commercial partners SpaceX and Orbital ATK—where each company contributed more than 50 percent of total development costs—for their respective cargo vehicles that service the Station.

[29] NASA OIG, *NASA's Use of Space Act Agreements* (IG-14-020, June 5, 2014).

[30] SpaceX is currently the only operational U.S. provider for crew transportation services to the ISS. SpaceX has flown astronauts to the ISS on eight missions as part of NASA's Commercial Crew Program, while Boeing—the second company awarded a crew transportation contract—has yet to demonstrate a successful crewed flight to the Station.

Case Study: Impact of Competition on NASA's Medium-Lift Launch Market

NASA's Launch Services Program—responsible for launching uncrewed science and robotics missions via commercial vehicles—analyzed the impact of competition on ULA's Atlas V rocket pricing and determined that the introduction of competitors significantly reduced per-flight costs. Before Boeing and the Lockheed Martin Corporation created the ULA joint venture in 2006, the companies competed for NASA's medium-lift launch market with their respective Delta IV and Atlas V rockets. With a lack of competition after the merger and the 2010 transition from the NASA Launch Services I to NASA Launch Services II contract, the Atlas V base launch service price increased by approximately $50 million per launch.[31] However, once SpaceX's Falcon 9 v1.1—the upgraded and more powerful version equipped with a payload fairing—became eligible to compete for NASA launch contracts in 2012 and flew its inaugural flight in 2013, the cost of the Atlas V decreased approximately $30 million per launch.

Sources: NASA.

While competition may not be practicable at this time given the substantial investment in SLS components, it is important to note that without competition to help drive costs down, NASA's negotiations with DST to establish a fixed-price contract that significantly reduces the cost for a single SLS mission will be difficult. During the course of our audit, we found that the Agency was finalizing its strategy to incentivize contractors to reduce costs in EPOC. That said, the Federal Acquisition Regulation (FAR) contains provisions that could assist in contract negotiations and potentially help NASA maximize the long-term efficiency and affordability of its ESD programs. Available options include utilization of a fixed-price contract structure and inclusion of the following FAR provisions in EPOC:

- *Incentives and penalties* including performance-based incentives as well as penalties for failing to meet deadlines or quality standards. In the DST contract, NASA has the ability to use incentive fees tied to a deliverable or milestone that would provide money to the contractor when completed on or ahead of schedule.
- *Liquidated damages* including clauses that impose reasonable predetermined financial damages on the contractor to compensate the government for delays or failures to meet key project milestones.[32]

[31] The Launch Services Program awards multiple NASA Launch Services contracts to a variety of launch service providers. Contracts under NASA Launch Services I were awarded between 2000 to 2010 and under NASA Launch Services II from 2010 through June 2025. For example, SpaceX's Falcon 9 rocket that transports both humans and cargo to the ISS is awarded under the NASA Launch Services II contract, which offers the option to on-ramp new launch vehicles annually.

[32] FAR 52.216-16 and FAR 52.211-10, respectively.

With these options, the Agency has flexibility to shift the risk of schedule and cost overruns from the federal government—who assumes the risks under cost-reimbursable structures—to the contractor. In addition to these key FAR clauses, which would strengthen the Agency's negotiating position and reduce the government's risk, we found that several current SLS contracts are fixed price for their deliverables but include cost-reimbursable components for additional tasks because requirements were not finalized prior to contract award. Our past audit work has shown that failure to lock in all requirements before contract award often results in substantial cost increases. Moreover, including additional contract funding for other activities beyond the actual deliverable such as developing new systems and parts or redesigning components results in additional costs and reduces the transparency of the contractor's actual charges for producing the item.

Another factor that will make it difficult for NASA to negotiate reduced launch prices from DST is that the Agency has relinquished significant data rights and property—such as tooling and welding machines—to the current SLS contractors making it hard for other companies to compete in the future. Specifically, to leverage potential cost savings and existing technology possessed by Boeing and its subcontractors, since 2012 NASA has allowed limited rights data to be incorporated into the design of core stages and the Exploration Upper Stage.[33] Allowing limited rights data effectively blocks other potential contractors from competing to build the system. In effect, a potential new contractor would not be able to use data developed by Boeing and its subcontractors under the SLS development period and instead would need to establish agreements with suppliers that possess the data rights—a potentially time consuming and costly endeavor—or risk substantial cost and schedule delays by redesigning the stages launch system. Given the impracticality of a new contractor establishing such agreements with Boeing and its suppliers, the cost to duplicate the core stage and Exploration Upper Stage without obtaining data rights would exceed $4.5 billion and add 10 years to the schedule according to the JOFOCs used for the Stages Production and Evolution Contract and Exploration Upper Stage. Like Boeing, Aerojet's RS-25 and RL10 engines contain license rights, limited access, and permissions that prevent the Agency from sharing data with other contractors and, as a result, the cost of another company producing and certifying similar engines would exceed $3 billion.

