

# NASA

National Aeronautics and Space Administration

Office of Inspector General

Office of Audits

# 2021 REPORT ON NASA'S TOP MANAGEMENT AND PERFORMANCE CHALLENGES

November 15, 2021





## **Office of Inspector General**

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# MESSAGE FROM THE INSPECTOR GENERAL

This report presents the Office of Inspector General's (OIG) independent assessment of the top management and performance challenges facing NASA.<sup>1</sup> For 2021, we identified eight challenges and linked each challenge to one or more of NASA's strategic goals and objectives (see Appendix A).<sup>2</sup>

- Challenge 1: Returning Humans to the Moon
- Challenge 2: Improving Management of Major Projects
- Challenge 3: Sustaining a Human Presence in Low Earth Orbit
- Challenge 4: Managing and Mitigating Cybersecurity Risk
- Challenge 5: Improving Oversight of Contracts, Grants, and Cooperative Agreements
- Challenge 6: Attracting and Retaining a Highly Skilled and Diverse Workforce
- Challenge 7: Managing NASA's Outdated Infrastructure and Facilities
- Challenge 8: Managing the Impacts of COVID-19 on NASA's Mission and Workforce

NASA stands at the forefront of aeronautics, science, and space exploration and is responsible for numerous scientific discoveries and technological innovations. The Agency's achievements in long-term human space flight missions such as Apollo, the Space Shuttle Program, and the International Space Station (ISS or Station) are unparalleled. Likewise, science and aeronautics research such as the continuing Voyager missions into interstellar space and the X-15 hypersonic aircraft demonstrate NASA's position as a global leader in space and aeronautics. To maintain its preeminence, NASA must remain agile in an environment of shifting Administration priorities, evolving international interests, and unanticipated global events such as the ongoing Coronavirus Disease 2019 (COVID-19) pandemic.

In 2020, NASA altered—essentially overnight—how it does business to protect its employees and contractors from the COVID-19 virus by closing facilities and having 90 percent of its workforce operate from home for an extended period of time. Nonetheless, NASA maintained vital operations such as the ISS and successfully launched and landed the Perseverance Rover on Mars as well as the first commercial flight of astronauts into space, closing a 9-year crew transportation gap after the end of the Space Shuttle Program in 2011. To avoid another gap—this time in a low Earth orbit destination when the ISS retires—NASA is again pursuing alternative acquisition approaches, such as purchasing services instead of using traditional developmental contracts, to become a customer on commercially owned and operated space destinations. The Agency is increasingly relying on public-private partnerships and alternative acquisition approaches in an attempt to achieve cost savings and accelerate development of new technologies, including several key systems for its Artemis mission to return humans to the Moon. This shift in acquisition approaches, however, does not negate the Agency's long-standing challenge to temper its culture of optimism and develop more realistic cost and schedule estimates for its many and varied major projects (see Figure 1). In addition, NASA continues to face long-standing challenges with

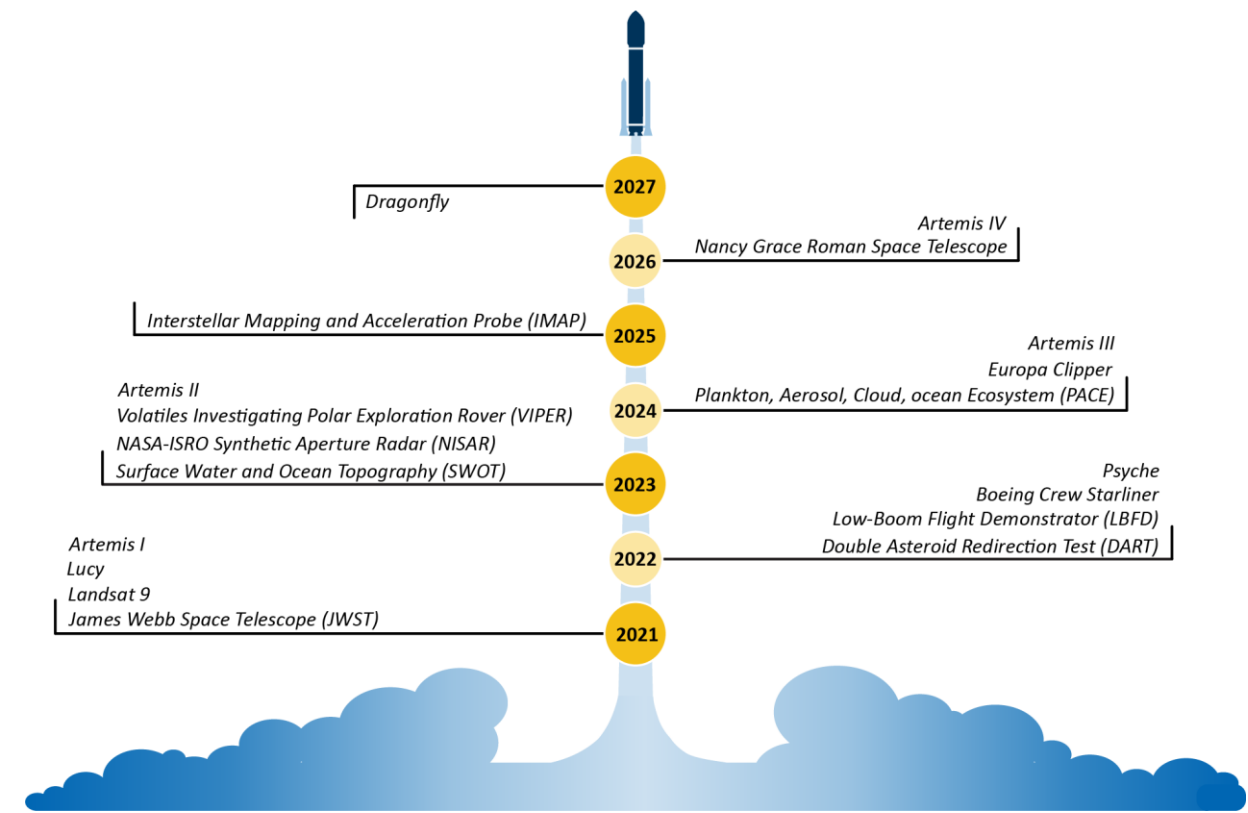
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<sup>1</sup> The Reports Consolidation Act of 2000 (Pub. L. No. 106–531) requires NASA to include in its performance and accountability report a statement by the Inspector General summarizing the most serious management and performance challenges facing the Agency and the progress made in managing them.

<sup>2</sup> NASA, [NASA Strategic Plan 2018](#) (February 12, 2018; last accessed October 7, 2021).

cybersecurity, workforce gaps, and aging infrastructure. As the Agency moves forward with key decisions on several of its major projects, addressing the challenges discussed in this report will be paramount to its success.

**Figure 1: Agency Timeline of Major Projects and Missions**



Source: NASA OIG presentation of Agency information.

Note: Indian Space Research Organisation (ISRO).

In deciding whether to identify an issue as a “top challenge,” we considered its significance in relation to NASA’s mission; whether its underlying causes are systemic in nature; and its susceptibility to fraud, waste, and abuse. These eight highlighted challenges are not the only significant issues that confront NASA. Moreover, identification of an issue as a top challenge does not denote lack of attention on the Agency’s part. Rather, most of these issues are long-standing, difficult challenges that are central to NASA’s core missions and will likely remain top challenges for many years. Consequently, they require consistent, focused attention from NASA leadership and ongoing engagement with Congress, the public, and other stakeholders.

This year’s list includes many of the same challenges discussed in previous reports. However, we reframed the Artemis and workforce challenges to reflect the most up-to-date Agency perspectives on these issues, and we added a standalone COVID-19 challenge because the impact of the pandemic on NASA’s operations will cost billions of dollars, lead to schedule delays, and affect how the Agency conducts business for years to come. Our discussion of each challenge includes an explanation of why it is a challenge, identification of NASA’s progress in addressing the challenge, and remaining work that needs to be done.

In this report and all related work, the OIG 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.

Handwritten signature of Paul K. Martin in black ink.

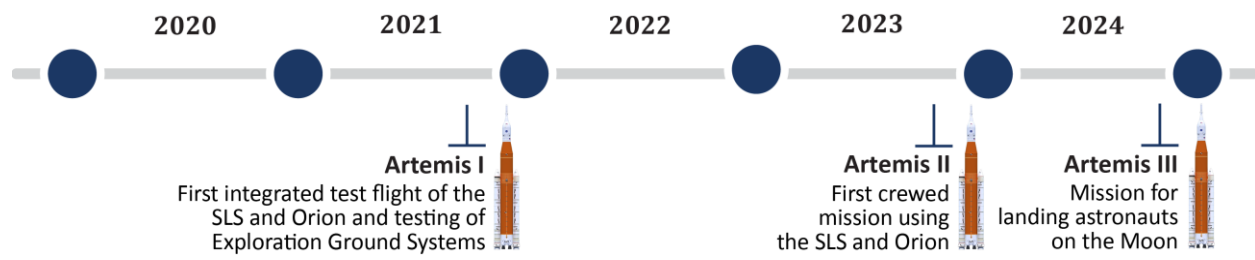
Paul K. Martin  
Inspector General

# Challenge 1: Returning Humans to the Moon

## Why This Is a Challenge

The Artemis program—currently NASA’s most ambitious and costly ongoing activity—is projected to cost the Agency \$93 billion by fiscal year (FY) 2025 and will require decades-long engagement from NASA and its commercial and international partners to build and support multiple exploration systems, conduct research and technology demonstrations to return humans to the Moon, and prepare for an eventual crewed mission to Mars.<sup>3</sup> Artemis will return astronauts to the Moon more than 50 years after the last Apollo mission, and NASA intends to maintain an ongoing lunar presence (see Figure 2). The date of the long-awaited return, however, remains a question since development delays compounded by the COVID-19 pandemic will preclude NASA from meeting its goal of landing astronauts on the Moon by late 2024.

**Figure 2: Planned Artemis Missions Through Moon Landing**



Source: NASA OIG presentation of Agency information.

Note: Space Launch System (SLS) and Orion Multi-Purpose Crew Vehicle (Orion). Exploration Ground Systems is comprised of the ground hardware, software, and Launch Control System.




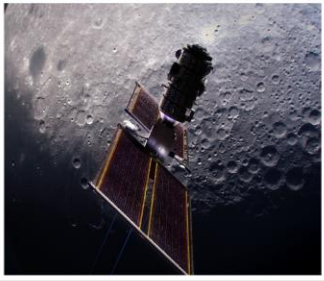


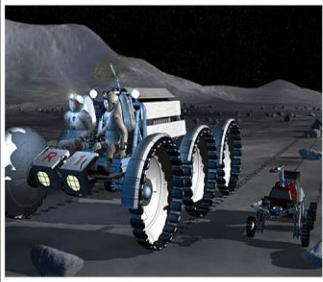
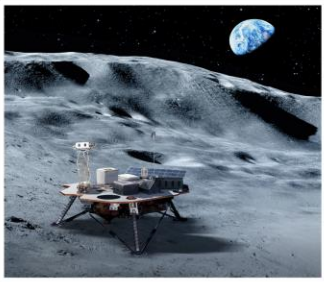
Artemis is a multi-mission program that allows NASA to extend the length and complexity of lunar missions over time. The first three missions—Artemis I, II, and III—culminate with astronauts landing on the Moon with Artemis III. NASA will use the Space Launch System (SLS) heavy-lift rocket and Orion Multi-Purpose Crew Vehicle (Orion) capsule in all three missions. Artemis I will be an uncrewed test flight, and Artemis II will fly 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 a Human Landing System (HLS) to transport astronauts to the lunar surface. Beginning with Artemis III, the astronauts will require next-generation spacesuits, known as Exploration Extravehicular Mobility Units, to explore the lunar surface. Prior to the astronauts’ arrival, NASA intends to explore the lunar landing area with robotic systems as part of the Commercial Lunar Payload Services initiative.<sup>4</sup> Subsequent Artemis missions are expected to

<sup>3</sup> We derived the \$93 billion figure from examining NASA’s obligations, appropriations, and budget projections across all Mission Directorates for programs and projects involved in the Artemis program from FY 2012 through FY 2025.

<sup>4</sup> Initiated in 2018, NASA’s Commercial Lunar Payload Services initiative seeks to rapidly acquire lunar delivery services from American companies for payloads that advance capabilities for science, exploration, and commercial development of the Moon.

include a longer-term presence on the Moon that incorporates additional systems including a lunar orbiting outpost called the Gateway and Lunar Terrain Vehicles to transport crew on the Moon's surface. See Figure 3 for images of the various Artemis systems in development. NASA intends to use its human presence on the Moon as a research platform to understand planetary processes, conduct experimental science, and investigate and mitigate long-term exploration risks to humans.

**Figure 3: Artemis Systems in Development**

|  |  |   |  |
|--|--|---|--|
|                                 |                                       |   |   |
| <p><b>Space Launch System</b></p> <p><i>Two-stage, heavy-lift rocket</i></p>                                     | <p><b>Orion Multi-Purpose Crew Vehicle</b></p> <p><i>Spacecraft to transport astronauts beyond low Earth orbit</i></p> | <p><b>Exploration Ground Systems</b></p> <p><i>Facilities, launchers, and systems required to support a launch</i></p>        | <p><b>Gateway</b></p> <p><i>Lunar outpost in orbit around the Moon</i></p>   |
|                                |                                      |    |    |
| <p><b>Human Landing System</b></p> <p><i>Ferry astronauts back and forth from lunar orbit to its surface</i></p> | <p><b>Spacesuits</b></p> <p><i>Modern spacesuits for use in a variety of conditions</i></p>                            | <p><b>Lunar Terrain Vehicle</b></p> <p><i>Pressurized and unpressurized rovers to transport crew on the lunar surface</i></p> | <p><b>Commercial Lunar Payload Services</b></p> <p><i>End-to-end commercial delivery of science payloads and experiments to the Moon</i></p> |

Source: NASA OIG presentation of Agency information.

As we have consistently reported in previous reports, NASA's greatest challenge with its human exploration ambitions is development of the systems required to get humans to the Moon and Mars safely with the funding Congress has allocated and within the timeframe the Administration has imposed. In September 2020, more than a year after the White House directed NASA to escalate its timeline to land the first woman and next man on the Moon by 2024, the Agency estimated it would need approximately \$28 billion between FYs 2021 and 2025 to achieve the initial crewed lunar landing 4 years ahead of its original schedule.<sup>5</sup> Funding is needed primarily to support development of multiple

<sup>5</sup> The \$28 billion figure is for Phase I of the Artemis missions and includes costs for Artemis I, II, and III, but does not include the Gateway.



Artemis systems including the SLS rocket and Orion capsule to transport astronauts to lunar orbit, a Moon orbiting outpost known as Gateway, the HLS to ferry astronauts to the lunar surface, and new spacesuits for the astronauts to operate outside of their spacecraft and on the lunar surface. However, Congress appropriated only \$850 million in FY 2021 out of an estimated need of \$3.4 billion for the HLS. As a result, the Agency selected a single company, thereby affecting NASA’s acquisition strategy to promote competition and redundancy.<sup>6</sup> To mitigate the risk of having only one provider, NASA decided to accelerate its Lunar Exploration Transportation Services procurement to allow other companies to develop technologies and potentially receive a contract to deliver astronauts to the Moon. We also found that delays in development of the Agency’s next-generation spacesuits—attributed to technical challenges, funding issues, and COVID-19 impacts—will preclude the new suits from being ready for flight until April 2025 at the earliest and will cost NASA more than a billion dollars for their development and assembly.<sup>7</sup> These are only two recent examples in a series of long-standing challenges to build the systems required for the Agency’s Artemis missions and follow-on Mars exploration plans.

## Progress in Addressing the Challenge

Artemis systems are making progress in their development and procurement. Over the past year, NASA’s SLS, Orion, and Exploration Ground Systems Programs that form the Exploration Systems Development (ESD) Division have made steady progress, and although in a November 2021 report we found that NASA’s planned November 2021 Artemis I launch date is not feasible, the Programs are in our estimation positioned to launch the first Artemis mission by summer 2022.<sup>8</sup> In addition, NASA completed all the contract awards necessary for the initial Gateway capability when it awarded Northrop Grumman a fixed-price contract in July 2021 for the final design and build phase of the Habitation and Logistics Outpost where astronauts will live and conduct research on the Gateway. Development continues for the electrical power system for the Gateway’s Power and Propulsion Element. For Artemis III, NASA allowed flexibility for HLS proposers to either dock with the Gateway or directly with the Orion. NASA’s award to Space Exploration Technologies Corporation (SpaceX) for the Artemis III demonstration includes its HLS Starship linking up directly with the crewed Orion in lunar orbit to ferry astronauts to and from the Moon’s surface. NASA aims to have the Gateway operational in time for Artemis IV. Lastly, the Agency continues to develop its next-generation spacesuit capabilities, including a testing suit, two qualification suits, an ISS demonstration suit, and two lunar flight suits. Overall, NASA has made progress towards executing the first three Artemis missions, culminating with the planned return of astronauts to the surface of the Moon.

**Artemis I.** Four years after inception of the Artemis program but over 10 years into development of its SLS rocket and Orion capsule, NASA’s preparations are nearly complete for the inaugural uncrewed flight of its rocket/capsule combination. The stacking of the SLS’s Core Stage, Upper Stage, and Solid Rocket Boosters on the Mobile Launcher is complete, and NASA is conducting tests on the Orion before placing

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<sup>6</sup> In April 2021, NASA selected SpaceX for the contract award, concluding that its proposal was the most highly rated, and that HLS funding availability did not allow for a second award.

<sup>7</sup> NASA OIG, *NASA’s Development of Next-Generation Spacesuits* ([IG-21-025](#), August 10, 2021). The \$1 billion includes \$420.1 million spent from 2007 through December 2020 and planned spending of \$625.2 million from FY 2021 through FY 2025. The work covered by this funding includes design, testing, qualification, an ISS demonstration suit, two flight-ready suits, related support, and future suit production costs. Related support includes vehicle support hardware, training hardware and facilities, testing facilities, and extravehicular activity tools.

