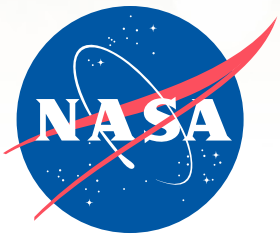
NASA Office of Inspector General

2022 Report on NASA's Top Management and Performance Challenges

NOVEMBER
2022



Office of Inspector General

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Message from the Inspector General

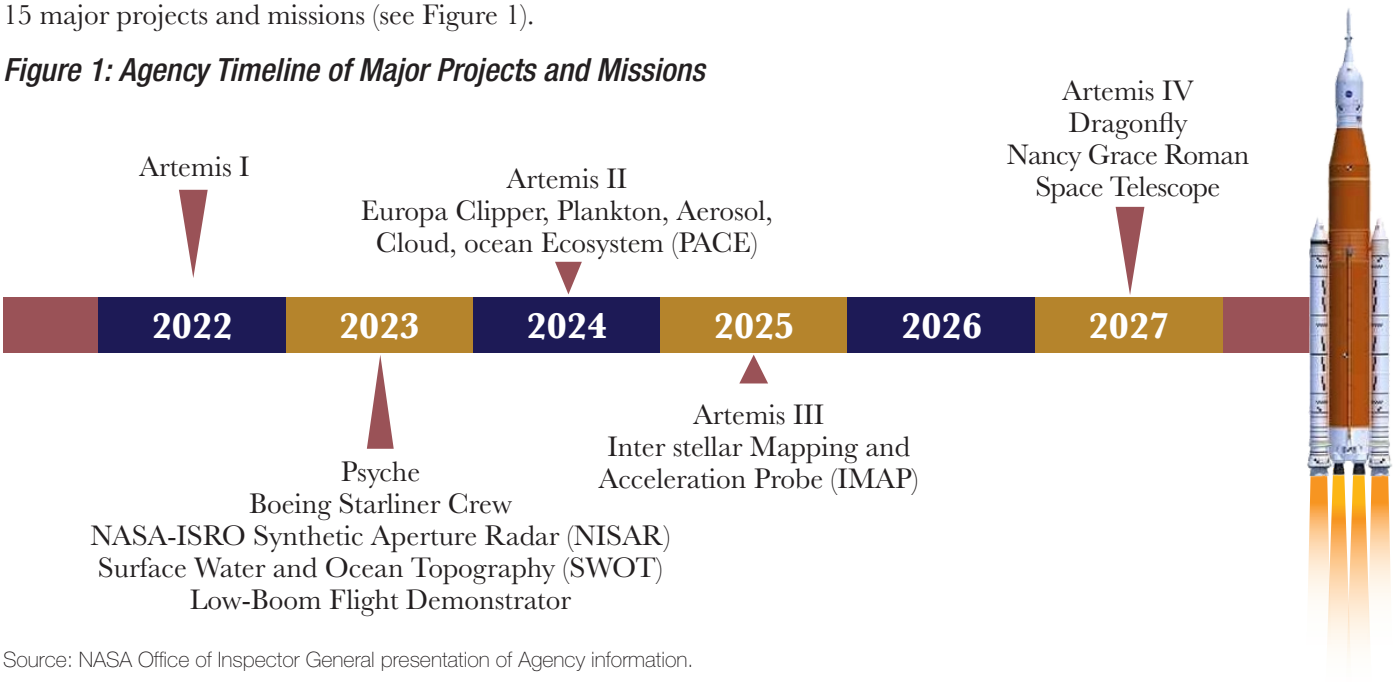
As required by the Reports Consolidation Act of 2000, this annual report presents the Office of Inspector General's independent assessment of the top management and performance challenges facing NASA.[1] For 2022, we identified seven challenges and linked each to one or more of NASA's strategic goals and objectives (see Appendix A).[2]

- Challenge 1: Returning Humans to the Moon
- Challenge 2: Improving Management of Major Programs and Projects
- Challenge 3: Sustaining a Human Presence in Low Earth Orbit
- Challenge 4: Managing and Mitigating Cybersecurity Risks
- Challenge 5: Improving Oversight of Contracts, Grants, and Cooperative Agreements
- Challenge 6: Attracting and Retaining a Diverse and Highly Skilled Workforce
- Challenge 7: Managing NASA's Outdated Infrastructure and Facilities

NASA stands at the forefront of aeronautics, science, and space exploration and is responsible for numerous scientific discoveries and technological innovations. Since its creation in 1958, NASA has made extraordinary achievements in human space flight with missions such as Apollo, the Space Shuttle Program, and the International Space Station. The Agency seeks to continue this legacy with the Artemis program, which intends to establish a long-term human presence on the Moon as a prelude to crewed missions to Mars.

However, substantial cost growth and lengthy schedule delays continue to impact not only human space flight programs like the Artemis mission's Space Launch System and Orion Multi-Purpose Crew Vehicle, but also other major science and exploratory programs, projects, and missions. In the next 5 years NASA anticipates launching 15 major projects and missions (see Figure 1).

Figure 1: Agency Timeline of Major Projects and Missions



Source: NASA Office of Inspector General presentation of Agency information.

Note: Indian Space Research Organisation (ISRO).

[1] The Reports Consolidation Act of 2000 (Pub. L. No. 106-531) requires NASA to include in its performance and accountability report a statement by the Inspector General summarizing the most significant management and performance challenges facing the Agency and the progress made in addressing them.

[2] NASA, *NASA Strategic Plan 2022* (February 12, 2022).

In addition, the International Space Station's planned retirement at the end of the decade poses a challenge for the Agency as it seeks to maintain an active human presence in low Earth orbit. To address this issue, NASA has increased funding for commercial development in low Earth orbit—including commercial space stations—and pursued public-private partnerships to achieve its goals for a continual human presence both in low Earth orbit and on the Moon. Apart from its high-profile human exploration activities, the Agency also faces long-standing challenges with cybersecurity, contracts, workforce gaps, and aging infrastructure and facilities. As the Agency moves forward with key decisions on its major programs, projects, and missions, addressing the challenges discussed in this report will be paramount to its success.

In deciding whether to identify an issue as a "top challenge," we consider its significance in relation to NASA's overall mission; whether its underlying causes are systemic in nature; and its susceptibility to fraud, waste, and abuse. These seven highlighted challenges are not the only significant issues that confront NASA, and identification of an issue as a top challenge does not denote significant deficiencies or lack of attention on the Agency's part. Rather, most of these issues are long-standing, difficult challenges central to NASA's core missions and will likely remain top challenges for years to come. Consequently, they require consistent, focused attention from NASA leadership and ongoing engagement with Congress, the public, and other stakeholders. Each section in this report includes an explanation of why the particular issue is characterized as a top challenge, identifies NASA's progress in addressing the challenge, and highlights additional efforts needed.

This year's list includes many of the same challenges discussed in previous reports. However, we did not include the challenge related to COVID-19 added last year because of the strides made in treating the disease and NASA's significant actions to address the issue. Specifically, the Agency sought to prioritize the health and productivity of employees by implementing a new operational model that increased off-site telework for much of its workforce while instituting protocols that enabled a more limited number of personnel to work on-site safely. Despite the challenges of the pandemic, these efforts contributed to NASA's ability to pursue mission priorities and advance several large-scale projects, including the long-awaited launch of the James Webb Space Telescope.

The Office of Inspector General is committed to providing independent, objective, and comprehensive oversight of NASA programs, projects, and personnel with the singular goal of improving Agency outcomes. To that end, we plan to conduct audits and investigations in the coming year that focus on NASA's continuing efforts to address these and other challenges.

Paul K. Martin
Inspector General

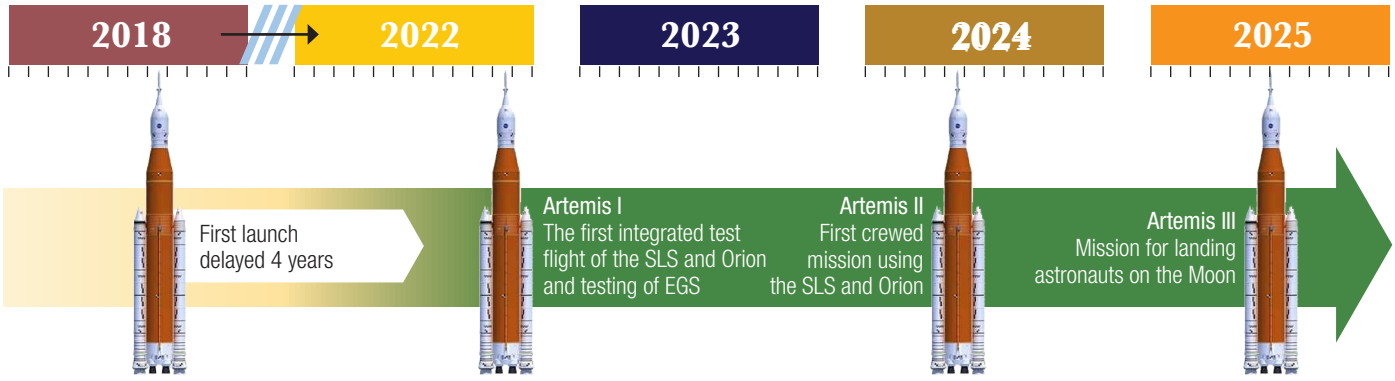
NOVEMBER
2022

Why This Is a Challenge

The Artemis program is NASA's most high-profile and expensive ongoing activity, spanning numerous Agency programs, private contractors, and international partner agencies, and projected to cost $93 billion by fiscal year (FY) 2025. Artemis missions will require decades-long engagement from NASA and its partners to build and support multiple human and robotic exploration systems, conduct research and technology demonstrations on the Moon, and prepare for an eventual crewed mission to Mars.

Artemis is a multi-mission program under which NASA intends to extend the length and complexity of lunar missions over time. Each Artemis mission involves multiple systems managed by different entities on different development timelines in which coordination and interoperability—the ability of a system to work with another system—is critical and deeply challenging. These systems include the Space Launch System (SLS) heavy-lift rocket and Orion Multi-Purpose Crew Vehicle (Orion) capsule that will transport astronauts to lunar orbit, the Human Landing System (HLS) that will ferry astronauts to the lunar surface, next-generation spacesuits that will enable astronauts to operate outside their spacecraft and on the lunar surface, and a Moon-orbiting outpost known as Gateway. Artemis I will be an uncrewed test flight of the combined SLS/Orion system, while Artemis II will fly four astronauts to the Moon's orbit and back. For Artemis III, the Orion capsule—with four astronauts on board—will dock in lunar orbit with an HLS to transport two astronauts to the lunar surface. Significantly, as part of the Artemis program NASA intends to land the first woman and first person of color on the Moon. Figure 2 shows the original launch date of Artemis I in 2018 and the current timeline for the first three Artemis missions.

Figure 2: Artemis Missions Through Moon Landing



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

Note: Exploration Ground Systems (EGS) is comprised of the ground hardware, software, and Launch Control System.

Fundamental to NASA meeting its human exploration ambitions is development of the systems required to get humans to the Moon and Mars safely within the funding Congress allocates. This has proven to be especially challenging in past years due to changing requirements, increased costs, overly optimistic schedules, and significant technical issues. Case in point, given the expense of the SLS/Orion system and related ground launch infrastructure, the launch cost for at least the first four Artemis missions will be $4.1 billion per year. Notably, this figure does not include the $12 billion in formulation and development costs spent over the past dozen years to get the rocket and capsule to this point. Given these enormous costs, the long-term sustainability of the Artemis program poses a significant challenge to the Agency's crewed exploration goals. At the same time, NASA has adopted a decentralized structure for managing the Artemis program—as opposed to a single-program structure used by the Apollo program—which makes risk management more difficult and may negatively impact costs and schedules.[3] In addition, the lack of an Agency-developed integrated schedule and comprehensive cost estimate for the Artemis program fails to provide the level of transparency and insight required to accurately inform stakeholders about the long-term cost of the program.

[3] Aerospace Safety Advisory Panel, *Annual Report for 2021* (January 1, 2022).

Progress in Addressing the Challenge

After years of delays and cost overruns, NASA is making progress on the development and procurement of key Artemis systems as well as initiatives to improve the overall management of the Artemis missions.

Development. After a series of ground tests during the summer of 2022, NASA moved forward with attempting to launch Artemis I, a key developmental milestone consisting of an uncrewed test flight of the SLS/Orion system around the Moon. On August 29, 2022, the first launch attempt for Artemis I was scrubbed after a faulty temperature sensor indicated that one of the SLS rocket's main engines was improperly cooled. A second attempt on September 3 was scrubbed due to a liquid hydrogen leak on the quick disconnect seals, which were subsequently replaced on the launch pad. As a result, NASA conducted a fueling test on September 21 to confirm the repairs were effective with an anticipated launch date of September 27. However, in late September, the SLS/Orion system was moved to the Vehicle Assembly Building to protect it from inclement weather caused by Hurricane Ian. NASA's next launch attempt is scheduled for November 2022.

In response to a request from Space Exploration Technology Corp. (SpaceX)—the HLS Program's main contractor—for a launch license to operate the HLS Starship and Super Heavy Booster, in June 2022 the Federal Aviation Administration (FAA) issued a final environmental assessment clearing the way for the vehicle's orbital flight test.[4] This key test was originally scheduled for early 2022 but was delayed due to bid protests from companies that were not awarded NASA's initial HLS contract and the FAA's initial environmental assessment. Meanwhile, the Power and Propulsion Element and Habitation and Logistics Outpost—the initial elements of the Gateway required for use during the Artemis IV mission—remain under development and will likely be launched in late 2025 or early 2026.

Procurement. The Agency successfully completed several procurement-related actions over the last year related to the initial and sustaining Moon missions. After spending more than $420 million on next-generation spacesuit development, in May 2022 NASA awarded contracts for spacesuit services to two companies, Axiom Space, Inc. (Axiom) and Collins Aerospace, worth a combined maximum value of $3.5 billion. Next-generation spacesuits will be tested first on the ground in a relevant space flight environment and subsequently, the spacesuits must successfully complete their first flight to be certified for recurring spacewalk services at the International Space Station (ISS or Station) and on the lunar surface as part of the Artemis III mission.

NASA also released two Requests for Information to support future Artemis missions, the first in October 2021 to gather information from industry on reducing the Agency's production and operating costs of the SLS rocket with the goal of eventually shifting production, integration, and launch operations to industry. As with other Artemis systems such as the HLS and spacesuits, NASA intends to transition to an acquisition strategy that involves the purchase of space flight services, as opposed to outright purchasing the systems, to reduce costs and decrease risks that come with ownership of such systems. The goal is to have a consolidated contract in place for the SLS by December 2023.

In March 2022, the Agency announced an updated acquisition approach and Request for Information to enable development of a second HLS. Utilizing multiple contractors to encourage innovation and drive down costs through competition was the HLS Program's original intent, but funding issues in FY 2021 prevented the Program from selecting more than one bidder. The second HLS contract, known as the Sustaining Lunar Development contract, will be a firm-fixed-price contract developed in parallel with SpaceX's HLS Starship with the hopes of delivering a second lander capability in 2026 or 2027.[5] The HLS Program's goal is to foster the full development and demonstration of lunar landing capabilities between these two contracts before transitioning to recurring transportation services in the future.