Drawing from these experiences and in anticipation of the EPOC award, the Agency is discussing FAR provisions to better position it to negotiate an appropriate data rights strategy to facilitate the protection of both government and industry intellectual property and limited rights data.[34] Without specific controls in the contract to ensure that remaining data rights and access are retained by the government to the fullest extent possible, NASA will find it difficult to negotiate pricing or leverage new and less costly commercial alternatives should they become available in the future. Table 2 provides a summary of NASA's initiatives to reduce costs.

[33] Limited rights data means data, other than computer software, that embodies trade secrets or is commercial, financial, confidential, or privileged, to the extent that such data pertains to items, components, or processes developed at private expense including minor modifications. As such, NASA would not be able to share this data with other companies.

[34] FAR 52.227-11 and FAR 52.227-14, respectively.

Table 2: NASA's Strategy to Reduce Production, Operations, and Maintenance Costs by 50 Percent Per Flight (as of July 2023)

NASA's Initiatives to Achieve Strategy	NASA Office of Inspector General Analysis
Employ ongoing affordability initiatives by reducing workforce, increasing efficiencies with manufacturing processes, and using fixed-price contracts.	There are cost increases in large contracts—in particular, SLS stages and engines contracts that applied affordability initiatives. Specifically, major contracts (SLS, Exploration Upper Stages, and RS-25 engines) are still cost plus and there is no commitment from DST to agree to a fixed-price contract which would help lock in savings.
Rely on DST to increase flight rate to 2 flights per year to affect economies of scale.	There is a lack of customers outside of NASA. Due to the high cost of the SLS, the Department of Defense and other entities have not shown an interest in using the SLS when commercial alternatives are more cost effective.
Transform SLS procurement strategy from a NASA-owned system to a commercial services contract with DST.	Due to a lack of competition and the use of sole-source contracts with the SLS, NASA may struggle to negotiate contract terms with DST. Boeing historically has increased costs under their contracts.

Source: NASA OIG presentation of Agency information.

EPOC is not the first time NASA has transitioned operations of a large human exploration program and consolidated those efforts under a single prime contractor. With the Space Shuttle Program, the Agency employed a similar strategy which resulted in an increase of operational costs rather than the savings that were envisioned. While EPOC is better positioned to achieve some degree of savings from efficiencies that may be gained in streamlining the manufacturing process, risks remain for the SLS Program similar to those experienced with the Shuttle Program's cost-reduction efforts.

Case Study: Space Shuttle Production Costs and Risks in a Commercial Services Contract

As a result of the transfer of Shuttle production and operations responsibilities from NASA-managed contracts to a commercial services contract, we estimate Space Shuttle operations costs increased approximately 38 percent to $1.45 billion per launch. NASA's Space Transportation System (STS)—known as the Space Shuttle Program—operated from 1981 to 2011 and shares several similarities with NASA's ongoing plan to transfer management of the SLS to a single prime contractor using a commercial services contract. In 1996, after two decades of NASA-led development and operations, STS was transferred to a commercial services contract, the Shuttle Flight Operations Contract, awarded on a sole-source basis to United Space Alliance, a joint venture between Boeing and the Lockheed Martin Corporation. This transition aimed to enhance operational efficiency and cost effectiveness in a manner akin to current efforts with the SLS. Notably, STS held the distinction of being NASA's largest budgeted program, and like the SLS, NASA recognized the imperative to reduce STS costs. However, the Program proved more costly than when operations were controlled by NASA.

Image of a Space Shuttle Orbiter (Plane), External Tank, and Solid Rocket Boosters

Source: NASA.

United Space Alliance—the prime contractor—shared the responsibility with NASA for the safety and success of the STS Program, and like the strategy under EPOC they also conducted the majority of critical SE&I tasks. Similar to the Shuttle services contract, EPOC includes a reduction of government oversight as a cost savings measure and therefore remains a risk area during the transition of SLS operations under EPOC.

