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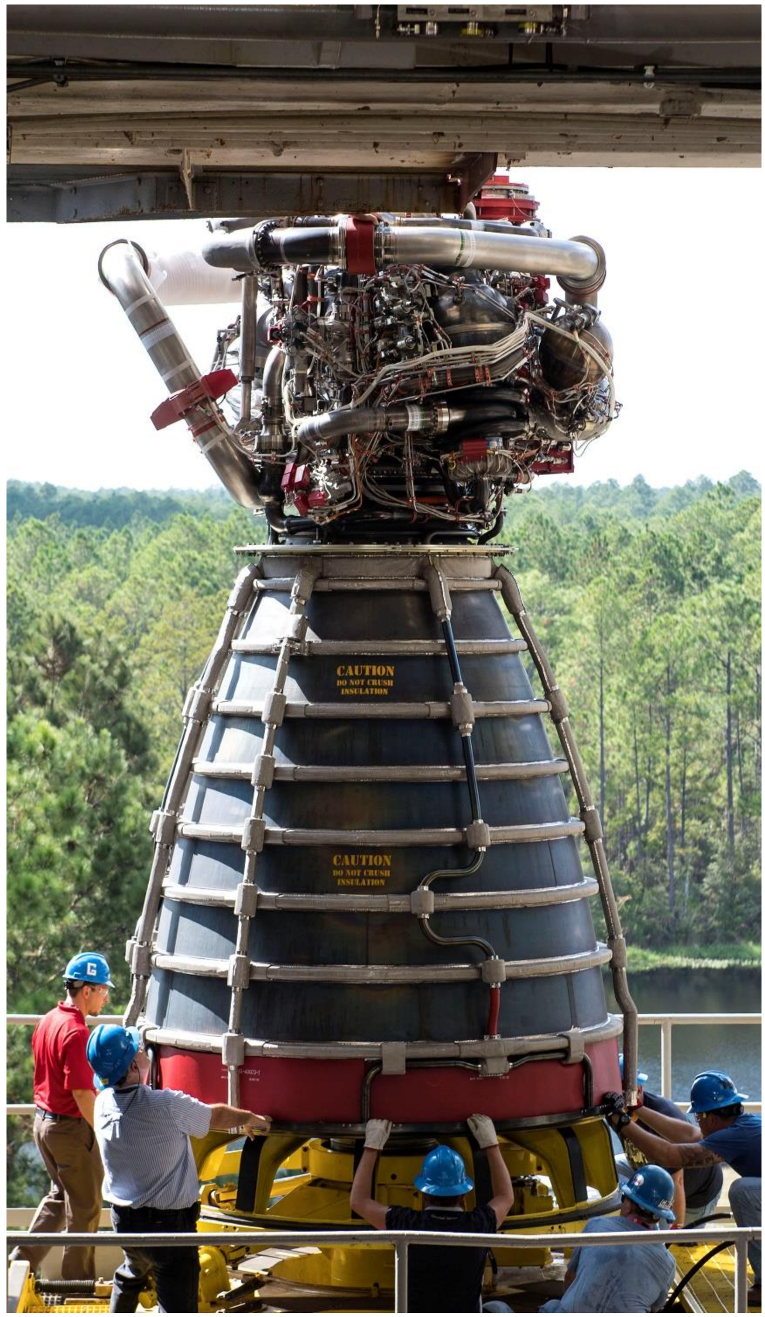
NASA's Management of the Space Launch System Booster and Engine Contracts



May 25, 2023 **IG-23-015**

Office of Inspector General

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Results in Brief

NASA's Management of the Space Launch System Booster and Engine Contracts

May 25, 2023 IG-23-015 (A-22-07-00-SOD)

Why We Performed This Audit

To facilitate its lunar ambitions, NASA is adapting heritage hardware from the Space Shuttle era, including solid rocket boosters and RS-25 rocket engines, to power the Artemis campaign's Space Launch System (SLS) that will launch the Orion crew capsule to the Moon. From fiscal years 2012 through 2025, NASA's overall Artemis investment is projected to reach $93 billion, of which the SLS Program costs represent $23.8 billion spent through 2022. For SLS launches, NASA entered into two booster contracts with Northrop Grumman and two RS-25 engine contracts with Aerojet Rocketdyne. The four contracts, performance periods, and values are: *Boosters*—April 2006 to December 2023, $4.4 billion; *Booster Production and Operations Contract (BPOC)*—June 2020 to December 2031, $3.2 billion; *Adaptation (RS-25 engines)*—June 2006 to September 2020, $2.1 billion; and *RS-25 Restart and Production*—November 2015 to September 2029, $3.6 billion.

Given the enormous cost of the Artemis campaign, NASA is exploring ways to make the SLS—which requires two boosters and four RS-25 engines per launch—more affordable by moving towards a fixed-price contract structure for booster production and establishing cost reduction targets on the production of new RS-25 engines. While these efforts may result in savings over the long term, ongoing schedule delays and cost increases raise questions about the Agency's ability to meaningfully reduce booster- and engine-related Artemis costs.

In this audit, we examined the extent to which NASA is meeting cost, schedule, and performance goals for the Boosters and Adaptation contracts, and whether BPOC and RS-25 Restart and Production, the follow-on production contracts, reduce the government's financial risk and promote affordability. To complete this work, we conducted interviews with NASA, Northrop Grumman, and Aerojet Rocketdyne officials. We also examined contract files; contractors' financial reports and schedules; acquisition data; NASA's integrated Artemis master schedule; budget and risk management documentation; and award fee evaluation plans, performance reports, and other related data.

What We Found

NASA continues to experience significant scope growth, cost increases, and schedule delays on its booster and RS-25 engine contracts, resulting in approximately $6 billion in cost increases and over 6 years in schedule delays above NASA's original projections. These increases are caused by long-standing, interrelated issues such as assumptions that the use of heritage technologies from the Space Shuttle and Constellation Programs were expected to result in significant cost and schedule savings compared to developing new systems for the SLS. However, the complexity of developing, updating, and integrating new systems along with heritage components proved to be much greater than anticipated, resulting in the completion of only 5 of 16 engines under the Adaptation contract and added scope and cost increases to the Boosters contract. While NASA requirements and best practices emphasize that technology development and design work should be completed before the start of production activities, the Agency is concurrently developing and producing both its engines and boosters, increasing the risk of additional cost and schedule increases.

Additionally, Marshall Space Flight Center procurement officials who oversee all four contracts are challenged by inadequate staff, their lack of experience, and limited opportunities to review contract documentation. Specifically, inadequate procurement management led us to question $24.5 million in payments to Northrop Grumman to resolve a disputed request for equitable adjustment (REA) of award fee payments. Marshall procurement officials also encountered significant issues with the award of BPOC, the follow-on booster contract, which started as an undefinitized letter contract in which terms, specifications, and price were not agreed upon before performance began. We found NASA took 499 days to definitize the letter contract, which is far outside the 180-day federal guidance. At definitization, BPOC also lacked scope details, omitted key contract clauses, underwent a limited legal review, and is at risk of making duplicate payments for overlapping work performed under BPOC and the upcoming Exploration Production and Operations Contract. We also questioned an additional $5.6 million payment NASA made to Northrop Grumman related to the Agency's improper liquidation of funds.

Further, NASA used cost-plus contracts at times where we believe fixed-price contracts should have been considered to potentially reduce costs, including the addition of 18 new production engines under the RS-25 Restart and Production contract and acquisition of Artemis IV booster long-lead materials under the BPOC letter contract. In addition, contractors did not receive accurate performance ratings in accordance with federal requirements, such as the "very good" rating awarded to Aerojet Rocketdyne on the end-item Adaptation contract despite only finishing 5 of 16 engines. As a result, we question $19.8 million in award fees it received for the 11 unfinished engines which were subsequently moved to the RS-25 Restart and Production contract and may now be eligible to receive additional award fees.

Faced with continuing cost and schedule increases, NASA is undertaking efforts to make the SLS more affordable. Under the RS-25 Restart and Production contract, NASA and Aerojet Rocketdyne are projecting manufacturing cost savings of 30 percent per engine starting with production of the seventh of 24 new engines. However, those savings do not capture overhead and other costs, which we currently estimate at $2.3 billion. Moreover, NASA currently cannot track per-engine costs to assess whether they are meeting these projected saving targets.

WHAT WE RECOMMENDED

To increase transparency, accountability, and oversight of the SLS booster and engine contracts and NASA's affordability efforts, and ensure duplicative award fees are not earned, we recommended NASA senior leadership: (1) assess whether the 18 new RS-25 production engines under the RS-25 Restart and Production contract can be adjusted to fixed price; (2) identify procurement needs and resources available to address staff shortages at Marshall; (3) ensure Marshall officials comply with best practices for establishing and maintaining internal controls related to REAs, fiscal law, and appropriate internal and external engagement; (4) ensure appropriate separation of program and procurement actions and compliance with federal requirements for use of letter contracts, proper definitization, overpayments, and duplicative payments of award fees for modified scope and contracts; (5) update RS-25 production per engine cost estimates to include investments in production restart; (6) review and update BPOC's scope of work and technical requirements needed to complete the respective periods of performance; (7) review BPOC's definitization to ensure proper liquidation of funds paid under the letter contract; and (8) develop a separate non-fee bearing contract line item for completion of the 11 unfinished heritage RS-25 adaptation engines.

We provided a draft of this report to NASA management, who concurred with Recommendations 1, 2, 3, 6, and 7, and partially concurred with Recommendations 4, 5, and 8. We consider management's comments responsive to all eight recommendations, and therefore the recommendations are resolved and will be closed upon completion and verification of the proposed corrective actions. Despite concurring and partially concurring with all eight recommendations, the Associate Administrator for Exploration Systems Development Mission Directorate's and Assistant Administrator for Procurement's response to the draft of this report stated that the directorate and program do not concur with the facts as presented in the body of the report. We take issue with this summary characterization and are disappointed that the Agency's formal response failed to specify the facts with which it disagrees. Consistent with professional standards, we carefully considered management's technical comments to our draft and, when sufficiently supported, incorporated that information in the final report.

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Acronyms

BPOC	Booster Production and Operations Contract
CLIN	contract line item number
ECU	Engine Controller Unit
EPOC	Exploration Production and Operations Contract
FAR	Federal Acquisition Regulation
MAP	Mission Support Future Architecture Program
OIG	Office of Inspector General
PLI	Propellant Liner and Insulation
REA	request for equitable adjustment
SLS	Space Launch System

INTRODUCTION

The Artemis campaign seeks to return humans to the surface of the Moon in 2025 before exploring 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) capsule into space. Over the past decade, Congress has directed NASA to adapt legacy hardware from the Space Shuttle era, including solid rocket boosters and RS-25 rocket engines, to power the SLS for the Agency's lunar missions.

In December 2022, Artemis I—an uncrewed Orion capsule 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. Specifically, NASA's total Artemis campaign costs are projected to reach $93 billion through fiscal year 2025 with SLS Program costs representing $23.8 billion, or 26 percent, of that overall Artemis investment. The launch system includes two booster and two RS-25 engine contracts which account for 32 percent and 24 percent of the total SLS cost, respectively. 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, including leveraging its procurement efforts to reduce production costs and establishing cost reduction targets on the production of new RS-25 engines. Additionally, the Agency is moving towards a fixed-price contract structure for booster production in an effort to reduce costs.

While NASA's plans to control future production costs of the boosters and engines may result in savings over the long term, continued schedule delays and cost increases in the immediate term raise questions about the Agency's ability to meaningfully reduce Artemis campaign costs. In previous audits, we found that complex contract structures, undefinitized contracts, cost overruns, schedule delays, and inconsistent performance and associated fee payments combined to result in significant delays to the launch schedule and concomitant cost increases. Given the enormous costs of the Artemis campaign, it is crucial that NASA effectively manage the SLS booster and engine contracts to ensure cost, schedule, and performance goals are met and that its efforts to make Artemis more affordable show success.

In this audit, we examined the extent to which NASA is meeting cost, schedule, and performance goals for its SLS booster and RS-25 engine development contracts and whether the two follow-on production contracts reduce the government's financial risk and promote affordability. Details of the audit's scope and methodology are outlined in Appendix A.

Background

Artemis Framework Rooted in the Canceled Constellation Program

The Artemis campaign is NASA's current exploration framework to return humans to the Moon for the first time since the final Apollo mission in 1972.[1] The Agency plans to follow the lunar landings by creating a sustainable presence on the Moon's surface by 2028, with the eventual goal of exploring Mars. The Artemis campaign's launch capability consists of the SLS, Orion, and Exploration Ground Systems Programs, each of which relies on heritage technologies from the Space Shuttle era (1981 to 2011) and whose development began under the Agency's previous space exploration framework known as the Constellation Program (2006 to 2010).[2]

To address sustainability concerns that arose during the Constellation Program and meet the congressional mandate to develop a deep space launch capability using existing resources, NASA utilized existing Shuttle-era workforce and systems, infrastructure at NASA Centers, and ongoing contracts as the basis of new development designs for SLS boosters and engines. According to the Aerospace Safety Advisory Panel's 2009 annual report and recent NASA Office of Inspector General (OIG) discussions with the Panel, transferring the Space Shuttle Program's budget and workforce to the Constellation Program was unrealistic and served to increase costs and slow flight element development, eventually contributing to the Program's cancellation.[3]

First Flight of Space Shuttle Atlantis on October 3, 1985

Source: NASA.

The Administration terminated the Constellation Program in 2010, and Congress subsequently directed NASA to develop a heavy-lift rocket capable of meeting the Agency's long-term goal of human exploration of Mars. In the NASA Authorization Act of 2010, Congress required NASA to incorporate

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[1] NASA has stated that Artemis is a campaign of the Agency's efforts towards lunar exploration and not an Agency-defined program. As such, Artemis is not required to develop cost estimates in accordance with best practices or provide additional transparency into specific development, production, and operation costs for programs and projects.

[2] The Exploration Ground Systems Program develops and operates the facilities and ground support equipment necessary to assemble, transport, launch, and recover rockets and spacecraft. The Space Shuttle Program flew from 1981 to 2011 and consisted of five reusable shuttles that could carry crew and cargo to space and back to Earth. 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. One goal of the program was to incorporate and utilize the private sector to drive innovation and provide U.S. leadership in space exploration. However, Congress stopped funding the Constellation Program in 2010.

[3] Aerospace Safety Advisory Panel, *Annual Report for 2009* (January 15, 2010).

existing Shuttle- and Constellation-era contracts and modify heritage equipment for use on the SLS and Orion, with an initial SLS operational date of December 31, 2016.[4] Similar to the transition from Shuttle to Constellation, Congress and NASA believed that focusing on Shuttle heritage technologies and equipment—hardware and software subsystems or components with previous flight history used as part of a new mission system—rather than developing new space flight technologies from scratch would reduce costs and speed development. In response to the congressional directive, the Agency modified existing contracts under the Constellation Program and the contractors' work was shifted to retrofitting heritage Shuttle-era boosters and engines for use on the SLS. Specifically, the 2006 Boosters contract with Northrop Grumman was modified to provide a set of two boosters rather than a single booster for each flight and convert the four-segment solid rocket booster to five segments, while the 2006 Adaptation contract with Aerojet Rocketdyne (Aerojet) was modified to include adaptation of the heritage RS-25, the Space Shuttle's main engine.[5]

The Agency's efforts to return to the Moon came to be known as Artemis, and Artemis I—the first test mission of the SLS and its systems—launched in November 2022 and successfully concluded in December 2022. NASA's Moon to Mars plan outlines the Agency's strategy for landing humans on Mars after demonstrating its initial research and deep space capabilities on the Moon. The Moon to Mars plan includes 63 objectives broken down into 26 science objectives, 13 infrastructure objectives, 12 transportation and habitation objectives, and 12 operations objectives, a majority of which are reliant upon the SLS for success.[6]

SLS Program Management Structure

The Moon to Mars Program Office within the Exploration Systems Development Mission Directorate oversees the SLS Program Office. Managed out of Marshall Space Flight Center (Marshall), the SLS Program is comprised of multiple "element" offices that develop, manage, and execute the different components of the SLS including portions of the launch vehicle, while the Systems Engineering and Integration Office is responsible for overall vehicle development and integration.

The SLS Program Manager is responsible for the operations of the Program, to include meeting programmatic, institutional, technical, safety, cost, and schedule commitments. The SLS element offices report administratively and programmatically to the SLS Program Office. The responsibilities of the element offices include (1) ensuring safety, schedule, performance, and cost goals are met in the design and development of hardware and related systems; (2) technology, manufacturing, test, and launch processing support; (3) flight performance; (4) anomaly resolution; (5) refurbishment of their respective elements; and (6) delivery of flight-ready assets for integration of a launch vehicle in support of the SLS flight schedule. Additionally, other offices under the SLS Program Office are responsible for planning, operations, and communications. See Figure 1 for the organizational structure of the SLS Program Office.