<sup>8</sup> NASA OIG, *NASA’s Strategy for the Artemis Missions* ([IG-22-003](#), November 15, 2021).

it on top of the rocket.<sup>9</sup> Once the Orion is stacked, fully integrated, and testing is complete, the system will be transported to Launch Pad 39B for additional testing and eventual launch. While NASA was attempting to launch the system by the end of 2021, in November 2021 we reported that a launch before summer 2022 is more likely due to the first-time challenges integrating a system of this magnitude and the impacts of the COVID-19 pandemic and multiple adverse weather events.<sup>10</sup> With respect to budget, NASA acknowledged the need to control the systems' cost and schedule through a June 2020 rebaselining of the SLS and Exploration Ground Systems Programs. For Artemis I, officials reported that additional cost increases and schedule slippages are expected to be minimal given the high probability of a launch before mid-2022.

**Artemis II.** For Artemis II, the Orion Program decided to purchase a second set of core avionics for its capsule and will only reuse non-core avionics. Given that astronauts will be flying on this second mission, the Agency needs to add to Orion an environmental control and life support system which is not on Artemis I. To reduce the risk of flying this system for the first time with astronauts on board, the Artemis II flight plan will include additional time in low Earth orbit to test the system before continuing to the Moon. NASA is actively building all the elements for Artemis II, but due to the reuse of the non-core avionics—considered on the critical path—launch preparations will take approximately 27 months between the first two Artemis flights.<sup>11</sup> Given that this flight is crewed, adjustments will also be made to the Mobile Launcher after Artemis I; however, these adjustments are not expected to impact the planned December 2023 launch date.

**Artemis III.** Besides continued production of the SLS and Orion, Artemis III preparations include development and testing of the HLS Starship being built by SpaceX. The HLS contract has faced numerous challenges from the start, beginning with Government Accountability Office (GAO) protests by two companies—Blue Origin Federation, LLC and Dynetics, Inc.—that were denied in July 2021.<sup>12</sup> Although the protests resulted in a 6-month delay to HLS development according to Agency officials, SpaceX still planned to conduct an orbital flight test of its Super Heavy Booster and Starship by the end of 2021. A subsequent civil suit brought by Blue Origin denied in November 2021 further delayed HLS development and testing.

Crosscutting all Artemis missions are NASA's efforts to reduce future costs of ESD systems. In January 2021, the Human Exploration and Operations Mission Directorate's Associate Administrator announced that a senior advisor would lead a sustainability assessment team to develop ideas on how to make ESD systems more cost effective. Further, as part of the recent FY 2023 budget process, programs were directed to present potential cost-saving actions. Among the ideas suggested were collaboration with contractors on process improvements and a reduction in both the civil servant and contractor workforce. For example, in June 2021 the SLS Program forecasted a 13 percent reduction in labor hours between the production of Core Stage 1 and Core Stage 2. As previously reported, Orion is moving forward on a number of initiatives aimed at reducing production costs with the Program aiming

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<sup>9</sup> The Mobile Launcher is the ground structure that will be used to assemble, process, and launch NASA's SLS rocket and Orion spacecraft from Launch Pad 39B at the Agency's Kennedy Space Center in Florida in support of Artemis mission objectives.

<sup>10</sup> [IG-22-003](#).

<sup>11</sup> Critical path is the sequence of tasks that determines the longest 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.

<sup>12</sup> NASA awarded contracts to three companies for initial design work of the HLS—SpaceX, Blue Origin, and Dynetics—which concluded in April 2021 when SpaceX was selected to further develop and demonstrate its HLS.

to transition to a fixed-price contract structure for Artemis IX and beyond.<sup>13</sup> There are also plans to reuse Orion’s high-value interior components, including avionics and life support systems beginning on Artemis V, and to reuse the entire assembled pressure vessels and all interior components for two missions beginning with Artemis VI. Additionally, NASA hopes to leverage economies of scale to reduce costs by 21 percent by ordering Orion capsules in batches of three with the first order in 2019 for Artemis III through V.

## ● Key Implemented Recommendations

Confirm at selection the launch system provider for the co-manifested Power and Propulsion Element and Habitation and Logistics Outpost will meet spacecraft mass, length, and other requirements ([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](#)).

Ensure procurement officials minimize the availability of award fees (for Orion) 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-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 That Needs to Be Done

Despite progress towards developing its Artemis systems, NASA still needs to produce a comprehensive estimate that consolidates all Artemis costs across Mission Directorates. Because Artemis is not a formal program as defined by the Agency’s Space Flight Program and Project Management Requirements, an Artemis-wide full life-cycle cost estimate was not required. Instead, NASA’s disparate programs and projects individually submit budget estimates through their divisions and directorates to the Office of the Chief Financial Officer. Without understanding and accurately reporting the overall cost of current and future missions, Congress will lack the information needed to make informed decisions about NASA’s long-term funding needs, and the Agency will be challenged to make Artemis a sustainable venture.

Overall, NASA has experienced cost increases of \$4.3 billion for SLS, Orion, and Exploration Ground Systems. Furthermore, given that we estimate the cost of the SLS/Orion system at \$4.1 billion per launch for at least the first four Artemis missions, NASA must continue to identify ways to make its ESD systems much more affordable.<sup>14</sup> Otherwise, relying on such an expensive heavy-lift rocket system will, in our judgment, inhibit if not derail NASA’s ability to sustain its long-term human exploration goals. We have also reported over the last several years that ESD continues to struggle to control its costs and

<sup>13</sup> NASA OIG, *NASA’s Management of the Orion Multi-Purpose Crew Vehicle Program* ([IG-20-018](#), July 16, 2020).

<sup>14</sup> The \$4.1 billion total cost represents production of the SLS, Orion, and the operations needed to launch the space flight system including materials, labor, facilities, and overhead, but does not include any money spent concurrently on the development of next-generation technologies such as the SLS’s Exploration Upper Stage, Orion’s docking system, or Mobile Launcher-2.

schedule using more traditional acquisition methods for development and production of its exploration systems, including sole-sourced development and cost-plus production contracts that have suffered from undefined contract requirements and overly generous award fees to underperforming contractors. However, NASA's Commercial Crew Program shows how competitively awarded fixed-price contracts can control costs if requirements are properly defined. NASA has applied this acquisition model to the Gateway's Power and Propulsion Element and HLS procurements and intends to use a commercial services approach for next-generation spacesuits.

Besides reducing costs, NASA needs to develop a realistic, risk-informed schedule that includes sufficient margin to better align Agency expectations with the development schedule. The Artemis I launch date has slipped 3 years, which has delayed the launch date for Artemis II. Although the Agency continues to work towards a late 2024 Moon landing, a Human Exploration and Operations Mission Directorate-directed schedule risk analysis showed that 2026 is a more likely date. While developmental delays in such a complex program are to be expected, NASA has consistently been challenged to manage space flight-related schedules for these primary reasons:

- Changing and evolving requirements, both internally and externally driven (including congressional and presidential directives);
- Developing an overly optimistic schedule for employees and contractors to work toward in the hope it will speed development;
- Underestimating the scope of work and technical challenges in developing human-rated systems; and
- Numerous severe weather events and COVID-19 restrictions affecting both production and testing.

Finally, NASA will continue to face risks maturing the design and critical technologies for the HLS until it ensures its new tailored programmatic approach meets the intent of traditional oversight milestones. While the HLS Program leveraged lessons learned and is modeled, in part, after the Commercial Crew Program, HLS tailored its programmatic milestone approach to better fit a services model approach versus the traditional hardware development program. The tailored approach replaces the traditional hardware development milestones with annual synchronization reviews that provide oversight of provider development.<sup>15</sup> NASA also stood up "collaboration teams" and insight teams that will work with SpaceX throughout HLS development. In our judgment, this is a useful resource but may not compensate for the oversight provided by the design and operational milestone reviews. Notably, NASA's initial success in defining its safety and engineering requirements during the initial HLS design phase will help ensure SpaceX and future HLS contractors understand the human rating standards they are required to achieve. Nonetheless, as was done in the Commercial Crew Program, the Agency will need to utilize a program board to evaluate hazards and variations to NASA standards to ensure safety and human rating standards are met.

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<sup>15</sup> For example, NASA is replacing the following milestone reviews that occur in a traditional acquisition: Key Decision Point-D is the milestone event that allows a project to proceed to Assembly, Integration and Test, and Launch; Key Decision Point-E moves the project into Operations and Sustainment. A Systems Integration Review ensures segments, components, and subsystems are on schedule to be integrated into the system. The Operational Readiness Review ensures that all system and support (flight and ground) hardware, software, personnel, procedures, and user documentation accurately reflect the deployed state of the system.

## ○ Key Unimplemented Recommendations

Baseline the Gateway requirements and specifications in contract modifications prior to updating and awarding the Power and Propulsion Element and Habitation and Logistics Outpost fixed-price contracts ([IG-21-004](#)).

Ensure Power and Propulsion Element and Habitation and Logistics Outpost delivery and launch dates are realistic by including sufficient schedule margin in their development schedules ([IG-21-004](#)).

Ensure the maturity of system requirements are fully understood before selecting the acquisition method and contract type for future acquisition strategies supporting Artemis and Mars missions by describing the state of the program requirements in the acquisition strategy memorandum for each new acquisition ([IG-21-004](#)).

To the extent practicable, adjust Orion's production schedules for Artemis IV and V to better align with the successful demonstration of Artemis II to reduce schedule delays associated with potential rework ([IG-20-018](#)).

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*

#### **NASA's Management of Its Astronaut Corps**

This audit will assess to what extent NASA's processes for sizing, training, and assigning its astronaut corps align with the Agency's current and future mission needs.

#### **Mobile Launcher-2**

This audit will examine the extent to which NASA has met its cost, schedule, and performance goals for the Mobile Launcher-2 development contract.

# Challenge 2: Improving Management of Major Projects

## Why This Is a Challenge

For six decades, NASA has been the world’s leader in space exploration, advancing knowledge of Earth while making discoveries about the furthest reaches of the universe with its portfolio of major projects.<sup>16</sup> These projects include satellites equipped with advanced sensors to study the Earth; rovers to collect soil and rock samples on other celestial bodies; telescopes intended to explore the far reaches of the universe; and complex systems to support transportation of humans to the ISS, Moon, and beyond. NASA is planning to invest at least \$69 billion over the life cycle of its portfolio of 34 major projects currently in development. However, this investment is likely to increase because the number of projects in development is expected to grow as the Agency plans for 8 of 13 major projects in formulation—including 6 Artemis projects—to enter development in 2021. Historically, NASA’s major projects have cost significantly more and taken much longer to complete than initially planned with the Agency’s current development projects resulting in total cumulative cost growth of \$9.6 billion since their original cost baselines were set. Moving forward, NASA’s ability to deliver projects on time and within budget is critical to meeting mission objectives, strategic goals, and commitments to Congress and taxpayers.

Although \$7.1 billion of \$9.6 billion in cumulative cost growth comes from two of NASA’s 34 major projects—James Webb Space Telescope (JWST) and SLS—other major projects such as Surface Water and Ocean Topography (SWOT), NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR), Low-Boom Flight Demonstrator (Lbfd), and Laser Communications Relay Demonstration (LCRD) have also experienced cost growth, schedule delays, or both—some of which can be attributed to the COVID-19 pandemic.<sup>17</sup>

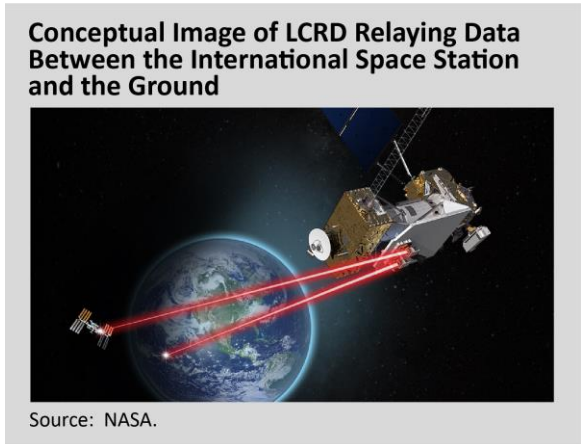
- *James Webb Space Telescope.* JWST is an infrared observatory designed to help understand the origin of the universe, creation and evolution of the first stars and galaxies, and formation of stars and planetary systems. Under development since 2008, in June 2018 NASA established a revised life-cycle cost commitment of \$9.7 billion and launch readiness date of March 2021—\$828 million more and 2 years later than the baselines established by the project in 2011. Since then, technical challenges, delays related to COVID-19, and issues with Ariane 5, the European Space Agency’s rocket that will launch JWST, have pushed the date out until at least December 2021.
- *Surface Water and Ocean Topography.* SWOT will use its wide-swath radar altimetry technology to take repeated high-resolution measurements of the world’s oceans and freshwater bodies to develop a global survey. SWOT entered implementation in 2016 with a life-cycle cost commitment of \$755 million and an April 2022 launch readiness date. Because SWOT used

<sup>16</sup> GAO categorizes “major projects” as those with life-cycle costs over \$250 million. GAO, *NASA: Assessments of Major Projects* ([GAO-21-306](#), May 20, 2021).

<sup>17</sup> The status of SLS is discussed in Challenge 1, *Returning Humans to the Moon*. COVID-19 impacts on cost growth are discussed in Challenge 8, *Managing the Impacts of COVID-19 on NASA’s Mission and Workforce*.

most of its cost and schedule reserves to mitigate instrument delivery delays prior to COVID-19, it did not have sufficient reserves to cover additional delays related to the pandemic.<sup>18</sup> Based on a recent assessment, NASA concluded SWOT will exceed its launch readiness date by 14 months and incur \$67.5 million in cost overruns to cover schedule delays and COVID-19 impacts.

- **NASA-ISRO Synthetic Aperture Radar.** NISAR is a joint project between NASA and ISRO to study Earth’s ice masses and ecosystems. NASA’s FY 2022 budget provides an additional \$104 million to support life-cycle cost increases associated with delayed delivery of the S-band SAR instrument and COVID-19 impacts.<sup>19</sup> The updated NISAR life-cycle cost exceeds the Agency’s development estimate of \$661 million by more than 15 percent and the baseline launch readiness date of September 2022 by 12 months.
- **Low-Boom Flight Demonstrator.** LBFD is a flight demonstration project that plans to show that noise from supersonic flights—a sonic boom—can be reduced to levels acceptable to the public for commercial use in overland flights. In August 2020, NASA approved a net increase of \$74.7 million over the LBFD Project’s life-cycle cost estimate of \$582.4 million and a delay of 5 months beyond its planned January 2022 first flight because the contractor delayed releasing design drawings and had quality issues with supplier deliveries.
- **Laser Communications Relay Demonstration.** LCRD is a technology demonstration mission to advance two-way optical (laser) communication technology for Earth using the LCRD relay satellite. In May 2021, LCRD’s launch readiness date was delayed due to launch vehicle readiness issues and launch slot availability, with November 22 or 23, 2021, providing the next available launch opportunity. The mission previously experienced a \$47.8 million life-cycle cost increase, with officials anticipating an additional \$6.1 million for funding to retain key staff to support this latest launch delay.



Due to the Agency’s history of persistent cost growth and schedule delays in the majority of its major projects, 30 years ago GAO first designated NASA’s acquisition management as a high risk and since then has identified a variety of management weaknesses that have exacerbated this challenge.<sup>20</sup> NASA has historically struggled to provide reliable life-cycle cost estimates for complex projects involving multiple, first-of-their-kind components. This includes projects such as JWST, and missions such as Artemis that involve multiple iterations of major projects without a definitive life-cycle end date, like the SLS rocket

<sup>18</sup> Cost reserves are for costs that are expected to be incurred—for instance, to address project risks—but are not yet allocated to a specific part of the project. Schedule reserves are extra time in project schedules that can be allocated to specific activities, elements, and major subsystems to mitigate delays or address unforeseen risks.

<sup>19</sup> The NISAR S-Band SAR instrument is a synthetic aperture radar that actively collects data by producing its own energy and then recording the amount of that energy reflected back after interacting with Earth.

<sup>20</sup> 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.



and Orion capsule, which because they are not completely reusable will be built multiple times for an indefinite number of years.<sup>21</sup> Overall, NASA remains challenged to complete its major projects within their planned costs and schedules due to a culture of optimism, underestimating technical complexity, and funding instability—all long-standing issues.

## Progress in Addressing the Challenge

NASA's efforts in the last few years to improve management of its major projects have shown indications of improved performance for several projects, including Landsat 9 and Psyche, which have seen reduced costs.<sup>22</sup> In fact, GAO's 2021 High-Risk Series report listed NASA's acquisition management as one of only seven high-risk areas throughout the entire federal government that showed progress toward meeting criteria for removal from the High-Risk List over the past 2 years.<sup>23</sup> Progress toward improving NASA's acquisition management is demonstrated by the Agency's commitment to implement its 2018 Corrective Action Plan, which was designed to address the causes of cost and schedule concerns highlighted in GAO's High-Risk List.<sup>24</sup> In August 2020, NASA updated the Plan and reported completing six of nine initiatives, closing and rewriting one initiative, and adding three new initiatives to expand data collection efforts, implement a schedule repository, and conduct financial evaluations of potential contractors prior to award.

As a result of the Corrective Action Plan's initiatives, NASA has developed best practices, added additional requirements, and implemented external monitoring related to cost and schedule of major projects. For example, NASA published a Technology Readiness Assessment Best Practices Guide that established standard definitions and best practices for critical technologies needed for exploration, science, and technology mission systems to meet operational performance requirements within defined cost and schedule parameters.<sup>25</sup> In addition, NASA added requirements for all projects with life-cycle costs over \$1 billion to conduct a Joint Cost and Schedule Confidence Level analysis at additional life-cycle phases to help reduce cost and schedule growth, improve transparency, and increase the likelihood of meeting project expectations.<sup>26</sup> Further, NASA plans to broaden its use of Earned Value Management by delegating all applicable contracts to the Defense Contract Management Agency to integrate information on a project's cost, schedule, and technical efforts for surveillance by

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<sup>21</sup> NASA indicated that it expects the cost of the SLS and Orion to decrease over time as the designs stabilize and production processes mature.

<sup>22</sup> Landsat 9, launched in September 2021, is the latest satellite in the Landsat series, which has provided a continuous space-based record of the Earth's land surface observations to study, predict, and understand the consequences of land surface dynamics, such as deforestation. Psyche, scheduled to launch in 2022, will be the first mission to visit a metal asteroid and aims to understand iron cores, a previously unexplored component of the early building blocks of planets.

<sup>23</sup> 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).

<sup>24</sup> NASA, [2020 High Risk Corrective Action Plan](#) (August 2020, last accessed June 24, 2021) is the Agency's most recent update to the Corrective Action Plan.