Less Costly Commercial Alternatives Will Impede Efforts to Expand SLS User Base

As part of its strategy to drive down costs, DST intends to increase its production rate and build more SLSs for other potential customers such as NASA's Science Mission Directorate, other government agencies including the Department of Defense, international space agencies, and commercial companies. Expanding the SLS's customer base beyond NASA's human exploration efforts would have the potential to increase economies of scale due to larger material purchases and efficiencies with the workforce. In fact, studies conducted in preparation for the EPOC contract included independent assessments that estimated building a second SLS rocket each year would reduce costs, in one estimate, by one-third.[35] However, despite Boeing's intent to increase production and secure additional SLS customers to achieve its cost reduction targets, to date these efforts have been

[35] The Aerospace Corporation, *SLS Commercialization and Organizational Complexity Cost Savings* (April 2022).

unsuccessful. For example, the Department of Defense, specifically the Air Force and Space Force, have declined to use the SLS due to lower-cost alternatives with existing capabilities that meet their needs such as SpaceX's Falcon Heavy and ULA's Atlas V, as well as ULA's forthcoming Vulcan Centaur rocket. Moreover, even though Congress initially directed NASA to use the SLS for the Science Mission Directorate's Europa Clipper mission, NASA subsequently received congressional approval to use another launch vehicle and the Agency contracted with Space X for a Falcon Heavy rocket at a cost of $178 million.[36]

In the near term, the SLS remains the only launch vehicle with the capability to lift the 27-metric ton Orion capsule to lunar orbit. However, in the next 3 to 5 years other human-rated commercial alternatives may become available. These commercial ventures will likely capitalize on multiple technological innovations, making them lighter, cheaper, and reusable. Further driving down costs is the competition between aerospace companies such as SpaceX, ULA, and Blue Origin, with both SpaceX and Blue Origin currently developing reusable medium- and heavy-lift launch vehicles that will compete with NASA's SLS single-use rocket.

Although Congress directed NASA in 2010 to build a heavy-lift rocket and crew capsule using existing contracts from the canceled Constellation effort to meet its space exploration goals, the Agency may soon have more affordable commercial options to carry humans to the Moon and beyond. In our judgment, the Agency should continue to monitor the commercial development of heavy-lift space flight systems and begin discussions of whether it makes financial and strategic sense to consider these options as part of the Agency's longer-term plans to support its ambitious space exploration goals.

[36] The fiscal year 2021 NASA funding bill removed the Agency's requirement to use the SLS to launch the Europa Clipper on its journey to Jupiter's icy moon. The goal of this mission is to investigate Europa's ice shell and any subsurface water, understand the ocean's composition and chemistry, and examine the formation of surface features. The Europa Clipper has a scheduled target launch date of October 2024 with an arrival date at Jupiter in April 2030.

CONCLUSION

To its credit, NASA has acknowledged the high costs of its Artemis goals—the SLS in particular—and since at least 2016 has been exploring ways to make the missions more affordable. The EPOC initiative is designed to transfer SLS production, integration, and launch to a Boeing-Northrop-Grumman joint venture known as DST using a commercial services construct. In our judgment, despite NASA's noteworthy adjustments to the EPOC transition plan and its affordability initiatives, the price of the SLS Block 1B rockets will not be significantly reduced through such a sole-source contract with DST.

NASA's aspirational goal is to achieve a 50 percent cost savings over current SLS costs using DST, which by our calculation would reduce the contract cost of a single SLS rocket from the current $2.5 billion to $1.25 billion. Our analysis shows this goal realistically cannot be achieved and the production cost alone will remain over $2 billion. We reach this conclusion after examining what we believe are a variety of unrealistic assumptions on NASA's part. First, the Agency expects to achieve cost savings by reduced SLS production costs under a contract with DST. However, ongoing affordability efforts by SLS contractors to reduce the workforce and improve manufacturing processes have yet to achieve cost savings on the high-cost stages and RS-25 engine contracts. Second, DST expects to drive down costs by increasing the SLS production rate by entering into contracts with non-NASA entities such as the Department of Defense and commercial entities. However, thus far other potential users have declined to use the SLS due to lower-cost alternatives. Finally, NASA's ability to negotiate less costly services with DST will be hindered by the lack of competition given EPOC is not subject to competition but rather sole sourced to the existing SLS contractors.