[4] NASA Authorization Act of 2010, Pub. L. No. 111-276 (2010).

[5] This report refers to the contract that included contract line item numbers—portions of work specified within the contract—for the J-2X Upper Stage Engine and RS-25 Adaptation activities as the "Adaptation" contract, although it included J-2X design, development, testing, and evaluation work under the Constellation Program.

[6] NASA, *Moon to Mars Objectives* (September 2022).

Figure 1: Space Launch System Program Office Structure (as of April 2023)

Source: NASA OIG presentation of Agency information and the SLS Program Plan.

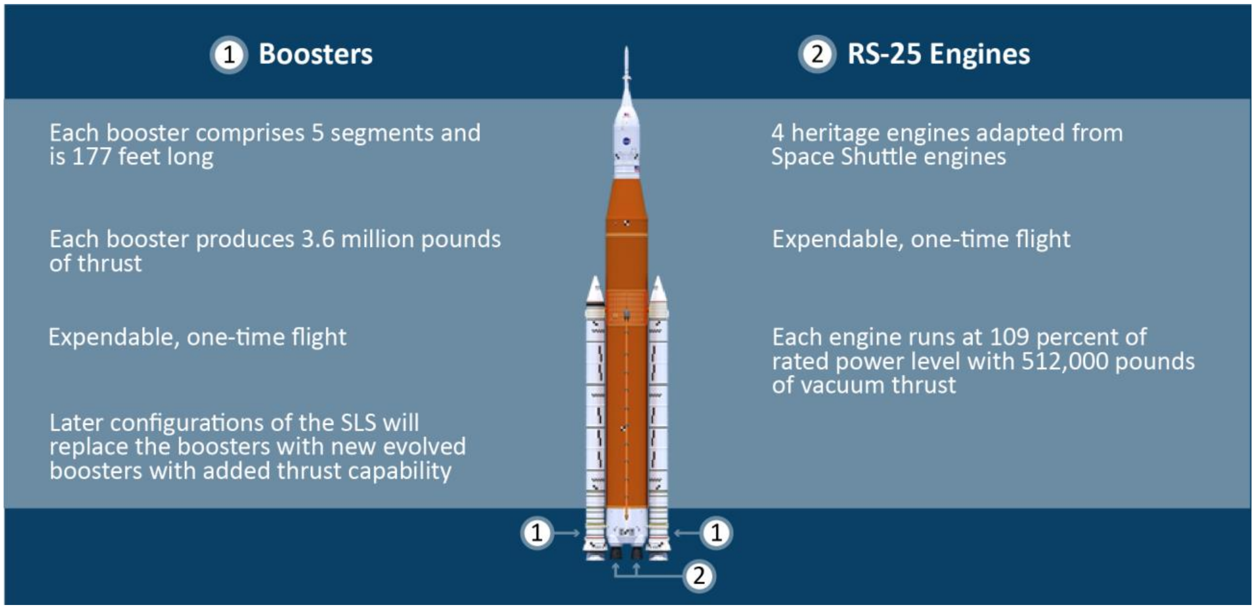
NASA's SLS Booster and RS-25 Engine Contracts

Since 2006 NASA has developed new exploration systems for Constellation and then for Artemis and evolved its efforts by retrofitting and reusing heritage Space Shuttle-era technologies including boosters and engines. Figure 2 shows the SLS Block 1's two main elements that will be retrofitted from the Shuttle.[7]

- *Two solid rocket boosters.* The two boosters together will provide 7.2 million pounds of thrust, which makes up 75 percent of the total thrust during the SLS rocket's first 2 minutes in flight needed to launch the spacecraft into low Earth orbit.
- *Four RS-25 engines.* Powered by liquid hydrogen and liquid oxygen, the four engines will power the SLS rocket with more than 2 million pounds of thrust for its 8.5-minute launch and ascent to space.

[7] The first three Artemis missions will use Block 1, the first iteration of the SLS vehicle, which can send 27 metric tons to orbits beyond the Moon and will be powered by two solid rocket boosters and four RS-25 engines. After reaching space, the rocket's upper stage—the Interim Cryogenic Propulsion Stage—will send Orion to the Moon. Beginning with Artemis IV, the SLS will be upgraded to the Block 1B configuration with a lift capability of 42 metric tons for cargo and will contain an enhanced upper stage, and eventually Block 2, which will lift more than 46 metric tons capable of sending cargo to the Moon, Mars, and other deep space destinations.

Figure 2: SLS Block 1 Booster and RS-25 Engine Elements



Source: NASA OIG presentation of Agency information.

Over the past 17 years, NASA has issued four SLS contracts that utilize the Agency's heritage solid rocket boosters and RS-25 engines (see Table 1). These four contracts contain a mixture of cost-plus and fixed-price contract line item numbers (CLIN) and award, incentive, and fixed fees.[8]

[8] Using a cost-plus approach, NASA approves all designs, manages all development and schedules, and owns the vehicle once delivered by the contractor. While this process gives NASA maximum control over the contractor's design and final product, the majority of cost, schedule, and outcome risks are borne by the federal government. In contrast, a fixed-price contract provides a set price that does not change, except in the event of government-directed changes, and therefore places upon the contractor maximum risk and full responsibility for all costs and resulting profit or loss. A contract line item number or CLIN is a specified portion of work within a contract used to organize and group related work and expenditures. Contracts also may include fee structures to motivate good contractor performance such as award, incentive, and fixed fees. An award fee consists of a base amount fixed at inception, if applicable to the contract, and an award amount based upon a judgmental evaluation by the government. An incentive fee provides for an initially negotiated fee to be adjusted later by a formula based on the relationship of total allowable costs to total target costs. A fixed fee is a negotiated fee that is fixed at the start of the contract.

Table 1: Summary of Booster and Engine Contracts (as of October 2022)

Contract	Contract Value	Period of Performance	Contractor
Boosters	**$4.4 billion[a]**	**4/17/2006 to 12/31/2023**	**Northrop Grumman**
CLIN 1: Design, development, test, and evaluation of the Ares I First Stage			
CLIN 2: Ares-I-X Test Flight			
CLIN 3: Ares Flight Test-1, -2, and -3 to lead certification of a human-rated vehicle			
CLIN 4: Design, development, test, and evaluation of SLS booster through Design Certification Review including a five-segment solid rocket motor			
CLIN 5: Manufacture of flight sets for Exploration Missions 1, 2, and 3 and Flight Support Booster			
CLIN 6: Booster flight support			
CLIN 7: Indefinite-delivery, indefinite-quantity for boosters			
CLIN 8: Task directives			
CLIN 9: Indefinite-delivery, indefinite-quantity for Booster Obsolescence and Life Extension program			
CLIN 10: Restructures CLIN 5			
Booster Production and Operations Contract[b]	**$3.2 billion**	**6/29/2020 to 12/31/2031**	**Northrop Grumman**
CLIN 1: Design, development, test, and evaluation of boosters for Booster Obsolescence and Life Extension program			
CLIN 2: Reserved (no work included)			
CLIN 3: Artemis IV to IX flight support			
CLIN 4: Operations and production for Artemis IV (booster flight set 4)			
CLIN 5: Operations and production for Artemis V (booster flight set 5)			
CLIN 6: Operations and production for Artemis VI (booster flight set 6)			
CLIN 7: Operations and production for Artemis VII (booster flight set 7)			
CLIN 8: Operations and production for Artemis VIII (booster flight set 8)			
CLIN 10: Operations and production for Artemis IX (booster flight set 9)			
CLIN 11: Government-driven changes (formerly CLIN 0002)			

Contract	Contract Value	Period of Performance	Contractor
Adaptation	**$2.1 billion[c]**	**6/2/2006 to 9/30/2020**	**Aerojet Rocketdyne**
CLIN 1: J-2X engine rocket basic development			
CLIN 2: Reserved (no work included)			
CLIN 3: RS-25 adaptation of 16 Shuttle-era engines			
CLIN 4: Risk mitigation on funds received through the American Recovery and Reinvestment Act			
CLIN 5: Indefinite-delivery, indefinite-quantity for initial recertification of RS-25 engine			
RS-25 Restart and Production	**$3.6 billion**	**11/1/2015 to 9/30/2029**	**Aerojet Rocketdyne**
CLIN 1: RS-25 engine recertification including completing adaptation of 11 of 16 engines under prior Adaptation contract			
CLIN 2: Material lot buy for RS-25 engines 1 through 6			
CLIN 3: Production of RS-25 engines 1 through 6			
CLIN 4: Program operations for RS-25 engines 7 through 24			
CLIN 5: Production and material for RS-25 engines 7 through 24			

Source: NASA OIG presentation of Agency contract data.

[a] The total contract value includes work conducted under the Constellation Program. The contract value specific to the SLS booster is approximately $2.8 billion, which is the total contract value minus CLINs 1 to 3 (approximately $1.6 billion) that was for work under the Ares program from 2006 to 2011.
[b] The Booster Production and Operations Contract has a total of 10 CLINs. There is no CLIN 9.
[c] This figure is rounded up from $2.06 billion. The total contract value includes work conducted under the Constellation Program. The CLINs specific to the RS-25 engines for the SLS total $580.9 million. However, J-2X engine development efforts under the contract have been used to inform new Engine Controller Unit development and integration onto the RS-25 engines.

Boosters Contract. All six SLS boosters for Artemis I to III under this contract will use steel cases repurposed from the remaining Shuttle-era steel-cased solid rocket boosters currently manufactured by Northrop Grumman. While the Boosters contract was first awarded in April 2006 as the Ares First Stage Booster contract at the cost of approximately $1.8 billion, it was modified in 2011 to add SLS Program requirements and then definitized—meaning its contract terms and specifications were agreed to—in April 2013 at the cost of approximately $2.8 billion. Since then, the contract has grown to $4.4 billion with a period of performance through December 2023.[9] Each SLS mission will require one set of two boosters comprised of solid rocket motors; an aft skirt and a forward skirt that house systems and electronics to ignite, steer, and jettison the boosters; and a nose piece that ensures proper aerodynamics of the rocket. The physical length of the boosters was extended by adding a fifth segment that increases the amount of solid rocket fuel the boosters can hold, increasing thrust capabilities by 25 percent.

[9] Definitization means the agreement on, or determination of, contract terms, specifications, and price, which converts an undefinitized contract action to a definitive contract. Undefinitized contract action means any contract action for which contract terms, specifications, or price are not agreed upon before performance begins under the action. Examples are letter contracts.

Booster Production and Operations Contract. In November 2021, NASA awarded the follow-on Booster Production and Operations Contract (BPOC), with a value of $3.2 billion, that definitized a June 2020 letter contract.[10] The BPOC letter contract initially authorized Northrop Grumman to order long-lead materials for Artemis IV's booster flight set four, work that needed to be completed immediately before the contract could be negotiated and awarded.[11] The BPOC letter contract evolved from flight set four to orders for additional long-lead items, including starting to build twin steel-cased boosters for the next five SLS flights after Artemis III and developing and producing a new composite booster design for Artemis IX with a period of performance through December 2031.[12] NASA planned the scope of BPOC to include production and operations for Shuttle-era steel-cased boosters for Artemis IV through VIII and the design, development, testing, and evaluation of a new composite booster set as part of the Booster Obsolescence and Life Extension program for Artemis IX.[13]

Adaptation Contract. In addition to the solid rocket boosters, the SLS will utilize the remaining 16 RS-25 engines left over from the Space Shuttle era, which Aerojet began retrofitting in 2011 for lunar exploration as part of the Adaptation contract. Using a cost-plus-award-fee and incentive-fee structure, the contract was initially awarded to Aerojet in June 2006 as part of the Constellation Program.[14] The Adaptation contract ended in September 2020, costing a total of $2.1 billion of which $581 million was for the recertification and delivery of 16 completed retrofit engines.[15] As four engines are required for each SLS flight, 4 of the 16 remaining RS-25 engines originally designed, built, and used during the Space Shuttle Program were flown on the first Artemis mission and the other 12 are expected to be flown on Artemis missions II through IV. For Artemis I alone, engine one had previously flown 12 times on Shuttle missions, engine two had flown 4 times, engine three had flown 6 times, and engine four had flown 3 times. Unlike the Shuttle Program where the engines were built to be reusable, the SLS engines will be expendable. Beginning with the fifth Artemis flight, the engines are being redesigned with improved performance to operate at a higher thrust level and produced using new manufacturing techniques to reduce costs.

RS-25 Restart and Production Contract. NASA awarded Aerojet a follow-on contract, RS-25 Restart and Production, in November 2015 with a current total value of $3.6 billion through September 2029. It provides a framework under which Aerojet will restart the RS-25 production line and deliver 24 new upgraded RS-25 production hydrogen-fueled engines to support future deep space exploration missions starting with Artemis V. In June 2019, NASA moved completion of 11 of the 16 RS-25 Adaptation engines onto the RS-25 Restart and Production contract. In October 2022, the four RS-25 Adaptation

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[10] A letter contract is a preliminary contractual instrument that authorizes the contractor to begin immediately manufacturing supplies or performing services when (1) the government's interests demand that work start immediately and (2) negotiating a definitive contract is not possible in sufficient time to meet the requirement. See Federal Acquisition Regulation (FAR) 16.603-1*, Description* (2019) and 16.603-2(a), *Application* (2019). Because a letter contract has undefined terms, its use increases cost risk to the government. NASA OIG and the Government Accountability Office have previously reported on risks to the government associated with the use of letter contracts. See Appendix A.

[11] Under the definitized contract, booster flight set four work is delineated under CLIN 4.

[12] NASA has eight flight sets of booster hardware (steel cases and internal structures, for example) available from the Space Shuttle Program for use on Artemis I through VIII.

[13] The Booster Obsolescence and Life Extension program is a joint effort between NASA and Northrop Grumman to develop a new solid rocket booster design with modern composite production and manufacturing processes. The new design, intended to replace the current SLS boosters based on a five-segment steel-cased solid rocket motor, will first take flight with the Artemis IX mission.

[14] NASA spent $1.4 billion under the Constellation Program to develop J-2X engines for use on the Ares I rocket.

[15] CLINs 3 and 5 of the Adaptation contract were for the design, development, testing, evaluation, and recertification of the RS-25 engine for human space flight.

engines that will help power Artemis II—the first crewed Artemis mission—were delivered to NASA's Michoud Assembly Facility in New Orleans to be installed onto the Artemis II core stage, which is in the final phase of assembly.[16]

Monitoring Contractor Performance

For contracts that utilize an award fee structure, NASA evaluates contractor performance on an ongoing basis and develops a formal award fee performance evaluation report to determine the award fee score and amount of award fee the contractor will receive. The award fee is intended to incentivize and reward the contractor for a timely, safe, high-quality, and cost-effective performance. The contractor's award fee total is determined by multiple criteria NASA has developed to evaluate contractor performance. For the SLS booster and each of the RS-25 engine contracts, NASA uses four weighted evaluation factors—technical, program management, cost control, and small business utilization—to determine the total award fee score for each evaluation period.[17] Each factor is evaluated separately and given a numerical value that the evaluation team recommends to the Award Fee Board and, ultimately, the Fee Determining Official. Per the NASA Federal Acquisition Regulation (FAR) Supplement, the Fee Determining Official has the final determination of the award fee score and rating.[18]

Both the SLS Boosters development and Adaptation contracts employed "end-item" award fee structures under which the fees earned by the contractor during award fee periods—known as interim award fee periods—are not final until completion of the contract.[19] The Fee Determining Official determines the performance score and award fee after consulting with the contracting officer's representative and Award Fee Board. Figure 3 shows the criteria and numerical score required for each adjective rating. For each of the contracts, the Deputy Associate Administrator for Common Exploration Systems Development in the Exploration Systems Development Mission Directorate serves as the Fee Determining Official.[20] Once the Fee Determining Official completes an award fee determination letter, the contracting officer is responsible for preparing a contract modification that includes the award fee adjective rating, weighted evaluation score, and award fee amount. At the end of the contract—during

[16] As the backbone of the SLS rocket, the core stage is the world's tallest rocket stage at 212 feet in height and 27.6 feet in diameter. The SLS uses cryogenic liquid hydrogen and liquid oxygen to power the four RS-25 engines, and the core stage houses the flight computers and much of the avionics needed to control the rocket's flight.

[17] NASA FAR Supplement 1816.405-273, *Award fee evaluations* (2021).

[18] NASA's Award Fee Board evaluates the contractor's performance every award fee period based on input from the technical monitors, contracting officer's representative, contracting officer, and Program/Project Manager. The Fee Determining Official meets with the board before making a final decision on the award fee amount. NASA FAR Supplement 1816.405-273.