<sup>25</sup> NASA Office of the Chief Technologist SP-20205003605, *Technology Readiness Assessment Best Practices Guide* (June 30, 2020).

<sup>26</sup> A Joint Cost and Schedule Confidence Level analysis produces a point-in-time estimate that includes all cost and schedule elements in project life-cycle Phases A through D (i.e., concept and technology development through system assembly, integration and testing, and launch), incorporates and quantifies known risks, assesses the impacts of cost and schedule to date, and addresses available annual resources, among other things.



management and decision makers.<sup>27</sup> Prior to its 2020 update to the Corrective Action Plan, NASA only surveilled 37 percent of its contracts. NASA is also requiring that these same applicable contracts submit data to NASA's new centralized schedule repository to improve access to historical data and include Earned Value Management data during project review.

## ● Key Implemented Recommendations

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](#)).

Document and provide the Joint Cost and Schedule Confidence Level analysis approach used by LBFD to the NASA Chief Knowledge Officer to serve as a reference for future large-scale X-plane development projects ([IG-20-015](#)).

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

Direct Boeing to complete delivery of the two Core Stages and the Exploration Upper Stage using an Earned Value Management System with realistic schedule assumptions and appropriate cost estimates through the end of the contract in 2021 ([IG-19-001](#)).

## Work That Needs to Be Done

We have consistently reported on NASA's culture of optimism and the effects this has had on project management. NASA's ability to overcome technological and scientific obstacles to accomplish its objectives has become part of the Agency's culture and helped foster a belief that NASA can accomplish anything. However, many of the Agency's planned missions are ambitious endeavors that need to be grounded in more realistic cost and schedule commitments, which NASA needs to remain cognizant of when establishing baselines for the newly announced Earth System Observatory and Venus missions.<sup>28</sup> NASA should carefully consider its commitment to Congress and other stakeholders and seek to establish sustainable budgets and realistic timelines that take into account the Agency's overall goals and priorities. To put NASA's budget into historical context, during the Apollo missions of the late 1960s the Agency's budget reached a high of 4.4 percent of the overall federal budget, while NASA's current funding amounts to 0.5 percent of the federal budget. Artemis is NASA's most ambitious and costly mission to date, with a projected cost of \$93 billion through FY 2025. Given that the Agency is

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<sup>27</sup> Earned Value Management measures the value of work accomplished in a given period and compares it with the planned value of work scheduled for that period and the actual cost of work accomplished. At the Defense Contract Management Agency, surveillance is often a multifunctional insight effort to review and analyze contractor plans, schedules, policies, procedures, systems, processes, process outputs, and/or products to determine compliance to contractual, statutory, regulatory, or contractor requirements.

<sup>28</sup> The Earth System Observatory will provide key information to guide efforts related to climate change, disaster mitigation, fighting forest fires, and improving real-time agricultural processes. NASA recently selected two new missions to Venus, Earth's nearest planetary neighbor, to understand how Venus became an inferno-like world when it has so many other characteristics similar to Earth, and how it may have been the first habitable world in the solar system, complete with an ocean and Earth-like climate.

anticipated to operate with an annual budget of approximately \$25 billion for the next several years, absent transparent and accurate reporting of cost and schedule commitments, it will be difficult for NASA, Congress, and external stakeholders to make informed decisions that will ensure the success of current and future programs and projects. To this end, NASA must redouble its efforts to ensure that its science and space exploration projects are grounded in accurate estimates and meet cost, schedule, and performance goals. Given a limited budget to fund multiple ambitious projects, it is critical that NASA implement planned changes to its Joint Cost and Schedule Confidence Level policy, as well as demonstrate sustained progress completing initiatives in its 2020 Corrective Action Plan.

Furthermore, when taking on a mission, requirements should be clearly defined, affordable, captured, and communicated early in the development effort to reduce the risk of costly design changes.<sup>29</sup> NASA has begun to acquire major Artemis systems such as the Gateway and HLS through public-private partnerships, but it has still not fully defined the lunar system architecture or established requirements for its lunar missions. Consequently, NASA will need to address potential requirements and technology development knowledge gaps in Artemis projects due to a lack of firm requirements before entering implementation.

## ○ Key Unimplemented Recommendations

Implement the National Academies recommendation to establish a common interface for Commercial Lunar Payload Services contractors between instrument and spacecraft or to require that each commercial provider supply a document that describes provider and payload capabilities ([IG-20-023](#)).

Evaluate whether the monetary threshold for performing internal Earned Value Management is sufficient or additional criteria would be beneficial regarding the dollar-value of tasks related to providing government furnished equipment and performing in-house development work (discrete work) compared to NASA personnel performing integration, review, and management functions (level-of-effort work) ([IG-20-015](#)).

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***

#### **NASA's Multi-Mission Program Cost Estimating and Reporting Practices**

This audit will assess the effectiveness of the Agency's cost estimating and reporting practices for large, multi-mission programs such as those supporting the Artemis program.

#### **Audit of the Volatiles Investigating Polar Exploration Rover (VIPER) Mission**

This audit will assess NASA's management of VIPER relative to achieving technical objectives, meeting established milestones, and controlling costs.

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<sup>29</sup> GAO, *Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes* ([GAO-02-701](#), July 15, 2002).

**Review of Astrophysics Portfolio**

This audit will evaluate the current state of the Agency's Astrophysics portfolio, identify and assess risks to future missions, and provide recommendations in support of the next decadal survey.

**Review of NASA's Management of the Johns Hopkins University Applied Physics Laboratory Portfolio**

This audit will assess NASA's processes and controls ensuring the effective management of the contracts and portfolio of Agency projects developed by the Johns Hopkins University Applied Physics Laboratory.

# Challenge 3: Sustaining a Human Presence in Low Earth Orbit

## Why This Is a Challenge

For more than 20 years, humans have continuously lived and worked in space, building the ISS, conducting microgravity research, and testing new technologies required for long-term deep space travel to the Moon and Mars including those needed for the Agency’s near-term Artemis missions. At a cost of approximately \$3 billion annually to operate the ISS and transport astronauts to and from the Station, NASA’s activities in low Earth orbit—the region in space from 100 to 600 miles above the Earth’s surface—consume about one-third of the Agency’s annual human space flight budget.<sup>30</sup> This expense is expected to continue through the Station’s anticipated retirement in 2030.<sup>31</sup>

The continuous operation of research and technology demonstrations in low Earth orbit is critical to achieving NASA’s goals in science, technology, and human space flight. The unique microgravity laboratory offered by the ISS has delivered benefits in human health, Earth observations and disaster response, innovative technology, global education, and the economic development of space. Without the availability of a low Earth orbit platform to conduct critical health research and demonstrate key technologies, NASA would be faced with the difficult decision of accepting a higher level of risk or delaying human missions to the Moon and Mars.

While the U.S. segment of the ISS is structurally certified to operate until 2028, recent events highlight some of the risks associated with the harsh space environment, which require continuous assessment of the Station’s operational performance.<sup>32</sup> Since October 2020, astronauts have identified several cracks in the Russian-built Service Module Transfer Tunnel that are causing cabin air to leak at twice the normal rate.<sup>33</sup> While the current amount of cabin air leakage does not pose an immediate risk to astronaut health and safety, and to date, ISS teams have not observed any indications that crack growth is continuing towards a catastrophic failure, cracks can grow over time increasing risk. NASA and Russia’s space agency continue to investigate the cause of the leaks and potential structural impacts. In addition, in February 2021 NASA identified a hole in the Station’s Canadarm2 caused by a micrometeoroid or orbital debris.<sup>34</sup> On-orbit inspections revealed that the damage would have no

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<sup>30</sup> The ISS orbits roughly 250 miles above the Earth’s surface.

<sup>31</sup> The United States Innovation and Competition Act of 2021 (S.1260), a bill approved by the Senate in June 2021, would extend ISS operations through September 30, 2030.

<sup>32</sup> Currently, the U.S. portions of the Station are certified to operate through 2028—30 years after the first segment of the ISS was launched.

<sup>33</sup> The Service Module—the structural and functional center of Russia’s ISS segment and the third oldest segment of the Station—is currently the source of multiple cabin air leaks of unknown cause, some of which have yet to be located.

<sup>34</sup> Orbital debris consists of human-made objects in space that no longer serve a useful purpose. With the rapid increase of space activity and the state of orbital debris in low Earth orbit, we reported in January 2021 that the Agency’s mitigation-only activities focused solely on prevention were insufficient to stabilize the orbital debris environment. NASA OIG, *NASA’s Efforts to Mitigate the Risks Posed by Orbital Debris* (IG-21-011, January 27, 2021). Canadarm2—part of Canada’s contribution to the ISS—is used to conduct regular maintenance checks and operations on the outside of the Station; move supplies, equipment, and astronauts conducting spacewalks; and capture visiting vehicles to connect them to the Station.

impact on the arm's operations through the end of the Station's certified life. In July 2021 the ISS also experienced a loss of attitude control after Russia docked its new Multi-Purpose Laboratory Module.<sup>35</sup> The new module inadvertently fired its thrusters, resulting in the vehicle becoming inverted and losing satellite communications for several minutes on two separate occasions. After the event, NASA assessed the inadvertent thruster firing anomaly data and determined there was no structural damage or long-term concerns as a result of structural loading. While NASA determined that these events do not pose an immediate threat to the Station's operational longevity, either in response to an emergency event or at the end of the Station's useful service life, NASA and its partners will eventually have to come to a decision to initiate its decommissioning and deorbit.

Looking forward, NASA plans to maintain a human presence in low Earth orbit after the ISS is retired by becoming a customer of commercially owned and operated space destinations, which will require a sustained but largely undetermined financial investment by the federal government and private companies. To further its goal to become one of many customers in a commercial low Earth orbit economy, NASA has made several attempts over the past decade to commercialize space. The Agency's initial efforts to commercialize low Earth orbit were unsuccessful after 10 years of trying to develop a commercial market and relying on the Center for the Advancement of Science in Space, Inc. (CASIS) to advance research endeavors for the commercial sector.<sup>36</sup> In response, NASA released a plan in 2019 focused on near-term actions to expand commercial opportunities in space beyond what was initially allowed under CASIS, including private astronaut missions to the ISS. However, Congress authorized NASA to spend only \$17 million to support commercial low Earth orbit development in FY 2021—just over 10 percent of the Agency's requested \$150 million.

Key to maintaining a presence in low Earth orbit is reliable and cost-effective transportation of cargo and crew. Between the end of the U.S. Space Shuttle Program in 2011 and the first commercial crew mission in November 2020, NASA faced a 9-year transportation gap where it was forced to pay Russia for crew transportation to the Station. In the intervening years, NASA's Commercial Cargo and Crew Programs have enabled commercial partners to successfully transport cargo to and from the ISS since 2012 and crew since 2020. However, the road to developing a commercial crew transportation capability has been long. While SpaceX has successfully launched three commercial crew missions to the ISS, as of November 2021 the Boeing Corporation (Boeing), the other of the Agency's two commercial crew partners, has encountered numerous delays and technical issues that have to date thwarted its first crewed flight. Crew transportation is crucial, not just for fully utilizing the ISS, but also for developing and utilizing future commercial destinations to maintain a continuous human presence in low Earth orbit.

NASA continues to face challenges with low Earth orbit transportation and commercialization, as we have reported in previous audits and prior top management and performance challenges reports. Addressing these challenges is more urgent as NASA works to avoid the possibility of a gap in maintaining a human presence in low Earth orbit without the ISS or a commercial destination.

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<sup>35</sup> Attitude is the orientation of the ISS with respect to the Earth and Sun, which is important for maintaining communications, microgravity, power, and thermal levels on the Station.

<sup>36</sup> CASIS is a non-profit organization that manages the ISS U.S. National Laboratory, a U.S. government-funded laboratory with principal research facilities located in the U.S. Orbital Segment of the ISS. In August 2011, NASA signed a 10-year, \$136 million cooperative agreement with CASIS to manage all non-NASA research on the ISS. In July 2017, NASA extended the cooperative agreement to September 2024 and added another \$60 million to the agreement.

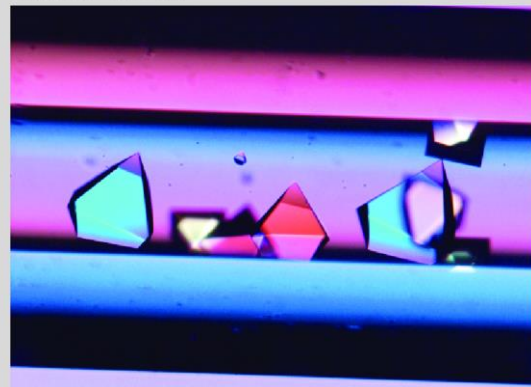
## Progress in Addressing the Challenge

To its credit, during a pandemic that closed NASA's facilities and forced 90 percent of its workforce to operate from home, the first certified commercial flight of astronauts was launched into space in November 2020 from Crew Dragon, SpaceX's commercial crew transportation vehicle. This flight represents the first time in 9 years that American astronauts were able to launch on a U.S. vehicle since the end of the Space Shuttle Program.

In June 2021, NASA also completed installation of its new Roll-Out Solar Array to increase the Station's power production and ensure its future power requirements are met through the life of the ISS including power needed for new commercial modules. Astronauts also replaced the Station's aging batteries with more efficient lithium-ion batteries. In addition, NASA installed the first privately-funded commercial airlock on the ISS in late 2020—the NanoRacks Bishop Airlock increased the Station's capability for transferring equipment, payloads, and deployable satellites to meet growing customer demands.

In FY 2021, NASA invested more than \$13 million in seed money for seven companies to develop in-space production applications in what industry studies indicate are the most promising areas for profitable manufacturing in space, such as advanced fiber optics, crystals, and regenerative medicine. Most of these in-space production applications are sponsored by CASIS, which in response to long-standing issues with oversight, its organizational structure, and its integration with the scientific community, is working with NASA to implement a six-point plan to ensure they maximize the benefit of the ISS National Laboratory for the remainder of its time in orbit.

**Protein Crystals Formed in Microgravity Aboard the ISS**



Source: NASA.

In addition, NASA is expanding commercial access to low Earth orbit beyond the scientific research and development allowed in the National Laboratory by enabling commercial and marketing activities onboard the ISS, such as shooting photographs and videos of an Estée Lauder skin serum using the backdrop of space, and allowing private astronaut missions, such as the first Axiom Space mission expected to launch to the ISS in February 2022. In fact, due to the level of demand for private astronaut missions to the Station, in June 2021 NASA moved to an annual competitive process for selecting up to two private astronaut missions per year based on availability.

Finally, NASA is contributing to the development of low Earth orbit commercial destinations. In 2020, the Agency awarded Axiom Space a firm-fixed-price contract of \$140 million to provide at least one habitable commercial module attached to the ISS, which will detach and become a free-flying destination prior to deorbiting the Station. In July 2021, NASA announced its Commercial Low Earth Orbit Destinations initiative to encourage development of a commercial successor to the ISS through public-private partnerships.

## ● Key Implemented Recommendations

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

Complete all end-of-mission critical systems and open work related to nominal and contingency deorbit operations ([IG-18-021](#)).

## Work That Needs to Be Done

Reliable transportation to low Earth orbit continues to be a priority for the Agency. Despite recent progress, the Commercial Crew Program continues to be challenged by Boeing's CST-100 Starliner vehicle, which encountered numerous delays and technical issues that precluded a second uncrewed test flight planned for July 2021. This second test flight was necessary because Boeing's first flight in December 2019 encountered significant software glitches that prevented the capsule from reaching the ISS.<sup>37</sup> Given the ongoing root cause analysis and technical issues facing the Boeing vehicle, it is not clear when the Starliner will conduct its first crewed flight. Until that time, NASA will be required to rely on SpaceX for commercial transportation to the ISS.

Whether on the ISS or a future commercial low Earth orbit destination, NASA is counting on the availability of a continuously crewed laboratory well beyond 2030 to conduct research and technology demonstrations required for deeper and longer-term space travel. Eleven of 27 technology gaps that require microgravity testing and 8 out of 12 critical human health risks that require mitigation using a microgravity environment will not be completed by the Station's proposed end-of-life in 2030.<sup>38</sup>

NASA intends for one or more commercial low Earth orbit destinations to be operational by 2028, allowing a 2-year overlap with the ISS before its anticipated retirement in 2030. The Agency's plan to develop a commercial economy continues to be an urgent priority so that it can avoid a gap in its ability to sustain a human presence in low Earth orbit.

## ○ Key Unimplemented Recommendations

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](#)).

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](#)).

Correct identified safety-critical technical issues before the crewed test flights, including parachute, propulsion, and launch abort systems, to ensure sufficient safety margins exist ([IG-20-005](#)).

<sup>37</sup> NASA and Boeing cooperated to form a joint Independent Review Team in December 2019 following the Starliner's first test flight. The assessment examined the three primary anomalies experienced during the initial test. NASA officially closed all actions recommended by the Independent Review Team which included additional dress rehearsals, refurbishing of the first Orbital Flight Test crew module, and outfitting a new service module.

<sup>38</sup> Eight of the 11 technology gaps that require microgravity testing are individual components of the Environmental Control and Life Support System, which will be integrated into a single system on the ISS by 2029.

***Ongoing and Anticipated Future Audit Work***

**NASA's Management and Utilization of Low Earth Orbit**

This audit will examine NASA's utilization and management of the ISS and its plans and progress toward developing a commercial market in low Earth orbit.