Management. The Agency has taken several steps to improve the management of the Artemis missions. In response to an Office of Inspector General (OIG) recommendation, NASA is developing a methodology to provide Congress a cost assessment for each Artemis mission to coincide with the annual President's Budget Release.[6] This approach

[4] For SpaceX to conduct launch operations of the HLS Starship and Super Heavy Booster from its Boca Chica launch site in Texas, the company needs to obtain an experimental permit or launch license from the FAA. As part of that process, an environmental assessment is conducted to assess the potential impacts on air quality, biological and water resources, and pollution prevention.

[5] A firm-fixed-price contract places maximum risk on the contractor and full responsibility for all costs and resulting profit or loss.

[6] NASA OIG, *NASA's Cost Estimating and Reporting Practices for Multi-Mission Programs* (IG-22-011, April 7, 2022).

will increase transparency and provide decision-makers and taxpayers important information on the Agency's most expensive activity. In response to another OIG recommendation, NASA codified the charters of the Cross-Directorate Federated Board as well as the Joint Directorate Program Management Council between the Exploration Systems Development and Space Operations Mission Directorates.[7] The Federated Board seeks to ensure that Agency priorities and general architectural direction are integrated for activities that require coordination across multiple mission directorates, activities especially vital given Artemis's cross-program and directorate activities.

Further, to foster collaboration and share costs of expensive development projects, NASA is pursuing partnerships with several international space agencies. Building off successful relationships developed during the construction and operation of the ISS, key partner agencies—such as the European Space Agency, Canadian Space Agency, and Japan Aerospace Exploration Agency—plan to contribute significant elements to the Artemis program, allowing NASA to focus its efforts and budgets elsewhere. In addition, several countries including those with well-established space agencies like Canada and Japan as well as countries with emerging space agencies like Israel and the United Arab Emirates have signed on to the Artemis Accords, a set of shared principles for exploration, science, and commercial activities in space.

Finally, in 2022 NASA gained feedback from its employees, industry partners, and international space agencies on its draft Moon to Mars Objectives that will serve as anchors for its plan to establish a continuous presence on the Moon, progress to Mars analog missions (i.e., tests that simulate Mars' environment in lunar orbit), and begin the initial human mission to Mars. With 63 objectives now established, the next goal is to develop a mission architecture based on this feedback by the end of the year.

Key Implemented Recommendations

Codify the remaining governance structure such as the Federated Boards and Joint Directorate Program Management Council (IG-22-003).

Develop an acquisition strategy for the next-generation spacesuits that meets the needs of both the ISS and Artemis programs (IG-21-025).

Work with the contractors to obtain a credit for the amount already spent on launch services under the Power and Propulsion Element contract (IG-21-004).

Ensure total development and production contract costs (for Orion) currently not reported as part of the Agency Baseline Commitment are included in quarterly financial status reporting to the Office of the Chief Financial Officer, Office of Management and Budget, and Congress (IG-20-018).

For new acquisitions of SLS deliverables, develop a cost accounting model that separates each deliverable into its own contract line item number for tracking costs, performance, and award fees (IG-20-012).

Work Remaining to Address Challenge

While NASA has made progress on its Artemis program, a significant amount of work remains to be done, making 2026 the likely earliest date for a crewed lunar landing. The Agency's most immediate challenge is a successful launch of Artemis I that will test the combined SLS/Orion system in an uncrewed flight around the Moon. Notably, the Agency did not fully complete the SLS's wet dress rehearsal in any of its four attempts due to technical issues including a hydrogen leak.[8]

Looking forward, several non-core avionics (electronics) systems from the Artemis I Orion capsule will be refurbished and reused for Artemis II, meaning delays in the Artemis I launch also affect the launch readiness of Artemis II. In fact, the Exploration Systems Development Mission Directorate considers the non-core avionics reuse to be the primary

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

[8] During the wet dress rehearsal, teams at Kennedy Space Center load cryogenic or super-cold propellants into the SLS rocket, conduct a launch countdown, and practice safely removing propellants at Launch Pad 39B.

critical path for the Artemis II mission, with total preparation work between missions to take about 27 months.[9] For the crewed Artemis III mission that will return humans to the surface of the Moon, developmental questions remain for both the HLS and spacesuits critical to the mission. Looking beyond Artemis III, the second mobile launcher (ML-2) is a key part of the infrastructure needed to launch the upgraded SLS Block 1B and Block 2 beginning with Artemis IV. In June 2022, we reported that NASA is estimated to spend approximately a billion dollars or at least 2.5 times more than initially planned for the ML-2 contract, with final delivery of the launcher to NASA expected to take at least 2.5 years longer than initially planned, jeopardizing future Artemis launch schedules.[10]

Given the $4.1 billion cost-per-launch for at least its first four Artemis missions, it is important that the Agency identify meaningful ways to reduce costs and maintain fiscal sustainability for its flagship human exploration effort. The Agency has acknowledged the high costs of its lunar and Mars goals and is examining ways to make the missions more sustainable by transitioning some programs to fixed-price contracts. Our office, as well as the Government Accountability Office (GAO) and Congress, have identified long-standing problems with the completeness and credibility of NASA's life-cycle cost estimates for major acquisitions. Ultimately, NASA is not providing full visibility into its investments as it begins a multi-decade initiative to transport humans to Mars at a cost that could easily reach into the hundreds of billions of dollars. Because the programs that support these exploration missions are still in their early development stages, it is critical that NASA establish credible, complete, and transparent cost and schedule estimates. Despite agreeing to develop a per mission cost methodology, NASA still needs to produce a comprehensive estimate that consolidates all Artemis costs across mission directorates. Additionally, in a recent report we found NASA is circumventing required cost and schedule controls by categorizing certain production costs as operations costs when, in our opinion, they should be categorized as development costs.[11]

Key Unimplemented Recommendations

Issue policy guidance to reinforce current Federal Acquisition Regulation and NASA FAR Supplement regulatory guidance for stopping or withholding payments to a contractor for significant deficiencies in business systems, such as the Earned Value Management (EVM) System (IG-22-012).

Develop an Artemis-wide cost estimate, in accordance with best practices, that is updated on an annual basis (IG-22-003).

Develop a Human Exploration and Operations Mission Directorate policy that establishes a reasonable amount of recommended schedule margin by phase of program or project (IG-21-004).

Require the ML-2 project to develop an Agency Baseline Commitment separate from the Exploration Ground Systems Program (IG-20-013).

Conduct a thorough review of each major SLS contract's scope of work and technical requirements needed to complete the period of performance to assist in eliminating incremental contract value increases to the contract and lessen contract management burden (IG-20-012).

Ongoing and Anticipated Future Audit Work

NASA's Management of the Artemis Program's Supply Chain

This audit will evaluate supply chain risks for short- and long-term Artemis missions and processes to effectively identify and mitigate disruptions to the program's supply chain and industrial base.

[9] Critical path is the sequence of tasks that determines the minimum duration of time needed to complete a project. It is important to identify the critical path and the resources needed to complete the critical tasks along the path if a project is to be completed on time and within its allocated resources.

[10] NASA OIG, *NASA's Management of the Mobile Launcher 2 Contract* (IG-22-012, June 9, 2022).

[11] IG-22-011.

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

This audit will examine the major SLS elements and corresponding contracts with The Boeing Company (Boeing), Aerojet Rocketdyne, and Northrop Grumman and assess the extent to which the SLS Program is managing costs and schedule for these contracts.

Review of NASA's Partnerships with International Space Agencies for Artemis Missions

This review will examine NASA's efforts to partner with international space agencies for the Artemis missions.

NASA's Space Communication Infrastructure Upgrade and Modernization Projects

This audit will assess the progress towards upgrading the Near Space Network and Deep Space Network ground stations and the ability of the Networks to support current and future mission requirements.

Relevant OIG Reports

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

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

NASA's Volatiles Investigating Polar Exploration Rover (VIPER) Mission (IG-22-010, April 6, 2022)

NASA's Management of Its Astronaut Corps (IG-22-007, January 11, 2022)

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

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

Challenge 2: Improving Management of Major Programs and Projects

Why This Is a Challenge

NASA has an extensive portfolio of major programs and projects that reflect its leadership in space exploration, science and aeronautics research, and innovation.[12] These programs and projects include satellites equipped with advanced sensors to study the Earth; rovers to collect soil and rock samples on other celestial bodies; telescopes that explore the far reaches of the universe; and complex systems to support transportation of humans to the ISS, Moon, and beyond. The overall management of a program or project requires expertise with cost, schedule, transparency of external reporting, development risks, staffing and training, and program and project requirements. Effectively managing NASA's portfolio of major programs and projects has been a continuous challenge for the Agency with cost and schedule overruns particular areas of concern.

Historically, NASA's major programs and projects have cost significantly more and taken much longer to complete than initially planned. According to GAO, NASA plans to invest more than $80 billion over the life cycle of its portfolio of major programs and projects, 21 of which are currently in development. However, 15 of those programs and projects have already experienced a cumulative cost growth of about $12 billion and 28 years of delay since original cost and schedule baselines were established.[13] In 2021, NASA completed six programs and projects, including launching the James Webb Space Telescope, but in the last year the Agency's major programs and projects collectively exceeded their cost estimates by almost $3 billion and surpassed their collective schedules by almost 10 years.

NASA has struggled for years to provide reliable life-cycle cost and schedule estimates for complex programs and projects involving multiple, first-of-their-kind components.[14] The Agency remains challenged to complete its major programs and projects within planned costs and schedules due to a variety of factors including a culture of optimism deeply rooted in the Agency coupled with a pattern of underestimating the time, effort, and technical complexities required to accomplish its objectives. In June 2022, we reported the ML-2 project experienced extreme cost growth and schedule delays primarily because the prime contractor, Bechtel National, Inc. (Bechtel), underestimated the overall scope and complexity of designing and building the ML-2 at the onset of the project. Further impacting the project was NASA's decision to move forward with the ML-2 contract while the SLS's new Exploration Upper Stage—the main component requiring a second mobile launcher—was early in its design cycle and lacked finalized requirements. In spring of 2021, 2 years into the contract, Bechtel provided updated cost and schedule estimates that revealed significant cost increases in subcontractor costs, labor hours, equipment, material and supplies, and management reserve. Specifically, the project's total projected cost grew from

Image of Stephan's Quintent Taken by the James Webb Space Telescope

This image shows a visual grouping of five galaxies and provides new insights into how galactic interactions may have driven galaxy evolution in the early universe. Seen are sparkling clusters of millions of young stars and starburst regions of fresh star birth; sweeping tails of gas, dust, and stars being pulled from several of the galaxies; and huge shock waves as one of the galaxies smashes through the cluster.

Source: NASA

[12] 51 U.S. Code § 30104, *Baselines and cost controls*, defines a "major program" as an activity approved to proceed to implementation that has an estimated life-cycle cost of more than $250 million. GAO categorizes "major projects" as those with life-cycle costs over $250 million. GAO, NASA: Assessments of Major Projects (GAO-22-105212, June 23, 2022).

[13] GAO-22-105212. Three projects—SLS, Orion, and James Webb Space Telescope—are responsible for more than three-quarters of the cost growth and almost half of the schedule delays.

[14] Examples of first-of-their-kind projects include the SLS; Low-Boom Flight Demonstrator, an experimental aircraft with a low noise sonic boom; and the recently launched James Webb Space Telescope, a large infrared telescope designed to study the origins of the universe.

$383 million to $960.1 million, an increase of 150.7 percent. Additionally, current projections show the ML-2 will not be delivered to NASA until October 2025 rather than March 2023 as originally planned.[15]

GAO first designated NASA's acquisition management as a high-risk area three decades ago and over the years has recommended improvements to tackle related risks and challenges.[16] NASA's ongoing struggle with acquisition management performance undermines congressional and public confidence in the Agency's ability to spend taxpayer dollars responsibly and to deliver major programs and projects on time and within budget to meet mission objectives and strategic goals.

Our work has consistently found that NASA also struggles to provide transparency and accountability for the life-cycle costs and schedules of its multi-billion-dollar space flight programs such as those supporting the Artemis missions.[17] Contrary to federal statute, NASA does not estimate, commit to, or report the full life-cycle costs for major multi-mission programs and projects such as the SLS rocket and Orion capsule that involve iterations of deliverables (i.e., will be built multiple times due to lack of complete reusability) without defined life-cycle end dates. This lack of transparency and accountability for life-cycle cost and schedule makes it more difficult for NASA and its stakeholders to assess the overall affordability and sustainability of its major, long-term programs.

In April 2022, we reported that NASA established an Agency Baseline Commitment life-cycle cost estimate of $433.5 million for the Volatiles Investigating Polar Exploration Rover (VIPER) that excluded the cost of the lunar delivery and did not consider the delay risks associated with the lander's development.[18] Subsequently, those risks came to fruition in large part because the contract for the delivery service was established before requirements and design of the rover and lunar lander had been finalized. Consequently, the cost to deliver the rover to the Moon has grown more than 60 percent ($320.4 million versus the $199.5 million initial projected cost), and the mission has been delayed a year to November 2024.

Because NASA continues to circumvent federal policy related to baselines and cost controls, Congress is not receiving the cost and schedule information it needs to make fully informed funding decisions. In doing so, the Agency appears to be setting a troubling precedent for future programs and projects by providing stakeholders and decision-makers limited insight into the complete costs of its programs, projects, and initiatives.

Progress in Addressing the Challenge

NASA's efforts in the last few years to improve management of its major programs and projects have shown indications of improved performance for several, including Landsat 9 and Lucy, which collectively cost $196 million less to develop than planned and both launched early.[19] In fact, GAO's 2022 High-Risk Series report listed NASA's acquisition management as one of only six high-risk areas throughout the entire federal government that showed progresss toward

[15] IG-22-012.

[16] GAO first cited the Agency's acquisition management as a high-risk area in 1990. GAO, High-Risk Series: Dedicated Leadership Needed to Address Limited Progress in Most High-Risk Areas (GAO-21-119SP, March 2, 2021) is the most recent list in which NASA's acquisition management was cited as a high risk.

[17] 51 U.S. Code § 30104 defines life-cycle cost as the total of the direct, indirect, recurring, and nonrecurring costs, including construction of facilities and civil servant costs, and other related expenses incurred or estimated to be incurred in the design, development, verification, production, operation, maintenance, support, and retirement of a program over its planned lifespan, without regard to funding source or management control. Schedules should include events from life-cycle Phases A and B (concept and technology development and preliminary design) and Phases C through F (final design and fabrication; system assembly, integration, test, and launch; operations; and closeout).

[18] NASA OIG, *NASA's Volatiles Investigating Polar Exploration Rover (VIPER) Mission* (IG-22-010, April 6, 2022). VIPER is planned for end-to-end launch and delivery to the lunar surface in late 2024 by NASA's Commercial Lunar Payload Services which delivers ready-to-fly payloads to the surface of the Moon using emerging commercial landers. The costs associated with this initiative were not included in VIPER's baseline commitment.