Despite these challenges, NASA can take steps to improve EPOC's cost savings potential. In the near term, NASA can maximize potential savings by stabilizing technologies and requirements to maximize the use of fixed-price contracts. The continued use of SLS cost-reimbursable contracts by EPOC will likely stymie any significant cost saving efforts. In addition, several FAR provisions may assist NASA in contract negotiations and mitigate the impact of schedule and cost overruns. Finally, in the long term, commercial competition in launch services will be more practicable for the Agency to better leverage less costly commercial alternatives while achieving its mission goals. Several U.S. space flight companies are already implementing multiple technological innovations, making heavy-lift systems lighter, cheaper, and reusable. In the end, failure to significantly reduce the high costs of the SLS launch vehicle will significantly hinder the overall sustainability of the Artemis campaign and NASA's deep space human exploration efforts.

RECOMMENDATIONS, MANAGEMENT'S RESPONSE, AND OUR EVALUATION

To improve sustainability of the SLS system as the EPOC strategy is finalized, we recommended the Associate Administrator for Exploration Systems Development Mission Directorate:

1. Establish achievable cost saving metrics beginning with Artemis IV SLS elements and production contracts.
2. Transition the core stage and Exploration Upper Stage contracts to fixed-price contracts with a per mission price to codify the actual costs.
3. If keeping contracts as cost-plus-award-fee, increase the percentage of cost as a factor when conducting contractor evaluations for award fee purposes.
4. Conduct a detailed review of all contractor-submitted documents to ensure the government's rights to data and processes are not unnecessarily transferred to the contractor.
5. Include contract flexibility on future SLS acquisitions that will allow NASA to pivot to other commercial alternatives.
6. For each Artemis SLS rocket under EPOC, add compensation to the DST contract such as incentive fees for when the contractor achieves specific cost saving goals.
7. Ensure Government Mandatory Inspection Points and government oversight teams remain throughout the EPOC transition period.

We provided a draft of this report to NASA management who concurred or partially concurred with the recommendations and described planned actions to address them. We consider management's comments responsive; therefore, the recommendations are resolved and will be closed upon completion and verification of the proposed corrective actions.

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

Major contributors to this report include Ridge Bowman, Human Exploration Audits Director; Kevin Fagedes, Assistant Director; Moriah Lee; Gina Bartholomew; Shari Bergstein; Shani Dennis; Tyler Mitchell; Rachel Pierre; Robert Rose; and Lauren Suls.

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.

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Paul K. Martin
Inspector General

APPENDIX A: SCOPE AND METHODOLOGY

We performed this audit from February 2023 through September 2023 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.

This report is one in a series of audits examining NASA's development of space flight systems for its Artemis IV and future missions. In this report we evaluated NASA's planned consolidation of SLS production contracts under EPOC into one commercial services contract managed by the Boeing-Northrop Grumman joint venture called DST and assessed to what extent EPOC is positioned to achieve the Artemis campaign's performance and affordability goals. Our review included interviews and discussions with officials at NASA Headquarters, Marshall Space Flight Center, Boeing, The Aerospace Corporation, and DCMA. We also conducted a site visit at the Michoud Assembly Facility in New Orleans, Louisiana, to observe production of the SLS core stage and Exploration Upper Stage.

To assess NASA's acquisition strategy to transfer production and integration responsibilities to a single provider under a commercial services contract, we reviewed acquisition memorandums, EPOC's JOFOC and RFI, and SLS elements' and projects' cost projections and estimates. In addition, we surveyed 48 SLS Program and procurement officials to gain insight into the challenges of transitioning to EPOC. We also reviewed SLS Program and contractor cost and budget documentation, to include financial management reports and budget documents. To establish baseline costs for each SLS element, we examined the contract files for the major SLS contracts—Stages, Stages Production and Evolution Contract, Boosters Production and Operations Contract, RS-25 Restart and Production, RL10 Engines, and Universal Stage Adapter, including documents related to modifications and pre- and post-negotiation.

Due to several deficiencies in the current SLS production, we reviewed quality control documents for SLS stages production and interviewed DCMA and NASA Safety and Mission Assurance representatives embedded at Michoud Assembly Facility. We also interviewed personnel from the ESD Mission Directorate, SLS Program Planning and Control Office, and Headquarters Office of Procurement and Safety and Mission Assurance, as well as Boeing officials to understand the costs and development issues involved with the transfer of the contracts to a commercial services operation. Finally, we interviewed external cost analysts at The Aerospace Corporation to gain their perspective concerning the cost projections of a commercial services contract.