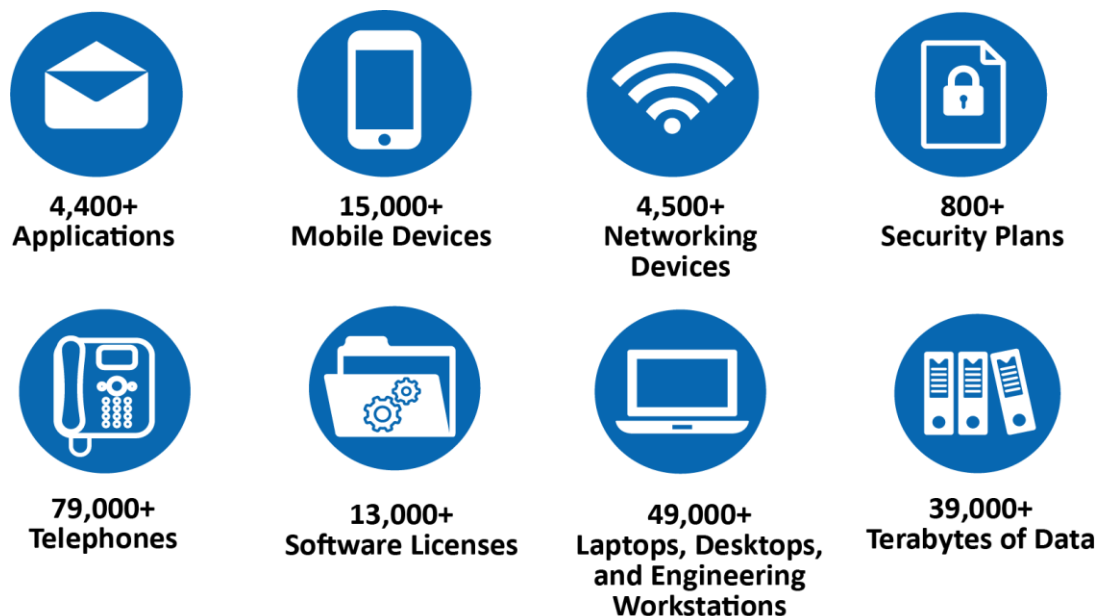


# Challenge 4: Managing and Mitigating Cybersecurity Risk

## Why This Is a Challenge

Cybersecurity is profoundly difficult and complex to manage, especially in an ever-changing threat environment where mitigation is a marathon, not a sprint. Over the past 20 years, we identified securing NASA's information technology (IT) systems and data as a top management challenge due, in large part, to the Agency's deficient IT management practices.<sup>39</sup> Given its more than 500 IT systems, high-profile mission, and broad connectivity with the public, educational institutions, research facilities, and other outside organizations, NASA is a larger and more attractive potential target for cybercriminals than most government agencies (see Figure 4).

**Figure 4: NASA IT by the Numbers**



Source: NASA OIG representation of Agency data.

With more than 72,000 applications and devices connecting to NASA's networks, effectively managing and mitigating cybersecurity risk is key to ensuring mission success—a fact underscored by mandatory telework as a result of the COVID-19 pandemic and the 2020 SolarWinds cyberattack.<sup>40</sup> To this end,

<sup>39</sup> NASA's IT systems include institutional systems that support the day-to-day work of Agency employees, such as laptop and desktop computers, and mission-specific systems that support the Agency's aeronautics, science, and space exploration programs, such as the Deep Space Network, which supports interplanetary spacecraft missions.

<sup>40</sup> Hackers believed to be operating on behalf of the Russian Foreign Intelligence Service breached software provider SolarWinds and deployed a malware-laced update to infect the networks of multiple U.S. companies and government networks, including NASA.

the Office of the Chief Information Officer (OCIO) allocated approximately \$69 million during FY 2021 to implement institutional cybersecurity measures because challenges and threats continue to evolve as adversaries routinely attempt to compromise NASA's IT assets.<sup>41</sup> For instance, in 2019 two Chinese nationals, members of a hacking group operating in China, were indicted on criminal charges for gaining unauthorized access to a NASA computer to steal data. Separately, in April 2020 we issued a Management Referral detailing the unauthorized access and deletion of data from an Agency IT system following an employee's separation. The investigation found that a contractor was permitted access to a NASA system following termination in which artifacts were deleted in violation of Agency policy and best practices. In addition, our investigation found that mission IT personnel did not follow established NASA incident response procedures that precluded the possibility of pursuing criminal charges against the former employee related to the potential intentional destruction of Agency data.

To help frame the scope and urgency of cybersecurity, the Federal Information Security Modernization Act (FISMA) and Federal Information Technology Acquisition Reform Act (FITARA) ratings provide broad insight into NASA's cyber health.<sup>42</sup> During the 2021 FISMA evaluation, NASA's information security program showed some improvement but still fell short of the Office of Management and Budget's watermark for a program to be considered effective.<sup>43</sup> Similarly, in July 2021 NASA received an overall FITARA grade of C+ given its challenges in managing cyber risks.

Strengthening foundational cybersecurity efforts, such as Enterprise Architecture and Enterprise Security Architecture—the blueprints for how an organization analyzes and operates its IT and cybersecurity—continues to be challenging as the Agency struggles to balance two competing priorities: protecting against cyber threats and fulfilling its mission. As we reported in May 2021, the Agency's cybersecurity preparedness is strained due to ambiguity surrounding the requisite technical integration between Enterprise Architecture and Enterprise Security Architecture as well as disjointed internal management structures and funding authorities.<sup>44</sup>

The Agency's organizational structure has three primary levels with varying responsibilities—and numerous lines of funding control—for cybersecurity management. Typically, missions fund their own computer networks and IT personnel; therefore, in most cases the mission directorate personnel rather than OCIO have visibility over the operational and security aspects of mission networks. This long-standing practice of having missions with independent budgets and sometimes competing interests impedes the Agency's ability to build a comprehensive Enterprise Architecture.

While the OCIO has responsibility for institutional governed IT that support the day-to-day work of NASA employees, missions are left to their own discretion to interpret and implement requirements and, importantly, absorb costs associated with cybersecurity. Smaller missions lack assets (people, tools, and funding) to devote to cyber efforts and tend to prioritize gathering science while putting cybersecurity low on their "to-do" lists.

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<sup>41</sup> OCIO personnel oversee the systems and security capabilities that comprise NASA's institutional networks, data centers, web services, and computers.

<sup>42</sup> FISMA, as amended in 2014 (Pub. L. No. 113-283), requires agencies to develop, implement, and document an agency-wide information security program. FITARA puts federal agency Chief Information Officers in control of their agency's IT investments.

<sup>43</sup> NASA OIG, *Evaluation of NASA's Information Security Program under the Federal Information Security Modernization Act for Fiscal Year 2021* ([ML-22-001](#), November 9, 2021).

<sup>44</sup> NASA OIG, *NASA's Cybersecurity Readiness* ([IG-21-019](#), May 18, 2021).

Adopting an integrated Enterprise Architecture and Enterprise Security Architecture would not only dramatically improve situational awareness but would also enable NASA's decision makers to effect positive change on the Agency's cybersecurity posture. However, these efforts take time to implement and require sustained leadership commitment. This year, we focused on three specific cybersecurity challenges the Agency is facing with an emphasis on practical issues where meaningful improvement and near-term progress is achievable: (1) improper use incidents, (2) mobile device security, and (3) assessment and authorization (A&A) process.<sup>45</sup>

- *Improper Use Incidents.* Improper use incidents result from a violation of an organization's acceptable use policies. In a May 2021 audit, we found that improper use incidents increased from 249 in 2017 to 1,103 in 2020—a 343 percent growth—with failing to protect Sensitive But Unclassified information the most prevalent abuse.<sup>46</sup> For instance, unencrypted email containing Sensitive But Unclassified data, Personally Identifiable Information, and International Traffic in Arms Regulations data continues to expose the Agency to unnecessary cyber risk that can affect national security, loss of intellectual property, and compromise of employee and contractor data.<sup>47</sup>
- *Mobile Device Security.* The OCIO manages over 15,000 mobile devices that store, process, and transmit Agency information, thereby requiring continuous protection. In an August 2020 audit, we found that the OCIO is not adequately monitoring and enforcing the business rules established for mobile devices, potentially exposing the email system and data to viruses, malware, or hacking through connected mobile devices.<sup>48</sup> Moreover, since the outbreak of COVID-19, exposure to cyber threats has increased because NASA's workforce has shifted to a work-from-home environment, increasing the usage of mobile devices.
- *Assessment and Authorization Process.* To ensure its IT systems meet cybersecurity requirements, NASA is required to perform a thorough A&A review process for newly introduced systems and annually for all other systems. In May 2021, we reported that NASA is inconsistent and ineffective with its A&A process because of its decades-long decentralized approach to cybersecurity.<sup>49</sup> Over the past 6 years, we have reported that certain types of assessment data have been ignored or discarded as irrelevant during the A&A process, leaving systems incorrectly categorized at lower risk impact levels than their criticality requires and resulting in increased vulnerability to cyber risks.

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<sup>45</sup> A&A consists of a review of security policies and procedures (management controls); physical facility infrastructure (operational controls); and network testing, server testing, application security testing, penetration testing, and scanning (technical controls). End products of A&A include an authorization to operate the IT system, risk-based decisions on the application of individual controls, and a plan of action and milestones to address identified deficiencies.

<sup>46</sup> [IG-21-019](#). Sensitive But Unclassified has been replaced by a newly mandated government-wide initiative and renamed as Controlled Unclassified Information. NASA was issued a waiver that permitted both information classifications to coexist until October 1, 2021.

<sup>47</sup> Personally Identifiable Information is any data, such as a social security number or date of birth, that could potentially identify a specific individual. International Traffic in Arms Regulations control the export and import of defense-related articles and services on the United States Munitions List and affects the manufacture, sale, and distribution of technology.

<sup>48</sup> NASA OIG, *Audit of NASA's Policy and Practices Regarding the Use of Non-Agency Information Technology Devices* ([IG-20-021](#), August 27, 2020).

<sup>49</sup> [IG-21-019](#).

## Progress in Addressing the Challenge

The Agency has taken steps to improve its management and mitigation of cybersecurity risks over the last several years. Most important has been the stability of having a tenured Senior Agency Information Security Officer in place for more than 4 years—longer than any other in NASA history. The continuity of leadership has been critical for the OCIO, and the Agency as a whole, to advance cybersecurity readiness. Additionally, NASA senior management has made a combination of strategic, risk management, and collaboration decisions that have begun to strengthen the Agency’s cybersecurity posture.

- *Strategic Decisions.* Agency officials formed a Cybersecurity Program Management Board with key senior team members to broaden visibility and provide input into programmatic decision-making to better manage cyber risk for programs, projects, and initiatives. In addition, NASA implemented security enforcements requiring End-of-Life/End-of-Support systems to be upgraded in order to remotely connect to NASA’s Virtual Private Network (VPN).
- *Risk Management Decisions.* NASA replaced and expanded the Agency’s secure VPN infrastructure in the fall of 2019, an action that proved critical for supporting the unanticipated move in March 2020 to mandatory telework for approximately 90 percent of the Agency’s workforce during the COVID-19 pandemic. Likewise, NASA has deployed Agency Endpoint Threat Detection and Response software across more than 50,000 systems.<sup>50</sup> The Agency is also creating a mobile VPN for government furnished iOS phones and tablets that utilize Mobile Device Management, allowing secure access over the internet to files stored on shared drives.<sup>51</sup>
- *Collaboration Decisions.* In 2020, NASA embedded a cybersecurity executive within the Artemis program to provide coordination and codify a tailored cross-Center enterprise cybersecurity risk approach for the program. The Agency also established the Cybersecurity Integration Team—comprised of stakeholders across the Agency including all mission organizations—which issued guidance to improve High Value Asset identification and management.<sup>52</sup>

Lastly, the OCIO is in the process of implementing two important cyber-related initiatives. In January 2022, under the Mission Support Future Architecture Program, Center Chief Information Security Officers and cybersecurity staff will be realigned from the Center OCIO to the Senior Agency Information Security Officer, moving the Agency towards an enterprise computing model that would centralize and consolidate IT capabilities, such as software management and cybersecurity. Additionally, in February 2022 the OCIO anticipates it will award the Cybersecurity and Privacy Enterprise Solutions and Services contract that expects to eliminate duplicative cyber services and the need for Center-based IT security contracts.

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<sup>50</sup> Endpoint detection and response software is used to gather and analyze security threat-related information from computer workstations and other endpoints with the goal of finding security breaches as they happen and facilitating a quick response to discovered or potential threats.

<sup>51</sup> iOS is a mobile operating system for Apple-manufactured devices such as the iPhone and iPad.

<sup>52</sup> A High Value Asset is information or an information system that is so critical to an organization that the loss or corruption of this information or loss of access to the system would have serious impact to the organization’s ability to perform its mission or conduct business. These sensitivities make High Value Assessments of particular interest to criminal, politically-motivated, or state-sponsored actors for either direct exploitation of the data or to cause a loss of confidence by the public.

## ● Key Implemented Recommendations

Require the Jet Propulsion Laboratory Cybersecurity/Identity Technologies and Operations Group to identify and remediate weaknesses in the security problem log ticket process and provide periodic aging reports to the Jet Propulsion Laboratory Chief Information Officer detailing the status of open security problem log tickets, pending patches, and outdated security waivers ([IG-19-022](#)).

Ensure OCIO and Office of Strategic Infrastructure representatives are included in functional reviews of NASA's critical infrastructure assets and facility security assessments so that cyber and facility interdependencies are addressed appropriately ([IG-17-011](#)).

## Work That Needs to Be Done

As cyber threats continue to evolve and become more sophisticated, they pose ongoing challenges for NASA to fortify and safeguard its IT systems. Space is both a collaborative and competitive business; NASA's potential cyber threats are as varied as its missions. The ongoing tension between collaboration and competition will continue to define space activities in the coming years requiring the Agency to combat threats in order to maximize the utility of space partnerships while protecting intellectual property against theft.

While NASA has implemented countermeasures to reduce the likelihood and overall risk associated with cyber threats, it continues to face challenges in improving its defenses to protect mission data and thwart vulnerabilities. The Agency's cybersecurity preparedness continues to be strained due to ambiguity surrounding the technical integration between Enterprise Architecture and Enterprise Security Architecture and gaps in visibility of the mission networks. To counter a broad range of exploitation techniques and to continue forward progress, the OCIO needs to (1) reduce improper use incidents, (2) ensure that mobile device security is addressed, and (3) implement a consistent A&A process. Additionally, as the Mission Support Future Architecture Program and Cybersecurity and Privacy Enterprise Solutions and Services contract come to fruition, sustained focus by Agency leadership is critical to integrating these dual initiatives into its enterprise-wide cyber portfolio to avoid implementation gridlock.

Furthermore, previous concerns such as the large size of the Agency's web footprint and emerging concerns related to the supply chain warrant continued action by NASA officials. Activities to streamline websites, revamp the main website, create an Agency web-archiving program, and implement a new Agency web governance structure are ongoing. As of July 2021, NASA has completed a comprehensive internal review of 2,867 websites and is working toward implementing a new nasa.gov information architecture to streamline the Agency web space. Finally, like many other agencies, NASA is dependent on a supply chain that is vulnerable to disruption and cyber threats, and the impact on NASA IT systems must be monitored with a sense of urgency because much of the supply chain issues stem from the dependence on single and sole-source nations, primarily China.

## ○ Key Unimplemented Recommendations

Improve the patch and vulnerability management program ([IG-21-005](#)).

Assign the personnel resources necessary to ensure the Agency's security plans for systems that inherit the controls within the Agency's new hybrid common controls system are updated and that those hybrid controls are removed from the Agency Common System security plan ([IG-21-010](#)).

Integrate Enterprise Architecture and Enterprise Security Architecture and develop metrics to track the overall progress and effectiveness of Enterprise Architecture ([IG-21-019](#)).

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*

#### **Review of NASA's Information Security Program under the Federal Information Security Modernization Act for Fiscal Year 2021**

As required by FISMA, this annual review will evaluate NASA's information security program for FY 2021.

#### **Audit of NASA's Insider Threat Program**

This audit will examine whether the Agency has established and implemented an effective insider threat program in accordance with federal policies, NASA policies, and best practices.

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

## Why This Is a Challenge

NASA uses contracts, grants, and cooperative agreements to fund research and development activities and purchase services, supplies, and equipment to support every facet of its operations. In FY 2020, NASA spent approximately \$19.7 billion of its \$27.7 billion in available resources on contracts, grants, and cooperative agreements awarded primarily to businesses, educational institutions, and nonprofit organizations. The breadth and scale of these acquisitions underlie the significant challenge NASA faces to ensure the Agency receives good value for its investments and that recipients spend NASA funds appropriately to accomplish agreed-upon goals.<sup>53</sup> Moreover, the Agency is also increasingly relying on public-private partnerships and alternative acquisition approaches in an attempt to achieve cost savings and accelerate development of new technologies, including several key systems for its Artemis mission to return humans to the Moon.

NASA has faced long-standing challenges with oversight of its contracts, grants, and cooperative agreements. GAO first designated the Agency's acquisition management as a high risk in 1990, and it has remained a high-risk area for three decades due to persistent cost growth and schedule delays in many of NASA's major projects.<sup>54</sup> Similarly, we have highlighted acquisition as an Agency management challenge for the past 15 years with identified weaknesses in both oversight of the acquisition process and the readiness of its acquisition workforce.

NASA also continues to be challenged with oversight of its acquisition process. Most recently, in a July 2021 audit of NASA's cooperative agreements with the Universities Space Research Association, we reported that the Agency needed to take additional steps to improve its management and financial oversight of cooperative agreements, especially with regard to significant extensions and augmentations to those agreements.<sup>55</sup> Furthermore, our financial statement audits over the past decade have

### 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 specific purpose. A cooperative agreement typically requires substantial collaboration between the Agency and the recipient.

<sup>53</sup> NASA's contracts are managed by the Office of Procurement, while grants and cooperative agreements are issued by the NASA Shared Services Center and managed by the Office of the Chief Financial Officer.

<sup>54</sup> This issue is discussed in Challenge 2, *Improving Management of Major Projects*.

<sup>55</sup> NASA OIG, *NASA's Management of Universities Space Research Association's Cooperative Agreements* ([IG-21-022](#), July 14, 2021). Funded extensions are supplements used to extend grants that require additional funding beyond their expiration dates. Augmentations are supplements that can be used at any time for work outside the scope of the approved proposal.



identified challenges in timely closing out of contracts to ensure the government received what it contracted for, detected and recovered erroneous payments, made final payments to the contractors, and deobligated excess funds. Our FY 2020 financial statement audit also revealed oversight issues with the Agency's internal controls related to the grant management process that we found were not designed to effectively monitor grantees and the federal awards they received.<sup>56</sup> Also, over the past 3 years our Office of Investigations conducted 40 criminal investigations involving grant fraud and abuse. The investigations resulted in 4 indictments, 2 prosecutions, and 4 suspensions with NASA receiving \$341,266 in restitution, \$731,131 in recoveries, and \$3,272,790 in civil settlements.

More broadly, NASA is challenged with Agency-wide oversight of its acquisition workforce. In an October 2020 audit, we found that NASA does not collect Agency-wide acquisition workforce workload or performance data, which limits its ability to have an accurate picture of who comprises the acquisition workforce, determine whether they are certified as required, and measure workforce performance consistently across the entire Agency.<sup>57</sup> Further, the practice of Center procurement offices functioning autonomously resulted in institutionalized inefficiencies such as redundant capabilities and contracts, legal and policy offices reviewing inconsistent monetary thresholds across Centers, and lack of workforce flexibility.