[19] Landsat 9, launched in September 2021, is the latest satellite in the Landsat series providing a continuous space-based record of the Earth's land surface; it launched 2 months early with development costs $138.5 million below its baseline. Lucy, launched in October 2021, is the first space mission to study the Jupiter Trojan asteroids; it launched 1 month early with development costs $57.2 million below its baseline.

meeting criteria for removal from the High-Risk List.[20] In August 2022, NASA updated its 2020 Corrective Action Plan to create initiatives and areas of emphasis that address the causes of cost and schedule overruns highlighted in GAO's High-Risk List.[21] At that time, NASA reported completing five of six initiatives and adding three initiatives to expand data collection efforts, implement a schedule repository, and conduct financial evaluations of potential contractors prior to award.

As a result of these initiatives, NASA has developed best practices, added requirements, and implemented external monitoring related to cost and schedule for major projects. For example, NASA completed an initiative to establish a Program Planning and Control training curriculum and additional courses continue to be developed with the intent of creating a curriculum that is reflective of best practices and methods to strengthen the Agency's programmatic capabilities and bridge the gap between the current and future workforce of analysts. Moreover, in January 2022 NASA established a Chief Program Management Officer with responsibility for strengthening the Agency's oversight, management, and implementation of program management policies, processes, and best practices.

Further, in alignment with the Federal Acquisition Regulation requirement for contracting officers to ensure prospective contractors have adequate financial resources to perform the contract, NASA has implemented new policy and guidance requiring a comprehensive financial capability assessment during the procurement process for NASA's most significant contracts. Specifically, for design and development programs and projects with a life-cycle cost of $500 million or more, NASA now requires an evaluation of the financial health, stability, and outlook of the organizations under consideration prior to selection and contract award.

Key Implemented Recommendations

Develop a formal process by which a risk-based probabilistic analysis is conducted to cover the global and interdependency risks of major programs and projects when those individual programs and projects are required for the successful implementation of a mission; regardless of how those programs and projects are categorized (i.e., tightly coupled, single-project program, etc.) (IG-22-011).

Ensure total development and production contract costs currently not reported as part of the Agency Baseline Commitment are included in quarterly financial status reporting to the Office of the Chief Financial Officer, Office of Management and Budget, and Congress (IG-20-018).

Establish a process to be used during source evaluation boards and source selections that includes direct contact with the Center EVM Working Group Representative and cognizant Defense Contract Management Agency office to verify all contractor proposed information related to EVM (IG-20-015).

Work Remaining to Address Challenge

NASA's ability to overcome technological and scientific obstacles to accomplish its objectives has helped foster a long-standing belief that the Agency can accomplish anything it puts its collective mind to. This culture of optimism, however, and its effect on project management have contributed to cost growth and schedule delays in several programs and projects over the years. NASA should seek to establish sustainable budgets and realistic timelines that consider the Agency's overall goals and priorities. For example, the Roman Space Telescope has already experienced significant delays and cost growth due to the COVID-19 pandemic that necessitated a replan in 2021.[22] The replan produced a new

[20] NASA now meets three of five criteria for removal from GAO's High-Risk List (leadership commitment, action plan, and monitoring) and partially meets the other two (capacity and demonstrated progress).

[21] NASA, *2022 High Risk Corrective Action Plan* (August 2022).

[22] The Roman Space Telescope is an observatory designed to unravel the secrets of dark energy and dark matter, search for and image exoplanets, and explore many topics in infrared astrophysics.

life-cycle cost estimate that increased from $3.9 billion to $4.3 billion and delayed the launch readiness date by 7 months from October 2026 to May 2027.[23]

Furthermore, requirements should be clearly defined, affordable, and communicated prior to a mission entering the development phase to reduce the risk of costly design changes later in the life cycle.[24] Before NASA begins to acquire major Artemis systems such as the Gateway, Exploration Extravehicular Activity Services, and the HLS through FY 2025. Consequently, NASA will need to solidify requirements and address unresolved technology development decisions before Artemis projects enter implementation (e.g., moves to final design, development, integration, and operations).

The House Committee on Appropriations included language in a 2019 report directing NASA to establish (1) cost and schedule baselines for the SLS and Exploration Ground Systems and (2) separate cost and schedule baselines for each additional capability of the SLS, Orion, and Exploration Ground Systems that encompass all life-cycle costs.[25] Although NASA recently committed to establishing cost and schedule baselines for additional capabilities of the SLS Program, the Agency must redouble its efforts to ensure that its science and space exploration projects are grounded in transparent and accurate full life-cycle cost estimates that meet cost, schedule, and performance goals.[26] Given a limited budget to fund multiple ambitious projects, it is critical that NASA implement further changes to its space flight program and project management policy, demonstrate sustained progress in completing Corrective Action Plan initiatives, and establish full life-cycle cost and schedule commitments to Congress and the Office of Management and Budget for all ongoing and future projects.

Key Unimplemented Recommendations

Estimate, track, and report ongoing production costs for all major programs, such as SLS and Orion, as development costs (Phases C and D) and not as Operations and Sustainment (Phase E) costs (IG-22-011).

Establish procedural requirements to ensure compliance with the Title 51 requirement to report full life-cycle cost and schedule for all major programs should NASA elect to estimate, track, and report baseline costs for major programs or activities that exceed $250 million by component rather than by mission (IG-22-011).

Update NASA Procedural Requirements 7120.8 to require major acquisition projects that cost over $250 million to complete a Joint Cost and Schedule Confidence Level analysis (IG-22-010).

Update NASA Procedural Requirements 7120.8 to require major acquisition projects that cost over $250 million to implement EVM (IG-22-010).

Review Human Exploration and Operations Mission Directorate and NASA program management policies, procedures, and Agency Baseline Commitment reporting processes to provide greater visibility into current, future, and overall cost and schedule estimates for the SLS Program and other human space flight programs (IG-20-012).

Ongoing and Anticipated Future Audit Work

Review of NASA's Space Technology Mission Directorate Portfolio

This audit will examine NASA's management of this Directorate's portfolio.

[23] Under Title 51, NASA is required to notify Congress and provide a replan if a mission's cost increases beyond 15 percent of its baseline and/or a key milestone is delayed by 6 months or more. [24] GAO, *Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes* (GAO-02-701, July 15, 2002).

[24] GAO, Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes (GAO-02-701, July 15, 2002).

[25] H. Rep. No. 116-101 (2019). NASA established the Exploration Ground Systems Program to develop and operate the systems and facilities necessary to process and launch government and commercial rockets and spacecraft.

[26] GAO, *High Risk Series: Key Practices to Successfully Address High-Risk Areas and Remove Them from the List* (GAO-22-105184, March 3, 2022).

Review of NASA's Mars Sample Return Mission

This audit will evaluate NASA's management of the mission relative to meeting cost, schedule, and technical goals and objectives.

NASA's Electrified Aircraft Propulsion Research and Development Efforts

This audit will assess NASA's progress towards developing and testing new technologies and sustainable energy options for aircraft propulsion and examine whether the Aeronautics Research Mission Directorate is meeting its established goals and priorities.

Relevant OIG Reports

NASA's Management of Its Johns Hopkins University Applied Physics Laboratory Portfolio (IG-22-017, September 29, 2022)

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

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

NASA's Volatiles Investigating Polar Exploration Rover (VIPER) Mission (IG-22-010, April 6, 2022)

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)

COVID-19 Impacts on NASA's Major Programs and Projects (IG-21-016, March 31, 2021)

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

NASA's Planetary Science Portfolio (IG-20-023, September 16, 2020)

NASA's Management of the Stratospheric Observatory for Infrared Astronomy Program (IG-20-022, September 14, 2020)

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

Management of the Low-Boom Flight Demonstrator Project (IG-20-015, May 6, 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)

Challenge 3: Sustaining a Human Presence in Low Earth Orbit

Why This Is a Challenge

Sustaining a human presence in low Earth orbit is critical to NASA achieving its goals in science, technology, and human space flight. For 22 years, humans have continuously lived and worked onboard the ISS conducting microgravity research and testing new technologies to reduce the risk of long-term deep space travel. NASA's activities in low Earth orbit—the region in space from about 100 to 600 miles above the Earth's surface—consume approximately one-third of the Agency's annual human space flight budget.[27] This level of expenditure will likely continue with Station operations expected to be extended through 2030.

Without the availability of a low Earth orbit platform to conduct critical health research and demonstrate new technologies, NASA will be faced with the difficult decision of accepting a higher level of risk or delaying crewed missions to the Moon and Mars. NASA plans to sustain a human presence in low Earth orbit beyond the retirement of the ISS by becoming a customer of one or more commercially owned and operated space destinations.[28] The transition to commercial destinations will require a sustained, but largely undetermined, financial investment by NASA and private companies as well as growth in non-NASA demand for these services to ensure their long-term financial viability. Avoiding a gap between the advent of a commercial low Earth orbit destination and the end-of-life for the ISS by 2030 is the crux of this challenge.

NASA Astronaut Kjell Lindgren Participates in a Hearing Study Onboard the ISS

This photo from July 8, 2022, on the ISS shows Kjell Lindgren participating in the Acoustics Diagnostics study to explore whether equipment noise levels and the microgravity environment create possible adverse effects on astronaut hearing.

Source: NASA

Reliable and cost-effective transportation of cargo and crew is key to maintaining a long-term presence in low Earth orbit. NASA's Commercial Cargo and Crew Programs have enabled partners to successfully transport cargo and crew to and from the ISS since 2012 and 2020, respectively. Crew transportation is crucial not only for the ISS, but also for the development and utilization of future commercial destinations.[29] While SpaceX has launched four successful commercial crew missions to the Station from November 2020 until April 2022, NASA's second commercial crew partner—Boeing—has faced numerous delays and technical issues and has yet to fly a crewed mission.

Progress in Addressing the Challenge

Despite its ongoing overall challenge to sustain a thriving human presence in low Earth orbit, the Agency has made progress in several related areas. In November 2021, we reported on the potential risks to the structural integrity of the ISS. While the Station leaks cabin air as part of its normal operations, NASA and Roscosmos—Russia's space agency—identified three leaks in the Russian-built Service Module Transfer Tunnel that caused cabin air to leak at more than double the normal rate.[30] As of March 2022, all three areas have been sealed and measurements of the leakage rates showed improvement after sealing the third crack although readings have not returned to pre-leak rates.[31] However, the cracks were determined not to pose a significant threat to the overall structural integrity or functionality of the Station.

[27] The ISS orbits approximately 250 miles above the Earth's surface.

[28] NASA OIG, *NASA's Management of the International Space Station and Efforts to Commercialize Low Earth Orbit* (IG-22-005, November 30, 2021).

[29] NASA OIG, *NASA's Management of Crew Transportation to the International Space Station* (IG-20-005, November 14, 2021).

[30] IG-22-005. The Service Module, which contains the Service Module Transfer Tunnel at one end, is the third oldest segment of the Station.

[31] The normal leak rate before the cracks were found measured about 0.6 pounds mass air/day. In 2019 that amount had doubled, and in 2020 the leak rate increased to about 3 pounds mass air/day. Prior to the third crack's temporary patch, the ISS leak rate was stable at about 1.5 pounds mass air/day and after a more permanent patch was applied, the leak rate was reduced to about 1.2 pounds mass air/day.

NASA has also experienced advancements related to transportation to the ISS. With SpaceX's Crew Dragon vehicle successfully providing routine crewed services to the Station, NASA is no longer required to buy seats on the Russian Soyuz spacecraft for U.S. transportation to the ISS as it had done since the end of the Space Shuttle Program in 2011. To ensure a continuous U.S. presence in space and safe operations of the ISS, NASA reached a non-monetary, seat-swap agreement with Roscosmos in July 2022 to allow two U.S. astronauts to fly on separate Soyuz launches, while two Russian cosmonauts will fly on separate Crew Dragon launches. Despite ongoing geopolitical disputes, NASA and Roscosmos continue their decades-long partnership, working together to maintain ISS operations. Notwithstanding their cooperation, Roscosmos has not indicated its full support of the ISS extension to 2030.

In June 2022, a Northrop Grumman Cygnus spacecraft docked to the ISS and fired its main engine to complete the first limited reboost—or adjustment—to the orbit of the Station. This procedure adds a critical capability to help maintain and support the ISS, counteract drag that pulls the Station down over time, and return the ISS to operating altitude levels. Although the Cygnus reboost capability is helpful, it does not currently provide the same reboost capability as the Russian segment.

Post-ISS, NASA plans to rent space on one or more commercial platforms once the Station is deorbited. To help create a more robust low Earth orbit economy, in 2019 NASA began to allow private astronaut missions and approved commercial and marketing activities on the Station. The following year, NASA established the Commercial Low Earth Orbit Development Program to facilitate development and stimulate growth of commercial low Earth orbit destinations and activities. For the first time since the line item appeared on NASA's budget in FY 2019, Commercial Low Earth Orbit Development received its full request of $150 million in FY 2022, and outyear funding requests in the FY 2023 President's budget shows an increase to $224 million. The approved level of funding positions NASA to advance the development of commercial platforms, catalyze new markets, and facilitate the transition to a sustainable low Earth orbit economy.

NASA awarded Axiom a $140 million contract in 2020 to provide a habitable commercial module to attach to the ISS, a module eventually expected to detach and become a free-flying destination. Additionally, in 2021 as part of NASA's phased approach to develop commercial destinations in low Earth orbit, the Agency awarded $416 million in Space Act Agreements to three companies—Blue Origin, Nanoracks LLS, and Northrop Grumman—to design and mature commercial low Earth orbit destinations.[32] These four awards are intended to ensure NASA has at least one private entity ready to provide a commercial destination prior to the retirement of the ISS to mitigate the risk of a gap in human presence in low Earth orbit. When compared to current ISS operations, NASA estimates the Agency will save approximately $1 billion to $1.5 billion per year based on the current expected capabilities and prices for commercial low Earth orbit destination services.

To help encourage regular demand from the private sector for these services, NASA has allocated a portion of ISS resources for commercial use activities and private astronaut missions. In April 2022, Axiom's first AX-1 private astronaut mission successfully launched and the crew spent 15 days on the ISS. The private astronaut crew accomplished all planned commercial scientific experiments and outreach activities onboard the ISS, including over 20 experiments and 50 media events. NASA identified several lessons from AX-1, such as updates to private astronaut training, more flexibility in the astronauts' schedule once on the ISS, and additional clarity to operating procedures onboard the Station. The Agency is working to incorporate these lessons ahead of Axiom's AX-2 mission, tentatively scheduled to launch in 2023. In September 2022, NASA requested proposals from industry for private astronaut missions 3 and 4. To further support commercial use activities, NASA and the ISS National Laboratory have partnered to develop commercial in-space manufacturing initiatives.[33]

[32] The National Aeronautics and Space Act, 51 U.S.C. §§ 20101-20164, grants NASA broad discretion in the performance of its functions, specifically to enter into and perform such contracts, leases, cooperative agreements, or other transactions as may be necessary in the conduct of its work and on such terms as it may deem appropriate, with any agency or instrumentality of the United States.