Assessment of Data Reliability

We used computer-processed data to perform this audit, and that data was used to materially support our findings, conclusions, and recommendations. First, we reviewed and analyzed NASA cost data for fiscal years 2007 through 2023 in NASA's financial accounting system for the entire SLS Program, each SLS Element Office, and each contract—Stages, Stages Production and Evolution Contract, Boosters, Boosters Production and Operations Contract,RS-25 Adaptation, RS-25 Restart and Production, RL10 Engine, and Universal Stage Adapter. We then compared these results with data

provided by the SLS Program in the form of briefing charts and Excel spreadsheets. In addition, for each contract we obtained monthly and quarterly contractor financial management reports from the respective contractors.

Review of Internal Controls

We evaluated the internal controls associated with NASA's management of the SLS, specifically their Certification of Reasonable Assurance over Internal Controls, and evaluation of program controls. In addition, we reviewed program documents designed to manage their cost, schedule, and performance for the production of the core stage, Exploration Upper Stage, boosters, RS-25 and RL10 engines, and Universal Stage Adapter, and the extent to which the projected cost savings will be realized based on whether they offer an accurate and complete picture. The control weaknesses we found were identified and discussed previously in this report. Our recommendations, if implemented, will improve the identified control weaknesses. However, because our review was limited to these internal control components and underlying principles, it may not have disclosed all internal control deficiencies that may have existed at the time of this audit.

Prior Coverage

During the last 7 years, the NASA Office of Inspector General and Government Accountability Office have issued 18 reports of significant relevance to the subject of this report. Reports can be accessed at https://oig.nasa.gov/audits/auditReports.html and https://www.gao.gov, respectively.

NASA Office of Inspector General

NASA's Management of the Space Launch System Booster and Engine Contracts (IG-23-015, May 25, 2023)

Report on NASA's Top Management and Performance Challenges (MC-2022, November 14, 2022)

NASA's Management of the Mobile Launcher 2 Contract (IG-22-012, June 9, 2022)

NASA's Cost Estimating and Reporting Practices for Multi-Mission Programs (IG-22-011, April 7, 2022)

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

Artemis Status Update (IG-21-018, April 19, 2021)

NASA's Management of the Gateway Program for Artemis Missions (IG-21-004, November 10, 2020)

NASA's Management of Its Acquisition Workforce (IG-21-002, October 27, 2020)

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

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

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

Government Accountability Office

NASA: Assessments of Major Projects (GAO-23-106021, May 31, 2023)

NASA Lunar Programs: Improved Mission Guidance Needed as Artemis Complexity Grows (GAO-22-105323, September 8, 2022)

NASA: Lessons from Ongoing Major Projects Could Improve Future Outcomes (GAO-22-105709, February 9, 2022)

NASA Lunar Programs: Significant Work Remains, Underscoring Challenges to Achieving Moon Landing in 2024 (GAO-21-330, May 26, 2021)

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

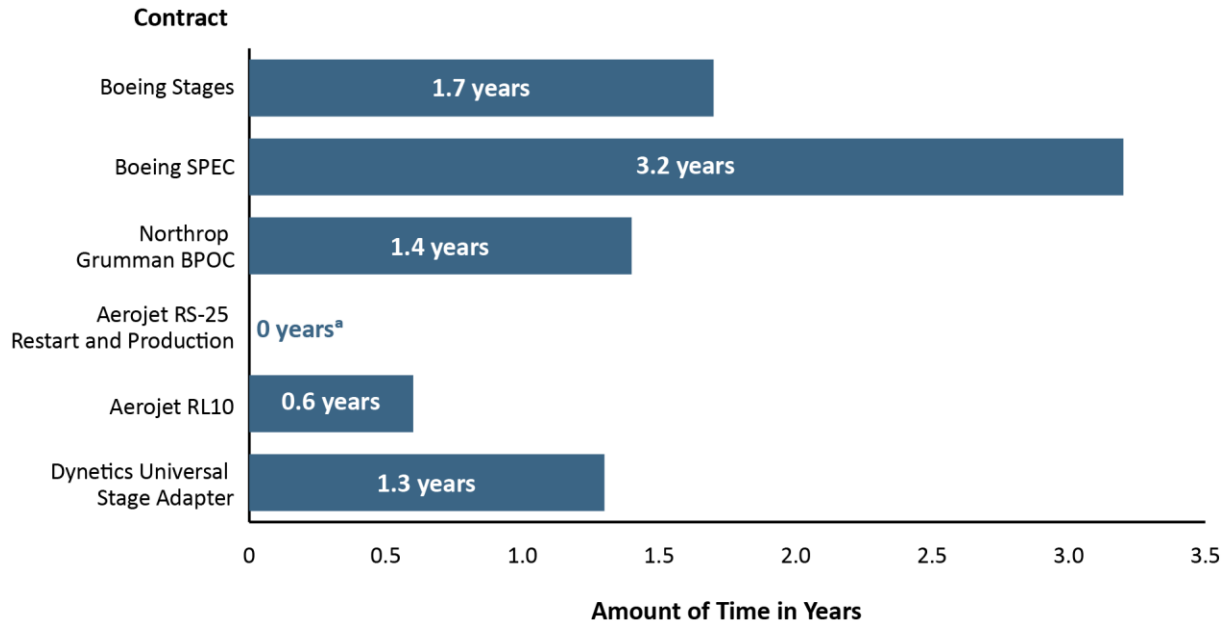
NASA Human Space Exploration: Significant Investments in Future Capabilities Require Strengthened Management Oversight (GAO-21-105, December 15, 2020)