[19] For end-item contracts, only the last evaluation is final when the true quality of contract performance can be measured after the item is delivered. Once the last evaluation is final, the total contract award fee pool is available for consideration and the contractor's total performance is evaluated against the award fee plan to determine the total earned award fee. With end-item contracts, NASA pays the contractor up to 80 percent of what is earned at the end of each award fee evaluation period and holds the remaining amount until the final evaluation. Whereas with service contracts, each period's evaluation is final and NASA pays the contractor the total amount earned; unearned fees cannot be rolled over to the next performance period. NASA FAR Supplement 1816.405-273 and 1816.405-276, *Award fee payments and limitations* (2017).

[20] For the Adaptation contract, which concluded in September 2020, the Deputy Associate Administrator for the Exploration Systems Development Division of the Human Exploration and Operations Mission Directorate held the Fee Determining Official position. In September 2021, NASA split the Human Exploration and Operations Mission Directorate into two separate directorates—Exploration Systems Development Mission Directorate and Space Operations Mission Directorate. Exploration Systems Development manages systems development for programs critical to the Artemis missions and is planning the Moon to Mars exploration approach. Space Operations focuses on launch and space operations, including the International Space Station, commercialization of low Earth orbit, and sustainment of operations on and around the Moon.

the final award fee period—all prior interim award fee evaluations can be superseded by the earned score determined at contract completion. For example, award fees not previously earned during the interim periods could be earned at the final evaluation.[21] However, in a prior NASA OIG report, we found that NASA's practice of including unearned funds from interim award fee periods in the final award pool promotes a philosophy that cost and schedule overages will be overlooked so long as the end product performs well.[22]

Figure 3: FAR Award Fee Performance Ratings

Source: NASA OIG presentation of FAR award fee performance ratings. FAR Subpart 42.15, *Contractor Performance Information* (2019).

[21] The ongoing Boosters development contract was modified to remove end-item award fees after the Design Certification Review in 2020.

[22] NASA OIG, *NASA's Use of Award-fee Contracts* (IG-14-003, November 19, 2013).

NASA Actions to Reduce SLS Costs

In recognition of the rising costs and focus on making Artemis—specifically the SLS Program—sustainable, NASA has undertaken affordability initiatives through its two production contracts for boosters and RS-25 engines. For example, BPOC's contract structure provides traceability of costs—meaning the Agency can identify the cost of each booster flight set—and is procuring flight sets 4 through 8 for the Artemis IV through VIII missions on a fixed-price-incentive-fee basis.[23] The maturity of the design and production of the SLS boosters under BPOC, in comparison to the Boosters contract, allowed for the use of a more cost-conscious contracting type, transferring a greater share of the risk from the government to the contractor. Further, in response to the former Human Exploration and Operations Mission Directorate instructing its programs to include a roadmap with metrics to monitor potential cost savings, the RS-25 new engine production contract is the only SLS-related program element or project to have established cost reduction targets for its contractor. NASA and Aerojet established a 33 percent cost reduction target starting with the completion of the seventh of 24 new RS-25 engines under the Restart and Production contract. To achieve these savings, starting with the completion of the seventh engine, NASA and Aerojet made component design changes and modernized processes, methods, and materials. However, when calculating the total cost of the new RS-25 engines, NASA and Aerojet are only including material, engineering support, and touch labor (hands-on labor effort), while project management and overhead costs are excluded.

NASA's Procurement Workforce

NASA has internally identified and is taking actions to address cost and schedule challenges through its Mission Support Future Architecture Program (MAP), with an emphasis on creating a greater enterprise-wide consistency across the Agency for program and project management in areas including financial management, human capital, information technology, and procurement. This undertaking includes efforts to (1) create a more robust structure for acquisition planning—early framing, standardization, focus on high-dollar acquisitions, and annual forecasting; (2) strengthen project management—use of assessments, revised performance metrics, an early definition of the tailoring approach, and a coordinated approach to Agency and industry discussions; and (3) address acquisition risks.[24] These efforts have been implemented throughout the Agency, including the procurement portfolio managed at Marshall and early acquisition and ongoing contract management processes related to procurement, planning, budgeting, legal, and oversight. Through the MAP process, Marshall and SLS procurement offices have received additional resources to offset increased workloads and decreased staff levels. However, despite the implementation of MAP, staffing shortfalls at Marshall remain due to hiring challenges.

[23] A fixed-price-incentive-fee contract provides for adjusting profit and establishing the final contract price by application of a formula based on the relationship of total final negotiated cost to total target cost.

[24] Specific to acquisition planning, framing means defining and tracking key program assumptions made early in program development and throughout the program life. Forecasting means developing an annual and semiannual outlook of future acquisition opportunities in a given fiscal year. Tailoring is a method of adjusting the acquisition outside the defined parameters outlined in the FAR and NASA FAR Supplement. It is intended to give the acquisition workforce the flexibility to adapt the acquisition process, documentation, and approval levels based on the specific characteristics of a particular program.

Federal and Agency Required Cost and Schedule Reporting

NASA is required to create, track, and report on the life-cycle costs and schedule commitments for any program with a budget exceeding a life-cycle cost of $250 million.[25] Life-cycle costs include all costs related to a program over its planned lifespan. NASA policy further requires space programs to set a formal Agency Baseline Commitment—the cost and schedule baseline committed to Congress and the Office of Management and Budget against which a program is measured—at Key Decision Point C, which occurs after program formulation is complete but before development begins.[26] We previously reported that the initial Agency Baseline Commitment for the SLS, completed in 2014, established a commitment to Congress and the Office of Management and Budget to launch by November 2018.[27] The SLS Program was rebaselined in early 2020 and a new Agency Baseline Commitment was established in which the Agency committed to a November 2021 Artemis I launch date. Additionally, work on several SLS contracts related to Artemis IV and beyond, as well as to Block 1B—the SLS's more extensive and powerful configuration—is being completed without a baseline. The baseline was initially scheduled to be completed in June 2022. As of May 2023, it was still pending and the Agency plans to complete a review and establish a baseline agreement by August 2023.

Prior NASA Office of Inspector General Coverage

Since 2017, the NASA OIG has issued 19 reports covering the SLS and NASA's Artemis efforts, including program and contract reviews that identified multiple issues and made recommendations to move the SLS Program and Artemis missions closer to sustainability. Specific to the SLS Program, we conducted audits in 2018 and 2020 that delved into the contracting efforts for the elements that comprise the SLS—the Stages, Boosters, Engines, and Spacecraft/Payload Integration and Evaluation offices—and the cross-cutting Program Operations and Strategic Communications, Systems Engineering and Integration, and Program Planning and Control offices. Our work has identified several management issues that resonate across the Agency's Artemis programs, elements, and projects. These include limited cost oversight and insight, underestimated complexity of Artemis programs and projects, concurrent development and production work, undefinitized work, reliance on cost-plus rather than fixed-price contracts, inadequate procurement workforce, and the need for greater emphasis on affordability.[28]

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[25] NASA Procedural Requirements 7120.5F, *2.4 Approving and Maintaining Program and Project Plans, Baselines, and Commitments* (August 3, 2021) specifies that baseline commitments for cost and schedule are made at Key Decision Point C, which occurs after the Preliminary Design Review. Cost increases of more than 30 percent of development costs require official notification to Congress and program or project rebaseline. Schedule delays of 6 months or more require immediate written notice to Congress and a recovery plan be provided to the program or project manager and Mission Directorate Associate Administrator by the program or project.

[26] Key Decision Points are the point of time when the approving official decides on the program's readiness to progress to the next life-cycle phase. At approval for Key Decision Point C, for a program to move from early design work to final design and fabrication, a program is expected to demonstrate that (1) it is in place and stable, (2) it addresses critical NASA needs, (3) it has adequately completed formulation activities, (4) it has an acceptable plan for implementation that leads to mission success, (5) the proposed projects are feasible within available resources, and (6) the program's level of risk is commensurate with the Agency's risk tolerance. The decisions made at Key Decision Point C establish the Agency Baseline Commitment agreement for the program.

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

[28] A cost-plus contract is a contracting vehicle whereby the contractor will be paid based on the actual, allowable costs that it incurs, plus any fee or profit earned under the criteria established in the contract through negotiation between the contractor and the agency.

LONG-STANDING MANAGEMENT ISSUES RESULTED IN $6 BILLION IN COST INCREASES AND OVER 6 YEARS IN SCHEDULE DELAYS ON NASA'S SLS BOOSTER AND ENGINE CONTRACTS

NASA continues to experience significant scope growth, cost increases, and schedule delays on its booster and RS-25 engine contracts, resulting in approximately $6 billion in cost increases and over 6 years in schedule delays since the contracts were negotiated. These significant increases are caused by a variety of long-standing, interrelated management issues impacting both the SLS Program and Artemis campaign, some of which represent potential violations of federal contracting requirements. These poor contract management practices caused us to question $49.9 million in costs and award fees.

SLS Booster and Engine Development Efforts Have Experienced Significant Cost Increases and Schedule Delays

Collectively, the four booster and engine contracts were initially projected to cost $7 billion over 14 years but now will cost at least $13.1 billion over nearly 25 years, approximately $6 billion more than anticipated. This increase is due to added scope from NASA, both under the Constellation Program and Artemis campaign, and contractor cost overruns in development and production of the solid rocket boosters and RS-25 liquid rocket engines.[29] Of note:

- The most significant increase was related to Northrop Grumman's Boosters contract, which grew from $1.8 billion to $2.5 billion under Constellation and then from $2.5 billion to $4.4 billion under Artemis. Booster-related work also increased the contract's schedule by 5 years beyond the original December 2017 launch readiness date.
- Between June 2006 through September 2020, Aerojet's Adaptation contract grew from $1.1 billion to $1.5 billion under Constellation and then to $2.1 billion under Artemis.[30] Upon closeout in September 2020, NASA elected to move $10.9 million in uncompleted Adaptation work to the RS-25 follow-on production contract.

[29] Approximately 36 percent of the Boosters contract value and 72 percent of the Adaptation contract value were related to the Constellation Program and Ares I rocket, respectively.

[30] Aerojet's Adaptation contract grew from $1.1 to $2.1 billion due to scope changes associated with J-2X engine development under the Constellation Program, new SLS tasks, and associated cost growth and overruns. Of the $2.1 billion, approximately $581 million is specific to RS-25 engine adaptation efforts, but both NASA and Aerojet have used work performed under the Adaptation contract to improve the RS-25 engine, including but not limited to design work on the Engine Controller Unit. However, this work is excluded from the $581 million NASA identifies as RS-25-specific costs.

As a continuation of the work performed on the Adaptation and Boosters development contracts, NASA issued two follow-on production contracts—RS-25 Restart and Production to Aerojet and BPOC to Northrop Grumman. These production contracts have experienced the following growth since they were initially let:

- The RS-25 Restart and Production contract grew from $1.2 billion to $3.6 billion between November 2015 and June 2022. This increase in contract value was due in part to added scope for the production and operation of 18 new RS-25 engines to support the Artemis campaign, starting with Artemis V. The contract's current completion date is September 2029.
- Further, BPOC began as a letter contract in June 2020 limited to a not-to-exceed amount of $49.5 million for long-lead material buys for the Artemis IV flight set of boosters, but that grew to $199 million before NASA definitized the contract in November 2021.[31] BPOC was definitized at $3.2 billion in November 2021. BPOC is currently contracted through December 2031 and includes significant work for the Booster Obsolescence and Life Extension program, which will develop new solid rocket boosters for the Block 2 iteration of the SLS—a version of the rocket's configuration that NASA plans to utilize for the Artemis IX mission as early as 2031.

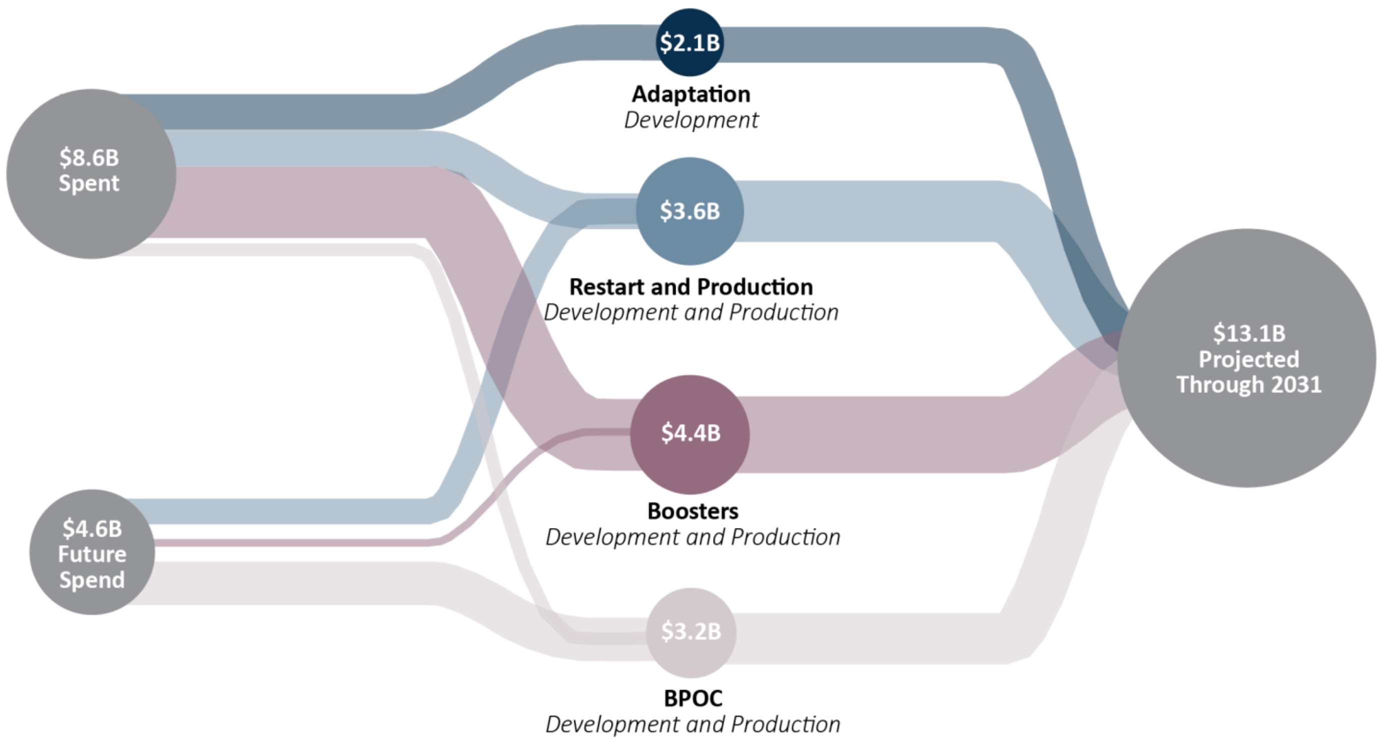
As a result of the cost and schedule increases under these four contracts, we calculate NASA will spend $13.1 billion through 2031 on boosters and engines, which includes $8.6 billion in current expenditures and obligations and at least $4.6 billion in future contract obligations.[32] Looking more broadly, the cost impact from these four contracts increases our projected cost of each SLS by $144 million through Artemis IV, increasing a single Artemis launch to at least $4.2 billion.[33] Figure 4 shows funding for NASA's development and production efforts across the SLS booster and RS-25 engine contracts.

[31] According to the Agency, the $149.5 million increase in the not-to-exceed amount was for additional work needed to continue progression as BPOC was being definitized. A not-to-exceed amount is a price ceiling set under which work is to be conducted.

[32] The $8.6 billion and $4.6 billion amounts are rounded to a higher amount and as a result the sum does not equal $13.1 billion. Of the total $13.1 billion to be spent on the solid rocket boosters and RS-25 engines, $9.1 billion is contracted explicitly to the SLS and the remaining $4 billion was related to development of the Ares I rocket and J-2X engine under the Constellation Program. However, these costs have been included to capture the full extent of funds used under the four contracts for solid rocket boosters and liquid rocket engines including enhancements identified under Constellation development efforts that have been brought forward into Artemis development, adaptation, and production.

[33] In 2021, we reported that the total projected cost of a single Artemis mission was $4.1 billion (IG-22-003). The $144 million cost increase pertains to just the SLS and does not include any potential cost increases for Orion and Exploration Ground Systems.

Figure 4: Development and Production Funding across the Booster and Engine Contracts (as of January 2023)



Source: NASA OIG analysis of Agency data.

Note: Amounts are rounded to a higher amount and as a result the sums differ from the total projected through 2031. Total value is inclusive of the contracts for boosters and engines under the Constellation Program and the added SLS scope for the Artemis campaign.