[33] The ISS National Laboratory is a U.S. government-funded laboratory with principal research facilities located in the U.S. Orbital Segment of the ISS. In-space manufacturing develops the technologies and processes which will enable on-demand manufacturing capabilities (fabrication, repair, and recycling) during long-duration space missions, for example 3D printing on the ISS.

Key Implemented Recommendations

Continue to ensure the purchase of future commercial space services complies with government contracting regulations (IG 20-005).

Complete a contingency plan for delayed Commercial Crew Program delivery (IG 20-005).

Work Remaining to Address Challenge

Currently, the ISS partners have an agreement in place to operate the Station through 2024. The extension of operations to 2030 is expected to allow for a 2-year overlap with planned commercial destination availability in 2028. Although the Administration supports extension to 2030, international partnerships must be renewed. As noted above, Roscosmos has not indicated its full support of the ISS extension to 2030. In addition, while other international partners have signaled a desire to continue ISS operations, the space agencies need to work with their respective governments to officially approve the extension. Nonetheless, Boeing has certified the integrity of the U.S. segment's structure through 2028, and NASA is currently working with Boeing to extend the certification to 2030.[34]

While the Station's structure is expected to remain viable through 2030, the rapid increase of space activity has accelerated the creation of orbital debris—human-made objects, or space junk, that no longer serve a useful purpose—increasing the safety threat to the ISS and its crew. As we discussed in a January 2021 audit assessing NASA's efforts to mitigate the risks posed by orbital debris, mitigation-only activities focused on prevention are not sufficient to stabilize the orbital debris environment. We urged NASA to take more significant actions to address orbital debris including developing cost-effective debris removal technologies and increasing its leadership in responsible mitigation activities.[35]

Crew-related issues also remain a top priority for the Agency, including transportation to the ISS. In May 2022, the Boeing CST-100 Starliner spacecraft completed its second uncrewed test flight mission to the ISS, putting the Agency one step closer to having a second vehicle—in addition to the Crew Dragon—to carry astronauts to and from the Station from U.S. soil. NASA is preparing for a crewed flight test on the Starliner in early 2023.

NASA will require the use of a continuously crewed laboratory well beyond 2030 to conduct research and technology demonstrations for longer-term space travel to deep space destinations including Mars. Until the ISS is retired, it will continue to serve as a microgravity location for research validation and technology demonstrations. However, 8 of 12 human health risks and 11 of 27 technology gaps related to long-duration human space flight that require a microgravity environment for testing and mitigation efforts will not be completed by the Station's proposed end-of-life in 2030.

Further, current gaps in spacesuit capabilities impact not just crew health and safety but also ISS operations and maintenance. In March 2022, water leaked into an astronaut's helmet during an extravehicular activity (spacewalk) forcing its immediate termination. In response, non-urgent spacewalks were placed on hold and the impacted suit was returned to Earth for assessment. NASA officials do not believe there is a design flaw in the spacesuit, but the ISS Program is testing new materials to add as additional absorbent material to the helmet.[36] NASA intended to upgrade its solar power system in the fall of 2022, which requires astronauts to conduct spacewalks, but if the issue is not resolved by that time ISS officials will either accept the risks of using the suit or delay the upgrade.[37]

[34] NASA has an engineering contract with Boeing that includes original design, development, testing, and evaluation of the Station as well as spares, subsystem management, modifications, repairs, and life-extension analysis.

[35] NASA OIG, *NASA's Efforts to Mitigate the Risks Posed by Orbital Debris* (IG-21-011, January 27, 2021).

[36] After a previous incident of water found inside a helmet in 2013, helmet absorption pads were added to the back of the helmet which absorbs water and swell. NASA is testing materials like a chamois that does not swell for the additional material.

[37] NASA OIG, *NASA'S Development of Next-Generation Spacesuits* (IG-21-025, August 10, 2021).

Key Unimplemented Recommendations

Ensure the risks associated with cracks and leaks in the Service Module Transfer Tunnel are identified and mitigated prior to agreeing to an ISS life extension (IG 22-005).

Explore alternative orbital debris radar assets to fill the data gaps caused by the increased costs of utilizing existing radars and the loss of legacy assets (IG-21-011).

Lead national and international collaborative efforts to mitigate orbital debris including activities to encourage active debris removal and the timely end-of-mission disposal of spacecraft (IG-21-011).

Ongoing and Anticipated Future Audit Work

Currently, we have no ongoing audits related to the low Earth orbit management challenge. We will continue to closely monitor NASA's current ISS operations and future commercial destination efforts and plan to initiate an audit in a future audit cycle.

Relevant OIG Reports

NASA's Management of the International Space Station and Efforts to Commercialize Low Earth Orbit (IG-22-005, November 30, 2021)

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

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

Challenge 4: Managing and Mitigating Cybersecurity Risks

Why This Is a Challenge

NASA's work ranges from space missions to advanced electric aircraft designs to studying climate change, making the Agency a top target for both foreign and domestic hackers. Within NASA's FY 2022 $2 billion-plus information technology (IT) budget, the Office of the Chief Information Officer (OCIO) is allocated $667 million, of which $137 million is designated for institutional cybersecurity in support of Agency operations.[38] Separate from the OCIO, mission organizations invested almost $215 million on mission-based cybersecurity at locations around the country.

Cybersecurity—protecting computer systems and data from unauthorized access—is an extraordinarily complex undertaking that involves multiple trade-offs in securing IT systems. For more than two decades, we have identified efforts to secure NASA IT systems as a top management challenge due, in large part, to the Agency's lack of an enterprise-wide approach to cybersecurity. Given the increasing number of cyber threats across its Centers and facilities, the difficulty of ensuring the security and reliability of IT systems and strengthening its cybersecurity program remains a top Agency challenge.[39] In addition, as technology's role in the workplace continues to evolve with an increasingly hybrid and remote workforce, NASA's IT services are vital to enabling and protecting the Agency's activities.

To help frame the scope and urgency of cybersecurity, federal evaluations and ratings provide broad insight into NASA's cyber health.[40] During the 2022 Federal Information Security Modernization Act evaluation, NASA's information security program, while showing improvements, remains rated at the third of five tiers—a "consistently implemented" maturity level, below the "managed and measurable" rating the Office of Management and Budget considers effective. Similarly, in July 2022, NASA received an overall Federal Information Technology Acquisition Reform Act rating of C+ given its challenges in managing cyber risks.

Progress in Addressing the Challenge

NASA is making solid progress improving its cyber hygiene—the set of practices and steps intended to manage cybersecurity risks. With consistency and focus, the Agency's Chief Information Officer and Senior Agency Information Security Officer (SAISO) have implemented a blend of strategic decisions, risk management best practices, and collaboration initiatives for enhancing the Agency's cyber posture. We are encouraged by the following initiatives:

Strategic Decisions. As an outgrowth of the Mission Support Future Architecture Program, the Center Chief Information Security Officers and all 133 OCIO cybersecurity staff were realigned under the SAISO in April 2022. This change shifts the Agency towards an enterprise delivery process that centralizes and consolidates IT capabilities, including cybersecurity. Additionally, in May 2022

NASA's Computing Technology

Mission Control Center at Johnson Space Center (top left), Pleiades supercomputer (top right), high-end computing systems at Ames Research Center (center), Proteus aircraft at Langley Reseach Center (bottom left), and Unitary Wind Tunnel with flying drone in front at Ames Research Center (bottom right).

Source: NASA

[38] NASA's IT assets generally fall into two broad categories: institutional and mission. Institutional systems include desktop and laptop computers, enterprise business applications, web services, data centers, and networks. Mission systems support the Agency's aeronautics, science, and space exploration programs. While the OCIO has responsibility for institutional systems, mission organizations fund their own networks and IT personnel; therefore, in most cases, mission personnel, rather than OCIO staff, have visibility over the operational and security aspects of mission networks.

[39] Notably, even the OIG's network is not immune to cyberattacks. In April 2022, our organization experienced a significant cyber incident that disrupted operations for weeks.

[40] The Federal Information Security Modernization Act (Pub. L. No. 113-283), requires agencies to develop, implement, and document an agency-wide information security program. The Federal Information Technology Acquisition Reform Act puts federal agency Chief Information Officers in control of their agency's IT investments.

NASA awarded the Cybersecurity and Privacy Enterprise Solutions and Services contract. For the first time, this new contract brings together all aspects of cybersecurity across NASA—at headquarters and all Centers and Agency facilities—under a single contract to include IT systems, operational technology systems, and mission systems.

Risk Management Best Practices. In June 2022, NASA released a comprehensive *Cybersecurity Performance Scorecard* for leadership to view cyber risks associated with their IT systems. This integrated web scorecard provides visibility on key cybersecurity performance metrics such as device vulnerability, patching compliance, and the status of over 800 Security Plans. Importantly, recent internet perimeter enhancements strengthened NASA's ability to combat cyberattacks and malware threats and helped prevent numerous malicious and unauthorized traffic attempts per day from accessing internal networks.[41]

Collaboration Initiatives. The recent emphasis on collaboration between the OCIO and mission organizations is promising with the formation of a dedicated office for Cybersecurity Mission Integration and the expansion of the Security Operations Center from Ames Research Center to Johnson Space Center. Additionally, the May 2022 *Artemis Security Summit* joined OCIO cybersecurity experts with their counterparts from the Space Communications and Navigation, SLS, and Orion programs, as well as mission organizations to discuss cyber threats that could potentially impact Artemis operations. Lastly, OCIO and mission stakeholders identified communications improvements to ensure critical patching is appropriately accounted for during a mission freeze—significantly reducing cyber risk.[42]

Key Implemented Recommendations

Ensure that the information system oversight process identifies delinquent control risk assessments and initiates timely corrective action (IG-20-017).

Establish a formal, documented threat-hunting process that includes metrics to track success (IG-19-022).

Work Remaining to Address Challenge

Although the Agency is making strides in maturing its IT cyber infrastructure, it faces persistent challenges in three key areas: (1) right-sizing NASA's digital footprint, (2) implementing Enterprise Architecture—the blueprints and cyber safeguards for how an organization analyzes and operates its information systems, and (3) managing insider threat risks.

Right-Sizing NASA's Digital Footprint. The inherent risk of operating approximately 2,625 decentralized public-facing web domains—administered across all NASA Centers, facilities, and the Jet Propulsion Laboratory—is enormous.[43] With bad actors frequently targeting vulnerable web servers for cyber-crime and cyber-espionage alike, protecting these Agency resources in a hostile cyber landscape is vital.

NASA, like all federal agencies, is required to exercise governance over its websites and ensure legacy websites are regularly reviewed, eliminated, and consolidated.[44] In May 2019, the NASA Administrator issued a memorandum directing "a full review of NASA's web footprint and digital presence…to result in an enhanced cyber-posture and an improved focus for communicating our messages."[45] While the Agency acknowledges that its digital portfolio is subject to serious threats that can exploit and compromise sensitive information and has taken steps to address these concerns, progress on website consolidation remains slow. After more than 3 years of effort, technical complexity and cost remain the primary hurdles to completing the Agency's web modernization effort.

[41] Perimeter security in cybersecurity refers to the process of defending an organization's network boundaries from hackers and intruders. This entails surveillance detection, pattern analysis, threat recognition, and effective response. Each private network is surrounded by a perimeter that serves as a secure wall between networks, such as an organization's private intranet and the public internet.

[42] Mission freeze is a restriction that prevents updates to a computer before, during, and after a launch activity. During a mission freeze, computers are unable to install new software or update existing software.

[43] A domain is the name of a website and comes after the "@" symbol in an email address or after "www" in a web address.

[44] 21st Century Integrated Digital Experience Act, Pub. L. No. 115-336 (2018).

[45] NASA Administrator memorandum to the Agency's workforce on Web Site Modernization and Enhanced Security Protocols (May 15, 2019).

Protecting complex IT infrastructure from evolving cyber threats is an enormous challenge. But without an enterprise-wide cybersecurity approach, NASA's systems and information remain vulnerable to attacks. While the Agency is taking positive steps by engaging in strategic approaches to securing its IT systems, it is equally important to focus on the day-to-day fundamentals of cybersecurity—visibility, process, and metrics—the building blocks of a resilient cybersecurity program.

Implementing Enterprise Architecture. In a May 2021 audit, we found that although Enterprise Architecture has been in development at NASA for more than a decade, it remains disorganized and incomplete due to gaps across mission and institutional IT boundaries.[46] While the OCIO has responsibility for institutional governed IT, missions are left to their own discretion to interpret and implement requirements and, importantly, absorb costs associated with addressing cybersecurity risks. Larger programs such as Orion and the Joint Polar Satellite System are better at managing cybersecurity risks while smaller missions such as CubeSats tend to struggle because of their specialized technology and lack of assets (people, tools, and funding) to devote to cybersecurity efforts.[47] Specifically, larger programs understand the National Institute of Standards and Technology guidance for the selection and implementation of protective security controls while smaller programs generally lack familiarity and expertise with these complex cyber concepts.[48] Agency officials explained that smaller missions tend to put cybersecurity last on their "to-do" lists, with science—not IT—their first priority. Consequently, until NASA establishes an integrated Enterprise Architecture program across organizational boundaries, face increased cybersecurity risks.

Managing Insider Threat Risks. NASA has implemented appropriate countermeasures to reduce the risk of insider threats to classified systems posed by an organization's employees and contractors, but in a March 2022 audit we found the Agency continues to face challenges in improving its defenses to protect unclassified systems—the vast majority of the Agency's systems.[49] At a time when there is growing concern about the continuing threats of foreign influence, taking the proactive step to conduct a risk assessment to evaluate NASA's unclassified systems will help ensure that IT security gaps cannot be exploited in ways that undermine the Agency's ability to carry out its mission. While the Agency's insider threat program is supported by ad hoc communication between several Office of Protective Services divisions, we found no consistent collaboration across NASA offices (e.g., human resources, legal, IT) to proactively assess insider threat risk to its unclassified systems. In our view, these cross-discipline challenges need to be evaluated to identify the best approach for mitigating potential insider threats to unclassified systems.

Key Unimplemented Recommendations

Establish a cross-discipline team to conduct an insider threat risk assessment to evaluate NASA's unclassified systems and determine if the corresponding risk warrants expansion of the insider threat program to include these systems (IG-22-009).

Collaborate with the Chief Engineer on strategies to identify and strengthen Enterprise Architecture gaps across mission and institutional IT boundaries (IG-21-019).

Ongoing and Anticipated Future Audit Work

NASA's Software Asset Management

This audit will examine whether NASA is managing its software assets in an effective and efficient manner while complying with security best practices.

[46] NASA OIG, *NASA's Cybersecurity Readiness* (IG-21-019, May 18, 2021). Enterprise Architecture is a blueprint for how an organization analyzes and operates its IT and cybersecurity—a crucial component for effective IT management.

[47] Orion is the capsule that will carry astronauts to the Moon and other deep-space destinations, the Joint Polar Satellite System is a polar-orbiting environmental satellite system, and a CubeSat is a type of space research nanosatellite with a base dimension of 10x10x11 centimeters (one "Cube" or "1U") or approximately four inches.