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

APPENDIX B: DEFINITIZATION OF SLS CONTRACTS USED FOR ARTEMIS IV

NASA has historically struggled to definitize contracts within the 6-month time frame outlined in the NASA FAR Supplement.[37] Employing SLS contractors for extended periods without contract definitization increases the risk of rising costs and hinders monitoring contractor progress. Moreover, modifying original contracts to include additional requirements increases the contract value. For example, Northrop Grumman's Boosters contract—originally awarded in 2007—saw nearly 240 contract modifications *after* NASA definitized a letter contract in 2013 transitioning the scope of work from the Ares I rocket under the Constellation Program to the SLS. In nearly all the contracts listed in Figure 3, NASA issued a separate letter contract which allowed the contractor to continue work while negotiations on final costs were conducted, but this led to significant delays in completing the contract terms.

Figure 3: Amount of Time from Initial Contract Action to Definitization (as of May 2023)



Source: NASA OIG presentation of Agency information.

Note: Stages Production and Evolution Contract (SPEC) and Boosters Production and Operations Contract (BPOC).

[a] Definitization occurred at initial contract action.

[37] NASA FAR Supplement 1843.7005(a), *Definitization* (2018) provides that the NASA goal is to definitize contracts within 180 days, or approximately 6 months, of issuance..

APPENDIX C: MANAGEMENT'S COMMENTS

National Aeronautics and Space Administration

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

Reply to Attn of: Exploration Systems Development Mission Directorate

TO: Assistant Inspector General for Audits

FROM: Associate Administrator, Exploration Systems Development Mission Directorate
Assistant Administrator, Office of Procurement

SUBJECT: Agency Response to OIG Draft Report, "NASA's Transition of the Space Launch System to a Commercial Services Contract" (A-23-08-00-HED)

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 Transition of the Space Launch System to a Commercial Services Contract" (A-23-08-00-HED), dated August 31, 2023.

This report is one in a series of audits examining NASA's development of space flight systems for its Artemis IV and future missions. In the report, the OIG found that the Defense Contract Management Agency reported significant deficiencies in The Boeing Company's (Boeing's) quality control efforts at Michoud Assembly Facility. Additionally, the OIG determined that NASA's ability to reduce costs and negotiate a fixed-price contract with Deep Space Transport LLC (DST), a joint venture consisting of Boeing and Northrop Grumman, will be impeded by the lack of competition in procuring heavy-lift launch services, a characteristic that historically has helped drive down cost.

In the draft report, the OIG makes seven recommendations to the Associate Administrator for Exploration Systems Development Mission Directorate designed to improve the sustainability of the Space Launch System (SLS) as the Exploration Production and Operations Contract (EPOC) strategy is finalized.

Specifically, the OIG recommends the following:

Recommendation 1: Establish achievable cost saving metrics beginning with Artemis IV SLS elements and production contracts.

Management's Response: NASA concurs. The SLS program will continue to develop cost savings metrics. Before initiating the EPOC, an assessment will be conducted to determine what cost goals would be most appropriate for the contractor and what metrics will be used to measure progress toward such a goal.