In our judgment, these challenges expose NASA's contracts, grants, and cooperative agreements to an increased risk of fraud, waste, and abuse. In particular, fraud and misconduct with the Agency's Small Business Innovation Research (SBIR) and Small Business Technology Transfer programs are a long-standing OIG concern. Recent examples include:

- A Kansas engineering company agreed to a civil settlement of \$672,352 to resolve allegations that it submitted false claims to obtain grant funds from the SBIR and Small Business Technology Transfer programs. The investigation determined that the company received small business funding for which it was ineligible.
- A New York company agreed to a settlement of \$490,000 to resolve allegations under the civil False Claims Act that it did not satisfy ownership and control requirements under the SBIR program. The company was ineligible for SBIR awards from NASA and the U.S. Department of Defense due to the involvement of Canadian investors.
- A Wyoming small business agreed to pay damages of \$557,684 in a civil settlement to resolve allegations that it accepted SBIR funding to which it was not entitled from NASA, the U.S. Department of Energy, and the U.S. Department of Health and Human Services.

In addition, the ongoing COVID-19 pandemic has impacted NASA's management of its contracts. Under Section 3610 of the Coronavirus Aid, Relief, and Economic Security Act—the pandemic relief legislation known as the CARES Act—agencies are permitted to reimburse contractors for work stoppages caused by the pandemic to keep employees and subcontractors in a ready state given the closure of NASA Centers.<sup>58</sup> This provision is particularly relevant to an agency like NASA that relies so heavily on private contractors for its science and space exploration projects. The CARES Act provided NASA with \$60 million for safety, security, and mission support to prevent, prepare for, and respond to the

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<sup>56</sup> NASA OIG, *Fiscal Year 2020 Financial Accounting Management Letter* (IG-21-008, December 14, 2020).

<sup>57</sup> NASA OIG, *NASA's Management of Its Acquisition Workforce* ([IG-21-002](#), October 27, 2020).

<sup>58</sup> Coronavirus Aid, Relief, and Economic Security Act, Pub. L. No. 116-136 (2020).



coronavirus. However, the Agency is planning to pay for subsequent adjustments using non-CARES Act appropriated funds and we anticipate additional significant costs to NASA in the future.

## Progress in Addressing the Challenge

NASA has taken numerous steps to address its contract management challenges. The Office of Procurement continues to implement the ongoing Mission Support Future Architecture Program, NASA's transition to an enterprise-wide workforce that leverages employees' skills for use across the Agency; developed a Strategic Workforce Plan to maintain a workforce capable of responding to current and future contracting needs; and developed an Acquisition Portfolio Assessment Team to assess all Agency contracts and identify redundant contracts managed at the Center level.

In the past year, NASA has also made several enterprise-wide changes to address acquisition management and oversight concerns. The Agency has consolidated the award and administration of grants and cooperative agreements through the NASA Shared Services Center. This consolidation is designed to improve service and data quality, standardize processes, leverage skills and investments, and provide economies of scale. NASA has also developed and implemented a new pre-award risk assessment policy and the Pre-Award Risk Assessment Tool to help standardize reviews across Centers. This tool has been in use by the NASA Shared Services Center for all recipients of new grants and cooperative agreements since October 1, 2020. In addition, NASA has made efforts to increase its efficiency in closing expired grants by incentivizing closeout contractors to complete timely and proper grant closeout.

In an August 2021 report, we found that NASA appropriately managed \$60 million provided by the CARES Act. For the Section 3610 transactions, NASA developed advanced agreements, a vehicle contracting officers and contractors use for special or unusual costs, specifically designed for the unique circumstances presented by the pandemic. We found that the advanced agreements and supporting documentation for the 27 Section 3610 transactions in our sample were all pandemic-related, and the advanced agreements adequately described the conditions such as facility closures and listed the contractor employees and the job functions that could not be performed remotely.<sup>59</sup>

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<sup>59</sup> NASA OIG, *Review of Coronavirus Aid, Relief, and Economic Security (CARES) Act Funding* ([IG-21-024](#), August 9, 2021).

## ● Key Implemented Recommendations

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

Provide information and training to contracting officers and source evaluation board members on the availability, use, and responsibilities of the Defense Contract Management Agency during source evaluation boards and source selections. Specifically, the NASA Federal Acquisition Regulation Supplement and NASA-Defense Contract Management Agency Memorandum of Understanding for Earned Value Management ([IG-20-015](#)).

Establish policies and procedures as part of the NASA Grant and Cooperative Agreement Manual to periodically review a recipient's actual cost match and document award requirements are met prior to obligating the next increment of funding ([IG-16-013](#)).

## Work That Needs to Be Done

Collectively, our audit and investigative work has shown that NASA's inadequate management and oversight of contracts, grants, and cooperative agreements has, at times, resulted in inappropriate expenditures and wasted taxpayer dollars that negatively impacted the Agency's mission.

Successful implementation of NASA enterprise-wide initiatives—such as the Mission Support Future Architecture Program—should provide more consistency in oversight and management of contracts, grants, and cooperative agreements, as well as sharing of lessons learned. However, as we have seen in past enterprise-wide initiatives, progress can be slow and halting due largely to the Agency's decentralized management structure, lack of insight into Agency-wide operations, and the limited authority of Headquarters officials to control budgets and implement change at the Center level. We have similar concerns with the Agency's ability to reorganize procurement management authority, operations, and oversight into a headquarters-based, enterprise-level function. A recent recommendation made as part of our audit of NASA's acquisition workforce to link program and project managers to their contract assignments remains unresolved because the Office of Procurement lacks an existing source that contains this data. In our view, the ability to link contract assignments to acquisition workforce personnel is essential to the Office of Procurement's efforts to monitor and measure workforce performance and establish a baseline for operations at an enterprise level as part of the Agency's Mission Support Future Architecture Program.

NASA also needs to continue its work towards improving the timely closeout of contracts. In FY 2020, the Office of Procurement implemented several corrective action plans regarding timely closing out of contracts, especially the controls over the deobligation of any funds remaining on such contracts. The plans included establishing a Closeout Capability Group, Contract Closeout Guidebook, and a closeout repository to strengthen communication about closeout duties and store closeout documentation in a centralized location to expedite the closeout process. In November 2020, the Contract Closeout

Guidebook was incorporated into the NASA FAR Supplement. The Office of Procurement also continuously monitors closeout performance at each Center and collects quarterly and annual metrics for review.

Additionally, NASA needs to improve its oversight of the grants process to include strengthening documentation requirements and developing a process for tracking questioned costs. Moving forward, ensuring proper use of NASA's resources remains a top priority and Agency contracting personnel need to be proactive in their efforts to prevent fraud, waste, and abuse.

Finally, with regard to COVID-19 contracting challenges, Agency officials have reported as much as \$89 million in potential Section 3610 reimbursements as of June 2021, and they expect that amount will increase as they receive additional requests from contractors. NASA officials said they intend to follow their established contracting practices for future pandemic-related adjustments, with contracting officers responsible for ensuring invoices and claims are in line with the contracts, advanced agreements, and NASA policies. Given the significant costs and efforts that will likely be associated with these adjustments, we plan to continue our oversight work in this area.

## ○ Key Unimplemented Recommendations

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](#)).

In coordination with the NASA Shared Services Center, comply with the Federal Grant and Cooperative Agreements Act of 1977 on the proper use of grants and contracts to allow Center and Program personnel greater visibility into partner operations and to ensure that funding levels and performance are commensurate with requirements ([IG-20-023](#)).

### ***Ongoing and Anticipated Future Audit Work***

The OIG's Offices of Audits and Investigations, in conjunction with our Advanced Data Analytics Program, will continue to assist NASA in strengthening its acquisition oversight efforts by examining Agency-wide procurement and grant-making processes.<sup>60</sup> These efforts will include assessing actions NASA is taking to identify and mitigate grant fraud risks; auditing individual contracts, grants, and cooperative agreements; and investigating potential misuse of contract and grant funds. Additionally, we plan a second round of contracts with several external entities to perform incurred cost audits of NASA contractors.

#### **Review of NASA's Management of the Johns Hopkins University Applied Physics Laboratory Portfolio**

This audit will assess NASA's processes and controls ensuring the effective management of the contracts and portfolio of Agency projects developed by the Johns Hopkins University Applied Physics Laboratory.

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<sup>60</sup> Since 2015, our Advanced Data Analytics Program has provided analytic products to our audit and investigative teams that show indicators of and help identify potential contract, grant, and procurement fraud. We continue to use a variety of statistical and mathematical techniques to gather, analyze, and interpret Agency and open-source data to identify fraud indicators and help target OIG audit and investigative resources.

**Science Mission Directorate’s Management of Research and Analysis Grants**

This audit will evaluate whether the Science Mission Directorate and NASA Shared Services Center have sufficient controls in place to adequately oversee its Research and Analysis grants.

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

## Why This Is a Challenge

The success of NASA’s missions, programs, and projects relies on the Agency attracting and retaining a highly skilled and diverse workforce with varied technical and management skills. As of May 2021, NASA had approximately 18,000 civil service employees working at its facilities nationwide, most in science and engineering fields. Our prior work has shown that NASA faces interrelated workforce challenges including not having enough employees with the right skills in technical areas; implementation shortfalls; an aging workforce; and Science, Technology, Engineering, and Mathematics (STEM) pipeline risks. Workforce challenges are not unique to NASA but are a government-wide concern. The U.S. Office of Personnel Management’s 2018 Federal Workforce Priorities Report observed that human capital challenges appeared in at least 10 percent of 221 Inspectors’ General management challenges and at least 25 percent of GAO’s 32 High-Risk List areas.<sup>61</sup> In GAO’s 2021 High-Risk List, federal strategic human capital management—a high risk since at least 2001—was downgraded from “met” to “partially met,” with GAO noting that persistent mission-critical skills gaps within federal agencies reduce their effectiveness.<sup>62</sup>

NASA OIG and GAO have reported on multiple NASA projects—Low-Boom Flight Demonstrator, Europa Clipper, and Mars 2020 to name a few—that have experienced workforce challenges, including not having enough staff at the right times or staff with the right skills.<sup>63</sup> Last year we reported that NASA’s engineering technical disciplines faced significant risks to their specialized workforces, with particular concern to the loss of unique skillsets from retiring employees before their knowledge could be passed on to others within the Agency. More recently, we reported on NASA’s challenges to develop an agile and mission-driven acquisition workforce as it continues to implement an enterprise-wide approach to procurement under the Mission Support Future Architecture Program. Our audits have shown that despite establishing strategic frameworks for change, NASA has had limited success implementing these efforts to reorganize Agency-wide operations.<sup>64</sup> Furthermore, the Aerospace Safety Advisory Panel noted in its 2020 Annual Report that NASA was not addressing certain workforce issues at the strategic level, risking an “erosion of expertise and experience in the NASA workforce, thereby

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<sup>61</sup> U.S. Office of Personnel Management, *2018 Federal Workforce Priorities Report* (February 2018).

<sup>62</sup> [GAO-21-119SP](#).

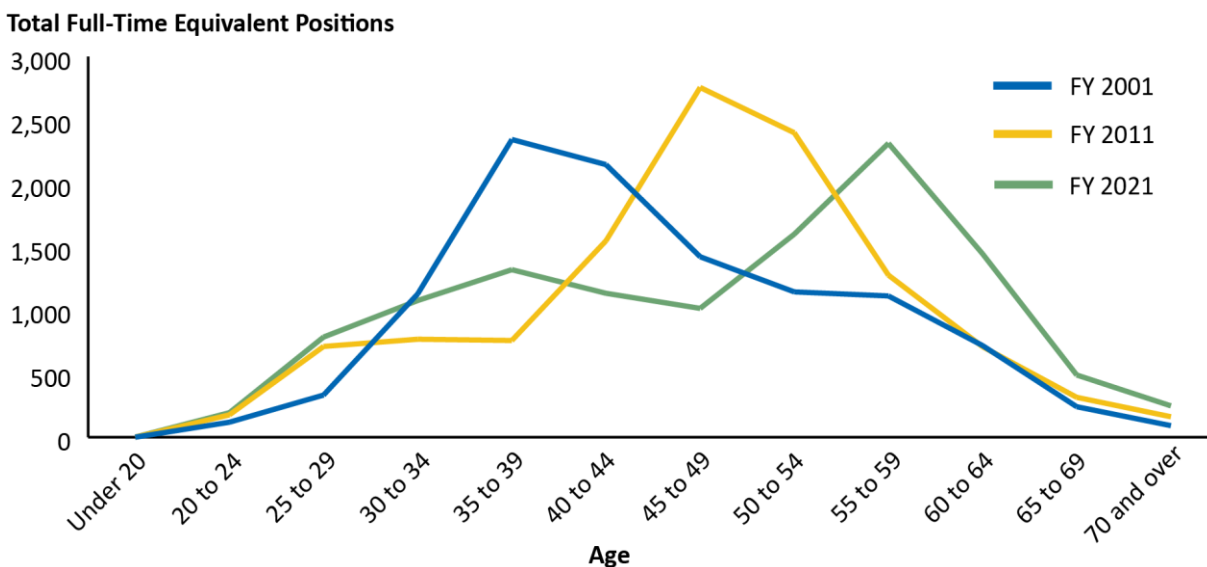
<sup>63</sup> NASA OIG, *Management of the Low-Boom Flight Demonstrator Project* ([IG-20-015](#), May 6, 2020), *Management of NASA’s Europa Mission* ([IG-19-019](#), May 29, 2019), and *NASA’s Mars 2020 Project* ([IG-17-009](#), January 30, 2017). GAO, *NASA: Assessments of Major Projects* ([GAO-18-280SP](#), May 1, 2018). The Europa Clipper plans to launch in October 2024 to Jupiter’s moon Europa and over a 4-year period investigate whether conditions on the moon are potentially suitable for life. The Mars 2020 Perseverance Rover, which launched in July 2020 and landed in February 2021, seeks to better understand the geology of Mars, identify evidence of ancient life, collect Martian surface samples, and test new technologies.

<sup>64</sup> NASA OIG, *NASA’s Planetary Science Portfolio* ([IG-20-023](#), September 16, 2020) and [IG-21-002](#).

undermining NASA’s ability to effectively manage the highly complex risk problems of future exploration programs, including those envisioned for the Artemis campaign.”<sup>65</sup>

Our prior top management and performance challenges reports have also highlighted that NASA’s workforce age distribution should raise additional human capital concerns. Nearly 12,000 of NASA’s 18,000 civil service employees (65 percent) fall under the occupation category “science and engineering”—the portion of the workforce that provides technical capabilities to enable space flight and science missions. Within this category, 6,000 are more than 50 years old, and of those employees approximately 3,000 are eligible to retire in 2021. These potential impending retirements, shown in Figure 5, could result in a significant loss of institutional knowledge and skills.

**Figure 5: Science and Engineering Workforce Trend**



Source: NASA OIG presentation of Agency workforce data.

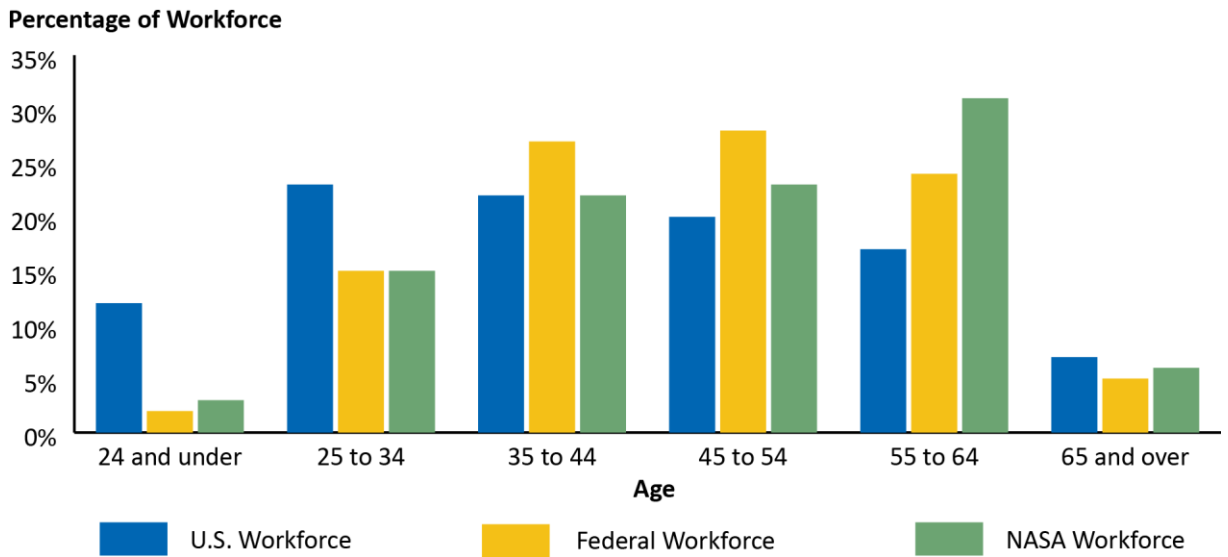
The Partnership for Public Service recently reported that agencies struggle with staffing shortages and report gaps in knowledge and skills. These issues are compounded by an aging federal workforce with a wave of retirements threatening to further stretch staffing capabilities as roughly one-third of employees onboard at the beginning of FY 2019 were eligible to retire by the end of FY 2023.<sup>66</sup> The Office of Personnel Management reported for June 2021 that there were six times more federal employees older than 50 than under 30 (44.1 percent compared to 6.9 percent).<sup>67</sup> It is noteworthy that NASA has a significantly larger percentage of its workforce in the 55 to 64 year age range than the federal average (see Figure 6).

<sup>65</sup> Aerospace Safety Advisory Panel, *Annual Report for 2020* (January 2020). The Panel evaluates NASA’s safety performance, advises the Agency on ways to improve that performance, and reports to both NASA and Congress.

<sup>66</sup> Partnership for Public Service, *A Time for Talent—Improving Federal Recruiting and Hiring* (August 2020). Partnership for Public Service is a nonpartisan, nonprofit organization that works to make the government more effective and efficient.

<sup>67</sup> The Office of Personnel Management serves as the chief human resources agency and personnel policy manager for the federal government.

**Figure 6: Workforce Distribution by Age in May 2021**



Source: NASA OIG presentation of U.S. Department of Labor, Office of Personnel Management, and NASA data.