[48] The National Institute of Standards and Technology has issued information security standards and guidelines for managing cybersecurity risk. Common security issues include patch management, password control, and system configuration.

[49] NASA OIG, *NASA's Insider Threat Program* (IG-22-009, March 14, 2022).

Review of NASA's Information Security Program under the Federal Information Security Modernization Act for Fiscal Year 2022

As required by the Act, this annual review will evaluate NASA's information security program for FY 2022.

NASA's Management of Its Artificial Intelligence Capabilities

This audit will examine the Agency's progress in developing its Artificial Intelligence governance framework and standards and will assess whether security controls have been implemented to protect data and technologies from cyber threats.

Relevant OIG Reports

NASA's Insider Threat Program (IG-22-009, March 14, 2022)

Audit of NASA's Fiscal Year 2021 Financial Statements (IG-22-004, November 15, 2021)

Evaluation of NASA's Information Security Program under the Federal Information Security Modernization Act for Fiscal Year 2021 (ML-22-001, November 9, 2021)

NASA's Cybersecurity Readiness (IG-21-019, May 18, 2021)

Fiscal Year 2020 Federal Information Security Modernization Act Evaluation—A Contractor-Operated Communications System (IG-21-015, March 24, 2021)

Fiscal Year 2020 Federal Information Security Modernization Act Evaluation—A Center Command and Control System (IG-21-014, March 2, 2021)

Fiscal Year 2020 Federal Information Security Modernization Act Evaluation—A Center Communications System (IG-21-013, February 16, 2021)

Fiscal Year 2020 Federal Information Security Modernization Act Evaluation—An Agency Common System (IG-21-010, December 22, 2020)

Audit of NASA's Policy and Practices Regarding the Use of Non-Agency Information Technology Devices (IG-20-021, August 27, 2020)

Evaluation of NASA's Information Security Program under the Federal Information Security Modernization Act for Fiscal Year 2019 (IG-20-017, June 25, 2020)

NASA's Management of Distributed Active Archive Centers (IG-20-011, March 3, 2020)

Cybersecurity Management and Oversight at the Jet Propulsion Laboratory (IG-19-022, June 18, 2019)

Challenge 5: Improving Oversight of Contracts, Grants, and Cooperative Agreements

Why This Is a Challenge

In FY 2021, NASA obligated approximately $19.3 billion on contracts, grants, and cooperative agreements to fund research and development activities as well as to purchase services, supplies, and equipment to support Agency operations and missions. In light of the billions of dollars NASA expends and the volume and variety of these obligations, the Agency remains challenged to ensure the funds are appropriately spent to achieve agreed-upon goals and taxpayers receive good value for their investments. In addition, NASA is increasingly utilizing public-private partnerships and alternative acquisition approaches to achieve cost savings and accelerate development of new technologies, including several key systems for its Artemis missions. However, these alternative acquisition approaches do not diminish the Agency's long-standing challenge to develop more realistic cost and schedule estimates and temper its culture of optimism with respect to contract oversight.

More broadly, oversight of contracts, grants, and cooperative agreements are long-standing challenges as evident in GAO's continued designation of NASA's acquisition management as a high-risk area since 1990.[50] For the past three decades, NASA has remained at high risk due to persistent cost growth and schedule delays in many of the Agency's major programs and projects.[51]

Contract, Grant, and Cooperative Agreement Definitions

Contract
Mutually binding legal relationship obligating the seller to furnish the supplies or services and NASA to pay for them. Contracts include but are not limited to awards, job orders, task letters, purchase orders, letter contracts, and bilateral contract modifications.

Grant
A type of financial assistance a federal agency enters into with a recipient that supports or stimulates a public purpose. A grant does not provide for substantial involvement or collaboration between NASA and the recipient.

Cooperative Agreement
An arrangement where NASA provides funds to a recipient for a public purpose. A cooperative agreement typically requires substantial collaboration between the Agency and the recipient.

These same challenges are common findings in the OIG's audit work as well. For example, we reported in June 2022 that NASA's ML-2 project experienced substantial cost increases and schedule delays due primarily to poor contractor performance and, to a lesser extent, NASA's management practices. Although NASA withheld award fees from Bechtel, the prime contractor, for a 6-month performance period in spring 2021, the Agency awarded Bechtel $2.9 million in the subsequent award period despite their continued poor performance—a decision we questioned.[52] Further, we identified avoidable contracting practices that have cost NASA money in other programs. For example, in a September 2022 audit, we found NASA moved $172 million of remaining in-scope work for two task orders with Johns Hopkins University's Applied Physics Laboratory (APL) from the original contract to a follow-on contract that contained a higher fixed-fee rate. As a result of this discretionary action, NASA will pay over $3.8 million more in fees for the same scope of work than if it had remained under the first contract.[53]

Moreover, our financial statement audit continues to identify challenges in closing out contracts and grants timely, making final payments to the contractors and grantees, and deobligating excess funds. In FY 2021, almost 20 percent of the 4,196 contracts closed exceeded 3 years, which is the maximum amount of time allowed to close contracts that require the settlement of indirect cost rates.[54] Further, final grant payment and closeout procedures were not performed timely.

[50] GAO first cited the Agency's acquisition management as a high-risk area in 1990. GAO-21-119SP is the most recent list in which NASA's acquisition management was cited as a high risk.

[51] GAO-22-105212. For more information on major projects, see *Challenge 2: Improving Management of Major Programs and Projects*.

[52] IG-22-012.

[53] NASA OIG, *NASA's Management of Its Johns Hopkins University Applied Physics Laboratory Portfolio* (IG-22-017, September 29, 2022).

[54] Indirect costs are costs the contractor bears that are not directly attributable to a specific project or function, such as the cost of administrative staff, employee health benefits, and payroll taxes. An indirect cost rate is the proportion of a contractor's indirect costs that should be allocated to each of its contracts. Temporary rates are established for interim contractor reimbursement and are adjusted to determine final rates during settlement.

For the period August 2019 to August 2022, our Office of Investigations' work related to grant fraud and other waste and abuse resulted in 5 indictments, 1 conviction, 7 suspensions, and 4 debarments, with over $2.8 million in civil settlement fines returned to NASA. In addition, more than $534,646 in criminal restitution and nearly $2.3 million in civil settlement fines were returned to the U.S. Treasury as a result of OIG investigations. Collectively, our audit and investigative work has shown shortcomings in NASA's management and oversight of contracts, grants, and cooperative agreements that has resulted, at times, in inappropriate expenditures and a waste of taxpayer dollars that negatively impacted the Agency's mission.

Progress in Addressing the Challenge

To address these challenges, NASA continues to focus on updating policies and practices, as well as implementing recommendations and best practices resulting from the OIG's audit and investigative work. For the ML-2 project, NASA now includes additional assessments for Bechtel in the Contractor Performance Assessment Reporting System, which government agencies use to report performance during a contract. After completion of our audit work and based on its performance assessment, NASA decided not to issue Bechtel any award fees for the period ending March 31, 2022. Additionally, in part due to the results of our audit work on the APL task orders, NASA decided not to move the work of three other task orders to the follow-on contract and agreed to share lessons learned with the Agency's procurement community.

Conceptual Rendering of the SLS Rocket on Top of the ML-2 Platform

Source: NASA

NASA has also made several enterprise-wide changes over the past 2 years to address acquisition and other management and oversight concerns. The Office of Procurement continues to implement the Mission Support Future Architecture Program—NASA's transition to an enterprise-wide workforce that leverages employees' skills for use across the Agency—and developed a Strategic Workforce Plan to maintain a workforce capable of responding to current and future contracting needs as well as an Acquisition Portfolio Assessment Team to assess all Agency contracts and identify redundant contracts managed at the Center level.

In addition, in July 2022 the Agency moved its Grants Policy and Compliance Branch Office from the Office of the Chief Financial Officer to the Office of Procurement's Procurement Management and Policy Division.[55] With this realignment, NASA hopes to strengthen its acquisition practices by integrating all financial assistance management, oversight, and execution under the Associate Administrator for Procurement and the Deputy Chief Acquisition Officer. While these plans follow GAO's best practices for acquisition management, additional data and performance metrics could improve data validity, help the Office of Procurement accurately assess staff and resource capabilities, increase visibility of workforce staffing needs and skill gaps, and inform management reporting.[56]

Key Implemented Recommendations

Reevaluate and reassign grant officers to specific agreements to improve oversight and accountability (IG-21-022).

Conduct periodic reviews of cooperative agreements to ensure work performed under the agreement is consistent with a cooperative agreement and not a contract (IG-21-022).

Develop a community of practice to analyze what contract structure changes lead to the greatest efficiencies and to share these lessons learned with the Agency's procurement community (IG-19-014).

[55] The Grants Policy and Compliance Branch Office provides leadership and oversight in grants management policy and compliance and internal guidance and training to NASA Technical Officers, Grant Officers, and the Grants Community implementing government-wide and NASA specific regulations for awarding and administering grants and cooperative agreements.

[56] GAO, *Leading Practices in Acquisition Management* (last accessed August 8, 2022).

Work Remaining to Address Challenge

While NASA has taken steps to improve oversight and management of its contracts, grants, and cooperative agreements, the Agency must do more to ensure recipients are meeting NASA's objectives and spending funds appropriately. During our ML-2 audit, we urged NASA to take immediate corrective action to address the significant performance and management issues related to the Bechtel contract. In response, the Agency is working to identify areas of the ML-2 contract that can be converted to a firm-fixed-price contract to control costs; however, it remains to be seen what impact these and other efforts by NASA and Bechtel will have on the ML-2 project's overall cost and schedule.

As NASA expands its use of public-private partnerships and alternative acquisition approaches, the Agency needs to protect against excessive optimism, rising costs, and unanticipated delays. In particular, the delivery of science and technology to the lunar surface through the Commercial Lunar Payload Services initiative in support of the Artemis program has yet to see a mission successfully completed. Of the first three task orders issued in May 2019, one company requested to be released from the task order just 2 months later and the other two who had been tasked with delivering payloads to the lunar surface in July 2021 have yet to launch even as their task order values increased by as much as 20 percent.[57] In addition, Masten Space Systems, which was awarded a task order in April 2020 to deliver up to 8 payloads to the Moon in 2022, filed for bankruptcy in July 2022. NASA had already paid Masten $66.1 million of its initial $75.9 million award value (with the overall cost subsequently rising to $81.3 million) and as of September 2022 it was unclear how the payloads would be affected by Astrobotic Technology's acquisition of the company. Furthermore, NASA is paying Astrobotic Technology an additional $84.7 million for more testing of its Griffin lunar lander and as of July 2022, NASA delayed VIPER by a year.

Finally, the Agency will need to continue to ensure contract and grant closeout policies and procedures are effectively adhered to among the procurement and grant community to close out current and future contracts and grants in a timely manner.

Key Unimplemented Recommendations

Ensure acquisition officials minimize the availability of award fees when contract modifications and value increases are the result of shortcomings in contractor performance and require documentation of the rationale for any award fees granted (IG-22-012).

Finalize and fully implement the performance metrics dashboard to measure acquisition performance (IG-21-002).

Document contract assignments to contracting officers, contracting officer's representatives, and program and project managers in a centralized system for inclusion in the performance metrics dashboard (IG-21-002).

Ongoing and Anticipated Future Audit Work

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

This audit will examine the major SLS engine elements and the corresponding contracts with Boeing, Aerojet Rocketdyne, and Northrop Grumman and assess the extent to which the SLS Program is managing costs and schedule for these contracts.

[57] The companies issued task orders in May 2019 were Astrobotic Technology, Intuitive Machines, and Orbit Beyond. Astrobotic Technology was awarded $79.5 million to deliver as many as 14 payloads to the Moon by July 2021. Intuitive Machines was awarded $77 million to deliver as many as five payloads by July 2021. Orbit Beyond was awarded $97 million to deliver as many as four payloads by September 2020 before requesting to be released in July 2019.

Relevant OIG Reports

NASA's Management of Its Johns Hopkins University Applied Physics Laboratory Portfolio (IG-22-017, September 29, 2022)

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

NASA's Volatiles Investigating Polar Exploration Rover (VIPER) Mission (IG-22-010, April 6, 2022)

Fiscal Year 2021 Management Letter, Prepared by Ernst & Young LLP (IG-22-006, December 15, 2021)

NASA's Management of Universities Space Research Association's Cooperative Agreements (IG-21-022, July 14, 2021)

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

Challenge 6: Attracting and Retaining a Diverse and Highly Skilled Workforce

Why This Is a Challenge

NASA's workforce at its headquarters, 10 Centers, and other Agency-operated facilities continues to be its greatest asset for advancing missions in space and on Earth. The Agency is actively seeking to reshape, identify, recruit, and retain a diverse, multi-generational workforce that possesses the technical skills critical to its varied missions. As of June 2022, NASA had approximately 18,000 civil service employees working at facilities nationwide with the majority in science and engineering fields; however, the Agency remains challenged to ensure its workforce has the requisite skills and is sufficiently diverse to meet its mission needs. To address this challenge, the Agency is working to prioritize and implement strong diversity, equity, inclusion, and accessibility (DEIA) initiatives.

The success of the Agency's DEIA initiatives significantly impacts NASA's reputation and remains a strategic goal because of its benefits to the talent pipeline and workplace productivity. Studies have shown that companies with more leadership diversity financially outperform industry competitors with less diversity.[58] Similarly, leaders from companies that qualify as "Best Places to Work" rate their companies substantially higher in multiple categories related to diversity and inclusion. In a September 2021 Policy Statement on DEIA, the NASA Administrator explained that DEIA unites a workforce; optimizes productivity; and mitigates groupthink, biases, and complacency. While NASA has made strides to raise its DEIA profile over the past several years, opportunities exist for it to further leverage its equity-conscious culture.

Paving the Way for Future Generations of Women in STEM

NASA celebrates the women who are breaking barriers and paving the way for future generations. In this image, Dr. Nancy Grace Roman (1925–2018, third from left), NASA's first Chief of Astronomy and the "Mother of Hubble" visited the Goddard Space Flight Center on March 31, 2017, and met some woman from the Hubble Space Telescope project.

Source: NASA

Our prior work has shown that NASA faces interrelated workforce challenges including a static pipeline of women and minorities into Science, Technology, Engineering, and Mathematics (STEM) positions; an aging workforce; and a growing shortfall of employees qualified in technical areas. NASA, much like the federal government as a whole, has struggled to ensure a diverse STEM workforce for decades. According to a report by the National Science and Technology Council, while women and individuals from underrepresented racial and ethnic groups comprise about 43 percent and 38 percent of the total federal workforce, respectively, they comprise only 29 percent and 10 percent of the federal STEM workforce.[59] NASA's diversity statistics are similar to the federal government's overall STEM workforce numbers with regard to race, ethnicity, and gender. As shown in Table 1, in FY 2020 NASA employed approximately 11,000 staff in the science and engineering fields, of which 25 percent are from underrepresented groups and 24 percent are women. That said, the percentage of Blacks in the NASA science and engineering workforce (6.2 percent) is lower than the federal STEM workforce average of 10 percent while the percentage of Hispanics is higher, with 8 percent at NASA compared to the federal science and engineering workforce of 6.2 percent.