While the Agency will use anticipated cost efficiencies and risks to develop its goals and related metrics, it reserves the right to define achievability based on the latest

manufacturing and production data available from each contract and employ enhancements to incentivize the contractor to further develop a market for additional users in order to reduce overall production costs.

Estimated Completion Date: December 31, 2027.

Recommendation 2: Transition the core stage and Exploration Upper Stage contracts to fixed-price contracts with a per mission price to codify the actual costs.

Management's Response: NASA partially concurs. As currently structured, a cost-type arrangement affords the Government the opportunity to monitor cost efficiencies and risk and ultimately discontinue development if deemed unaffordable or unachievable from a technical perspective. As Core Stage (CS) production stabilizes and Exploration Upper Stage (EUS) design matures, risks will be reduced and evolving to a fixed-price compensation arrangement may be appropriate. The EPOC contract is currently planned to be fixed-price, which will encompass all of the content, including the CS and EUS. Note that per-mission cost may not be the most effective contract implementation. NASA will make the specific decision in their procurement strategy deliberation for the EPOC structure. One purpose of pre-EPOC is to reduce risks, both technically and programmatically, in the future transition to a launch services model.

Estimated Completion Date: December 31, 2027.

Recommendation 3: If keeping contracts as cost-plus-award-fee, increase the percentage of cost as a factor when conducting contractor evaluations for award fee purposes.

Management's Response: NASA concurs. NASA assesses the relative areas of emphasis and other appropriate award fee plan modifications during each performance evaluation board based on the prevailing performance issues and concerns. For contracts where "cost control" is incentivized through award fee evaluations, NASA continually assesses the weighting of "cost control" as a factor during each evaluation period.

Estimated Completion Date: December 31, 2027.

Recommendation 4: Conduct a detailed review of all contractor-submitted documents to ensure the government's rights to data and processes are not unnecessarily transferred to the contractor.

Management's Response: NASA concurs**.** NASA will continue to protect the Government's rights to data and processes and will incorporate this recommendation as new contracts are negotiated, including in the future EPOC.

Estimated Completion Date: December 31, 2027.

Recommendation 5: Include contract flexibility on future SLS acquisitions that will allow NASA to pivot to other commercial alternatives.

Management's Response: NASA concurs. The procurement strategy for EPOC has not been established, pending performance under the pre-EPOC evaluation and readiness

effort. However, at that time, NASA will ensure appropriate flexibilities through the use of contract options or other means to explore the use of commercial alternatives, if feasible.

Estimated Completion Date: December 31, 2027.

Recommendation 6: For each Artemis SLS rocket under EPOC, add compensation to the DST contract such as incentive fees for when the contractor achieves specific cost saving goals.

Management's Response: NASA partially concurs. The procurement strategy for EPOC has not been established, pending performance under the pre-EPOC evaluation and readiness effort. However, at that time, NASA will determine a contract compensation arrangement that promotes affordability and technical excellence, whether through incentive fee or through another mechanism.

Estimated Completion Date: December 31, 2027.

Recommendation 7: Ensure Government Mandatory Inspection Points and government oversight teams remain throughout the EPOC transition period.

Management's Response: NASA concurs. A combination of Government Mandatory Inspection Points and In-Line Assessments (ILAs) will continue to be used throughout pre-EPOC. A risk-based surveillance strategy will use these ILAs to gain insight into critical processes.

Estimated Completion Date: June 28, 2024

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 draft report. If you have any questions or require additional information regarding this response, please contact Ruth Siboni at (202) 358-4555.

James Free Digitally signed by James Free Date: 2023.09.29 14:06:11 -04'00'

James Free
Associate Administrator,
Exploration Systems Development
Mission Directorate

Karla Jackson Digitally signed by Karla Jackson Date: 2023.09.28 18:23:42 -04'00'

Karla Smith Jackson
Assistant Administrator,
Procurement

APPENDIX D: REPORT DISTRIBUTION

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Deputy Administrator
Associate Administrator
Chief of Staff
Associate Administrator for Exploration Systems Development Mission Directorate
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Senate Committee on Commerce, Science, and Transportation
    Subcommittee on Space and Science

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    Subcommittee on Government Operations and the Federal Workforce

House Committee on Science, Space, and Technology
    Subcommittee on Investigations and Oversight
    Subcommittee on Space and Aeronautics

(Assignment No. A-23-08-00-HED)