Long-Standing Management Issues Drive Increases in SLS Engine and Booster Contracts' Costs and Schedules

The RS-25 engine and booster contracts' cost and schedule increases result from several long-standing interrelated management issues that the OIG previously identified, including underestimated scope and complexity of work, concurrent development and production contract activities, inadequate procurement workforce, poor contract definitization, reliance on cost-plus contract structures for production efforts, and inappropriate use of award fees.[34]

[34] IG-22-003 and NASA OIG, *NASA's Management of Space Launch System Program Costs and Contracts* (IG-20-012, March 10, 2020).

Underestimated Complexity of Work Associated with Heritage Systems

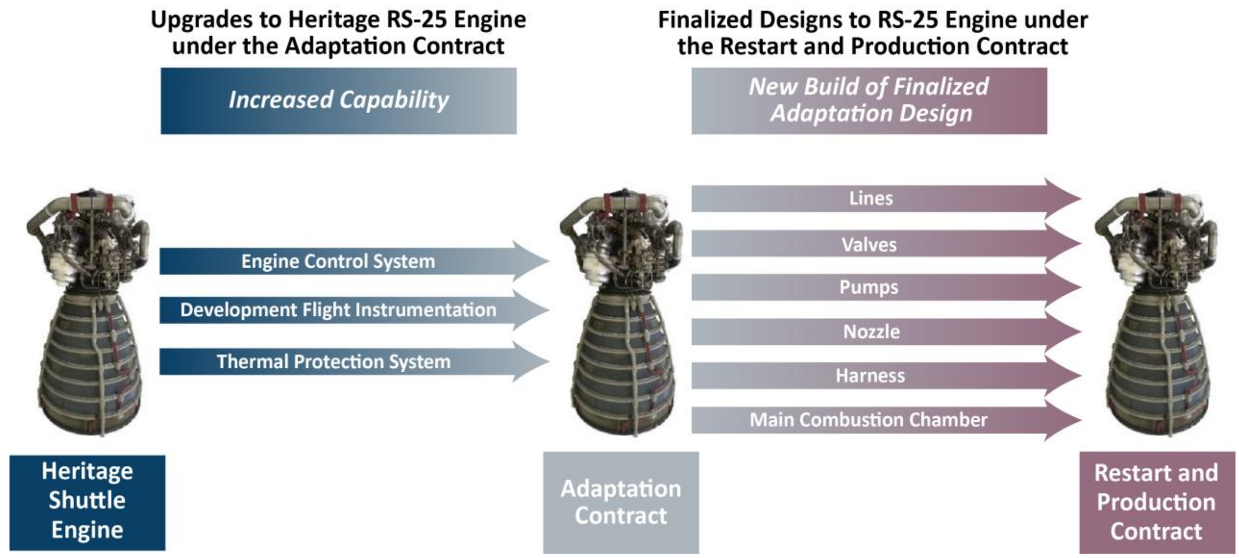
With a congressional mandate to incorporate existing Shuttle- and Constellation-era contracts and use heritage equipment for the SLS, NASA decided to retain its sole-source contracts with Northrop Grumman and Aerojet under the Constellation Program and only modified the contracts specific to SLS work as necessary.[35] Trade studies conducted during this time found that heritage technologies would save significant cost and schedule compared to developing new systems. As such, two key components of the SLS are the RS-25 engine, also known as the Space Shuttle Main Engine, and the Shuttle's solid rocket boosters. The RS-25 was selected as the primary propulsion system for the SLS core stage alongside the five-segment solid rocket boosters. Selection of the RS-25 was based on the maturity of the engine and the extensive experience gained over its three decades of use by the Space Shuttle Program through 135 missions and 3,000 ground tests. A total of 46 RS-25 engines were produced during the Shuttle era—today, 16 flight engines remain that can be used for Artemis I through IV. Regarding booster reuse, each of the cone segments atop the Artemis I boosters flew on over 10 Shuttle missions as far back as 1984, and all of the heritage steel structures used for Artemis have flown on Shuttle flights.

Complexity of RS-25 Heritage Technology

Despite the Agency's intention to capitalize on proven systems and production capabilities and adhere to congressional requirements, the complexity of updating, developing, and integrating new systems alongside the heritage Shuttle-era components proved to be greater than NASA anticipated. While the RS-25 is a highly mature system, significant technical upgrades are required before it can be installed on the SLS due to the rocket's increased technical complexity (see Figure 5 for information on RS-25 engine heritage technologies and upgrades). For example, to integrate the RS-25 engine with the SLS core stage, significant changes were needed related to environments (increased heat requiring new insulation), interface conditions (systems connection points), and operational constraints (ground system modifications for increased flow of fuel). Nonetheless, according to Agency officials and contract justification documentation, the magnitude of accomplishing this effort is less than what would have been required to develop and test a completely new engine system.

[35] Sole-source procurements are typically used when an agency deems that the contractor is the only source available that can meet government requirements, thereby eliminating competition and any potential benefits that could be gained from it.

Figure 5: RS-25 Engine Heritage Technologies and Upgrades



Source: NASA OIG presentation of Agency data.

Due to the amount of time elapsed between the conclusion of the Shuttle Program and the beginning of the Artemis campaign, NASA faces significant challenges maintaining the industrial base and supply chains required to produce the RS-25. Specifically, many of the parts in the engine controller system were no longer available, which necessitated a new Engine Controller Unit (ECU) design by the contractor. Further, Aerojet's early technical assumptions for the new ECU—which contains the electronics that operate the engine and communicate with the SLS vehicle—lacked a comprehensive understanding of controller design requirements and an agreed-upon scope of work, which resulted in significant technical issues culminating in increased costs and expanded schedule.[36] As a result, by the end of the Adaptation contract performance period in September 2020, NASA had spent nearly $2.1 billion instead of the originally proposed $1.1 billion, including Constellation expenses. Excluding Constellation expenses, NASA spent $581 million for the adaptation of 16 RS-25 engines at a cost that exceeded its initial estimate by $238 million. Moreover, for that $581 million, only 5 of the 16 engines were completed at the contract's close.

Therefore, the remaining 11 heritage engines under the Adaptation contract were moved to the Restart and Production contract. The Adaptation contract is currently in close-out, but as we last reported in March 2020, NASA spent nearly $238 million more than initially planned to complete the scope of work under the contract. As of October 2022, the RS-25 Restart and Production contract experienced $102 million in cost growth and 17 months in schedule delays due to the need to establish a production line and begin development and testing of the new production engine. Further, NASA also modified the Restart and Production contract to include the manufacture of 24 new RS-25s—which incorporate the new ECU design—for future flights for Artemis V through X. Given the design, development, and testing

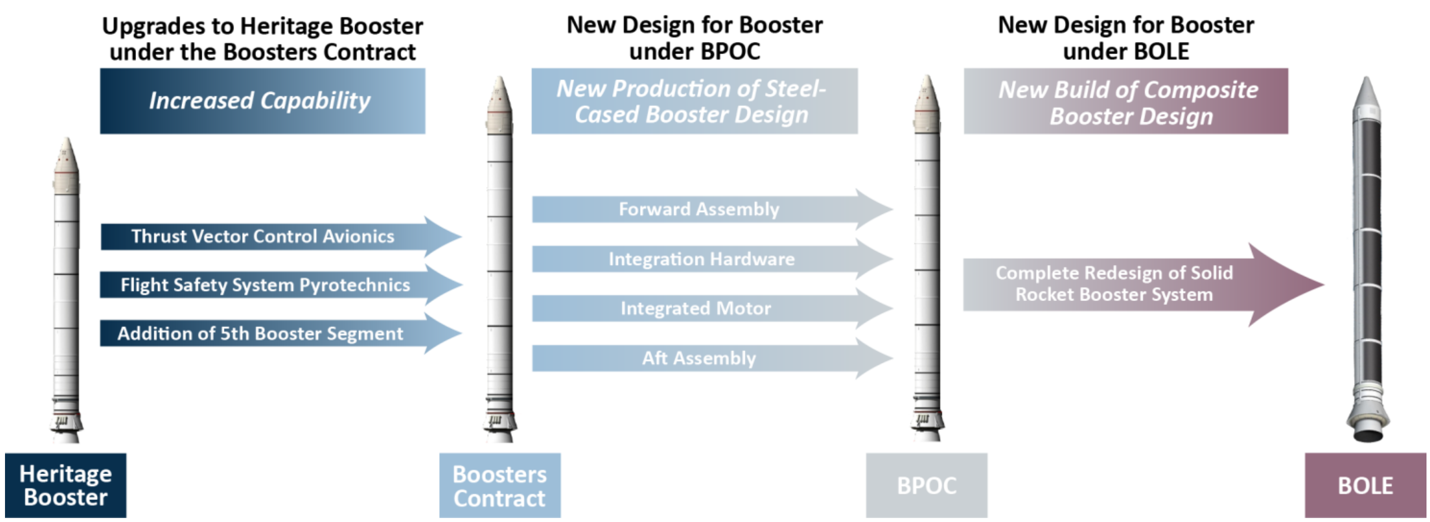
[36] The heritage Shuttle ECU was technologically obsolete and incompatible with the SLS's power and data architecture, and ECU components were no longer available for purchase from industry. To address this issue, Aerojet anticipated reworking a new ECU design developed initially for the J-2X engine during the Constellation Program for the SLS but found instead it needed to develop an entirely new ECU, which added time and cost to the contract. Aerojet underestimated the cost of specialized electrical, electronic, and electromechanical parts for the new RS-25 ECU and did not seek direction or additional contract value from NASA when they decided to alter the ECU design.

efforts needed for the new RS-25 production engines, we anticipate further cost growth related to recertification and restart of the production line for the new engine.

Complexity of Booster Heritage Technology

Like the heritage RS-25 engine, NASA and Northrop Grumman officials acknowledge the scope and complexity were greater than anticipated for utilizing and retrofitting Shuttle boosters to Artemis (see Figure 6 for information on booster heritage technologies and upgrades). NASA experienced significant requirement changes under the Boosters contract that will result in approximately $2.5 billion in cost growth over a 15-year period (2007 to 2022). Specifically, NASA added $561 million in additional scope to produce two boosters for the third Artemis mission and one test booster. In addition, NASA increased the cost by at least $370.5 million related to NASA's and Northrop Grumman's underestimation of the effort needed to meet contract requirements.[37] This large volume of added scope and resulting cost and schedule increases was due primarily to evolving and unclear requirements from NASA at the start of the contract—evolving requirements that could continue to affect the follow-on BPOC contract.

Figure 6: Booster Heritage Technologies and Upgrades



Source: NASA OIG presentation of Agency data.

Note: Booster Obsolescence and Life Extension (BOLE).

[37] Some technical changes in 2021 and 2022, initially valued at $5.5 million collectively, have the potential to drive significant future cost overruns. In September 2021, NASA added $5 million related to upgrading the system used to collect data from boosters while in flight, along with new navigation control. In December 2021, NASA added $540,000 to upgrade the cable harness jacket—the device that affixes the boosters to the rocket's core stage—to retrofit the Constellation-designed harness to the SLS.

Redesign of the Propellant Liner and Insulation (PLI)—perhaps the most significant redesign of a heritage component—resulted in $365 million of booster-related cost overruns and one year of schedule delay according to NASA officials.[38] While the redesign was ultimately successful, according to NASA officials it required hundreds of tests, 2 years of work, and thousands of hours of labor. The PLI protects the booster's metal casing from the extreme heat and pressure created by burning propellant. During the Space Shuttle Program, the boosters used an asbestos-based insulation material. However, due to the health hazards of asbestos, a new liner material for the SLS boosters was required.[39] While this new liner mitigates these health concerns, issues were encountered during fabrication and qualification of the boosters for Artemis I. A temporary design solution was implemented for Artemis I, while a certified design was approved for the boosters to be used for Artemis II through VIII. As of October 2022, both NASA and Northrop Grumman were confident the issue was fully resolved as part of the PLI installation process for Artemis II and therefore have removed PLI as a program-level risk.

Concurrent Development and Production Contract Activities

Further exacerbating the cost and schedule increases are the Agency's concurrent development and production efforts. NASA requirements and best practices emphasize that technology development and design work should be completed before the start of production activities.[40] As we have previously reported, without mature technologies and a stable design, production is subject to rework as the design is finalized.[41] However, we found that the SLS engine and booster contracts have followed this same inefficient approach. While this can partially be attributed to the acceleration in the lunar landing timeline in 2019 from 2028 to 2024, the concurrency of design and production within the SLS Program's Engines and Boosters Element offices predates the timeline change.

RS-25 Engine Being Installed on the A-1 Test Stand at Stennis Space Center in Preparation of a Hot Fire Test

Source: NASA.

Engines. As of April 2023, 12 of the 16 heritage engines were complete. Concerning the RS-25 Restart and Production contract, Aerojet continues to adapt the remaining four heritage RS-25 engines that were moved from the Adaptation contract while concurrently restarting production capabilities to build 24 new engines. Looking ahead, the

[38] The $365 million in PLI-related costs include a $253 million cost overrun for rework and requalification as well as additional cost growth associated with the PLI modified into the contract. Northrop Grumman requested NASA pay them for the $253 million and in February 2023 NASA and the contractor settled a claim for $24.5 million related to award fees for PLI work. We excluded the $24.5 million settlement in our calculation of $365 million of overruns that the Agency already paid to Northrop Grumman. NASA legal officials stated the $24.5 million would be paid to the contractor using SLS fiscal year 2023 funding. The one-year schedule delay did not result in an overall delay in delivering the SLS vehicle to Kennedy Space Center.

[39] While asbestos minerals are resistant to fire, heat, electrical, and chemical damage properties, the silicate mineral (asbestos) has severe health risks when inhaled over a prolonged period.

[40] NASA Procedural Requirements 7120.5F.

[41] In a 2020 report, we noted that the Orion Program proceeded with production of crew capsules for later Artemis missions before completing key development activities and later experienced additional cost growth and schedule delays as issues were discovered late in the development effort, requiring costly rework. *NASA's Management of the Orion Multi-Purpose Crew Vehicle Program* (IG-20-018, July 16, 2020).

extended commitment of 24 new engines for Artemis V through X, with planned launch dates from 2029 through 2034, represents a significant funding commitment to a modified heritage system that has yet to fly and is still undergoing testing and evaluation.

Boosters. Under the Boosters contract, Northrop Grumman simultaneously developed and tested six boosters (three flight sets) for the first three Artemis missions, one set of which was successfully flown on Artemis I. Boosters experienced cost growth because of concurrently developing and producing the avionics harnesses for Artemis I through III. Looking forward, while boosters for Artemis II and III are awaiting integration, under BPOC Northrop Grumman is producing—effectively retrofitting, with production upgrades—10 Shuttle-era steel-cased boosters using the certified design for Artemis IV through VIII. Given the costly technical issues experienced under the Boosters program, we have concerns that additional requirements to BPOC steel-cased boosters may be necessary thereby increasing the risk of cost and schedule issues associated with concurrent development and production.

Looking at all three ongoing SLS booster and engine contracts broadly, NASA can expect additional changes as data is collected through future Artemis missions. Historically, technologies often change as programmatic or mission-related changes occur, system requirements are revised, or technologies fail to mature as planned, potentially resulting in significant costs to revise the systems. Consequently, NASA likely faces technical issues and rework on the SLS after the first several Artemis flights.

Inadequate Procurement Workforce

NASA's SLS procurement workforce—specifically the Boosters and Engines Element procurement offices—is responsible for managing the four contracts, collectively valued at over $13 billion. The mix of development and production contract work undertaken by these offices requires a highly skilled and fully staffed procurement workforce to manage and oversee its execution. However, we found that the complexity and size of the contract management effort continues to test the procurement offices' capacity, resulting in limited oversight and potential violations of federal requirements.[42]

Underutilized MAP Initiative. Marshall has one of the largest and most complex procurement portfolios in the Agency and, as a result, receives additional shared assets to help manage this workload through the Mission Support Future Architecture Program (MAP).[43] However, according to the Office of Procurement, the MAP realignment of resources—which helps provide key procurement resources throughout the Agency as needed—does not provide a long-term solution to resource allocation, which requires an increase in direct program funding. Additionally, the use of MAP resources varies across NASA Centers. Several Marshall procurement officials report that the size of the workforce for the Boosters and Engines Element Offices is inadequate to manage multiple contracts that involve both technically complex work with concurrent development and production work. Even though the MAP initiative has shared additional resources with Marshall, management at the Marshall procurement office has not fully utilized these shared resources to alleviate some of the burden placed on their booster and RS-25 engine teams. Despite some use of MAP resources, challenges with inadequate staff,

[42] The FAR is the primary regulation for use by all executive agencies to acquire supplies and services with appropriated funds. The NASA FAR Supplement is an integrated document that contains both acquisition regulations and internal Agency guidance and procedures. NASA personnel must comply with all regulatory and internal guidance and procedures contained within the FAR.