Table 1: NASA STEM Employees by Race, Ethnicity, and Gender (Fiscal Year 2020)

NASA Workforce	Total Number	AAPI	Black	Hispanic	Multi-Racial	AIAN	White	Male	Female
All NASA Employees	17,458	8.4%	11.1%	8.4%	0.4%	1.0%	70.6%	65.8%	34.2%
Science and Engineering	11,338	9.7%	6.2%	8.0%	0.2%	0.8%	75.0%	76.0%	24.0%
Comparison Population									
Federal STEM Workforce	333,842	9.3%	10.0%	6.2%	1.9%	0.8%	69.2%	70.1%	29.9%

Source: National Aeronautics and Space Administration (NASA) Model Equal Opportunity Program Status Report: FY 2020.

Note: Asian American and Pacific Islander (AAPI) and American Indian and Alaska Native (AIAN).

[58] Development Dimensions International, *Diversity and Inclusion Report 2020*, from the Global Leadership Forecast series helps organizations answer key questions about the benefits of DEIA initiatives.

[59] National Science and Technology Council, *Best Practices for Diversity and Inclusion in STEM Education and Research: A Guide by and for Federal Agencies, A Report by the Interagency Working Group on Inclusion in STEM, Federal Coordination in STEM Education Subcommittee Committee, and the Committee on STEM Education of the National Science and Technology Council* (September 2021).

Further expanding efforts to increase the size and diversity of NASA's STEM workforce are significant barriers posed by traditional talent acquisition systems that have limited access to the hiring and onboarding of skilled STEM workers. In September 2021, the Partnership for Public Service reported that federal government agencies struggle with recruiting, hiring, and retaining diverse talent—those with specialized knowledge and skills needed in the workplace.[60] As an agency dependent on skilled STEM workers to accomplish its mission, NASA remains at risk from a shortage of such staff as competition for talent increases with the growth of the commercial space industry.

Moreover, success in increasing the size and diversity of NASA's STEM workforce may help alleviate workforce challenges related to pending retirements. The Office of Personnel Management reported that as of December 31, 2021, there were five times more federal employees 50 years of age or older than those under 30 (43 percent compared to 8 percent).[61] In fact, NASA has a larger percentage (51 percent) of its workforce in the 50+ age range than the federal average. Nearly 40 percent of the Agency's science and engineering workforce falls in the 55 and over range, employees that are nearing retirement. Given this situation, it is imperative that NASA develop a pipeline of skilled STEM workers.

Progress in Addressing the Challenge

For the past 10 years, NASA has been voted the best large agency to work for in the federal government according to the Partnership for Public Service. At the same time, the Agency continues to pursue the strategic goal of cultivating a diverse, motivated, and highly qualified workforce through modernizing its human capital processes and talent acquisition systems; increasing its workforce agility and flexibilities; and implementing a robust DEIA approach to ensure systematic and sustainable fairness, impartiality, and equity in its business practices.

Since 2011, federal agencies have been required to develop implementation plans to address government-wide objectives for recruiting, hiring, training, developing, advancing, promoting, and retaining a diverse workforce. In 2021, the Administration also issued multiple Executive Orders to advance racial equality and support underserved communities.[62] To comply with federal regulations and enhance the Agency's capabilities to engage underserved populations, NASA's Equity Action Plan (2022) seeks to, among other things, increase the percentage of minority-serving higher education institutions receiving grants and cooperative agreements from the Agency.[63]

Additionally, NASA's senior leadership has stated that creating an environment where all employees can flourish contributes to camaraderie and excellence, increasing the probability of retaining an experienced, diverse workforce. NASA's 2019 Unity Campaign called for employees to reflect on the practices and environments in which they feel safe and empowered to provide diversity of thought and build trustworthy relationships with their coworkers. In July 2020, the NASA Administrator added "inclusion" as the Agency' fifth core value, placing it on equal standing with the Agency's four other core values (safety, integrity, teamwork, and excellence). Further, in August 2022 the Agency issued its updated DEIA Strategic Plan that directed the Chief Diversity Officer to report directly to the Administrator and Deputy Administrator on all DEIA matters.[64] Center DEIA Councils and Employee Resource Groups are collaborating and advising on policy and implementation of the plan. To ensure leadership accountability, since 2020 supervisor performance plans now include sub-elements to promote a diverse and inclusive environment.

[60] Partnership for Public Service, *Roadmap for Renewing Our Federal Government* (accessed July 19, 2022). Partnership for Public Service is a nonpartisan, nonprofit organization that works to make the government more effective and efficient.

[61] The Office of Personnel Management serves as the chief human resources agency for the federal government. Data was accessed from *fedscope.opm.gov*.

[62] These executive orders include Executive Order 13985, *Advancing Racial Equity and Support for Underserved Communities Through the Federal Government* (January 20, 2021); Executive Order 14035, *Diversity, Equity, Inclusion, and Accessibility in the Federal Workforce* June 25, 2021); and Executive Order 14041, *White House Initiative on Advancing Educational Equity, Excellence, and Economic Opportunity Through Historically Black Colleges and Universities* (September 3, 2021).

[63] Elements of NASA's 2022 Equity Action Plan are in direct support of Executive Order 14041.

[64] The Chief Diversity Officer is the Associate Administrator for Diversity and Equal Opportunity.

NASA also recognizes both the Agency's and the nation's need for a pipeline of skilled STEM workers and through its Office of STEM Engagement (OSTEM) is hoping to engage students to enter the STEM workforce.[65] For the FY 2023 budget, NASA requested additional funding for OSTEM's Next Gen STEM and Minority University Research and Education Project to attract and retain underrepresented students in STEM fields. In addition, OSTEM is seeking opportunities to work with mission directorates to match funds and bolster STEM initiatives. Some of NASA's current initiatives include Historically Underutilized Business Zones, the CubeSat Launch Initiative, and the Robotics Alliance Project.[66]

Key Implemented Recommendations

Develop procedures for periodic communication of the available hiring authorities (IG-20-023).

Evaluate current and future critical technical staffing requirements by project over the next 5 years (IG-19-019).

Work Remaining to Address Challenge

NASA's ambitious plans ranging from the Mars Sample Return Campaign to the Moon to Mars effort and transformative space technology developments all require a sustained pipeline of talent. Significantly, for the first time the Planetary Science Decadal Survey included a "state of the profession" section.[67] The report highlighted the importance and urgency of DEIA, specifically broad access and participation to maximize excellence in an environment of fierce competition for limited human resources and ensure continued American leadership in planetary science and astrobiology. The Decadal made eight recommendations that included collecting accurate and complete DEIA data across industry, educating the workforce about the costs of bias and institutional improvement, engaging underrepresented communities at secondary and college levels, and creating an inclusive and inviting community for all.

An ongoing OIG audit is finding that representation of women and minorities in NASA's civilian workforce has remained static over the past decade, and the Agency has struggled to promote women and minorities in senior leadership positions and experienced a decrease in veteran hiring. To address these shortcomings, NASA will need visibility into its specific workforce skill types, experiences, and responsibilities, as well as the Agency's demographic representation and trends—data that currently is collected disparately among multiple systems.

For example, in a recent audit we found that the Astronaut Office's personnel databases lacked comprehensive demographic information specific to the astronaut corps such as race, national origin, gender, birthplace, education, or disability. Consequently, these data limitations restrict NASA's ability to fully measure its progress towards meeting broader DEIA goals—a significant issue given that astronauts are the most publicly visible employees at the Agency.[68]

A diverse STEM pipeline will help NASA to fill current workforce gaps and mitigate the effects of impending retirements. To address this challenge, the Agency should consolidate demographic representation and trend data into a single data set and continue to use its expanded hiring flexibilities.

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[65] OSTEM partners with organizations and educators to attract, engage, and prepare future STEM professionals. To encourage a multi-generational pipeline, OSTEM enhances school curriculums, publishes resources, and champions DEIA by exposing a diverse crowd to NASA and STEM opportunities.

[66] The Historically Underutilized Business Zones program encourages economic development in historically underutilized business zones; NASA policy is to provide the maximum practical number of acquisition opportunities to such businesses. The CubeSat Launch Initiative provides a low-cost pathway for CubeSats built by U.S. universities, high schools, and non-profit organizations to fly on upcoming launches. The Robotics Alliance Project seeks to increase STEM interest and create a future technical workforce for the aerospace community through the support of robotics competitions that pair high school students with engineering and technical professionals.

[67] National Academies of Sciences, Engineering, and Medicine, *Origins, Worlds, and Life: A Decadal Strategy for Planetary Science and Astrobiology 2023-2032* (2022).

[68] NASA OIG, *NASA's Management of Its Astronaut Corps* (IG-22-007, January 11, 2022).

Key Unimplemented Recommendations

Centralize and maintain the collection and monitoring of detailed astronaut data to better fulfill NASA's strategic goals, including continuing to expand the diversity of the astronaut corps (IG-22-007).

Finalize and fully implement the performance metrics dashboard to measure acquisition performance (IG-21-002).

Engage relevant Centers and technical capability leaders to identify budgetary and accounting system solutions within the current budgetary and full cost accounting system to adequately fund and sustain critical technical discipline capabilities needed to support current and future projects (IG-20-023).

Review and identify opportunities based on existing NASA leading practices to foster and monitor mentoring to ensure a robust pipeline for Planetary Science Division-related disciplines (IG-20-023).

Ongoing and Anticipated Future Audit Work

NASA's Efforts to Advance Diversity, Equity, Inclusion, and Accessibility

This audit will evaluate NASA's efforts to advance DEIA.

NASA's Science, Technology, Engineering, and Mathematics Engagement

This audit will examine NASA's STEM engagement activities to determine whether the Agency is effectively implementing its strategic objectives and STEM projects.

Relevant OIG Reports

NASA's Management of Its Astronaut Corps (IG-22-007, January 11, 2022)

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

NASA's Planetary Science Portfolio (IG-20-023, September 16, 2020)

Management of NASA's Europa Mission (IG-19-019, May 29, 2019)

Challenge 7: Managing NASA's Outdated Infrastructure and Facilities

Why This Is a Challenge

NASA is one of the largest property holders in the federal government with $47 billion in physical assets and an inventory of more than 5,300 buildings and structures across 12 states and the District of Columbia. Over its past six decades, NASA and its commercial partners have relied on the Agency's facilities and infrastructure, including office buildings, laboratories, launch complexes, test stands, and wind tunnels, to develop new and innovative technologies to advance space exploration missions, scientific research, and aeronautics. However, more than 75 percent of NASA's facilities are beyond their original design life and the Agency faces a deferred maintenance backlog estimated at $3 billion as of 2022.[69] Deferring maintenance until equipment fails has resulted in repair and replacement costs up to three times more than had NASA conducted regular maintenance.

NASA is also at a crossroads regarding the number and size of facilities it will need in the future as the Agency expands its hybrid work environments following the COVID-19 pandemic. Currently, the Agency is in an experimental phase of its return-to-work plan with many employees having options to telework from their home on a full-time, part-time, or ad hoc basis, or work regularly from a NASA facility. The Agency is in the process of evaluating this experimental phase to identify work patterns and assess which options are the most productive for the Agency. That analysis will, in turn, inform investment and divestment decisions regarding NASA's office space requirements.

NASA has several options for facilities for which there is no current or future mission need. The Agency may retain the property in its present state, demolish the property, transfer the property to the General Services Administration for sale, or lease the property. Leasing is an option that has the benefit of generating revenue the Agency can use to help reduce expenses and defray the costs of maintaining and improving facilities. Since 2003, NASA has had the authority to develop underutilized property using enhanced use leases—an authority granted by Congress that allows the Agency to accept cash and in-kind consideration from federal and non-federal entities for real property leases and for the Agency to retain the proceeds. The proceeds may be used for maintenance, revitalization, and improvements of real property assets. NASA's current enhanced use lease authority extends through December 31, 2032. While leasing enables NASA to keep facilities in its inventory that may be needed for future projects, the Agency must ensure that leasing does not replace disposing of property that is not needed now or in the foreseeable future.

Progress in Addressing the Challenge

NASA's Construction of Facilities (CoF) program is working to modernize the Agency's infrastructure into fewer, more sustainable facilities and repair and replace failing infrastructure to reduce overall maintenance costs. Between FYs 2016 and 2022, NASA received over $2.5 billion in CoF funding that it used for construction projects and facility upgrades. For example, the Exploration Ground Systems Program at Kennedy Space Center upgraded infrastructure and facilities required for the Artemis program, including modernization of Launch Pad 39B and modification of the Vehicle Assembly Building to accommodate the SLS rocket and Orion capsule. During this period, the Agency also made other significant investments in facilities and infrastructure such as antennas, laboratories, office buildings, and wind tunnels at Centers across the country and satellite locations around the world.

NASA Deep Space Network Antenna

Deep Space Station 53, an 111-foot antenna, went online in February 2022 at the Deep Space Network's facility located outside of Madrid, Spain. This is the Network's 14th antenna, all of which enable engineers and scientists on Earth to communicate with spacecraft on deep space missions exploring the solar system.

Source: NASA

[69] Deferred maintenance is the total essential but unfunded maintenance work necessary to bring facilities and related equipment to acceptable maintenance standards.

As recommended in our September 2021 audit, NASA is working to make its CoF program more effective and efficient by developing an Agency-wide process to prioritize and fund CoF projects that better align with Agency missions.[70] In addition, the Agency is revising policies to establish parameters for the use of CoF funds, require energy savings projects to consider life-cycle costs, and request the demolition of like facilities during reduction and consolidation efforts.[71] NASA is also instituting a process to ensure facility requirements are identified and funding sources specified during a program's development and implementation phases. Lastly, the Agency is reexamining policies and processes to more effectively oversee the CoF program.

Key Implemented Recommendations

Revise NASA Procedural Requirements 8820.2G to define and establish parameters for the use of institutional and programmatic CoF funds and establish a cost-sharing method for facilities that will have more than one user, require energy savings projects to consider life-cycle costs as part of their cost-benefit analyses, and include requirements to reduce and consolidate the Agency's footprint that consider the demolition of like facilities when possible for discrete construction projects (IG-21-027).

Work Remaining to Address Challenge

Over the past few years, we have assessed a variety of infrastructure issues including the Agency's environmental remediation efforts; management of NASA's historic real and personal property; and efforts to "rightsize" NASA's workforce, facilities, and other supporting assets.[72] Additionally, we have assessed whether NASA met cost, schedule, and performance goals for the construction of new assets such as test stands and mobile launchers for the Artemis program; its efforts to reduce unneeded infrastructure and facilities; and the process to select, prioritize, and fund CoF projects. Common issues identified from these reviews include NASA's slow implementation of corrective actions, inconsistent implementation of Agency policies, inadequate life-cycle cost considerations in facility construction decisions, a decentralized strategy and decision-making processes, questioned costs related to the Agency's approach for cleaning soil contamination at the Santa Susanna Field Laboratory, and substantial cost increases and schedule delays due to poor contractor performance.