Additionally, as an agency highly dependent on skilled STEM workers to accomplish its mission, NASA remains at risk from a shortage of such staff. The U.S. Bureau of Labor Statistics reported the STEM labor market is highly segmented into different disciplines, sectors, and skill levels with varying degrees of supply and demand.<sup>68</sup> In 2018, the Executive Director of the American Institute of Aeronautics and Astronautics testified before Congress about a STEM worker shortage in the aerospace community.<sup>69</sup> The Institute also highlighted in its work the need to increase diversity and foster inclusion by encouraging women and underrepresented minorities to pursue careers in the aerospace industry and emphasized that STEM school curriculums should be aligned to current workforce needs.<sup>70</sup>

## Progress in Addressing the Challenge

For the past 9 years, NASA has been voted the best large agency to work for in the federal government and again held the top rank in 2020 according to the Partnership for Public Service.<sup>71</sup> NASA is attempting to cultivate a diverse and innovative workforce with the right balance of skills and experience to provide an inclusive work environment. Moreover, NASA added “inclusion” as an Agency core value in FY 2020.<sup>72</sup> To this end, NASA is rolling out at least two initiatives—“Agency Unity Campaign” for employees emphasizing mission success through increased collaboration, connection,

<sup>68</sup> Yi Xue and Richard C. Larson, U.S. Bureau of Labor Statistics, *Monthly Labor Review*, “STEM crisis or STEM surplus? Yes and yes” (May 2015).

<sup>69</sup> NASA’s Cost and Schedule Overruns: Acquisitions and Program Management Challenges. Before the Subcommittee on Space, Committee on Science, Space, and Technology, 115th Congress (2018) (statement of Executive Director Daniel L. Dumbacher). The American Institute of Aeronautics and Astronautics’ membership includes nearly 30,000 engineers and scientists from 88 countries involved in global aerospace.

<sup>70</sup> American Institute of Aeronautics and Astronautics, *A&D Workforce: Industry Overview, Industry Challenges, and Industry Needs* (February 2021).

<sup>71</sup> The Partnership for Public Service’s results were calculated based on responses to the Office of Personnel Management’s annual Federal Employee Viewpoint Survey.

<sup>72</sup> NASA core values are safety, integrity, teamwork, excellence, and inclusion.

and communication, and “Mission Equity,” a comprehensive effort to assess expansion and modification of NASA programs, procurements, grants, and policies, and examine potential barriers and challenges for communities that are historically underrepresented and underserved.

Furthering its efforts to strategically hire staff with the right skills, NASA’s Office of the Chief Human Capital Officer (OCHCO) is undertaking activities to better align the Agency’s workforce to its current and future missions. This includes aligning specific OCHCO goals to NASA’s strategic objectives. Other initiatives include implementing a flexible and agile workforce approach through the Strategic Workforce Plan and replacing NASA’s aging talent acquisition system with one that will enable the Agency to more strategically hire, develop, and manage its workforce. OCHCO has also made efforts to reduce the hiring cycle time, leverage special hiring authorities, clear the hiring backlog from prior years, and work with Centers and Mission Directorates to develop plans to lessen the impact of a future retirement wave.

As the Agency plans to improve the pipeline of candidates to fill current and future open positions, it is making efforts to attract and retain underserved and underrepresented students in engineering and other STEM fields in partnership with minority serving and other higher education institutions. One important change from previous years is that in its FY 2022 budget request NASA did not recommend eliminating its Office of STEM Engagement funding. Instead, the Agency requested \$147 million for FY 2022 after receiving \$127 million from Congress in FY 2021. The Minority University Research and Education Project, which is administered through NASA’s Office of STEM Engagement and provides financial assistance via competitive awards to minority serving institutions, is seeing the largest increase, with \$10 million more requested for 2022 over what it received in 2021. Further, NASA is integrating metrics and using data to inform decisions on how to better reach the public, engage stakeholders, and evaluate outcomes. Critically, the STEM Engagement strategy is designed to enable relevant student contributions to NASA’s mission and work.

## ● 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](#)).

Create standardized guidance for performing annual capability assessments that considers, at a minimum, the appropriate time and resources for performing the assessments and the required data, analyses, and expected goals or results ([IG-17-015](#)).

## Work That Needs to Be Done

To maintain a world-class workforce, NASA must fill current critical workforce gaps and prepare for those on the horizon by planning how to mitigate a forthcoming wave of retirements. Furthermore, the ability to successfully address that risk will require the Agency to have detailed visibility into workforce skill types—data that the Agency currently does not collect. The Center for Space Policy and Strategy recently emphasized the need for agencies to use data to measure their success in investing in their STEM workforce, stating “there should be a continuous evaluation of what works and what does not



work.”<sup>73</sup> Having the right data will also help NASA meet the Succession Planning and Knowledge Transfer priority outlined in the 2018 Federal Workforce Priorities Report, which notes that agencies should maintain “a multi-faceted succession plan that is designed to capture the valuable knowledge and insights of current employees, convey captured knowledge to new and retained employees, and create and utilize a multi-generational pipeline.”

NASA management knows it will need a significant number of well-trained engineers, scientists, statisticians, accountants, human resources and procurement professionals, IT developers, and support specialists into the next decade. They must continue to work to ensure that their ongoing investments develop a continuous stream of candidates with the passion and skills to study the Earth, the Sun, and solar system; conduct aeronautics research, testing, and development; and lead crewed and uncrewed space exploration efforts. Looking forward to a post-pandemic environment, NASA will need to confront head-on the challenges and opportunities in managing a workforce using much greater telework and remote work flexibilities.

## ○ Key Unimplemented Recommendations

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*

We will continue to monitor progress on the Agency’s workforce master plan and examine specific workforce issues as part of broader OIG audits and reviews.

#### **Review of Astrophysics Portfolio**

This audit will evaluate the current state of the Agency’s Astrophysics portfolio, identify and assess risks to future missions, and provide recommendations in support of the next decadal survey.

#### **NASA’s Management of Its Astronaut Corps**

This audit will assess to what extent NASA’s processes for sizing, training, and assigning its astronaut corps align with the Agency’s current and future mission needs.

#### **NASA’s Diversity, Equity, Inclusion, and Accessibility Efforts**

This audit will evaluate NASA’s efforts to advance diversity, equity, inclusion, and accessibility throughout the Agency.

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<sup>73</sup> The Center for Space Policy and Strategy provides nonpartisan research and strategic analysis in support of the development of well-informed, technically defensible, and forward-looking space and technology policy. The Center is part of The Aerospace Corporation, a nonprofit organization that advises the government on complex space enterprise and systems engineering problems. Colleen Stover, *Developing Future Space Workers: Leadership Needed Today* (April 2021).

# Challenge 7: Managing NASA's Outdated Infrastructure and Facilities

## Why This Is a Challenge

Over the past 60 years, NASA and its commercial partners have relied on the Agency's facilities and infrastructure, including laboratories, launch complexes, test stands, and wind tunnels, to develop new and innovative technologies to advance space exploration missions, scientific research, and aeronautics. NASA is one of the largest property holders in the federal government with \$40 billion in physical assets and an inventory of more than 5,000 buildings and structures across 12 states and at its headquarters in Washington, D.C. However, over 75 percent of its facilities are beyond their original design life and require a significant investment in maintenance, including 166 abandoned properties worth \$291 million that present a safety and maintenance liability due to their structural or interior deficiencies. To achieve its current exploration and research goals, the Agency needs to be smart about what facilities to invest, divest, or consolidate and maintain in a safe condition.

While it strives to keep its facilities operational, NASA faces a deferred maintenance backlog estimated at \$2.8 billion as of 2021, which has resulted in unscheduled maintenance costing up to three times more to repair or replace equipment after it has failed than if NASA conducted regular scheduled maintenance. Further compounding this issue, in March 2020 the Agency implemented its emergency pandemic response plan that closed facilities across the country except those necessary to protect critical infrastructure and ongoing missions. Consequently, NASA was forced to scale back work on construction and maintenance projects, resulting in increased costs and schedule delays. In a September 2021 audit, we found that 101 construction projects across the Agency reported nearly \$11 million in contractor requests for equitable adjustment, and facility closures delayed project schedules by 5 months on average.<sup>74</sup>

For facilities the Agency is not currently utilizing but may need to meet future mission needs, NASA has several options. The Agency may retain the property in its present state, demolish the property, transfer the property to the General Services Administration for sale, or make the property available for lease. Leasing has several benefits including generating revenue that the Agency can use to help reduce expenses and defray the costs of maintaining and improving facilities. In addition, leasing enables NASA to keep facilities in its inventory that although may be underutilized currently, may be needed for future projects. The challenge is ensuring that leasing does not replace disposing of property that is no longer needed now or in the foreseeable future.

In addition, we found in a December 2020 audit that hazardous materials pose a safety risk to NASA installations. Hazardous materials are used on a daily basis, including acids, bases, and oxidizers in research laboratories; propellants and fuels in engine testing; ethanol-based solvents in engineering laboratories; ammonia, acetone, and glycols in flight equipment operations; and chemicals in simulated

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<sup>74</sup> NASA OIG, *NASA's Construction of Facilities* (IG-21-027, September 8, 2021). A contractor may submit a request for equitable adjustment to the government for payment when unforeseen or unintended changes occur within the contract causing an increase in contract costs such as government modification of the contract, differing site conditions, defective or late-delivered government property, or issuance of a stop work order.

planetary environmental testing. These materials can be toxic, reactive, flammable, or explosive and, if poorly managed, can result in costly cleanup efforts, damage to facilities and equipment, personal injury, and loss of mission capabilities. Our review found that hazardous materials are not managed uniformly across NASA and the Agency lacks adequate internal controls for managing its hazardous materials inventory.<sup>75</sup>

Overall, NASA remains challenged to make the difficult decisions to invest, divest, 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. These decisions will become even more essential following the COVID-19 pandemic, which has resulted in widespread telework and highlighted issues about the number and size of facilities the Agency will need in the future.

## Progress in Addressing the Challenge

One key goal of NASA's Construction of Facilities (CoF) program is to modernize the Agency's infrastructure into fewer, more sustainable facilities and repair failing infrastructure to reduce overall maintenance costs. Between FYs 2016 and 2020, NASA received nearly \$1.8 billion in CoF funding that has resulted in an increasing number of projects to construct and facilities to upgrade. For example, the Exploration Ground Systems Program at Kennedy Space Center is upgrading 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. Langley Research Center utilized a large portion of its CoF funds to construct the Measurement Systems

Laboratory, a 175,000 square foot facility for research and development of new measurement concepts, technologies, and systems. In addition, the Center plans to begin construction on its Flight Dynamics Research Facility, a wind tunnel the Center will utilize for enhanced vertical spin testing of aircraft and spacecraft. The Jet Propulsion Laboratory continued construction on an array of antennas known as the Deep Space Network and also began construction of a 5-story, 85,000 square foot laboratory known as the Flight Electronics Integration Facility that will support spacecraft avionics and electronic hardware fabrication and testing. Glenn Research Center constructed a 64,000 square foot multi-use office building known as the Research Support Building along with a 55,000 square foot Aerospace Communications Facility that will be utilized for radio frequency communications technology research and development. Other significant projects included construction of a 41,000 square foot facility at Ames Research Center known as the Biosciences Collaborative Facility that houses laboratories for space biology, astrobiology, and synthetic biology and construction of the Goddard Space Flight Center's Instrument Development Facility, a 54,200 square foot multi-story laboratory and office facility.

**Aerial View of Launch Complex 39B with Exploration Ground Systems' Mobile Launcher for Artemis I on the Pad**



Source: NASA.

<sup>75</sup> NASA OIG, *NASA's Management of Hazardous Materials* ([IG-21-006](#), December 3, 2020).

In relation to hazardous materials, NASA is updating policies and procedures to designate appropriate officials to approve hazardous materials purchases, track and report hazardous material inventories, and inspect and evaluate storage sites.

## ● Key Implemented Recommendations

Establish a unified purchase card policy and designate an appropriate official at each Center to ensure hazardous material acquisitions made via purchase cards are appropriately approved, received, and tracked ([IG-21-006](#)).

Inspect and evaluate Centers' 90-day storage facilities and processes and make improvements as warranted ([IG-21-006](#)).

## Work That Needs to Be Done

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; efforts to "rightsize" NASA's workforce, facilities, and other supporting assets; construction of new assets such as test stands; NASA's efforts to reduce unneeded infrastructure and facilities; and the process to select, prioritize, and fund CoF projects. Common themes from these reviews are NASA's slow implementation of corrective actions, inconsistent implementation of Agency policies, the need for stronger life-cycle cost considerations in facility construction decisions, and a decentralized strategy and decision-making process.

For example, in September 2021 we reported that NASA's process for selecting and prioritizing CoF projects is largely driven by Centers regardless of Agency goals, mission needs, or economic efficiencies.<sup>76</sup> Further, at the time NASA lacked an Agency-wide facility master plan that considered consolidation of activities between Centers. Instead, the Agency has relied primarily on Center-based planning and may not be constructing the highest priority projects to meet future mission needs while diluting funds needed for repairs. We also reported that CoF projects incurred significant cost overruns ranging from \$2.2 million to \$36.6 million and took longer to complete than initially planned with projects running 3 months to more than 3 years behind schedule.

In December 2020 we reported that hazardous materials were not managed uniformly across the Agency, the Centers we visited did not consistently implement adequate controls, and employees and contractors at times circumvented existing controls to acquire hazardous materials.<sup>77</sup> Also, some storage facilities were in need of improvements and repairs, and one hazardous waste facility required physical improvements. As a result, NASA has accepted increased risks associated with the acquisition of hazardous materials that could result in personal injury or property and environmental damage.

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<sup>76</sup> [IG-21-027](#).

<sup>77</sup> [IG-21-006](#).

## ○ Key Unimplemented Recommendations

Develop and institute an Agency-wide process to prioritize and fund institutional and programmatic CoF projects that align with Agency-level missions and require business case analyses to be completed and considered as part of the process prior to the projects' approval ([IG-21-027](#)).

Reexamine policies regarding oversight of the CoF program to identify alternative approaches to more effectively oversee the program ([IG-21-027](#)).

Require Center Directors to inspect and replace, as required, laboratory hazardous material storage structures and improve shelters that do not follow Centers for Disease Control and Prevention guidelines or comply with Agency requirements ([IG-21-006](#)).

### *Ongoing and Anticipated Future Audit Work*

#### **Audit of Ames Research Center's Lease Management Practices**

This audit will examine Ames Research Center's implementation and management of its lease agreements.

#### **NASA's Efforts to Upgrade Its Space Communications Infrastructure**

This audit will assess NASA's progress towards upgrading the Agency's Space Network and Deep Space Network and the ability of the networks to support current and future mission requirements.

# Challenge 8: Managing the Impacts of COVID-19 on NASA's Mission and Workforce

## Why This Is a Challenge

Since March 2020, NASA and the entire federal workforce has faced unprecedented challenges due to the COVID-19 pandemic. In an effort to protect public health and safety, many businesses and government agencies—including NASA—changed the way they operate to restrict physical access to facilities, resulting in disruptions to the Agency's tens of thousands of civilian and contractor employees, materials, and supply chain that have increased costs, delayed launch readiness dates, and impacted operational activities.

During the first 6 months of the pandemic, we found that 56 of NASA's programs and projects were impacted and could potentially incur a total lifetime cost growth of \$3 billion.<sup>78</sup> In addition, we estimated that the pandemic would continue to affect 35 programs and projects into FY 2022 and beyond. As of July 2021, the top-line estimate of the total lifetime cost for these delays and challenges decreased to approximately \$2.75 billion. After more than 19 months in a mandatory telework mode for the bulk of its workforce, NASA continues to face similar challenges as it did during the onset of the pandemic, such as an inability to conduct on-site activities, workforce startup inefficiencies, and delivery delays of government furnished equipment. For example, the estimated cost impact to the Nancy Grace Roman Space Telescope for FY 2021 and beyond increased from \$400 million in October 2020 to \$502 million in April 2021 due to continued loss of efficiency, reduced availability of supply chain vendors, and limited on-site work access at Goddard Space Flight Center and the Jet Propulsion Laboratory.<sup>79</sup>

Illustration of Nancy Grace Roman Space Telescope



Source: NASA.

In addition, the dramatic shift in NASA's operations during which the Agency closed 12 of its 18 major facilities and required 90 percent of its workforce to work from home for an extended period of time has raised fundamental questions about how the workforce will "return to on-site work" after it is deemed safe to do so. As of September 2021, over 85 percent of NASA's workforce was still teleworking full-time, and many will continue to work from home until further guidance from the Centers for Disease Control and Prevention and Office of Management and Budget advise otherwise. Also, in September 2021 the Administration released a pair of Executive Orders requiring COVID-19 vaccinations

<sup>78</sup> NASA OIG, *COVID-19 Impacts on NASA's Major Programs and Projects* ([IG-21-016](#), March 31, 2021).

<sup>79</sup> Scheduled to launch no earlier than 2026, the Nancy Grace Roman Space Telescope (formerly known as the Wide Field Infrared Survey Telescope) is a NASA observatory designed to study dark energy and dark matter, search for and image exoplanets, and explore topics in infrared astrophysics.



for federal employees and contractors.<sup>80</sup> While last year we discussed the effects of COVID-19 in each of the top management and performance challenges sections of this report, this year we added it as a stand-alone challenge because it is clear that the impact of the pandemic on NASA's operations will cost billions of dollars, lead to significant schedule delays in multiple projects, and affect how the Agency conducts business for years to come.

## Progress in Addressing the Challenge

Despite the ongoing challenges NASA continues to face due to COVID-19, the Agency has demonstrated flexibility and adaptability in its operations. The Office of the Chief Financial Officer began categorizing and tracking COVID-19's impact on NASA programs and projects beginning in April 2020. Officials from NASA's Mission Support Directorate as well as the Agency's four Mission Directorates—Aeronautics Research, Human Exploration and Operations, Science, and Space Technology—provided the Office of the Chief Financial Officer monthly updates initially (and quarterly updates starting in October 2020) highlighting issues and impact levels. This regular communication across the organization allowed the Agency to be responsive and agile in order to continue critical operations.