[43] Marshall's booster and RS-25 engine contracts are cost-plus with award and incentive fees, requiring greater oversight and management by the Agency. For instance, NASA is required to collect, review, and score contractor performance to determine the appropriate fee to be paid out during each performance period.

inexperience, and limited supervisory review of contract documentation continue to impact the Marshall procurement workforce.

Limited Staff Size and Experience. Senior SLS procurement officials noted concerns with the size of the SLS booster and engine procurement workforce. Despite the complexity of the SLS booster and engine contracts, as of December 2022 the Boosters and Engines Element procurement offices only have a staff of nine managing approximately $900 million in contracts annually. These nine employees include four contracting officers working across the four contracts, with one or two support staff on each contract. Additionally, for the contract management of the $3.2 billion BPOC, staffing in the Boosters Element procurement office consists of a contracting officer, contracting officer's representative, and two support staff—one who was on extended leave until September 2022, and one newly hired with limited experience. We have previously reported on the ongoing acquisition workforce challenges in the Agency, including increased workloads and a shortage of these specialized workers in the federal government.[44] According to procurement officials at Marshall, their office is prone to higher attrition due to procurement employment opportunities outside of NASA in the Huntsville, Alabama, region.

Limited Supervisory Review. As a result of inadequate staff resources across the SLS procurement office, according to the Office of Procurement supervisory personnel are required to perform contract specialist and contracting officer responsibilities normally assigned to lower-graded employees, which could jeopardize these supervisors' ability to objectively review contract actions for quality and compliance. For example, compounded by the need for "warranted" authorization for high-dollar-value contracts, senior procurement management sign contract modifications rather than the contracting officers assigned to manage the contract, thereby removing essential supervisory review in the oversight process.[45]

Inadequate Procurement Management. We found that NASA denied Northrop Grumman's 2018 request for equitable adjustment (REA)—a request for payment when unforeseen or unintended changes occur within the contract causing an increase in contract costs—for a third time. As a result, NASA engaged in negotiations with Northrop Grumman regarding the $28.5 million in additional costs for award fees on PLI-related costs incurred by the contractor since 2013. When examining this issue, we identified a significant and continuous disregard for Agency regulations and official processes by NASA program and contracting management officials. Specifically, after the REA was twice denied, Boosters Element officials convened an "independent assessment team" to review the request.[46] According to the Office of Procurement, even though the contracting officer had issued a decision on the matter denying the payment, the independent assessment team recommended payment. However, a third denial was issued in August 2022 due to Agency legal officials' warnings of fiscal violations. We commend the Office of the General Counsel at Headquarters and Marshall for raising this concern and ensuring the prior REA denials were upheld. In September 2022, Northrop Grumman filed a formal certified claim that NASA officially denied 2 months later. We further detail the process and status of the REA and resulting claim in Appendix B.

In February 2023, NASA and Northrop Grumman reached a settlement for $24.5 million. While we do not question the Agency's decision to reach a settlement with the contractor, we do question the

[44] NASA OIG, *NASA'S Management of Its Acquisition Workforce* (IG-21-002, October 27, 2020).

[45] Warranted means that the contracting officer has the authority to enter into obligations and contracts on behalf of the federal government at different dollar thresholds depending on experience and qualifications.

[46] The independent assessment team consisted of four contractors and a former NASA manager. The team was established by Boosters Element leadership without the knowledge of procurement and legal officials responsible for managing the REA.

Agency's failure to follow established procedures, which according to Agency procurement and legal officials ultimately resulted in a settlement. Specifically, because the contract was not properly modified to add scope of work and funding, upon which an award fee would be payable, we question the $24.5 million in payment to resolve the disputed award fee payment. Appendix C provides a detailed breakdown of these questioned costs.

Poor BPOC Contract Definitization

We found BPOC was poorly definitized; specifically, it experienced slow definitization, lacked defined scope at definitization, omitted key contract clauses, underwent a limited legal review, and failed to properly transfer funds from the letter contract to the definitized contract.[47] These factors increase the financial risk to NASA over the duration of the contract, and since June 2020, have already contributed to a $5.6 million overpayment to the contractor.

Slow Definitization

SLS Rocket Booster Tested in Utah Desert Duplicated Actual Burn Time in Flight to Gather Data on a Propellant Component

Source: NASA.

The letter contract under which BPOC originated did not adhere to FAR and NASA FAR Supplement guidance for timely definitization. In June 2020, NASA issued an undefinitized contracting action—a letter contract—to Northrop Grumman for $49.5 million to purchase items for booster flight set 4 (two boosters for the Artemis IV mission).[48] In November 2021, when the letter contract's not-to-exceed value and letter contract scope of work increased to $199 million, it was definitized and awarded as BPOC after being undefinitized for 499 days outside of the 180-day guidance to definitize a letter contract.[49] While the overall scope of BPOC as defined in the request for proposal has remained consistent to date, without definitization, changes to a contract can go unchecked, significantly limiting NASA's ability to control scope, cost, and schedule growth. As we

[47] The growth of the letter contract was due, in part, to delays in finalizing the contract caused by a rephasing of the budget due to an Agency-wide budget cut of approximately 30 percent in February 2021.

[48] The letter contract material buy included the main propellant materials, insulation materials, operational pressure transducers, igniter propellant materials, floor plates, liner materials, insulation, case O-rings, avionics materials, and nozzle materials.

[49] In 2014, the Government Accountability Office concluded that employing SLS contractors for extended periods of time without contract definitization led to increased government risk of rising costs and limited the SLS Program's ability to monitor contractor progress. *Space Launch System: Resources Need to be Matched to Requirements to Decrease Risk and Support Long Term Affordability* (GAO-14-631, July 23, 2014). The NASA FAR Supplement provides that NASA should aim to definitize contracts within 180 days, or approximately 6 months, of issuance. NASA FAR Supplement 1843.7005(a), *Definitization* (2018).

reported in 2021, NASA has a long-standing issue of timely definitization of letter contracts past FAR and NASA FAR Supplement timelines.[50]

Significant Scope Increases Beyond Artemis IV for Long-Lead Items

In accordance with the FAR, a letter contract action can be used when an agency has an urgent need, but it should be as complete and definite as feasible under the circumstances.[51] We found the BPOC letter contract did not meet FAR requirements because it lacked adequate detail and experienced additions of scope and costs outside the original justification for the letter contract.[52] The letter allowed Northrop Grumman to purchase immediate-need materials to begin production of the boosters for Artemis IV to ensure there was no work stoppage, which according to NASA, would have occurred before the Agency and contractor could negotiate a definitive contract in time to meet the requirements for the Artemis IV boosters.

However, we question the additional work and not-to-exceed values that were added to the letter contract outside of Artemis IV long-lead items. In particular, we question NASA's immediate requirement to add $34.4 million in work for Artemis V to the letter contract in July 2021 just 4 months before definitization as well as the cumulative addition of $53.2 million in work to begin development under contract line item numbers (CLIN) 1 and 10 for the Artemis IX composite booster. More broadly, because the scope of work started under the letter contract for Artemis V and Artemis IX, missions that are not scheduled to fly for at least 6 to 10 years, we question whether expanding the use of the letter contract to include these additional boosters meets the requirement of an "urgent need" outlined in the FAR. In our judgment, increasing the scope of the letter contract before definitizing the contract lessens NASA's ability to control future cost and schedule increases.

Beyond these concerns related to the justification for immediate need, we also found letter contract terms missing or ill-defined. Although Agency officials claimed BPOC was fully defined when it was definitized in November 2021, we found that both the letter contract and definitized contract included multiple items listed as 'To be Determined' as well as contained ill-defined sections. Further, NASA did not initially establish requirements for the Earned Value Management System, which includes the metrics and milestones that the contractor's performance is evaluated against. When contract requirements are not final at the time of award, including both for the letter contract and the November 2021 definitized contract, final terms and prices are not yet agreed upon before the contractor begins purchases for which the government may be responsible for reimbursement. The letter contract, valued initially at a not-to-exceed amount of $49.5 million, grew to an amount not-to-exceed $199 million during the undefinitized period as the Agency added more work to ensure booster efforts progressed as BPOC was being definitized. Additionally, the lack of detailed requirements in a contract creates an environment in which the contractor works to undefined or less than fully defined specifications creating risk and potential rework at the government's expense. This situation also creates an increased workload for an understaffed procurement office and challenges NASA in negotiating favorable terms for the contract.

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[50] IG-22-003.

[51] Per FAR 16.603-2(a), use of a letter contract is reserved for instances when the government's interest demand that the contractor be given a binding commitment so that work can start immediately and negotiating a definitive contract is not possible in sufficient time to meet the requirement.

[52] FAR 16.603-2(a) and FAR 16.603-4, *Contract Clauses* (2019).

Omission of Contract Clauses and Limited Legal Review

BPOC Letter Contract. The contract was missing FAR clauses required in letter contracts that set parameters on the scope and schedule of work. The FAR states that letter contracts have significant shortcomings with respect to defined scope and guidelines directing the contractor and, as such, require certain clauses to provide greater protection for the government.[53]

In the June 2020 letter contract between NASA and Northrop Grumman, we identified the omission of required clauses and several CLINs that were not defined. In addition, the statement of work for CLIN 5—the Artemis V booster flight set—included a one-paragraph description of the work to be completed under this and other CLINs. The Agency acknowledged that it omitted several required clauses, due in part to software omitting language in some clauses and procurement's intention to add clauses and details as work was added and the contract was definitized.[54] In addition, according to Agency officials, some of the missing scope was not included in the initial letter contract because these details were intended to be added later as the specific work was awarded. Nonetheless, we believe these clauses are significant and help guide the contractor's scope of work before full definitization, and their omission and in some cases their late addition inhibits the Agency's ability to direct the contractor's work and limit scope growth and cost increases.

BPOC Definitized Contract. Equally concerning, more than a year after contract award, efforts are still ongoing to ensure the contract includes additional FAR-mandated contract clauses that were not in the signed contract. Specifically, three critical clauses are missing from BPOC that define how the contractor will perform and how that performance will be assessed.[55] These include a clause to allow NASA to rescope and remove production work that may be covered under the upcoming Exploration Production and Operations Contract (EPOC) leased services award.[56] Northrop Grumman officials told us they were unaware of this clause and the potential rescoping of work.[57] The potential overlap of work on Artemis V through IX booster flight sets under BPOC and EPOC could result in duplicative payments and will require significant oversight to determine whether the flight set and its components are procured under BPOC or EPOC. If this work is descoped from BPOC, the Agency may be unable to adjust the contract terms due to omission of the services rescoping contract clause and, as a result, will pay for portions of the boosters' production work and then pay again for use of the boosters under the EPOC services contract. NASA procurement officials are aware of this issue and note that steps need to be taken to

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[53] FAR 16.603-4.

[54] With respect to missing clauses in the June 2020 letter contract, NASA officials confirmed FAR 52.216-25, *Contract Definitization* (2019) was added later in Modification 3; FAR 15.408, *Certified Cost or Pricing Data* (2019) was submitted by the contractor in October 2021 and was added to the contract under Modification 14 at contract definitization; and FAR 52.216-26, *Payment of Allowable Costs Before Definitization* (2019) was incorporated by reference (meaning the contract was not required to include the full text) in the base award under Modification 13.

[55] FAR 16.603-4. Missing clauses include rescoping, liquidating damages, and defining statement of work.

[56] EPOC would shift procurement of SLS launches to a services contract for Artemis V through IX, with an option for Artemis X through XIV as well as other non-Artemis launches.

[57] BPOC contained a placeholder for this clause but content was missing.

remedy potential duplicate payments for boosters and RS-25 engines under BPOC and the Restart and Production contracts.[58]

Further, as of February 2023, several of the contract's clauses remain 'To be Definitized' or 'TBD.' This includes a clause on liquidated damages for catastrophic loss, which provides detail on cost responsibility in the event of mission failure. This clause and the section of the contract that delineates the period of time in which orders may be placed for supplies and services under BPOC both remain 'To be Definitized.'[59] In addition, a clause required to manage the schedule for order and delivery of supplies and services under the contract is similarly listed as 'TBD.' In February 2023, the Agency confirmed that these three clauses remained to be definitized and are currently being negotiated with the contractor. While the Agency said it intends to include these clauses in an "administrative clean up modification," it has not provided a timeline for when this will be completed.

In addition to the three missing clauses, the statement of work for BPOC's $3.2 billion contract included the Data Requirement Description, among other sections, that were ill-defined according to multiple contracting staff. These issues identified by the Marshall contracting office raise concerns that the scope was not clearly understood and defined at definitization. It also raises the risk of added scope and increased costs and schedule to production of the Artemis IV to VIII booster flight sets and development of the new composite booster for Artemis IX and beyond. This type of scope growth and cost and schedule increase was experienced under the original Boosters development contract.

Legal Review. Marshall procurement's legal office stated they were provided only 6 hours to review BPOC—a more than 1,500-page document—likely contributing to unidentified omissions of required clauses and lack of a fully-defined scope of work. According to NASA procurement and legal staff, this expedited review was driven by senior leadership in the Boosters Element and SLS procurement office who denied procurement and legal staff requests to conduct more thorough reviews and negotiations with the contractor before definitization. They further advised that the lack of adequate time for review resulted in additional procurement and legal work to address the deficiencies mentioned above in BPOC. However, Marshall procurement leadership disagreed with these claims and stated that staff had sufficient time for its legal review and "the lack of clauses and consideration for a future contract action under EPOC is appropriate considering the unknown nature of EPOC at the time of [BPOC's] award." In our judgment, given the size and complexity of the contract and the identified omissions in BPOC, program and procurement officials should have provided more time for legal and procurement staff to conduct the appropriate level of review required to examine a 1,500-page contract valued at $3.2 billion.

Contract Funding Management Issues

After NASA definitized BPOC, it revised the payment method with Northrop Grumman to move from progress payments—where payments are made based on costs incurred by the contractor as work progresses—to performance-based payments—where payments are made based on quantifiable

58 Per Agency procurement officials, the request for proposal for EPOC will contain language that instructs the contractor to develop a transition plan, scope, and methodology wherein any assets already produced under other contracts are removed from any costs; and that the contractor obtain concurrence and assurances from Northrop Grumman on the movement of assets, the reduction in scope on BPOC, and the benefit to NASA. They indicate that as a result of these actions, there will be no duplicative payments from NASA for efforts related to EPOC.

59 In accordance with FAR 16.506(a), FAR clause 52.216-18, *Ordering* (2020), is required in solicitations and contracts when a definite-quantity contract, requirements contract, or an indefinite-quantity contract is contemplated.

measures of accomplishments.[60] Per FAR requirements, all outstanding progress payments should be liquidated, or reduced, by the amount previously paid under a letter contract.[61] However, we determined that the Marshall procurement office violated the FAR by failing to liquidate $5.6 million in progress payments at definitization in November 2021. Specifically, NASA paid Northrop Grumman progress payments of $58.9 million, but the Agency only requested Northrop Grumman liquidate $53.3 million in the first performance-based payment request in December 2021.

Marshall procurement officials stated that they structured BPOC to be funded on an individual CLIN basis rather than funding the contract as a whole. As a result, this approach prevented liquidation of the $5.6 million in progress payments until the contractor reached its first contract-specified performance milestone and submitted an invoice for that period of performance. We are concerned with the Agency's approach since the FAR is explicit concerning financing of contracts for supplies or services awarded under a sole-source acquisition. Specifically, payments may be made under a single finance type, either progress or performance-based payments, but not both. Whatever the case, NASA's approach resulted in it leaving a $5.6 million unearned balance with the contractor for over 13 months. In February 2023, Agency officials indicated to us that they planned to liquidate the outstanding $5.6 million overpayment. However, as of May 2023 that has not happened. As such, we question the $5.6 million progress payment made under the definitized BPOC because the payment was required to be liquidated. Appendix C provides a detailed breakdown of these questioned costs.

In addition to not correctly liquidating and reducing the payment amounts, the Marshall procurement office paid $337,000 in fees for work performed during the BPOC letter contract period. While the Agency adhered to NASA policy by making payment one day after definitization, the work was clearly performed under the undefinitized terms of the letter contract.[62] In particular, a fee was paid on CLIN 1 for Booster Obsolescence and Life Extension design, development, testing, and evaluation work for a set of boosters that will not be used until Artemis IX in the 2030-time frame.[63] The initial letter contract was for long-lead material purchases for the Artemis IV steel-cased boosters that were a separate contract item, for a different mission, and with a different design for a solid rocket booster.