In August 2022 we reported on Ames Research Center's lease practices that resulted in the Center negotiating unfavorable financial terms and conditions such as not including required termination clauses and entering into leases that were not in the best interest of the government.[73] Overall, we found no assurances in the (1) fidelity of the leasing process, as it lacked key controls, oversight, and transparency relative to competition, selection, and process documentation; (2) fair return to NASA when there were no objective assessments of benefits and costs, and rental amounts were not based on fair market value; and (3) protection of NASA's interests as the process did not ensure inclusion of the required certifications, termination clauses, and coordination among key stakeholder organizations. Further, the nature of some of the leases raise security concerns as Ames Research Center and headquarters security personnel were not consistently consulted in a timely manner during lease negotiations.

Overall, NASA remains challenged to make the difficult decisions to invest, divest, lease, or consolidate unneeded infrastructure; effectively communicate those decisions to stakeholders; and withstand the inevitable political pressure to retain unnecessary capabilities and facilities at Centers throughout the country—all long-standing issues that we have discussed in previous top management and performance challenges reports.

[70] NASA OIG, *NASA's Construction of Facilities* (IG-21-027, September 8, 2021).

[71] Energy savings projects implement energy conservation measures and install renewable energy facilities such as solar plants.

[72] Environmental remediation is the removal of pollution or contaminants from water and soil to protect human health and restore the environment.

[73] NASA OIG, *Ames Research Center's Lease Management Practices* (IG-22-015, August 4, 2022).

Key Unimplemented Recommendations

Conduct cyclical reviews (no less than once every 5 years) of the Ames Research Center lease process to ensure compliance with federal and NASA requirements (IG-22-015).

Update applicable real estate policies and NASA-wide guidance to incorporate applicable security requirements and agreement clauses in leases (IG-22-015).

Ongoing and Anticipated Future Audit Work

NASA's Space Communication Infrastructure Upgrade and Modernization Projects

This audit will assess the progress towards upgrading the Near Space Network and Deep Space Network ground stations and the ability of the Networks to support current and future mission requirements.

Relevant OIG Reports

Ames Research Center's Lease Management Practices (IG-22-015, August 4, 2022)

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

NASA's Construction of Facilities (IG-21-027, September 8, 2021)

NASA's Management of Hazardous Materials (IG-21-006, December 3, 2020)

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

NASA's Progress with Environmental Remediation Activities at the Santa Susana Field Laboratory (IG-19-013, March 19, 2019)

Appendix A: Strategic Goals and Objectives

Figure 3 shows the seven challenges we identified for 2022 and the related NASA strategic goals and objectives.

Figure 3: 2022 Top Management and Performance Challenges Linked to NASA Strategic Goals and Objectives

Challenge 1: Returning Humans to the Moon

- ***Strategic Goal 2:*** Extend human presence to the Moon and on towards Mars for sustainable long-term exploration, development, and utilization
- ***Strategic Objective 2.1:*** Explore the surface of the Moon and deep space
- ***Strategic Objective 2.3:*** Develop capabilities and perform research to safeguard explorers
- ***Strategic Objective 3.1:*** Innovate and advance transformational space technologies
- ***Strategic Objective 4.2:*** Transform mission support capabilities for the next era of aerospace
- ***Strategic Objective 4.3:*** Build the next generation of explorers

Challenge 2: Improving Management of Major Programs and Projects

- ***Strategic Goal 1:*** Expand human knowledge through new scientific discoveries
- ***Strategic Goal 2:*** Extend human presence to the Moon and on towards Mars for sustainable long-term exploration, development, and utilization
- ***Strategic Goal 3:*** Catalyze econonic growth and drive innovation to address national challenges
- ***Strategic Objective 2.2:*** Develop a human space flight economy enabled by a commercial market
- ***Strategic Objective 2.4:*** Enhance space access and services

Challenge 3: Sustaining a Human Presence in Low Earth Orbit

- ***Strategic Objective 2.2:*** Develop a human space flight economy enabled by a commercial market
- ***Strategic Objective 2.4:*** Enhance space access and services
- ***Strategic Objective 3.1:*** Innovate and advance transformational space technologies
- ***Strategic Objective 3.2:*** Drive efficient and sustainable aviation

Challenge 4: Managing and Mitigating Cybersecurity Risks

- ***Strategic Objective 4.2:*** Transform mission support capabilities for the next era of aerospace

Challenge 5: Improving Oversight of Contracts, Grants, and Cooperative Agreements

- ***Strategic Goal 3:*** Catalyze econonic growth and drive innovation to address national challenges
- ***Strategic Objective 1.3:*** Ensure NASA's science data are accessbile to all and produce practical benefits to society
- ***Strategic Objective 2.2:*** Develop a human space flight economy enabled by a commercial market
- ***Strategic Objective 2.4:*** Enhance space access and services

Challenge 6: Attracting and Retaining a Diverse and Highly Skilled Workforce

- ***Strategic Objective 4.1:*** Attract and develop a talented and diverse workforce

Challenge 7: Managing NASA's Outdated Infrastructure and Facilities

- ***Strategic Objective 4.2:*** Transform mission support capabilities for the next era of aerospace

Source: NASA OIG analysis of the Agency's 2022 Strategic Plan.

Appendix B: Acronyms

APL	Applied Physics Laboratory
CoF	Construction of Facilities
DEIA	diversity, equity, inclusion, and accessibility
EVM	Earned Value Management
FAA	Federal Aviation Administration
FY	fiscal year
GAO	Government Accountability Office
HLS	Human Landing System
ISS	International Space Station
IT	information technology
ML-2	Mobile Launcher 2
OCIO	Office of the Chief Information Officer
OIG	Office of Inspector General
OSTEM	Office of STEM Engagement
SAISO	Senior Agency Information Security Officer
SLS	Space Launch System
STEM	Science, Technology, Engineering, and Mathematics
VIPER	Volatiles Investigating Polar Exploration Rover

NOVEMBER 2022

Appendix C: Management's Comments

National Aeronautics and Space Administration

Office of the Administrator
Mary W. Jackson NASA Headquarters
Washington, DC 20546-0001

October 26, 2022

TO: Inspector General

FROM: Administrator

SUBJECT: Agency Response to Office of Inspector General Report, "2022 Report on NASA's Top Management and Performance Challenges"

The National Aeronautics and Space Administration (NASA) appreciates the opportunity to review and comment on the Office of Inspector General (OIG) report entitled, "2022 Report on NASA's Top Management and Performance Challenges," (Q-22-04-AOQA) issued October 3, 2022.

The audits and investigations conducted by your office provide NASA's leadership and management with valuable insight into NASA's broad portfolio of programs, projects, and mission support activities. The efforts expended by your office during this past year have supported the cause of maximizing the value of taxpayer investments in NASA's ambitious, wide-ranging, and challenging portfolio. As an Agency, we continue to address and remediate findings related to the audit recommendations issued by your office, including those cited in your 2022 Report on NASA's Top Management and Performance Challenges.

While we fundamentally agree that the seven areas outlined in your 2022 report constitute significant challenges for the Agency, we would like to highlight the following efforts that have been taken or are underway to address your office's recommendations. These efforts substantively demonstrate NASA's commitment to addressing the management and performance challenges identified by the OIG:

Challenge 1: Returning Humans to the Moon by 2024

NASA has made significant strides in our efforts to return humans to the moon through the Artemis campaign. This includes significant progress by the programs contributing systems and functionality to the Artemis Missions, and by the overall management and integration organizations overseeing this campaign. The Artemis Campaign Development and Common Exploration Systems Development divisions within the Exploration Systems Development Mission Directorate (ESDMD) continue to partner and refine the roles, responsibilities, and authorities for the management of the Artemis missions. The collaborative work has included the creation of: joint risk and schedule reviews, joint boards for controlling technical and programmatic processes, common working groups, and technical integration forums to ensure the coordination and interoperability of the multiple systems that are needed to make up each

Artemis Mission. NASA is also implementing established programmatic processes to set Agency Baseline Commitments for the Artemis programs that are going through their development efforts. Furthermore, ESDMD is working closely with the Space Operations Mission Directorate to implement a novel services-based contract structure, Exploration Production and Operations Contract, which will reduce long-term costs in NASA's human spaceflight programs.

A key focus of the Agency over the past year has been preparation for the launch of the Artemis I mission, and the collection of valuable lessons learned from the first-time operations flow of the Space Launch System (SLS) Block 1 variant/Mobile Launcher (ML) at Kennedy Space Center (KSC). As learned from the Shuttle Program, each Wet Dress Rehearsal and launch attempt provides an excellent opportunity to simulate real-time issues. Over the course of four Wet Dress Rehearsals, NASA met all primary and secondary test objectives, including, among others: demonstrating cryogenic load operations, activating Launch Complex 39 and the KSC Launch Control Center (LCC) for Day of Launch terminal countdown operations, validating LCC interfaces and procedures for roll-out and roll-back, and collecting data on Orion, SLS, and ML launch configuration loads. Thereafter, two launch attempts occurred, each yielding important information. The first launch attempt, which took place on August 29, 2022, was ultimately scrubbed due to a pre-chill LCC violation; the second, which took place on September 3, 2022, was scrubbed due to a liquid hydrogen leak in the Tail Service Mast Umbilical, which has since been resolved. The next launch attempt is planned to occur on November 14, 2022.

NASA has also made tremendous progress toward the Artemis II launch and forward development for Artemis III missions and beyond. As is widely known, the Artemis II mission will require re-use of Artemis I non-core avionics. While this creates a dependency between the two missions, the Orion team has diligently performed parallel work to prepare both the Crew and Service Modules for integration. On the Crew Module, for example, all pressure vessel heater closeouts have been performed and wire harness connector mates continue in the forward section. Meanwhile, the team has also completed service module initial power on and several subsystem functional tests. Artemis III hardware development has similarly progressed.

While progress and schedules were impacted due to the contract award protests, NASA continues to make progress with the Human Landing System (HLS) program. NASA has awarded a contract to SpaceX for the certification and demonstration of a lunar lander that will deliver the first crew to the lunar surface during the Artemis III mission. HLS has also accelerated the HLS services acquisition approach, and in a standalone procurement (Broad Agency Announcement Appendix N), HLS selected five companies to perform risk reduction activities to advance the industry's proposed content for sustained lunar landing services. In September 2022, the HLS program posted the Broad Agency Announcement Appendix P solicitation. Through this solicitation, NASA is seeking proposals for the development and demonstration of a lunar lander that meets NASA's HLS sustaining requirements for missions beyond Artemis III. In addition to developing a sustainable HLS, commercial and international partners will be able to leverage new capabilities developed through this initiative for the execution of multiple other missions over the coming decades. This includes the potential to participate in regularly recurring hardware and services procurements by NASA.

Development on the SLS Block 1B variant, set to fly on the Artemis IV mission, has continued in preparation for a recurring cadence of missions with increasingly complex needs; establishment of an Agency Baseline Commitment for this upgrade is imminent. In parallel, the Exploration Ground Systems program has worked diligently with its prime contractor to work through performance issues on the development of the Mobile Launcher 2. Two independent review teams have provided recommendations currently undergoing implementation. A commitment will be established upon resolution of outstanding issues and consensus with the prime contractor on a revised cost and schedule plan that meets the Agency's exploration goals and needs.

After conducting a Program-level Preliminary Design Review-informed Sync Review earlier in 2022, the Gateway program is finalizing contractual updates as it transitions to the critical design and flight hardware production phase of the Gateway Initial Capability. The Gateway Initial Capability will provide the backbone of the multi-purpose outpost orbiting the Moon, made up of the Power and Propulsion Element (PPE) led by Maxar and the Habitation and Logistics Outpost led by Northrup Grumman. This outpost is planned to be expanded by international contributions that are currently in progress by the European Space Agency, Japan Aerospace Exploration Agency, and Canadian Space Agency. Gateway element-level Critical Design Reviews (CDR) are in progress and continue to refine and finalize requirements for PPE as it nears completion in expectation of an early 2023 PPE CDR.

NASA formulated the Extravehicular Activity and Human Surface Mobility Program (EHP) to lead the efforts needed to explore the surface of the moon. This new program has taken the lead for managing the development of lunar surface suits, tools, and vehicles that lunar astronauts will need to explore and conduct science outside of the lander and habitats on the lunar surface. EHP has awarded contracts to both Axiom and Collins for the development of Exploration Extravehicular Activity (xEVA) suits and systems that will be provided through the xEVA Services (xEVAS) contract in support of Artemis and the International Space Station (ISS). Axiom has further been awarded the initial task order for the Artemis suit development, which represents the completion of all major acquisition work needed to support the Artemis III mission. The accelerated development of the xEVAS systems has been enabled by the sharing of NASA's reference design information, including sharing of design verification test reports and integrated performance data from years of NASA-led research and development.

Challenge 2: Improving Management of Major Projects and Projects

NASA's major project portfolio spans five Mission Directorates and all NASA Centers. Further, NASA's program management discipline includes rigorous processes that encompass program formulation, approval, implementation, and ongoing evaluation. Recognizing that NASA develops unique hardware and new technologies to make new discoveries and expand the realm of the possible, challenges are inherent in the management of NASA's programs and projects. NASA has implemented a culture of continuous improvement and is committed to pursuing innovative policies and methods that enable effective technical and risk management, mature program planning and control practices, and ultimately successful missions that meet cost and schedule commitments.

In the past four years, NASA has fully implemented 11 new initiatives geared toward improving acquisition and project management. This includes the six implemented initiatives from the 2018 Corrective Action Plan and five of six initiatives from the 2020 Corrective Action Plan with the sixth initiative on path to closure. Moreover, NASA approved the new 2022 Corrective Action Plan that introduces five new initiatives addressing Government Accountability Office acquisition management concerns. These initiatives will: 1) improve NASA's capacity for program planning and control (PP&C) insight and analysis through greater capability and expanded civil servant workforce; 2) achieve more rigorous independent review of major projects at major life cycle reviews; 3) sustain insight into major project programmatic data; and 4) test innovative approaches to streamline and enhance major contract proposals and reviews. These initiatives are addressing critical needs as identified by subject matter experts both internal and external to the Agency and demonstrate a sustained commitment from NASA leadership to the improvement of the challenges highlighted by the OIG and others. As NASA's major project development timelines are long term in nature, these benefits are expected to take time to be realized.

NASA is fully compliant with Title 51 by having all major development activities be subject to Congressional reporting and performance thresholds. For programs and projects that plan continuing operations and production, including integration of capability upgrades with an unspecified Phase E end point, the initial capability cost estimate and other parameters become the Agency Baseline Commitment. In addition, NASA establishes Agency Baseline Commitments for all future major development activities and communicates a five-year, Phase E operations cost estimate prior to entering Phase E Operations and Sustainment. The Phase E operations cost estimate is updated annually. NASA's approach is in compliance with Title 51 and ensures the Agency is consistently and effectively communicating estimates of Phase E operations as the mission cadence matures.