Work on NASA programs and projects in formulation and development continues, as do operations on other missions. For example, in addition to maintaining ISS operations, NASA successfully launched the first astronauts on a Commercial Crew Program mission to the ISS, launched and landed the Mars 2020 Perseverance Rover on the Red Planet, and launched the Sentinel-6 Michael Freilich spacecraft.<sup>81</sup> To accommodate new work-life dynamics resulting from COVID-19, NASA successfully expanded its telework capabilities and continued software development remotely. In addition, NASA used about 35 percent of its \$60 million CARES Act appropriation to pay for contractor leave authorized under Section 3610. Our August 2021 review of the Agency's CARES Act spending found that NASA appropriately managed these funds to meet congressional mandates as well as Agency and federal guidance.<sup>82</sup>

### ● Key Implemented Recommendations

There are no key implemented recommendations related to COVID-19.

## Work That Needs to Be Done

Since uncertainties surrounding the pandemic likely will remain well into 2022, NASA must continue to address and anticipate impacts to its programs, projects, and workforce. Agency managers will need to continuously monitor workforce and supply chain readiness, and update program and project cost and schedule estimates. While NASA will be unable to quantify the complete impact of the pandemic until

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<sup>80</sup> Requiring Coronavirus Disease 2019 Vaccination for Federal Employees, Exec. Order No. 14043, 86 Fed. Reg. 175 (September 9, 2021) and Ensuring Adequate COVID Safety Protocols for Federal Contractors, Exec. Order No. 14042, 86 Fed. Reg. 175 (September 9, 2021).

<sup>81</sup> The Sentinel-6 Michael Freilich spacecraft launched in November 2020 to collect data on global sea level, atmospheric temperature and humidity, and how oceans are rising in response to climate change.

<sup>82</sup> [IG-21-024](#).

after the COVID-19 emergency has subsided, the Agency has established a long-term baseline for normal operations. Looking forward, the Agency faces new challenges in implementing a far-reaching return-to-onsite-work plan for large swaths of its workforce that likely will embrace significantly expanded telework and remote work flexibilities. We plan to continue monitoring the impact of COVID-19 on NASA's programs and projects as well as NASA's return to on-site work efforts.

## ○ **Key Unimplemented Recommendations**

There are no key unimplemented recommendations related to COVID-19.

### ***Ongoing and Anticipated Future Audit Work***

We will continue to monitor COVID-19 impacts as part of a series of broader OIG audits and reviews. Also, when appropriate, we will conduct a review of NASA's return-to-work efforts.



# APPENDIX A: STRATEGIC GOALS AND OBJECTIVES

The figure below shows the eight challenges we identified for 2021 and the related NASA strategic goals and objectives.

**Figure 7: 2021 Top Management and Performance Challenges Linked to NASA Strategic Goals and Objectives**



Source: NASA OIG analysis of the Agency's 2018 Strategic Plan.

## APPENDIX B: ACRONYMS

|           |  |
|-----------|--|
| A&A       | assessment and authorization                           |
| CARES Act | Coronavirus Aid, Relief, and Economic Security Act     |
| CASIS     | Center for the Advancement of Science in Space, Inc.   |
| CoF       | Construction of Facilities                             |
| COVID-19  | Coronavirus Disease 2019                               |
| ESD       | Exploration Systems Development                        |
| FISMA     | Federal Information Security Modernization Act of 2014 |
| FITARA    | Federal Information Technology Acquisition Reform Act  |
| FY        | fiscal year  |
| GAO       | Government Accountability Office                       |
| HLS       | Human Landing System                                   |
| ISRO      | Indian Space Research Organisation                     |
| ISS       | International Space Station                            |
| IT        | information technology                                 |
| JWST      | James Webb Space Telescope                             |
| LBFD      | Low-Boom Flight Demonstrator                           |
| LCRD      | Laser Communications Relay Demonstration               |
| NISAR     | NASA-ISRO Synthetic Aperture Radar                     |
| OCHCO     | Office of the Chief Human Capital Officer              |
| OCIO      | Office of the Chief Information Officer                |
| OIG       | Office of Inspector General                            |
| SBIR      | Small Business Innovation Research                     |
| SLS       | Space Launch System                                    |
| STEM      | Science, Technology, Engineering, and Mathematics      |
| SWOT      | Surface Water and Ocean Topography                     |
| VIPER     | Volatiles Investigating Polar Exploration Rover        |
| VPN       | Virtual Private Network                                |

# APPENDIX C: RELEVANT OIG REPORTS

## Returning Humans to the Moon

*NASA's Strategy for 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)

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

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

## Improving Management of Major Projects

*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)

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

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

*NASA's Surface Water and Ocean Topography Mission* ([IG-18-011](#), January 17, 2018)

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

*NASA's Mars 2020 Project* ([IG-17-009](#), January 30, 2017)

## Sustaining a Human Presence in Low Earth Orbit

*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)

*NASA's Management and Utilization of the International Space Station* ([IG-18-021](#), July 30, 2018)

*NASA's Management of the Center for the Advancement of Science in Space* ([IG-18-010](#), January 11, 2018)

## Managing and Mitigating Cybersecurity Risk

*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 Fiscal Year 2020 Financial Statements* ([IG-21-005](#), November 16, 2020)

[Cybersecurity at NASA: Ongoing Challenges and Emerging Issues for Increased Telework during COVID-19](#). Before the House of Representatives Subcommittee on Space and Aeronautics, Committee on Science, Space, and Technology, 116th Congress (2020) (statement of NASA Inspector General Paul Martin)

*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)

*Audit of NASA's Security Operations Center* ([IG-18-020](#), May 23, 2018)

*NASA's Efforts to Improve the Agency's Information Technology Governance* ([IG-18-002](#), October 19, 2017)

*Industrial Control System Security within NASA's Critical and Supporting Infrastructure* ([IG 17-011](#), February 8, 2017)

## **Improving Oversight of Contracts, Grants, and Cooperative Agreements**

*Review of Coronavirus Aid, Relief, and Economic Security (CARES) Act Funding* ([IG-21-024](#), August 9, 2021)

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

*Fiscal Year 2020 Financial Accounting Management Letter*, Prepared by CliftonLarsonAllen LLP ([IG-21-008](#), December 14, 2020)

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

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

*Management of the Low-Boom Flight Demonstrator Project* ([IG-20-015](#), May 6, 2020)

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

*Ames Research Center Protective Services Contract* ([IG-19-017](#), April 25, 2019)

*NASA's Strategic Assessment Contract* ([IG-19-015](#), March 28, 2019)

*NASA's Engineering and Technical Services Contracts* ([IG-19-014](#), March 26, 2019)

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

*Audit of the National Space Biomedical Research Institute* ([IG-18-012](#), February 1, 2018)

*NASA's Management of the Center for the Advancement of Science in Space* ([IG-18-010](#), January 11, 2018)

## **Attracting and Retaining a Highly Skilled and Diverse Workforce**

*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 the Low-Boom Flight Demonstrator Project* ([IG-20-015](#), May 6, 2020)

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

*NASA's Surface Water and Ocean Topography Mission* ([IG-18-011](#), January 17, 2018)

*NASA's Efforts to "Rightsize" its Workforce, Facilities, and Other Supporting Assets* ([IG-17-015](#), March 21, 2017)

*NASA's Mars 2020 Project* ([IG-17-009](#), January 30, 2017)

## **Managing NASA's Outdated Infrastructure and Facilities**

*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)

*Audit of NASA's Historic Property* ([IG-19-002](#), October 22, 2018)

*NASA's Efforts to "Rightsize" its Workforce, Facilities, and Other Supporting Assets* ([IG-17-015](#), March 21, 2017)

## **Managing the Impacts of COVID-19 on NASA's Mission and Workforce**

*Review of Coronavirus Aid, Relief, and Economic Security (CARES) Act Funding* ([IG-21-024](#), August 9, 2021)

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

# APPENDIX D: MANAGEMENT'S COMMENTS

National Aeronautics and  
Space Administration  
Office of the Administrator  
Mary W. Jackson NASA Headquarters  
Washington, DC 20546-0001



November 9, 2021

TO: Inspector General

FROM: Administrator

SUBJECT: Agency Response to Office of Inspector General Report, “2021 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, “2021 Report on NASA’s Top Management and Performance Challenges.”

The audits and investigations conducted by your office provide NASA’s leadership and management with valuable contributions to the collective effort to provide oversight and gain insight into NASA’s broad portfolio of programs, projects, and mission support activities with which it is entrusted. The efforts expended by your office during this past year have furthered the cause of providing the taxpayer with maximum value for each dollar invested in NASA’s wide-ranging, ambitious, and challenging portfolio. As an Agency, NASA continues to aggressively pursue the mitigation and remediation of findings related to the audit recommendations issued by your office, including those that underpin your observations as cited in your 2021 Report on NASA’s Top Management and Performance Challenges.

While NASA fundamentally agrees that the eight areas outlined in your 2021 report constitute significant challenges for the Agency, this response highlights the following mitigation and remediation efforts relative to each challenge outlined in your report that have either been taken or are currently under way. These efforts substantively demonstrate NASA’s commitment to addressing its most significant management and performance challenges faced by the Agency:

### **Challenge 1: Returning Humans to the Moon by 2024**

NASA agrees that landing the first woman and the first person of color on the Moon by 2024 is a significant challenge, but the Agency is still trying to develop this capability in a timely manner to ensure the safety of the crew and meet Artemis objectives. Despite challenges associated with the COVID-19 virus, an extended delay due to the Human Landing System (HLS) protest, and multiple storms severely affecting NASA facilities and workforce, NASA continues to make substantial progress towards the launch of Artemis missions.

NASA continues its preparation for Artemis I, which will be the first test flight of the launch vehicle that will carry astronauts into space for the lunar missions. Simultaneously, the



Agency has met numerous technical and programmatic milestones for Artemis II, which will be the first crewed mission in the Artemis sequence. After the successful completion of the Hot Fire test on the Space Launch System (SLS) Core Stage (CS) in March 2021, during which all four RS-25 engines were ignited to produce 1.6 million pounds of thrust, the CS was transported to Kennedy Space Center for final integration and testing activities. CS mating to the Mobile Launcher (ML) and Solid Rocket Boosters started on June 9, 2021. Since then, most of the remaining major hardware has been integrated in the Vehicle Assembly Building and the full system has been powered up. The Umbilical Release and Retract Test, which validated the ways by which connections between the rocket and the ML will disengage at lift-off, was completed in September 2021. After the Orion Crew Vehicle is stacked, only four key milestone tests—the Integrated Vehicle Interface Verification Test, the Communications End-to-End Test, the Countdown Sequence Test, and the Wet Dress Rehearsal—will stand before the Artemis I launch.

NASA has also made tremendous progress toward the Artemis II launch and forward development for Artemis III missions and beyond. The arrival of the Artemis II European Service Module in October 2021, now positions the Orion program to mate Service and Crew Modules together and complete qualification and testing before delivery to Kennedy Space Center. Work on Core Stages Two, Three, and Four has continued in spite of serious damage to the Michoud Assembly Facility caused by Hurricane Ida. Development on the SLS Block 1B variant and the Mobile Launcher 2 has continued in preparation for a recurring cadence of missions with increasingly complex needs.

While progress and schedules have been impacted due to contract award protests and ongoing litigation, NASA continues to make progress with the HLS program. NASA has awarded a contract for a design, development, and demonstration of a lunar lander which will deliver the first crew to the lunar surface on the Artemis III mission. HLS has also accelerated the HLS services acquisition approach, and in a standalone procurement (Broad Agency Announcement Appendix N), HLS has selected five companies to perform risk reduction activities to advance the industry's proposed content for lunar landing services.

The Gateway Program continues to make significant progress with the completion of Gateway Key Decision Point (KDP)-0. The Program has transitioned focus to the preliminary design and contractual updates across the Program. Element-level Preliminary Design Reviews (PDRs) are nearing completion, and a Program-level PDR-informed sync review is scheduled to occur in the first half of FY 2022. Contracts have been finalized for Gateway's Habitation and Logistics Outpost (HALO), to include Power and Propulsion Element (PPE) integration and launch. Updates to PPE contracts have been made to synchronize requirements. NASA has developed a strategy for competitive procurement of EVA (Extra-Vehicular Activity) suits with the release of the xEVAS (Exploration Extravehicular Services) Request for Proposal (RFP) in September 2021. Meanwhile, NASA has completed in-house builds of xEMU (Exploration Extravehicular Mobility Unit) Development Verification Test (DVT) systems, and the test reports will be used by future partners to reduce development risk.



NASA has also implemented a number of the OIG's key recommendations to improve cost, schedule, and technical performance and is working to complete implementation of the remaining open OIG recommendations.

## **Challenge 2: Improving Management of Major Projects**

NASA sees program management excellence as a core capability, critical for enabling its bold mission of exploration and discovery. NASA's program management discipline includes rigorous processes, encompassing program formulation, approval, implementation, and evaluation. NASA also has guidelines for bringing together the people, resources, and processes necessary to execute the Agency's most challenging and complex programs.

NASA maintains an unwavering commitment to the continued growth of its program and project management disciplines. For example, NASA is focused on improving program planning and control, while increasing transparency for the Agency's external stakeholders. NASA leadership continues to evaluate the considerable progress made to date implementing the initiatives contained in the Agency's High-Risk Corrective Action Plan (CAP). In July 2020, NASA leadership determined that seven of nine CAP initiatives had been fully completed, including the creation of a technology readiness assessment best practices document, an update to the Agency's probabilistic programmatic policy (i.e., Joint Confidence Level (JCL)), and increased transparency by inclusion of original Agency Baseline Commitments in external reporting for re-baselined projects, among other initiatives.

NASA leadership also added four initiatives to a renewed CAP in July 2020. New initiatives under way include a full implementation of a Schedule Repository, an Exploration Systems Development Mission Directorate (ESDMD)/Space Operations Missions Directorate (SOMD) Exploration Systems Development (ESD)/Advanced Exploration Systems (AES) cost and schedule transparency effort, enhancements to the Cost *Analysis Data* Requirement (CADRe) data collection for Category 3 Class D projects, and the adoption of a risk assessment and financial evaluation of contractors' activity. The 2020 CAP is accessible via the [NASA Reports and Transcripts Web page](#)<sup>1</sup>. NASA's progress on and renewal of the CAP is evidence that the Agency is committed to pursuing the most critical changes to increase transparency, improve cost and schedule estimation, and maintain focus on accountability. Several of these changes can be found in the Agency's most recent revision to its formal Space Flight Program and Project Management Requirements document ([NPR 7120.5F](#)), which was released in August 2021.

NASA also continues to make substantial progress in the implementation of the Program Management Improvement and Accountability Act (PMIAA). As part of PMIAA implementation, the Agency appointed a Program Management Improvement Officer (PMIO) within the Office of the NASA Associate Administrator (AA). The PMIO has convened an Agency stakeholder team to lead the implementation of PMIAA and has conducted three rounds of annual NASA portfolio reviews focused on the identification,

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<sup>1</sup> [https://www.nasa.gov/sites/default/files/atoms/files/nasa\\_high\\_risk\\_corrective\\_action\\_plan\\_2020.pdf](https://www.nasa.gov/sites/default/files/atoms/files/nasa_high_risk_corrective_action_plan_2020.pdf)

capture, and improvement of Project Management (PM) practices. Practices that have been addressed include improvements to schedule analyses, improvements to life-cycle reviews, and furthering implementation of tailoring approaches. The NASA PMIO is also implementing a program management integration function on behalf of the NASA AA with support from the Office of the Chief Financial Officer (OCFO), the Office of the Chief Engineer (OCE), and in partnership with the Mission Directorates and field Centers. This integration will promote overall synergy and integration of PM practices and capabilities across the Agency to further enhance PM performance and mission success.

NASA's missions will tackle activities that have never been done before, incorporating the leading edge of technology, as the Agency pursues the challenging goals that can only be accomplished in the hostile environment of space. This requires NASA to develop one-of-a-kind spacecraft and new technologies. The Agency cannot do this without taking on considerable risks. While doing so, NASA aggressively works to understand and manage those risks, while also communicating them to the Agency's stakeholders. One of the key ways the Agency attempts to manage expectations with external stakeholders is by waiting until KDP-C to make cost and schedule commitments. Only by KDP-C are technical designs and risk assessments mature enough to make these important commitments. Two of the cost growth examples cited by the OIG (the Europa Clipper and the Nancy Grace Roman Space Telescope) are measured against early estimates of cost instead of cost commitments. The Science Mission Directorate (SMD) has made substantial investment in pre-formulation mission studies and technology development in order to address some of the concerns identified by the OIG and continues to study large missions to identify best practices for future flagships<sup>2</sup>. Moreover, Independent Review Boards are being formed prior to KDP-B to identify cost risks and reduce "requirement creep," leading to improved early cost estimation. When cost performance is assessed against KDP-C baselines established since the implementation of the 70 percent JCL requirement, major SMD missions have, on average, cost two percent less than the NASA commitment. Due to the nature of NASA's mission, some projects will exceed cost or schedule commitments; however, by adopting the 70 percent JCL methodology, NASA is able to effectively manage the overall portfolio, including the occasional large overruns. Agency missions will employ technologies that must be developed and tested on Earth but can only be demonstrated in space. Innovation must remain at the core of everything NASA does and, thus, cannot encourage innovation and discovery without accepting some risk and some uncertainty.

NASA has institutionalized senior-level reviews to understand and address the ongoing risks that its portfolio of challenging missions faces. NASA's ongoing monthly internal Baseline Performance Review (BPR), chaired by the NASA AA, has continued to evolve and refine to better reflect portfolio performance against external commitments, focusing discussion on issues requiring leadership awareness, and the identification of solutions to challenges as they arise. NASA also maintains a variety of additional formal councils to ensure the right people and resources are brought together on a regularly occurring basis. These include the

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<sup>2</sup> The SMD Large Mission Study recommends ways of improving SMD's cost and schedule performance on very large, multi-billion-dollar science missions. The study draws on the collected experiences of a diverse team of experts from the civil, commercial, and defense space communities. Recommendations are being applied to future large SMD missions such as Mars Sample Return and others.

recently formed NASA Acquisition Strategy Council, which addresses acquisition decisions holistically under a single Decision Authority. NASA's renewed emphasis on strategic acquisitions will improve the Agency's efficacy in intelligently moving forward on large acquisitions and making data-driven decisions, ensuring a universal view of the aerospace industrial base, international partners, and NASA in-house performance and capacity.