NASA Procurement Officials Continued Reliance on Cost-Plus Contract Structure for Production Efforts

As we have previously reported, the Agency's reliance on cost-plus awards increases its financial risk. In our judgment, NASA has used cost-plus contracting structures for its SLS booster and engine contracts to a greater extent than warranted. In cost-plus contracts, NASA bears a greater cost risk because the final product required to meet program needs is unknown or less established when the contract is awarded. Although the SLS is a new vehicle, its heritage boosters and RS-25 engines are well-established. In fact,

[60] FAR 32.104(d), *Providing contract financing* (2022) and the Contract clause Special Provision for Performance-Based Payments authorizes the contracting officer to provide contract financing in the form of performance-based payments or customary progress payments. However, once definitized the terms of the contract dictate the use of performance-based payments, requiring funding for progress payments to be liquidated and transferred to be performance-based payments in line with contract performance milestones.

[61] FAR 32.104(d); FAR 52.232-16(b), *Liquidation* (2019); and FAR 52.232-32, *Performance-Based Payments* (2019).

[62] NASA FAR Supplement 1815.404-472, *Payment of profit or fee under letter contracts* (2019) states that NASA policy is to pay profit or fee only on definitized contracts.

[63] FAR 16.603-3(c), *Limitations* (2019) which notes that letter contracts shall not be amended to satisfy a new requirement unless that requirement is inseparable from the existing letter contract.

leveraging heritage technology was seen as a key feature in the development of the SLS rocket that would reduce costs. However, Boosters and Engines Element managers, procurement officials, and contractor officials still said that the current cost-plus contract elements were necessary as continued design, development, testing, and evaluation efforts had yet to be completed for differing flight set boosters and engines beyond Artemis III. Nonetheless, we found several instances where we believe fixed-price contracts were a viable option that NASA should have considered.

For example, NASA initially awarded the RS-25 Restart and Production contract for six new production engines under a cost-plus structure. Approximately 3 years later, the contract was modified to include an additional 18 production engines valued at $1.8 billion. Given its established design, purchase of these additional engines could have been structured under a fixed-price contract. Engines Element officials stated that the use of cost-plus rather than fixed-price contracts presented the best value for the government because of the high initial cost risk in early manufacturing, noting that at the time of the proposal no engines had been built. The officials also explained that while the 18-engine contract modification is incentive fee-based, NASA intends to pursue fixed-price contracts as soon as practical. In our judgment waiting for production deliverables from the initial award before proceeding with a contract modification for additional production engines would have better positioned the Agency to control costs. Under the contract's cost-plus structure, NASA has already experienced $102 million in cost increases and a 17-month delay.

Moreover, NASA structured its long-lead acquisition of materials for the Artemis IV booster flight set as cost plus under the letter contract. Initially valued at a not-to-exceed amount of $49.5 million in June 2020, the letter contract's scope and amount increased to include work for the Artemis V and IX booster flight sets and a not-to-exceed amount of $199 million by November 2021 when the contract was definitized. The use of a cost-plus contract is atypical for a long-lead material purchase, which would generally be fixed price, especially when the quantity and cost of the item are known, as was the case of the boosters. Agency officials noted that under the letter contract, it was appropriate to use a cost-plus structure as the contract type had not been determined. However, given an established scope and not-to-exceed amount, we question the rationale behind using a cost-based approach to purchase long-lead items. To NASA's credit, they have structured the Artemis IV to VIII booster flight sets under individual fixed-price CLINs to provide financial transparency and incentivize the contractor to control costs.

High Award Fee Percentages and Fee Payments

Award Fee Percentages Are Inflated for Cost-Plus Production Contracts

We found that the negotiated award fee percentage of costs for the RS-25 Restart and Production contract is higher than typically found in contracts of this type. While the award fee percentage for cost-plus production contracts could be as low as a 6 to 8 percent range, the RS-25 Restart and Production contract award fee is in the 10 to 13 percent range. According to Engines Element officials, the range targeted was benchmarked to the prior Adaptation contract's rate and "is typical for high-risk, high-value, high-complexity, human space flight program contracts." However, unlike the Adaptation contract, the follow-on contract is for certification of the RS-25 redesign production of new engines and leverages the matured RS-25 design. Given the maturity of the RS-25 engine design and the use of cost-plus CLINs, we question whether a lower target percentage should have been negotiated.

NASA's Payment of $19.8 Million in Award Fees for 11 Undelivered RS-25 Engines Is Inconsistent with Contractor Performance

We found that the performance evaluations for the Adaptation and Boosters development contracts did not accurately rate contractor performance in accordance with federal requirements. For example, to receive a score of "excellent" and between 91 percent and 100 percent of the available award fee, the contractor should have exceeded almost all the significant award fee criteria and met overall cost, schedule, and technical performance requirements of the contract (see Figure 3). In contrast, failure to meet cost, schedule, or technical performance requirements within a given performance period should receive an unsatisfactory score with a reduced or no earned award fee. However, under the Boosters contract, over three separate performance periods from 2015 to 2019, NASA rated Northrop Grumman as "very good," "very good," and "excellent" despite the Agency paying $253 million in cost overruns associated with the PLI-related work during this time frame.[64] In other unrelated contracts, the OIG has frequently identified similar concerns with NASA's overpayment of award fees to contractors that experienced significant cost increases, schedule delays, and performance deficiencies.[65]

We found that at the conclusion of the Adaptation contract, NASA gave Aerojet a final award fee score of 89 out of 100, signifying a "very good" performance, despite only completing 5 of 16 engines with $232.9 million in scope growth and cost overruns under CLIN 3 for RS-25 adaptation efforts. With this rating, Aerojet ultimately earned nearly $29 million in award fees over the life of the contract (see Table 2). Even though federal requirements clearly state that failing to meet cost, schedule, or technical performance requirements should earn an unsatisfactory score, performance scores and ratings for both the interim award fee periods and overall total were "excellent" or "very good."

Table 2: Adaptation Contract CLIN 3 Award Fee Performance Ratings (2011 to 2019)

Evaluation Period and Schedule	Potential Award Fee Amount	Total Earned Award Fee Amount	Unearned Award Fee Amount	Score[a]	Rating
Interim Period A (12/1/2011 to 9/30/2013)	$8,945,249	$8,408,534	$536,715	94	Excellent
Interim Period B (10/1/2013 to 9/30/2014)	$6,820,393	$6,138,354	$682,039	90	Very Good
Interim Period C (10/1/2014 to 9/30/2015)	$4,609,804	$4,287,118	$322,686	93	Excellent
Interim Period D (10/1/2015 to 4/30/2019)	$11,930,341	$11,214,521	$715,820	94	Excellent
Final Award Fee[b]	**$32,305,787**	**$28,752,150**	**$3,553,637**	**89**	**Very Good**

Source: NASA OIG presentation of Agency information.

[a] The performance rating score correlates with the percentage of fee earned for each performance period.
[b] Final award fee under the Total Earned Award Fee and Unearned Award Fee columns is based on the final award fee score and is not the sum of interim period award fee amounts.

[64] During the interim period in which Northrop Grumman received an "excellent" rating, the narrative noted that due to rework and requalification on the PLI and cables occurring during the period, CLIN 4 realized a cost overrun of $104.9 million. At the time, the overrun represented 12 percent of the CLIN's value.

[65] NASA OIG, *NASA's Management of the Mobile Launcher 2 Contract* (IG-22-012, June 9, 2022); IG-20-012; and *NASA's Management of the Space Launch System Stages Contract* (IG-19-001, October 10, 2018).

While the Adaptation contract CLIN 3 required the delivery of 16 redesigned RS-25 engines initially built for the Space Shuttle Program, by September 2020 Aerojet only completed 5 engines for $581 million—exceeding the original contract value by $291.6 million.[66] The Engines Element Office noted that the fee was awarded based on execution of the entire contract's scope of work, including integrations, certification, and program execution among other components of contract performance and that the percentage of contract scope associated with engine delivery is small compared to the entire scope of the contract. However, we disagree with how NASA rated the contractor's technical performance and program management end-items. Considering the contract is structured with end-item award fees for successful technical performance and program management, it is unclear how delivering 5 of 16 completed engines could be rated as "successful." Applying an evenly divided fee distribution for delivery of each of the 16 end-item RS-25 Adaptation engines, Aerojet was paid a total of $28.8 million in end-item award fees for the 16 engines: $9 million for the 5 completed engines and $19.8 million for the 11 unfinished engines.

According to Engines Element and procurement officials, when the engines were moved from the Adaptation to the Restart and Production contract, the contract modification included approximately $1 million in award fees and $9.8 million in costs associated with completion of the 11 engines. Under the new contract, the engines are eligible for additional award fees once delivered to the Agency. Therefore, we question the $19.8 million in award fees for the 11 RS-25 Adaptation engines in which the work was not completed and delivered to the Agency. Appendix C provides a detailed breakdown of these questioned costs.

[66] Under the Adaptation contract, CLINs 3 and 5 are specific to RS-25 engines. In December 2011, NASA, through a letter contract, added $265 million to CLIN 3 for RS-25 engine work. This letter contract was definitized—2.5 years later—in August 2013 for $274.7 million.

NASA's Affordability Plans under the RS-25 Engine and Booster Production Contracts Will Be Stymied by Continued Restart Cost Increases and Added Scope

Faced with continuing cost and schedule increases, NASA is undertaking efforts to make the SLS more affordable through its RS-25 Restart and Production and BPOC contracts. These follow-on efforts to the Adaptation and Boosters contracts will move engine and booster development into production. While both contracts represent positive steps toward emphasizing affordability through procurement actions, their ability to promote such affordability is dependent on limiting changes to the scope of work and related cost increases. In addition, NASA's efforts likely will fall short of its expected savings given the continuing impact of efforts to restart RS-25 engine production and manage the complexity of upgrading and integrating heritage components.

NASA's RS-25 Plans Project a 30 Percent Manufacturing Cost Savings but $2.3 Billion in Overhead Production Costs and Limited Transparency May Jeopardize Affordability Efforts

The Agency has emphasized its plans to make the production of the SLS more affordable. Specifically, NASA and Aerojet are now projecting manufacturing cost savings of 30 percent per engine starting with production of the seventh of 24 new engines under the RS-25 Restart and Production engine contract.[67] The current estimated manufacturing cost per engine, after Artemis VI, is $70.5 million. To achieve the 30 percent savings from NASA's calculated manufacturing cost of a Shuttle-era engine—$104.5 million—NASA and Aerojet identified several cost-saving measures such as (1) applying additive manufacturing (also known as 3D printing), (2) reducing the number of parts in the new production engine, and (3) using more efficient manufacturing practices borrowed from the company's RS-68 engine development for the Delta IV rocket.

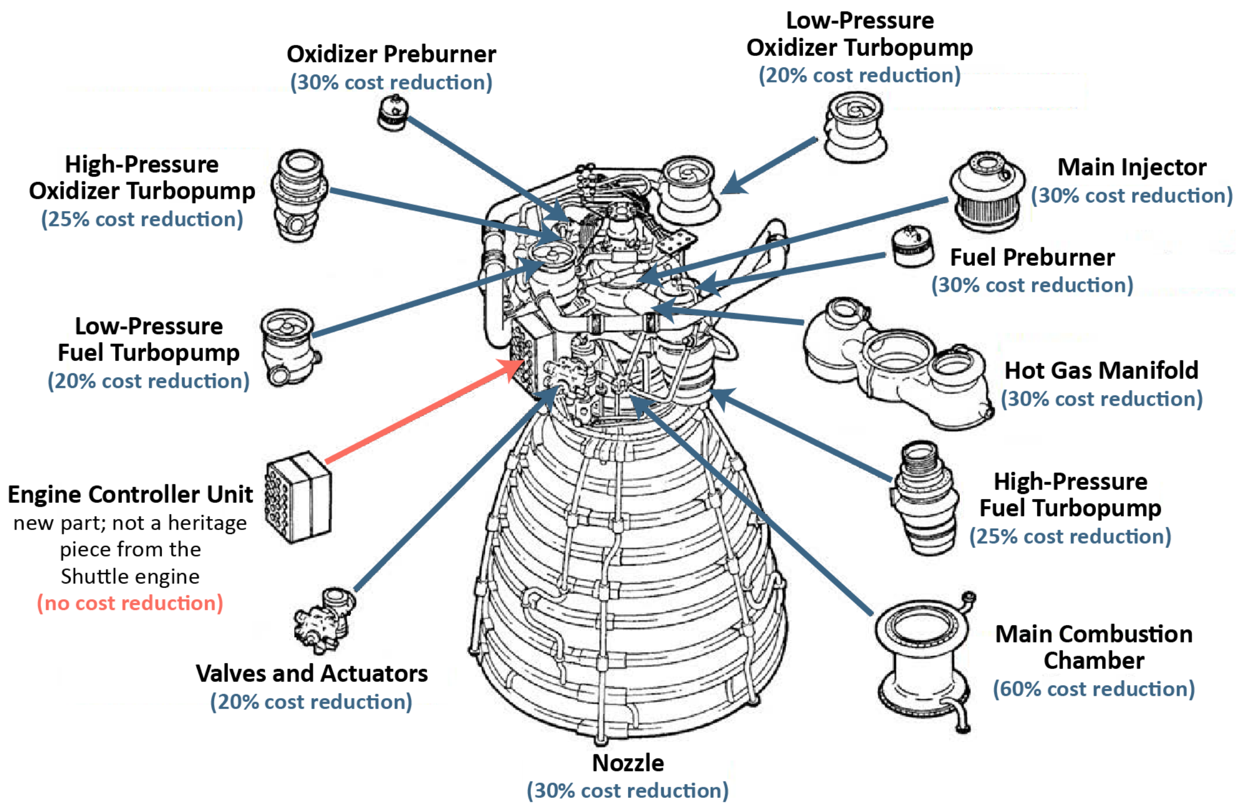
[67] As of February 2023, the Agency reduced the projected savings from 33 percent to 30 percent.

While the Agency's efforts may ultimately reduce manufacturing costs, we found several issues that limit the transparency of these efforts and muddy their impact. In particular, NASA's cost-savings calculation does not capture overhead and other associated costs with recertification, industry base restart, and production efforts for the 24 new engines—which we currently estimate adding a 13 percent cost increase under the Restart and Production contract.[68] NASA's reported savings are limited to individual engine components and manufacturing, which excludes these costs (see Figure 7). In total, we identified $2.3 billion in total costs and fees associated with these efforts that are not included in the Agency's calculation for making production of RS-25 engines more affordable.[69]

[68] The Agency is using Shuttle-era costs in 2015 dollars for a period of time under the Space Shuttle Program when a similar amount of engine components had been produced and were available to assemble RS-25 engines. NASA determined this period during the Shuttle era would be the most comparable to availability of new RS-25 engine components under the SLS Program. However, according to SLS Engines Element officials this comparison is limited to just manufacturing costs and components. These officials acknowledge that the comparison of the Shuttle and SLS Programs is not ideal as they have different structures, flight frequency, and objectives, and these differences prevented the Agency from making additional cost comparisons outside of manufacturing costs. The Shuttle-era production of RS-25 engines was more established with a larger workforce and the production rate and flight cadence was greater than planned under Artemis. The new RS-25 production line is still being restarted, the Artemis flight cadence is less frequent, the engines are not reusable, and the production workforce is much smaller, but production capabilities are much greater now.

[69] The $2.3 billion in costs and fees not included in the manufacturing costs is for work under CLINs 1 through 4 and the incentive fee for CLIN 5. Specifically, CLIN 1 contains a $799.2 million cost and $86.3 million fee for restarting the production line and supply chain and redesigning and recertifying the new RS-25 production engines. CLIN 2 contains a $354.6 million cost and $29.5 million fee for material for engines 1 through 6. CLIN 3 contains a $437.7 million cost and $51.9 million fee for production of engines 1 through 6. CLIN 4 contains a $427.2 million cost and fee for integration, testing, and program operations or overhead for engines 7 through 24. Under CLIN 5, a $147.8 million incentive fee pool is excluded as well.

Figure 7: RS-25 Engine Affordability Objectives and Production Engine Cost Comparison (as of January 2023)



Manufacturing Cost Per Engine - Heritage: $104.5 million

Manufacturing Cost Per Engine - Agency Projected Savings: $70.5 million[a]

Total Additional Restart and Production Costs of New Engines: $2.3 billion

Source: NASA OIG presentation and analysis of Agency information.

Note: The components and related cost reduction percentages were first established in 2015 but remain current as of January 2023.

[a] Cost is exclusive to manufacturing costs for 18 engines under CLIN 5. Cost is calculated with a projected 30 percent savings compared to Shuttle-era engine cost starting with the seventh engine.