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

With respect to updating NPR 7120.8, "NASA Research and Technology Program and Project Management Requirements" to require major acquisition projects that cost over $250 million to complete a Joint Cost and Schedule Confidence Level (JCL) analysis and implement Earned Value Management (EVM), NASA does not concur with the recommendation to include a JCL analysis for activities covered in this NPR. NPR 7120.8 policy follows a different philosophy than NPR 7120.5, which compiles a comprehensive set of requirements for space flight that may need to be tailored down for smaller scale efforts that are not crewed. NPR 7120.8 applies the principle of a minimum set of essential requirements and maximum flexibility for Research and Technology (R&T) development activities, and these projects are exploratory, requiring more management flexibility and have a higher risk acceptance by the Agency. Rather than tailoring

down from the directive's requirements, R&T projects may need to pull in additional requirements from NPR 7120.5 for more robust or structured project management, particularly on larger projects that may transition to flight. Specifically, concerning cost and schedule requirements, NPR 7120.8 does not specify any required probabilistic analysis technique. The recently established Chief Program Management Officer advises the Decision Authority (DA) on applicability of projects following NPR 7120.5 or NPR 7120.8, and the Office of the Chief Financial Officer advises the DA on whether JCL or EVM requirements should be applied.

The missions that the Nation entrusts NASA to accomplish are difficult and mission success is never guaranteed. As OIG recognizes in its report, overcoming the incredible challenges before us as we design, develop, and operate our mission portfolio requires consistent, focused attention from NASA leadership. NASA has made a number of advances in its governance and programmatic discipline in recent years, including: overhauling the monthly Baseline Performance Review; shifting the role of the Chief Acquisition Officer to the Deputy Administrator; adding several new requirements to the early acquisition decision process; advancing the analytical capability of the PP&C workforce at every phase of the mission lifecycle; expanding the implementation of EVM across the Agency; and generating new training curricula and fora for community exchange of ideas. The COVID-19 global pandemic added significant unanticipated pressure on project cost and schedule resources, through which the Agency achieved notable mission successes. During the pandemic, NASA successfully: landed the Perseverance rover on Mars; conducted the first launch of crew from United States soil with a U.S. commercial service provider; demonstrated controlled atmospheric flight on another planet; peered into the universe with the fully operational James Webb Space Telescope; impacted a small asteroid seven million miles from Earth to redirect its orbit; collected a sample from an asteroid and began returning it to Earth; took in-situ measurement from the surface of the Sun; and prepared to fly the X-57 to test an all-electric propulsion aircraft and the X-59 to test quiet supersonic flight. On the precipice of launching the first mission of the Artemis campaign, NASA will continue to pursue intelligent, efficient, and effective solutions to improve project management and ensure mission success.

Challenge 3: Sustaining a Human Presence in Low Earth Orbit (LEO)

NASA has made considerable progress on each of the Commercial LEO-related challenges identified in IG-22-005, "NASA's Management of the International Space Station and Efforts to Commercialize Low Earth Orbit," November 30, 2021. Specifically:

#1: Robust Market for Low Earth Orbit Yet to Materialize: SpaceX completed the Inspiration4 mission in September 2021, the first all civilian orbital spaceflight. Jared Isaacman and SpaceX announced plans for three additional crewed flights, dubbed the Polaris Program, slated for launch in 2022 and 2023. The Ax-1 private astronaut mission successfully launched, docked with the ISS, and safely returned to Earth in April 2022. NASA selected Axiom Space for the second private astronaut mission, targeted to launch in 2023, and the solicitation for a third and fourth private astronaut mission was released in September 2022. NASA selected eight In-Space Production Application flight demonstrations to help stimulate demand for microgravity. NASA continues to receive proposals for commercial and marketing activities on the ISS. Four such activities have successfully flown to the station. NASA has also contracted with BryceTech to refine the forecast for non-NASA market demand for microgravity services.

#2: Funding for Destination Platform is Inadequate for NASA to Meet 2028 Goal: The Fiscal Year (FY) 2022 NASA Appropriations ($101.1 million for Commercial LEO Development) fully supported NASA's near-term strategy to develop a human spaceflight economy enabled by a commercial market. The FY 2023 President's Budget Request included $224.3 million for the Commercial LEO Development Program (a 120 percent increase). The House Committee on Appropriations FY 2023 report fully supported the budget request and NASA continues to refine its out-year budget requirements.

#3: Unreliable Cost Estimates: Prior cost estimates primarily had to use parametric cost models assuming "generic" commercial LEO destination designs. Now, NASA is partnered with four industry partners (Axiom Space, Blue Origin, Nanoracks, and Northrop Grumman) to develop specific commercial LEO destination designs. The industry partners are maturing their designs, meeting their milestones, and maturing their cost estimates. NASA has extensive insight into all these activities.

#4: Optimistic Development Schedules: NASA's four industry partners for Commercial LEO Destinations are on track executing their milestones, maturing their concepts, and refining their schedule estimates. Some flight hardware has already begun fabrication. NASA has quarterly meetings with our industry partners to assess their progress and gain additional insight into their development schedule. The Commercial LEO Destinations partners are strongly incentivized to be first-to-market, particularly for their commercial customers. NASA continues to refine its acquisition strategy for the eventual certification and services purchases for Commercial LEO Destinations.

#5: Evolving Requirements: NASA has established a Commercial LEO Destinations Services Requirements Working Group to develop utilization requirements. NASA has also established a Commercial LEO Destinations Utilization Forum for science and research subject matter experts to share information and enable communication with Commercial LEO Destination partners. NASA released the first of several Request for Information (RFI) documents in May 2022 that contain draft crew certification requirements, and a white paper documenting the Agency's current assumptions and expectations on commercial destinations. NASA received 300 comments from industry and we are currently assessing the input. NASA plans to release future RFIs quarterly to include: draft Commercial LEO Destination System, Crew, and Utilization Services Requirements; Commercial LEO Destination Certification Strategy White Paper; draft Technical Management and Standards Requirements; and draft Concept of Operations.

NASA continues to work with its International Partners to extend ISS operations to 2030. All partner governments continue to indicate their intention to support operation ISS beyond 2024 as they work through their respective governments' processes.

NASA also continues to work with Roscosmos to identify and repair leaks in the transfer tunnel section of the Russian Service Module. Three locations have been sealed resulting in a total ISS leak rate of 1.2 lbm/day. Strain gauges were installed at the location of the first crack, and the results are consistent with accelerometer data and are well below the levels of concern for structural fatigue. Additional diagnostic devices including ultrasound and high definition borescopes will be delivered in early 2023. Materials testing to date does not indicate cracking

due to stress corrosion. As indicated in the response to OIG report A-21-003-00, "NASA's Utilization of the International Space Station and Commercialization of Low Earth Orbit", NASA remains confident in moving forward with plans to extend the ISS, noting that we will continue to monitor and evaluate ISS health moving forward.

Challenge 4: Managing and Mitigating Cybersecurity Risk

NASA has made significant progress in managing and mitigating cybersecurity risk. The Office of the Chief Information Officer (OCIO) consolidated Center Chief Information Officer (CIO)-managed cybersecurity resources into an enterprise-wide Cybersecurity Service Line that will support integrated cyber solutions across Centers and mission programs. The Cybersecurity Service Line will enable OCIO to proactively manage and mitigate cybersecurity risks. Over the past year, in partnerships with the NASA Office of Communication and the Science Mission Directorate, the NASA CIO has been leading an effort to modernize NASA's website presence, including reducing NASA's digital footprint, with results expected in FY 2023. As part of OCIO's restructuring, Agency Level Offices were established that will, among other things, bring an Agency-wide focus to issues of Information Technology (IT) Strategy, enterprise architecture, and technology roadmaps.

The NASA CIO established an Agency-level IT Strategy and Architecture Office (SAO), led by a newly appointed NASA Chief Enterprise Architect, comprised of enterprise-level architects across business and technology domains (including cybersecurity). The SAO will define and mature processes, procedures, and relationships across OCIO, Mission Directorates, and Mission Support organizations to ensure that a holistic and integrated Enterprise Architecture program exists across organizational boundaries. Finally, the NASA CIO and Office of Protective Services have established a strong partnership in implementing NASA's existing insider threat efforts and will continue to mature these efforts to address insider threats to unclassified networks, including strengthening partnership with other offices to support this work.

Challenge 5: Improving Oversight of Contracts, Grants, and Cooperative Agreements

NASA is making meaningful progress in addressing contracts, grants, and cooperative agreement oversight challenges, and continues to strengthen its overall procurement processes and policy. NASA's Office of Procurement (OP) has implemented the following improvements: OP established the Enterprise Service and Analysis Division (ESAD). Under ESAD, the E-Business Systems Office (ESBO) and the Enterprise Pricing Office (EPO) were established. Within ESBO, an Enterprise Procurement Data Architect will oversee all efforts to define and govern data (standardization and analysis) that will be used to manage OP services and create a Procurement Dashboard and other analytical data tools that will provide greater insight into the procurement function across the enterprise. Within EPO, the cost price function is centralized and will streamline pricing policies, processes, the cross utilization of pricing resources and training across the enterprise. In FY 2022, OP resumed Procurement Management Reviews annually to ensure Centers' compliance with procurement laws and regulations; to provide oversight over procurement practices; and to improve the operational effectiveness and efficiency of Centers procurements. Additionally, OP Grants Policy and Compliance has developed and implemented a Routine Monitoring Plan to enhance oversight of grants and cooperative agreements.

Challenge 6: Attracting and Retaining a Highly Skilled and Diverse Workforce

Competing for talent in today's increasingly fierce labor market requires a coordinated and strategic approach to attract and develop a pipeline of skilled and diverse science, technology, engineering, and mathematics workers to meet NASA's mission needs. To that end, NASA has implemented a workforce planning process that includes all NASA Centers and Mission Support Enterprise Organizations and incorporates known programmatic requirements such as our Artemis missions. NASA Mission Directorates are developing guidance that provides clarity on future work content and enhances the strategic planning process for Mission workforce to ensure success in all Mission areas. The guidance will establish the vector for work in the planning and budgeting horizon and beyond (for year five+) to prepare for the work demand in the long-term including enduring capabilities and disciplines. Guidance will be consistent with established Center roles and aligned with Mission Directorate acquisition strategies, major program/project initiation, and the completion of key milestones. This guidance integrates Mission work requirements with Center workforce planning efforts to drive the Agency continuously forward with a demand-driven approach to meet future program content. NASA Centers will respond to Mission Directorate guidance in their annual workforce plans.

NASA's Office of the Chief Human Capital Office modernized the recruiting process and developed a coordinated recruitment strategy using a standardized approach and leveraging digital platforms to engage with prospective candidates. A critical piece of the recruitment strategy focuses on increasing workforce diversity by reaching new talent communities and establishing NASA as an employer that celebrates diversity and inclusion as keys to success. NASA continually measures efforts and iterates on its recruitment strategy to ensure success. Multiple hiring authorities are utilized to quickly fill positions as well as pay incentives to recruit the right skills into the Agency.

NASA acknowledges the need to consolidate demographic representation and trend data into a single data set. The Enterprise Data Platform (EDP) elevates the Agency's ability to seamlessly find, harness, and translate data into actionable insights. The EDP will provide all NASA data stakeholders with a platform of easily searchable and usable data assets and a centralized data store for simple access to standardized and trustworthy data sets on a single platform.

Since the most recent OIG audit of the Astronaut Office, demographic information for the entire corps, including civilians and military personnel, has been centralized. Additionally, the Master Assessment and Qualifications History tool is currently undergoing software updates and will be used as the primary database for detailed astronaut data regarding skills, certifications, and training. While this data has historically been available and utilized to help inform the selection of astronaut candidates, maintaining this information comprehensively in centralized and secure locations better supports future recruitment and selection goals related to acquiring key skills for NASA missions and expanding the diversity of the astronaut corps.

The Agency remains committed to tackling workforce issues and to building an even stronger talent pipeline to accomplish NASA missions.

Challenge 7: Managing NASA's Outdated Infrastructure and Facilities

To address the challenges with aging infrastructure and facilities, NASA is implementing a top-down, mission-driven Agency Master Plan (AMP). This plan ensures that the required infrastructure is available and affordable, guides Agency investments to prioritize mission critical assets, reduces the risk of unplanned failures, and guides divestment of assets not needed for the Agency's missions. The AMP will establish a 20-year vision for physical infrastructure and real property assets that aligns with current, evolving, and future mission requirements. NASA will use this process to identify critical capabilities and areas for asset sustainment, investment, repurposing/out granting, or divestment of infrastructure. To alleviate the maintenance burden, NASA's Office of Strategic Infrastructure (OSI) will continue to strongly advocate to increase its funding for demolition of unneeded facilities.

NASA released NPR 8820.2 Revision H, "Facility Project Requirements", on September 27, 2022. This revision includes parameters for the assignment and use of institutional and programmatic Construction of Facilities (CoF) funds, the ability to identify cost-sharing as a funding method, a requirement for energy savings projects to conduct life cycle cost analyses, requirements to reduce and consolidate the Agency's footprint, tools to assist in the development of project requirements, and definition of new Headquarters roles that will improve oversight of the implementation of CoF projects.

OSI concurs with the challenges identified that are associated with leasing NASA facilities to non-NASA entities. In 2019, OSI began to conduct an analysis on the Agency's leasing policies, procedures, and practices. As a result of this analysis, in 2020, NASA decided to centralize real estate functions across all Centers to OSI-FRED (OSI-Facilities and Real Estate Division). Additionally, OSI-FRED is in the process of updating the NPR 8800.15, "Real Estate Management Program" and is conducting a complete analysis of the Agency's Enhanced Use Lease Program to ensure that internal controls are established, real estate agreements are properly coordinated with all stakeholders, and are compliant with all rules, regulations, and laws.

NASA has also identified investment strategies using Reliability Centered Maintenance (RCM) principles to stave off the increasing deferred maintenance liability within the Agency. OSI-FRED is implementing a Tiered Maintenance approach with foundations of Condition Based Maintenance principles for relevant and critical assets. These efforts will lead to optimized maintenance programs and prioritization of available operations and maintenance resources. OSI leadership continues to inform and carry forward advocacy for additional investments necessary to improve the condition of important building systems and facilities across the Agency. Ultimately, this will increase the availability and reliability of these critical assets to meet current, emerging, and future mission needs. Implementation of these RCM principles ensures that the right type of maintenance is performed on the most critical assets, at the right time, and for the right reasons. RCM, paired with immediate investments in the replacement of obsolete items associated with the Agency's higher-criticality assets, can provide near-term corrective mitigation for known risks, and avoid mission/schedule impacts. These maintenance strategies focus on increasing equipment availability and avoiding disruptive failures and unplanned repair costs.

These initiatives will mitigate the Agency's ongoing challenge of aging and outdated infrastructure and facilities. Through the implementation of the AMP and the ongoing investments in maintenance, demolition, repair, recapitalization, and out-granting, NASA continually strives to right-size the Agency's infrastructure toward more modern and efficient facilities that will continue to provide a robust real property asset portfolio for NASA mission objectives.

If you have any questions regarding NASA's response to the 2022 Top Management and Performance Challenges, please contact Anthony Mitchell, Audit Liaison Project Manager at (202) 358-1758.

cc:
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