As NASA strives to return humans to the surface of the Moon, and beyond, the Agency will continue to foster a culture where leaders and staff are incentivized to develop realistic cost and schedule estimates; take steps to recognize, mitigate, and communicate the risks that inform those estimates; and demonstrate progress in program management improvement efforts. As an example, NASA will establish production and operations cost reporting for SLS and Exploration Ground Systems (EGS) with a completion of a KDP-E milestone in early FY 2022. Additionally, the SLS Block 1B Exploration Upper Stage + capabilities and ML-2 Agency Baseline Commitments are also scheduled to be established by spring 2022. Both the production and operations estimates, as well as baseline cost commitments, will be reported to external stakeholders through established processes.

NASA takes its commitment to Congress and the American people seriously, and with stabilization of the Artemis manifest will be able to ensure exploration goals are achievable with better cost estimates, schedules, plans, and acquisition strategies that leverage public/private partnerships and international contributions. To this end, the EGS, SLS, and Orion programs are implementing a series of affordability initiatives that align with the ongoing transition from development to operations.

### **Challenge 3: Sustaining a Human Presence in Low Earth Orbit**

NASA agrees with this challenge. The International Space Station (ISS) is now entering its third and most productive decade of utilization, including research advancement, commercial value, and global partnership. The first decade of ISS was dedicated to assembly, and the second was devoted to research and technology development and learning how to conduct these activities most effectively in space. The third decade is one of results, in which exploration and human research technologies will be verified to support deep space exploration, medical and environmental benefits will continue to be returned to humanity, and the groundwork will be laid for a commercial future in space. ISS continues to support cutting-edge research that benefits humanity, including in-space manufacturing of novel materials; life-saving medical products; understanding Earth's climate; and Science, Technology, Engineering, and Mathematics (STEM) engagement. NASA's leadership of ISS ensures it will remain the preeminent destination in low-Earth orbit (LEO) until commercially owned and operated platforms are available.

Today, with commercial crew and cargo transportation systems online, the ISS is busier than ever. The ISS National Laboratory (ISSNL), responsible for utilizing 50 percent of NASA's resources aboard the ISS, hosts hundreds of experiments from other Government agencies, academia, and commercial users to return benefits to people and industry on the ground. Meanwhile, NASA's research and development activities aboard are advancing the technologies and procedures that will be necessary to send the first woman and first person of color to the Moon and the first humans to Mars.

The ISS is also now entering an era of robust commercial use, taking advantage of the utilities it provides to develop the capabilities industry needs to move from being dependent on NASA for access to space to providing the access NASA will need to continue its mission in LEO after the lifetime of the ISS. Commercial crew and cargo transportation are well known examples, and today they provide the vital lifeline from Earth to the ISS. There are over 20 commercial facilities operating aboard ISS today—including a 3D printer, a bioprinter, external Earth observation and materials platforms, and an airlock—that are available for use by both NASA and other paying customers. NASA awarded the use of an ISS docking port to Axiom Space, which plans to attach a series of commercial modules that will eventually detach to become a LEO free-flying destination. In addition, NASA issued a solicitation for proposals that were due in August 2021, for the formulation and design of Commercial LEO Destinations (CLDs) project capabilities, which will stimulate U.S. private industry development of free-flying orbital destination capabilities and create a market environment in which commercial LEO destination services are available to both Government and private-sector customers. It is NASA’s goal to be one of many customers purchasing only the goods and services the Agency needs. CLDs, along with commercial crew and cargo transportation, will provide the backbone of the LEO economy after the ISS retires.

To give future commercial providers a business model to work toward, NASA is refining its white paper on “Forecasting Future NASA Demand in Low-Earth Orbit: Quantifying Demand,”<sup>3</sup> which will define NASA’s anticipated service requirements for future CLD providers. These forecasts will include not only the anticipated NASA demand for crew accommodation, technology testing, human research, and science, but also capture the future needs of LEONL (Low-Earth Orbit National Laboratory) and potential international partner users. The intent of this activity is to allow future CLD and launch providers to scale their activities to meet the future needs of the U.S. Government, while also allowing them to design for private use of the capabilities. Given the unique barriers of access to space, NASA and the ISSNL are partnering to support and incubate promising commercial in-space manufacturing applications, such as advanced materials, regenerative medicine, and tissue engineering through the ISSNL, with the goal of creating sustained, self-sufficient demand for future CLD services. Other demand-enabling initiatives include allocating a portion of ISS resources for commercial-use activities and private astronaut missions on a reimbursable basis.

NASA’s Commercial Crew Program (CCP) is delivering its goal of safe, reliable, and cost-effective transportation to and from the ISS from the U.S. through a partnership with American private industry. This partnership is changing the arc of human spaceflight history by opening access to LEO and the ISS to more people, more science, and more commercial opportunities. The space station remains the springboard to NASA’s next great leap in space exploration, including future astronaut missions to the Moon and, eventually, to Mars.

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<sup>3</sup> [https://www.nasa.gov/sites/default/files/atoms/files/forecasting\\_future\\_nasa\\_demand\\_in\\_low-earth\\_orbit\\_revision\\_two\\_-\\_quantifying\\_demand.pdf](https://www.nasa.gov/sites/default/files/atoms/files/forecasting_future_nasa_demand_in_low-earth_orbit_revision_two_-_quantifying_demand.pdf)



In the time since NASA certified the SpaceX crew transportation system last year, the company has launched three operational missions to the ISS, Crew-1, Crew-2, and Crew-3. Also, SpaceX recently flew the Inspiration4 mission, a commercial mission consisting of a full crew of private astronauts. In addition, NASA has contracted with Axiom Space for a private astronaut mission to the ISS early next year.

NASA's other CCP partner, Boeing, is making good progress on characterizing and correcting the issue associated with the spacecraft valves that was identified prior to the Orbital Flight Test-2 (OFT-2) mission. Once that analysis and corrective action is in place, NASA and Boeing plan to launch OFT-2 and then the Crewed Flight Test (CFT). If those flights go well, NASA will be able to certify the Boeing system for operational crewed flights, and, for the first time in history, the U.S. will have independent, redundant human access to space.

NASA and its CCP partners need to remain vigilant moving forward, but all indications are that the U.S. commercial human space transportation capability envisioned by NASA a decade ago is coming to fruition.

#### ISSNL Status:

NASA is pleased to report that the bulk of the actions from the 2020 ISSNL Independent Review Team (IRT) have been completed successfully. NASA and the Center for the Advancement of Science in Space (CASIS) are now in better alignment than ever and are prepared to lead new advances in space research and development and cutting-edge science on the ISS. The following is a list of the actions and a summary of the progress NASA and CASIS have made over the last year:

- Work with CASIS on the best roles and composition of the CASIS board of directors and leadership. Progress: The CASIS board of directors has a majority of new members, along with a new board chair, Dr. Elizabeth Cantwell. The current board composition is well suited to manage the unique challenges and complexities associated with CASIS.
- Support CASIS' establishment of a User Advisory Committee to provide input to the organization about how best to manage resources. Progress: The new CASIS User Advisory Committee, along with five subcommittees, has been established, members and chairs for each subcommittee have been selected, and the committee's first meeting was held on February 26, 2021.
- Create transparent project and program evaluation and prioritization processes. Progress: Six new peer-reviewed CASIS solicitations have been announced along with new project evaluation processes, based on NASA best practices. CASIS will continue to refine its payload prioritization process for better transparency.
- Identify an ISSNL program executive at NASA Headquarters as the primary liaison to CASIS. Progress: Dr. Alex Macdonald, NASA Chief Economist in the Office of the Administrator, served as the ISSNL program executive this last year and has transitioned this role to Ms. Robyn Gatens, ISS Director at NASA Headquarters, who will be the primary liaison going forward.

- Update strategic priorities for the ISSNL on an annual basis. Progress: NASA and CASIS jointly agreed to and documented new CASIS annual performance goals for 2021 and are assessing those goals annually.
- Work with CASIS to optimize the allocation of ISSNL resources to meet strategic priorities. Progress: New ISSNL programmatic goals and operating principles have been agreed to with the CASIS board and will be incorporated into an update to the CASIS Cooperative Agreement, which is in work. CASIS will continue to refine its payload prioritization process.

Overall, the ISS Program is realizing its full potential in accomplishing NASA's and the Nation's goals in exploration, commercial development, international leadership, and extending human presence beyond LEO.

#### **Challenge 4: Managing and Mitigating Cybersecurity Risk**

The Office of the Chief Information Officer (OCIO) agrees that managing and mitigating cybersecurity risk is a profoundly difficult challenge and agrees with all of the reasoning in the summary paragraphs in the OIG report. The OCIO Cybersecurity and Privacy Division (CSPD) continues to improve NASA's cybersecurity posture within all Information Technology (IT) domains of NASA's infrastructure, including Corporate IT, Mission IT, and Physical IT. In addition to progress noted by the OIG, NASA has also accomplished the following to manage and mitigate specifically identified challenges:

1. Improper Use Incidents
  - OCIO agrees that technical and policy enforcement to control Improper Use is an ongoing challenge. However, OCIO does not agree that the referenced jump in Improper Use metrics represents a true escalation in risk. The increase, primarily comprised of a 301 percent jump in incident reports from FY 2018 to FY 2019, reflects improved detection and reporting provided by automated Data Loss Prevention (DLP) capabilities implemented by OCIO within the O365 environment. Additionally, increased awareness of Sensitive But Unclassified (SBU) (now Controlled Unclassified Information (CUI)) issues due to more focused staff training is another contributing factor for increased Improper Use metrics. The increase in Improper Use reporting represents improved OCIO identification and data protection capabilities, not an increase in cybersecurity risk to the Agency.
2. Mobile Device Security
  - OCIO agrees that evolving technology and increased usage patterns contribute to the challenge of managing the security of mobile devices and remote access. OCIO projects and initiatives are under way to help mitigate this challenge.
  - Network Access Control (NAC) enforcement on unauthorized devices has improved since the referenced IG report (IG-20-021), and progress continues in this area. NAC is now deployed at all NASA Centers, and closure of the corresponding IG audit finding has been requested.

- OCIO believes that e-mail access via a Mobile Device Management (MDM) solution on worker-owned mobile devices represents a greater benefit to NASA than the relative risk accepted. Benefits include enhanced connectivity and worker productivity at a low cost compared to alternative controls. The OIG's own assessment found the solution largely compliant except for three specific criteria:
  - Assertion of user need for the service, which is implied by the user request and confirmed by annual user validation of need for the service (E-mail is considered to be a Basic-Level Entitlement (BLE) for all NASA workers with logical access).
  - End-user device supply chain concerns, which are mitigated by compartmentalization of NASA data on the device by the MDM software as well as the ability to remotely wipe the device. Additionally, the NASA Security Operations Center (SOC) proactively identifies mobile connections from outside the United States and reports outside connections to the responsible Agency incident response manager if the connection source is an unauthorized traveler.
  - The possibility of operation of the mobile device outside of the United States, which is an edge case that is mitigated by instructing the user that this is not permitted. Additionally, the NASA SOC is now performing proactive monitoring for Government-Furnished Equipment (GFE) and Personally Furnished Equipment (PFE) mobile devices connecting outside the United States.

### 3. Assessment and Authorization Process

- The OCIO agrees that Assessment and Authorization (A&A) is a major challenge within a diverse IT environment such as NASA and that the current state of A&A is lacking consistent rigor in its application. However, OCIO does not agree that this specific challenge should be directed towards OCIO as sole owner to mitigate. The cause for inconsistent implementation of policy cannot be blamed on the policy itself. Rather, the overall risk acceptance and authorization actions, or lack thereof, must be examined to identify and address these A&A challenges. As noted by the OIG in draft report Q-21-005-00, "we reported that NASA is inconsistent and ineffective with its A&A process because of its decades-long decentralized approach to cybersecurity." System owners are responsible for the proper execution of defined A&A policy, and the challenges pertaining to A&A must be mitigated by the responsible parties defined within the process, including NASA's missions, not solely by those responsible for developing and maintaining the process itself.

To aid in mitigating this challenge, NASA OCIO intends to leverage the upcoming Cybersecurity and Privacy Enterprise Solutions and Services (CyPrESS) contract to provide a standardized internal security assessment team and process. This will provide a "level playing field" baseline assessment for all NASA systems, as well as realize significant cost savings for the Agency.

While the Agency continues to enhance its cybersecurity policies, processes, and governance in FY 2021, NASA recognizes there is still progress to be made, specifically in addressing Mobile Device Security and A&A. The Agency remains committed to tackling these issues and to building an even stronger, more proactive risk-based cybersecurity program that safeguards NASA's IT assets, data, and its users.

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

The NASA Office of Procurement (OP) is committed to making meaningful progress in addressing contract oversight challenges and continues to strengthen its overall procurement processes and policy. In response to an OIG recommendation, OP is pursuing the ability to link contract assignments to acquisition workforce personnel and is continuously monitoring closeout performance across the Agency. An annual closeout target metric of 6,000 contracts has been approved by Agency leadership, with quarterly reporting provided at the BPR. In FY 2021, 8,926 contracts were closed.

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

NASA agrees with the challenges identified in this section of the report. As the OIG has acknowledged in their report, within the last few years, NASA implemented several approaches and tools to increase agility within the workforce. To address NASA's dilemma created by low attrition and a need for new skills, the Office of the Chief Human Capital Officer (OCHCO) focused on expanding usage of time-limited appointments. Time-limited appointments do not currently count against NASA's permanent Full-Time Equivalent (FTE) "ceilings" and can be used in conjunction with the Agency's NASA-unique Direct Hire Authority to quickly recruit and hire people with new and critical skills. NASA is working with the Office of Personnel Management (OPM) to update the Government-wide time-limited appointment definition to "up to ten years" (rather than four) for STEM. Civil service employees on time-limited appointments can be part of the pipeline to permanent roles as retirements occur or they can end when the project or program is completed.

To promote workforce mobility and enable talented people to move to critical tasks, NASA launched its Talent Marketplace (TM). The Agency-wide TM gives NASA's civil service employees access to non-competitive development and/or lateral opportunities (e.g., internal detail opportunities, short-term/part-time assignments, lateral reassignments, etc.) across NASA. Managers are now able to look for talent across a wider pool than just their unit or Center, and employees are getting more diverse work experiences as a result. Through TM, NASA is embracing transparency, inclusion, and access by offering more and more opportunities remotely which enables additional cross-Agency talent to gain desirable experiences without relocation costs or personal move barriers.

Additionally, as the OIG states, "to maintain a world-class workforce, NASA must fill current critical workforce gaps and prepare for those yet to emerge." NASA has been moving to a more "demand-driven" workforce planning model/process in order to accomplish this goal. The Agency no longer employs a "back-fill only" way of performing the mission, since NASA must understand where the mission is going, Administration and Congressional priorities, what is going to be done by partners (e.g., private sector versus in-



house), what aspects of work will be performed by technology, and how technology will impact NASA's various work roles (e.g., digital transformation). OCHCO is looking at the degree to which reshaping the workforce size and skills will be possible through the use of the Agency workforce master planning process. An element of the master planning process includes projecting loss rates and the extent to which past patterns of employee tenure beyond retirement eligibility dates may change, providing opportunity for workforce reshaping.

Although not mentioned in this report, NASA is still reliant on an antiquated personnel system that does not match the complex and dynamic work NASA is required to perform. The current position-based, mid-century personnel system defines work as static and repeatable, requires lengthy hiring processes, is agnostic to the external labor market, rewards workers for longevity, disincentivizes mobility, and is overly complicated. This rigid, outdated personnel system has an impact on the Agency's ability to compete for talent in a very tight talent market and to retain talented individuals who are motivated by very different careers than in the past. NASA continues to seek workforce flexibilities for hiring, development, and other modern personnel practices. For example, NASA is seeking legislation that would allow engagement in talent exchange programs with the private sector.

#### **Challenge 7: Managing NASA's Outdated Infrastructure and Facilities**

NASA agrees with the challenges identified in the "*Managing NASA's Outdated Infrastructure and Facilities*" section of the OIG report. To address the challenges with outdated 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 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, or divestment of infrastructure. To alleviate the maintenance burden, NASA will continue to increase its funding for demolition of unneeded facilities.

NASA has also identified investment strategies using Reliability Centered Maintenance (RCM) principles to stave off the increasing deferred maintenance within the Agency. Condition Based Maintenance and a Tiered Maintenance approach for relevant and critical assets are cornerstones of this strategy. These efforts will lead to improving the condition of important building systems and facilities across the Agency and increasing the reliability of these assets to meet mission needs. Implementation of these RCM principles, with particular focus upon Tiered Maintenance, ensures 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 asset availability and avoiding 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, and recapitalization, NASA continually strives to right-size the Agency’s infrastructure towards more modern and efficient facilities that will continue to meet NASA mission objectives.

**Challenge 8: Managing the Impacts of COVID-19 on NASA’s Mission and Workforce**

NASA agrees with the OIG that COVID-19 is an unprecedented event and remains a challenge for the Agency mission and its workforce. As the OIG noted, COVID-19 is an unprecedented event, and NASA’s understanding of the impact of COVID-19 continues to evolve. NASA agrees with the OIG’s assessment that a final accounting of the full impact of COVID-19 on Agency activities will not be available until well after the Agency and its contractors and partners return to “normal.” Nevertheless, NASA is proud of the resiliency of its workforce in sustaining critical national missions and for being ranked first among large Federal agencies for the Agency’s response to the COVID-19 pandemic.

NASA appreciates the OIG’s recognition of the Agency’s operational flexibility and adaptability in the face of the COVID-19 pandemic. Of the \$2.8 billion in impacts to NASA’s programs and projects identified by the OIG, over 95 percent have been absorbed into Agency plans, mostly through a combination of deploying project- and Headquarters-held unallocated future expenses (UFE), program/project replans, and deferral of previously planned content. NASA has emphasized reporting on the impacts of COVID-19 through its Earned Value Management (EVM) activities and is highlighting if COVID-19 is a factor, as was the case with the Nancy Grace Roman Space Telescope and the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) spacecraft.

NASA is also taking steps to be in full compliance with the Administration’s Executive Order requiring vaccination of Federal and contractor employees. The Agency is reviewing its policies for the future of work, including consideration of workforce policies which embrace teleworking and other trends that accelerated under COVID-19, in order to ensure NASA attracts and retains the world-class talent needed to carry out its mission.

Finally, as of the close of FY 2021, NASA had obligated 100 percent of the \$60 million in supplemental funding the Agency received as part of the Coronavirus Aid, Relief, and Economic Security (CARES) Act.

If you have any questions regarding NASA’s response to the 2021 Top Management and Performance Challenges report, please contact Anthony Mitchell, Audit Liaison Project Manager, on (202) 358-1758.



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