More broadly, we question the use of Shuttle cost data as a benchmark to calculate the Agency's cost savings goal for the SLS. Shuttle-era manufacturing costs were a result of a stable design, ongoing and streamlined production, and a well-established flight cadence—none of which exist for the SLS and the new RS-25 production engines. It is also noteworthy that the engines built for the Shuttle were fully reusable, while the new RS-25 production engines are not. Historically, the Shuttle-era engines flew multiple times, sometimes ten or more before being retired. This reuse spreads the cost of the engine across multiple flights reducing the overall cost to the Agency for multi-launch programs.

Further complicating the Agency's efforts to identify and achieve cost savings is NASA's and Aerojet's inability to track per-unit costs for the new RS-25 production engines because the design, development, testing, evaluation, and additional modification efforts are tracked separately from the material and production of the engines. The inability to track per-unit costs outside of material and labor to build the engines does not meet current federal requirements for cost tracking. According to the FAR, CLINs should provide unit or lump sum prices for separately identifiable contract deliverables and associated delivery schedules or performance periods.[70] However, when requirements for the Restart and Production contract were set in 2016, individual CLINs were recommended but not required by the FAR. By failing to implement this recommended structure in the Restart and Production contract, NASA cannot determine the cost of a single engine and whether any cost savings beyond individual component production can be achieved.

Additional Requirements through Artemis VIII Could Limit Savings of BPOC's Move to Fixed-Price Contracting

In addition to the Agency's affordability efforts under the RS-25 Restart and Production contract, NASA identifies its procurement efforts under BPOC—procuring 10 boosters for flight sets 4 through 8 on a fixed-price-incentive-fee basis starting with Artemis IV—as an important step in its affordability initiatives.[71] This represents a positive development to provide greater cost transparency for each respective flight set's boosters. Use of fixed-price contracting helps to share risk between the government and contractor and has been shown to limit cost growth in some cases. However, BPOC's near-term affordability is dependent on the current scope of work incurring no additional flight set modifications or government-directed changes for these boosters. Any additional requirements will limit these projected cost savings. Boosters Element officials confirmed the risk of cost increases and reduced savings if scope were to be added. For example, NASA and the contractor continue to work through the development and production of the boosters, including the in-flight data collection system, navigation control, and cable harness jacket that have the potential to result in costly scope modifications to the Artemis IV to VIII boosters. Given this risk and based upon the historic scope growth encountered with development of the Artemis I to III boosters and their associated impacts to cost increases and schedule delays, we are concerned that BPOC's effectiveness as a cost-savings initiative may be limited since the scope of work is likely to continue to evolve through the fourth Artemis mission and beyond.

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[70] FAR 4.1001, *Policy* (2022), effective as of January 13, 2017.

[71] Fixed-price-incentive-fee contract structures involve progress payments, while cost-plus-incentive-fee contracts reimburse contractors for total costs incurred at a higher risk and cost to the government.

CONCLUSION

NASA continues to move into production from the design and development phase for its heritage-based SLS booster and engine systems, maturing these technologies into the Agency's new deep space hardware and software for the Artemis missions. Accelerating efforts to bring down costs and more effectively manage its portfolio of contracts will be vital to sustaining the Artemis campaign. The long-standing challenges we have reported on for the better part of a decade continue to hinder NASA's ability to oversee and ensure its contractors meet the Agency's cost and schedule goals, often exceeding initial milestones by billions of dollars and adding years of delay. Looking ahead, we believe that the Agency's current long-term contractual commitments to the SLS booster and engine heritage systems may hinder the affordability of the Artemis missions.

For its booster and RS-25 engine contracts, NASA needs to better manage its approach to developing and producing the complex systems required for Artemis by better understanding the SLS Program's needs and complexity before moving from development to production and adequately defining the scope of work at contract definitization. In addition, the Agency needs to adhere to the FAR and ensure greater accountability of its contractor base by increasing its procurement workforce capacity, moving away from cost-plus contracts, accurately scoring and rewarding contractor performance in terms of meeting cost and schedule, and accurately capturing program costs and risks. Furthermore, attempts to resolve the REA have highlighted a lack of management controls, internal and external stakeholder involvement beyond the established process, poor communication, and lack of sufficient training—all issues that continue to put the Agency in jeopardy of compounding the extensive Boosters contract's cost growth. Without greater attention to these important safeguards, NASA and its contracts will continue to exceed planned cost and schedule, resulting in a reduced availability of funds, delayed launches, and the erosion of the public's trust in the Agency's ability to responsibly spend taxpayer money and meet mission goals and objectives—including returning humans safely to the Moon and onward to Mars.

RECOMMENDATIONS, MANAGEMENT'S RESPONSE, AND OUR EVALUATION

To increase transparency, accountability, and oversight of NASA's SLS booster and engine contracts, we recommended NASA's Associate Administrator for Exploration Systems Development Mission Directorate, in coordination with the Assistant Administrator for Procurement:

1. Assess whether the 18 new RS-25 production engines under the RS-25 Restart and Production contract can be adjusted from cost plus to fixed price.
2. Coordinate with the Marshall procurement office to identify procurement needs and resources available under MAP to address staff capacity shortages at the senior procurement level to ensure sufficient oversight roles are staffed and separated from the contract actions.
3. Ensure Marshall procurement, legal, project planning and control, and SLS and booster program officials comply with best practices for establishing and maintaining internal controls, specifically on the appropriate process and procedures on REAs, fiscal law, and appropriate internal and external engagement.
4. Ensure Elements and procurement management comply with appropriate separation of roles and responsibilities for program and procurement actions and the FAR with respect to use of letter contracts, proper definitization, overpayments, and duplicative payments of award fees for modified scope and contracts.

To increase transparency and accountability of NASA's affordability efforts, we recommended NASA's Associate Administrator for Exploration Systems Development Mission Directorate, in coordination with the Assistant Administrator for Procurement:

5. Update RS-25 production per engine cost estimate to include investment costs in restart facilities, equipment, new production overhead costs, and government-funded property.
6. Conduct a thorough review of BPOC's scope of work and technical requirements needed to complete the respective periods of performance and update the contract as appropriate.
7. Conduct a thorough review of BPOC's definitization to ensure proper liquidation of funds paid under the letter contract as progress payments are returned to the Agency and are appropriately paid when the performance of the work, per the contract, is completed.

To ensure additional award fees are not earned on work that already received fees prior to completion under the Adaptation contract, we recommended NASA's Associate Administrator for Exploration Systems Development Mission Directorate, in coordination with the Assistant Administrator for Procurement:

8. Develop a separate non-fee bearing contract line item for completion of the 11 unfinished heritage RS-25 adaptation engines.

We provided a draft of this report to NASA management, who concurred with Recommendations 1, 2, 3, 6, and 7, and partially concurred with Recommendations 4, 5, and 8. We consider management's comments responsive to all eight recommendations, and therefore the recommendations are resolved and will be closed upon completion and verification of the proposed corrective actions. In its response to Recommendation 4, the Agency characterized the OIG's finding of overpayments and duplicative payments as unfounded and inaccurate. We disagree with this assessment. As noted in our report, we found a $5.6 million overpayment of progress payments that was not properly liquidated at the time of BPOC's definitization that the Agency agreed to act on in its response to Recommendation 7. While duplicative payments have not yet occurred (as explained in the report), we are raising concerns about the risk of duplicative award fees given ongoing work related to completion of the Adaptation RS-25 engines.

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

A final note: The Associate Administrator for Exploration Systems Development Mission Directorate's and Assistant Administrator for Procurement's response to the draft of this report stated that NASA leadership "was disappointed to find that few of the clarifications offered by the Agency's subject matter experts were incorporated herein" and thus "the directorate and the program do not concur with, nor endorse, the facts as presented in the body of the report." We take issue with this summary characterization and are disappointed that in its formal response the Agency failed to specify the facts in the report with which it disagrees. Consistent with professional standards, we carefully considered management's technical comments to our draft and, when sufficiently supported, incorporated that information in the final report. Further, we had multiple additional discussions with senior Agency officials at Headquarters and Marshall about the report's findings. However, from our perspective personnel involved in these conversations did not provide evidence to fundamentally change our findings and recommendations. In addition, in conducting this audit we followed the quality control procedures required by government auditing standards, including ensuring the report received an independent verification of its findings and supporting evidence by auditors unconnected with this review. The scope and methodology used to conduct this audit is further detailed in Appendix A.

Major contributors to this report include Ridge Bowman, Human Exploration Audits Director; James Smith, Assistant Director; Moriah Lee; Tommy Dodd; Kelsey Dalton; Benjamin Patterson; Wayne Emberton; Lauren Suls; Shani Dennis; and Norm Conley.

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 MARTIN

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Date: 2023.05.24 16:41:35 -04'00'

Paul K. Martin
Inspector General

Appendix A: Scope and Methodology

We performed this audit from February 2022 through April 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.

In this audit, we examined the extent to which NASA is meeting cost, schedule, and performance goals for the SLS Boosters and Adaptation contracts, and whether BPOC and RS-25 Restart and Production, the two follow-on production contracts, reduce the government's financial risk and promote affordability. To perform this audit, we examined the SLS Program's booster and RS-25 engine contracts from April 2006 through January 2023. Our review was conducted with officials from Headquarters, Marshall Space Flight Center, Stennis Space Center, Michoud Assembly Facility, Northrop Grumman, and Aerojet Rocketdyne. In preparation for the audit, we conducted routine coordination with the Associate Counsel to the Inspector General and the OIG Office of Investigations.

To assess the SLS booster and RS-25 engine projects' cost performance, we examined SLS Program budget documentation, base and conformed contract files, contract modifications, baseline documentation, and Northrop Grumman and Aerojet monthly financial reports (known as NASA Form 533M) for fiscal years 2011 through 2023. We further analyzed NASA's obligations and costs on the contracts for fiscal years 2006 through 2023 through NASA's financial accounting system. This is inclusive of contracted work under both the Constellation Program (2006 through 2010) and SLS Program (2011 through 2023). We conducted interviews with NASA, Northrop Grumman, and Aerojet officials, including, but not limited to, the SLS Boosters Element Manager, SLS Liquid Engines Office Element Manager, contracting officers, contracting officer's representatives, Project Planning and Control office, Office of the Chief Financial Officer, Office of the General Counsel, and Northrop Grumman and Aerojet project officials and engineering managers.

To assess the booster and RS-25 engine schedules, we examined NASA's acquisition planning data, booster and RS-25 engine contract modifications affecting schedule, Preliminary Design Review documents, NASA's integrated master schedule, and Northrop Grumman and Aerojet monthly forecast schedules. We analyzed schedule forecasts and quarterly program status reports to identify schedule slippages. We also conducted interviews with the SLS Boosters Element Manager, SLS Liquid Engines Office Element Manager, contracting officers, and contracting officer's representatives to better understand NASA's schedule concerns.

To assess Northrop Grumman's and Aerojet's performance and award fees, we examined the booster and RS-25 engines contracts' award fee evaluation plans, award fee performance evaluation reports, and SLS Program and Boosters' and Liquid Engines' risk management presentations. We also reviewed SLS Risk documentation and government guidance for analyzing undefinitized contracting actions. We conducted interviews with the SLS Boosters Element Manager, SLS Liquid Engines Office Element Manager, contracting officers, and contracting officer's representatives to better understand the tracking and management of project-level risks.

Assessment of Data Reliability

We used computer-processed data to perform this audit, which was used to materially support our findings, conclusions, and recommendations. First, we reviewed and analyzed NASA obligation and disbursement data for fiscal years 2012 through 2023 in NASA's financial accounting system for the SLS element offices and each contract—Boosters, Adaptation, BPOC, and RS-25 Restart and Production. Then we compared these results with data noted in briefing charts and Excel spreadsheets provided by the SLS Program. We determined that the data was sufficiently reliable for the purposes of this report.

Review of Internal Controls

We assessed internal controls and compliance with laws and regulations necessary to satisfy the audit's objectives. We evaluated the internal controls associated with NASA's management of the SLS, specifically the extent to which NASA's contractors are meeting their cost, schedule, and performance goals for the development and production of the boosters and RS-25 engines. Control weaknesses are identified and discussed in this report. Our recommendations, if implemented, will improve those identified 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 5 years, NASA OIG and the Government Accountability Office have issued 27 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 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)

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)

NASA's Development of Next-Generation Spacesuits (IG-21-025, August 10, 2021)

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

NASA's Efforts to Mitigate the Risks Posed by Orbital Debris (IG-21-011, January 27, 2021)

NASA's Challenges to Safely Return Humans to the Moon by 2024 (IG-21-007, December 1, 2020)

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

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 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)

NASA's Management of Crew Transportation to the International Space Station (IG-20-005, November 14, 2019)

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

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

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

Government Accountability Office

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)

NASA: Assessments of Major Projects (GAO-21-306, May 20, 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: Assessments of Major Projects (GAO-20-405, April 29, 2020)

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

Appendix B: Request for Equitable Adjustment on the Boosters Contract

As noted in the FAR, a request for equitable adjustment (REA) is a contractor's proposal to the government seeking an increase to the contract price based on a government-directed change to the contract requirements.[72] When a contractor submits an REA, it must demonstrate why the REA scope of work does not fall within the original scope of the contract. A contractor submits an REA to an agency first before filing a formal claim or a written demand by the contractor for payment related to a change to the contract requirements.[73] Between 2008 and 2018, Northrop Grumman, the Boosters contractor, worked with NASA to develop a new asbestos-free PLI.[74] Throughout this period, all parties agreed that the efforts were within the scope of the contract. However, the PLI development and integration proved substantially more complex than anticipated by the contractor.

The following identifies the series of events that occurred regarding the REA from Northrop Grumman:

- In 2011, NASA's Boosters Element Office processed a contract modification for $4.4 million to address the additional work involved with certification of the PLI.
- In October 2018, Northrop Grumman submitted to NASA an REA requesting $253 million. The REA also included an award fee of $28.5 million. While NASA reimbursed Northrop Grumman $224.4 million—the overrun of PLI costs less the fee—negotiations continued for the $28.5 million award fee.[75]
- In February 2019, a technical evaluation board made up of NASA subject matter experts was appointed to review the REA.
- In March 2020, after 20 months of review, the board reached the conclusion that all efforts to design and certify the PLI were in scope, and as such, was not fee-bearing (no additional fees were warranted). In response, the contracting officer issued a formal denial letter that same month.
- In September 2020, Northrop Grumman submitted supplemental information and included case law as an attempt to refute the contracting officer's denial.

[72] REAs are discussed in the Changes clause, FAR 52.243-1 through -5; the Differing Site Conditions clause, FAR 52.236-2; and the Government Property clause, FAR 52.245-1.

[73] FAR 2.101, *Definitions* (2022) defines a claim as "a written demand or written assertion by one of the contracting parties seeking, as a matter of right, the payment of money in a sum certain, the adjustment or interpretation of contract terms, or other relief arising under or relating to the contract. However, a written demand or written assertion by the contractor seeking the payment of money exceeding $100,000 is not a claim under 41 U.S.C. chapter 71, Contract Disputes, until certified as required by the statute."

[74] NASA originally awarded the Boosters contract to Alliant Techsystems, which merged in 2015 with Orbital Sciences Corporation to become Orbital ATK. In 2018, Orbital ATK was purchased by Northrop Grumman.

[75] NASA does not pay a fee on overages. NASA FAR Supplement 1816.405-274, *Award Fee Evaluation Factors* (2015).

- Between May and October 2020, NASA officials—Office of the General Counsel, procurement officials, and the SLS Program Office—reviewed Northrop Grumman's supplemental information and ultimately the contracting officer issued a second denial letter, directing Northrop Grumman to file a certified claim, whereby the contractor would be able to pursue a legal request for these funds if it disagreed with the final denial.[76] Northrop Grumman did not pursue a certified claim and instead began direct communication with NASA Headquarters leadership and the SLS Program Office.
- Between October and December 2020, NASA established an independent assessment team composed of former NASA Senior Executive Service employees. This team was established without the knowledge of the subject matter experts in procurement or the Office of the General Counsel that were responsible for managing the contract and who had been assigned to review and address the REA.
- In January 2021, the assessment team recommended that Northrop Grumman be paid because the PLI work was outside the scope of the contract and was therefore fee bearing. The team was established by and reported to SLS Boosters Element officials that lacked the authority to commit the government to the team's findings without procurement officials' approval. Further, the assessment team's conclusion ignores federal requirements that requires a formal contract change order for out-of-scope work, potentially resulting in disciplinary action for the SLS Boosters Element Office officials that initially allowed Northrop Grumman to perform the work.[77]

When NASA denied the REA for the second time in 2020 and Northrop Grumman chose not to pursue a certified claim, this limited the Agency's ability to pay the REA to only the funding that was available from prior year funds (fiscal years 2014 to 2018 in this case), as directed by fiscal law and the Antideficiency Act. However, these funds were expended, expired, and depleted to the extent that the maximum available was approximately $4 million. As a result, in August 2022, NASA provided a final denial of the REA to Northrop Grumman. In response, Northrop Grumman filed a certified claim. In November 2022, NASA formally denied the claim and subsequently Northrop Grumman appealed the denial of its claim to the Armed Services Board of Contract Appeals. The Office of Procurement requested that the Office of the General Counsel try to negotiate a settlement to resolve the claim appeal. Ultimately, the parties reached a settlement whereby NASA will pay the contractor $24.5 million to resolve the claim. On February 6, 2023, the Armed Services Board of Contract Appeals concurred and rendered a consent judgment based on the settlement. NASA requested the judgment be paid out of the U.S. Department of the Treasury's Judgment Fund, and the Agency will reimburse the Judgment Fund with fiscal year 2023 SLS funds in accordance with the requirements of the Contracts Dispute Act.[78]

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[76] FAR 2.101.

[77] According to FAR Subpart 43.2, *Change Orders* (2019), out-of-scope work triggers the need for formal change orders and cannot be legally paid until a ratification of the contract is issued because it exceeds the obligations on the contract.

[78] In accordance with 31 U.S.C. § 1304, a permanent indefinite appropriation managed by the Treasury Department is used to pay final monetary court judgments, Armed Services Board of Contract Appeals monetary awards, U.S. Department of Justice compromise settlements, and interest and costs specified in the judgments where payment is not otherwise provided for under appropriation. Payment is certified by the Secretary of the Treasury, and NASA is required to reimburse the Judgment Fund for these payments.

Appendix C: Questioned Costs on the Boosters, BPOC, and Adaptation Contracts

Boosters Development Contract Questioned Costs

We are questioning $24.5 million in costs resulting from the improper payment of an award fee on cost overruns related to the Boosters contract's PLI. Per NASA FAR Supplement 1816.405-274(4)(e)(1), an award fee should not be earned if there is a significant cost overrun within the contractor's control. Specific to the PLI work was conducted from 2008 through 2018, and Northrop Grumman's costs for the new PLI booster totaled nearly $253 million in costs and fees. A modification to the contract was never made to add this additional scope of work. In 2018, Northop Grumman submitted a REA for $253 million. In 2020, NASA paid Northrop Grumman $224.5 million in costs, but denied the contractor's REA for $28.5 million in award fees because Agency requirements prohibit paying an award fee on cost overruns. As detailed in Appendix B, the Agency officially denied the contractor's REA, appeal, and certified claim. However, in February 2023 the Office of Procurement requested that the Office of the General Counsel negotiate a settlement.

In our follow-on discussions, the Office of the General Counsel stated it assessed the risks surrounding the case dating back to 2018 and determined it was in the Agency's best interest to settle the claim. While we do not question the Agency's decision to reach a settlement with the contractor, we do question the Agency's failure to follow established procedures, which ultimately resulted in a settlement. Specifically, because the contract was not properly modified to add scope of work and funding, upon which an award fee would be payable, we question the $24.5 million in payment to resolve the questioned award fee payment. Table 3 summarizes the questioned costs identified during our audit and discussed in this report.

Table 3: Boosters Payment of Award Fee on Cost Overruns Per NASA FAR Supplement 1816.405-274(4)(e)(1)

Questioned Costs	Award Fee Amount
Payment of award fee on contractor cost overrun	$24,500,000
Total Questioned Costs	**$24,500,000**

Source: NASA OIG presentation of Agency information.

Boosters Production and Operations Contract Questioned Costs

We are questioning $5.6 million in costs resulting from the improper liquidation of funds. A change in payment methodology is required once a contract is transferred from a letter contract structure to a definitized contract structure. Per FAR 32.104(d), 52.232-16(b), and 52.232-32, once definitized the terms of the contract dictate the use of performance-based payments, requiring funding for progress payments to be liquidated and transferred to be performance-based payments.[79] NASA has issued payments under the BPOC letter contract that should have been liquidated via a short-pay option.[80] However, the manner in which Marshall procurement officials structured the funding of BPOC—making the contract specific to individual CLINs rather than the contract as a whole—meant the Agency was unable to liquidate CLIN 5 funds until a performance milestone "event" was reached. This occurred in January 2023 and the Agency intended to short-pay this invoice in February 2023. Given Marshall procurement's decision to structure the contract funding by CLIN they knew adding work and funding onto the letter contract in the form of a progress payment could not be liquidated until a performance milestone was reached. The FAR is specific on converting all payments to a single form—either progress- or performance-based. NASA's inability to liquidate the outstanding amount of $5.6 million with the contractor is a violation of the FAR. Table 4 summarizes the questioned costs identified during our audit and discussed in this report.

Table 4: BPOC Outstanding Liquidation Required Per FAR 32.104(d), 52.232-16(b), and 52.232-32

Questioned Costs	Unliquidated Amount
Outstanding progress payments to be liquidated and held for future performance-based payment	$5,600,000
Total Questioned Costs	**$5,600,000**

Source: NASA OIG presentation of Agency information.

Adaptation Contract Questioned Costs

We are questioning $19,767,103 in costs resulting from the improper award fee NASA gave to Aerojet under the Adaptation contract. Per NASA FAR Supplement 1852.216-77 the contractor can earn an award fee for this contract; however, all award fee evaluations, except for the last one, will be interim evaluations. At the last evaluation, which is final, the contractor's performance for the entire contract will be evaluated to determine the total earned award fee. No award fee will be paid to the contractor if the final award fee evaluation is "poor" or "unsatisfactory." CLIN 3 was an end-item contract for the adaptation of 16 Shuttle-era RS-25 engines.[81] While Aerojet was contracted to assemble, test, and formally deliver to NASA 16 RS-25 engines as part of the RS-25 Adaptation contract, the contractor failed to deliver 11 of the engines (68.75 percent) and the Agency later descoped and moved them to CLIN 1 of the Restart and Production contract. Award fees should be awarded when the completed end-items are delivered. NASA gave a final award fee score of 89 out of 100 and a "very good" rating to Aerojet and awarded the contractor $28,752,150 out of a possible $32,305,787 in total award fees for the Adaptation contract, which included work for the 11 unfinished engines. Table 5 summarizes the questioned costs identified during our audit and discussed in this report.

[79] FAR 32.104(d), FAR 52.232-16(b), and FAR 52.232-32.

[80] A short-pay invoice is an invoice that will not be fully satisfied by the payment to be submitted. This shorted difference would be used to equalize the balance, in this case $5.6 million.

[81] NASA FAR Supplement 1852.216-77, *Award fee for end-item contracts* (2012).

Table 5: RS-25 Engine Award Fee Calculations for the Adaptation and Restart and Production Contracts

Questioned Costs	Award Fee
Total award fee paid to Aerojet Rocketdyne under CLIN 3 of the Adaptation contract	$28,752,150
31.25 percent of engines delivered under the Adaptation contract (5 of 16 engines)	($8,985,047)
Award fee for the 11 engines that should have been moved to the Restart and Production contract	$19,767,103
Total Questioned Costs	**$19,767,103**

Source: NASA OIG presentation of Agency information.

APPENDIX D: 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 for Exploration Systems Development Mission Directorate
Assistant Administrator for Office of Procurement

SUBJECT: Agency Response to OIG Draft Report, "NASA's Management of the Space Launch System Booster and Engine Contracts," (A-22-07-00-SOD)

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 Management of the Space Launch System Booster and Engine Contracts," (A-22-07-00-SOD), dated April 13, 2023.

In the draft report, the OIG states their view that NASA continues to experience significant scope growth, cost increases, and schedule delays on its four booster and RS-25 engine contracts, resulting in what they assessed as approximately $6 billion in cost increases and over six years in schedule delays above NASA's original projections. Additionally, the OIG states their view that Marshall Space Flight Center (MSFC) procurement officials who oversee all four contracts are challenged by lack of adequate staff, experience, and limited opportunities to review contract documentation.

With the first crewed Artemis mission in lunar orbit clearly on the horizon, NASA programs in the Exploration Systems Development Mission Directorate (ESDMD) are tasked with one of humanity's most challenging and unique endeavors: to send human explorers into deep space as a means of enabling discovery, scientific progress, and inspiration. The mandate to do so is not one taken lightly by the Agency. NASA holds all its programs to the highest technical and programmatic standards levied on the spaceflight community, and ESDMD bears the responsibility of equipping Artemis astronauts with safe, reliable hardware to enable the most ambitious of engineering and scientific goals. The Space Launch System (SLS) program, responsible for the development of the vehicles that will send American astronauts, including the first woman and person of color to the lunar surface, is structured and managed to ensure these responsibilities are met and goals fulfilled.

ESDMD understands that the engineering performed by its programs can and should be subjected to robust scrutiny by independent reviewers. To this end, ESDMD programs have participated openly and transparently in numerous auditing engagements with OIG and the

Government Accountability Office (GAO), as was the case with the SLS program in the present audit. While both directorate and program leadership welcome the healthy debate and dispositioning of comments that accompany these engagements, they are concerned that the foregoing report offers an incomplete view of the program's decision-making regarding its boosters and engines elements and that the information in the report is presented without the context that would have rendered it more accurate. Despite several hours of follow-up meetings with the OIG team following the release of the initial draft report and submission of extensive supporting documentation by the SLS program, NASA leadership was disappointed to see that few of the clarifications offered by the Agency's subject-matter experts were incorporated herein. As a result, the directorate and the program do not concur with, nor endorse, the facts as presented in the body of the report.

Nonetheless, the program does concur or partially concur with the recommendations provided by the OIG since much of the suggested work was either already completed or scheduled prior to the initiation of the audit. It is evident that the OIG and directorate and program leadership agree on several key principles: major acquisitions and contract management practices should continue to be reviewed at the highest levels of leadership to ensure the Federal Acquisitions Regulation (FAR) is faithfully employed, accountability and oversight is rigorously practiced, and maximum transparency is evident in contract execution. NASA will continue to welcome engagements with audit teams while pushing forward its priority—the development, production, and testing of hardware for the next Artemis mission in a responsible manner.

The OIG makes eight recommendations to the Associate Administrator for ESDMD, in coordination with the Assistant Administrator for Office of Procurement (OP), intended to increase transparency, accountability, and oversight of NASA's SLS booster and engine contracts.

Specifically, the OIG recommends the following:

Recommendation 1: Assess whether the 18 new RS-25 production engines under the RS-25 Restart and Production contract can be adjusted from cost-plus to fixed-price.

> **Management's Response:** NASA concurs with this recommendation. Before initiating the RS-25 Production Restart contract, an assessment was conducted to determine the most cost-effective contract type. Due to the high amount of development, test, and engineering design work associated with the restart of new production lines and qualification of new manufacturing processes, we assessed that cost risk would have driven the contractor to propose an unaffordable fixed-price cost to cover their identified risk; therefore, a cost-plus-incentive-fee contract was determined to be more cost-effective and to provide additional insight.
>
> 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. A fixed-price contract does not equate to reduced costs; in development work, it can have the opposite effect if entered with high uncertainty in cost and/or technical requirements.

Estimated Completion Date: Complete.

Recommendation 2: Coordinate with the Marshall procurement office to identify procurement needs and resources available under MAP to address staff capacity shortages at the senior procurement level to ensure sufficient oversight roles are staffed and separated from the contract actions.

Management's Response: NASA concurs with this recommendation. Procurement officials at Headquarters (HQ) and MSFC have identified resources to provide surge staff to support critical contract actions. These new positions are in recruitment. Based upon an early assessment, HQ OP believes there will likely be a need for long-term program direct funding of procurement resources given the complexity and magnitude of the contracting mission to support the SLS program. ESDMD, the SLS program office, and OP have begun that analysis and discussion. While oversight and supervision of the procurement workforce is currently being employed, there is an opportunity for improvement which will be maximized with additional senior-level procurement professionals being assigned to the program.

Estimated Completion Date: July 31, 2023.

Recommendation 3: Ensure Marshall procurement, legal, project planning and control, and SLS and booster program officials comply with best practices for establishing and maintaining internal controls, specifically on the appropriate process and procedures on REAs, fiscal law, and appropriate internal and external engagement.

Management's Response: NASA concurs with this recommendation. HQ OP will review and further refine, as appropriate, its Request for Equitable Adjustment (REA) procedures. In addition to internal actions, MSFC OP sent a letter out to SLS contractors in February 2023, reminding them of the requirements associated with Limitation of Funds under FAR 52.232-22, Notification of Changes under FAR 52.243-7, and United States Code, Title 31, Subpart 15-2, Balance Available and subpart 1552 – Available of Appropriations to Pay Obligations. On September 19, 2023, a Defense Acquisition University class will be required for SLS contracting personnel to address policies and procedures associated with claims. Furthermore, once Block 1B capability is baselined on or about August of 2023, SLS will have completed all previously planned activities needed to be in full compliance with the commitment strategy laid out in the NASA Policy Requirement 7120.5F, "NASA Space Flight Program and Project Management Requirements."

Estimated Completion Date: September 30, 2023.

Recommendation 4: Ensure Elements and procurement management comply with appropriate separation of roles and responsibilities for program and procurement actions and the FAR with respect to use of letter contracts, proper definitization, overpayments, and duplicative payments of award fees for modified scope and contracts.

Management's Response: NASA partially concurs. NASA agrees with the recommendation to adhere to well-defined roles and responsibilities as well as FAR guidance on letter contracts, definitization, and overpayments. By fiscal year 2023 end, MSFC OP will provide refresher training to its workforce and the SLS program office regarding the findings herein, relevant policies and procedures, and procurement lessons learned, as part of its commitment to continuous improvement. OIG's reference to overpayments and duplicative payments of award fees are unfounded and inaccurate as detailed in previous comments to drafts of this report.

Estimated Completion Date: October 1, 2023.

To increase transparency and accountability of NASA's affordability efforts, the OIG recommends NASA's Associate Administrator for Exploration Systems Development Mission Directorate, in coordination with the Assistant Administrator for Procurement:

Recommendation 5: Update RS-25 production per engine cost estimate to include investment costs in restart facilities, equipment, new production overhead costs, and government-funded property.

Management's Response: NASA partially concurs with this recommendation. The SLS program office has consistently and clearly stated that the basis of its engine affordability cost estimates is the RS-25 manufacturing costs. The focus of the RS-25 affordability program is on manufacturing improvements and increased manufacturing efficiency. ESDMD and the SLS program office will coordinate with the Office of the Chief Financial Officer – Strategic Investment Division to complete an analysis and consider an appropriate methodology to communicate engine total contract costs in the manner recommended by the OIG.

Estimated Completion Date: December 31, 2023.

Recommendation 6: Conduct a thorough review of BPOC's scope of work and technical requirements needed to complete the respective periods of performance and update the contract as appropriate.

Management's Response: NASA concurs with this recommendation. The SLS booster project office will conduct a thorough review of the Booster Production and Operations Contract's (BPOC's) scope of work and technical requirements, then, as appropriate, work with OP to ensure any actions resulting from this review are updated in the contract.

Estimated Completion Date: November 30, 2023.

Recommendation 7: Conduct a thorough review of BPOC's definitization to ensure proper liquidation of funds paid under the letter contract as progress payments are returned to the

Agency and are appropriately paid when the performance of the work, per the contract, is completed.

Management's Response: NASA concurs with this recommendation. MSFC OP with coordination from the OP Enterprise Pricing Office and the Office General Counsel will provide the documentation evidencing the liquidation of funds and proper payments made to the contractor.

Estimated Completion Date: July 31, 2023.

To ensure additional award fees are not earned on work that already received fees prior to completion under the Adaptation contract, the OIG recommends NASA's Associate Administrator for Exploration Systems Development Mission Directorate, in coordination with the Assistant Administrator for Procurement:

Recommendation 8: Develop a separate non-fee bearing contract line item for completion of the 11 unfinished heritage RS-25 adaptation engines.

Management's Response: NASA partially concurs with this recommendation. Most of the work on the 11 unfinished heritage RS-25 adaptation engines is complete; it may not be practical to develop a separate non-fee bearing contract line item number. ESDMD, the SLS program office, and OP will evaluate this recommendation and consider action, if appropriate.

Estimated Completion Date: June 30, 2023.

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 Ruth Siboni at (202) 358-4555.

James Free Digitally signed by James Free Date: 2023.05.18 18:06:56 -04'00'

Karla Jackson Digitally signed by Karla Jackson Date: 2023.05.18 17:50:10 -04'00'

James Free
Associate Administrator,
Exploration Systems Development
Mission Directorate

Karla Smith Jackson
Assistant Administrator,
Office of Procurement

cc:
Marshall Space Flight Center Director/Ms. Singer

APPENDIX E: REPORT DISTRIBUTION

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Deputy Administrator
Associate Administrator
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(Assignment No. A-22-07-00-SOD)