National Aeronautics and Space Administration

FY 2025

VOLUME OF INTEGRATED PERFORMANCE

FY 2023 Annual Performance Report
FY 2024-2025 Agency Performance Plan
FY 2025 Annual Evaluation Plan

nasa.gov

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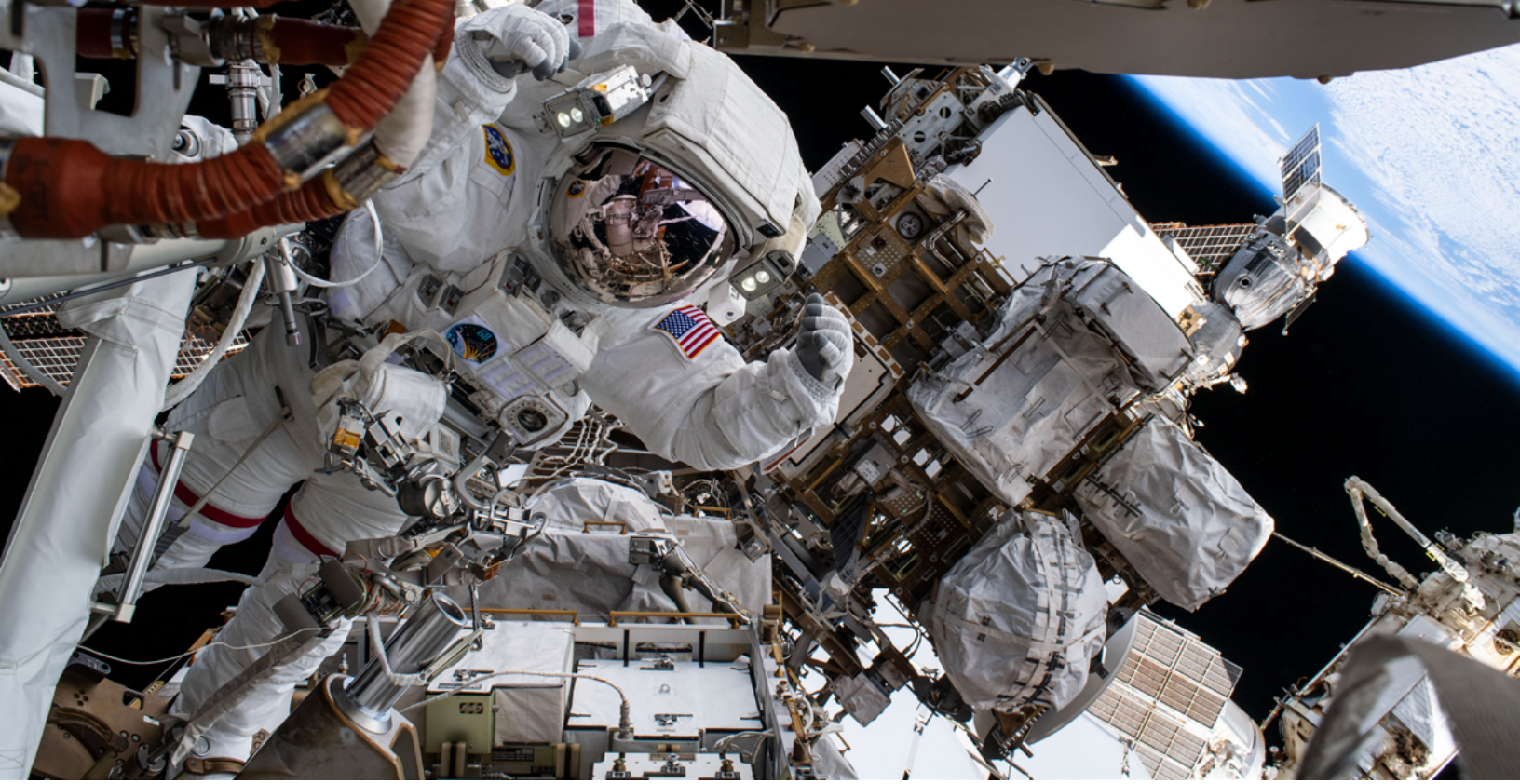
Cover: A brand-new look at Sun-like stars being born in this detailed close-up of Rho Ophiuchi, the closest-star-forming region to Earth. Webb spotted around 50 young stars, many close in mass to our star, giving us a glimpse into the early life of the Sun. Dark, dense dust cocoons still-forming protostars, while an emerging stellar newborn (top center) shoots out two huge jets of molecular hydrogen. Image credit: NASA, ESA, CSA, STScI, Klaus Pontoppidan (STScI), Image Processing: Alyssa Pagan (STScI)

Above: A SpaceX Falcon Heavy rocket with the Psyche spacecraft onboard is launched from Launch Complex 39A, Friday, October 13, 2023, at NASA's Kennedy Space Center in Florida. NASA's Psyche spacecraft will travel to a metal-rich asteroid by the same name orbiting the Sun between Mars and Jupiter to study its composition. The spacecraft also carries the agency's Deep Space Optical Communications technology demonstration, which will test laser communications beyond the Moon. Image Credit: NASA/Aubrey Gemignani

The FY 2025 Volume of Integrated Performance (VIPer) was managed and produced by the Strategic Insights and Budget Division of the Office of the Chief Financial Officer at NASA Headquarters, with contractor support from Deloitte Consulting, LLP. Performance content is provided by Mission Directorates and Mission Support Offices at NASA Headquarters. Part 1 of this document details NASA's commitment and approach to performance management. Part 2 presents a granular look at every Performance Goal across the Agency, with FY 2023 ratings and narrative details for each, as well as FY 2024 and FY 2025 Agency Performance Plans. Part 3 conveys evaluations that NASA will commence in FY 2025 to build evidence that will assist in decision-making.

PART 1:
PERFORMANCE MANAGEMENT

NASA's James Webb Space Telescope has observed the well-known Ring Nebula in unprecedented detail. Formed by a star throwing off its outer layers as it runs out of fuel, the Ring Nebula is an archetypal planetary nebula. This new image from Webb's NIRCam (Near-Infrared Camera) shows intricate details of the filament structure of the inner ring. There are some 20,000 dense globules in the nebula, which are rich in molecular hydrogen. In contrast, the inner region shows very hot gas. The main shell contains a thin ring of enhanced emission from carbon-based molecules known as polycyclic aromatic hydrocarbons (PAHs).
Image Credit: ESA/Webb, NASA, CSA, M. Barlow (University College London), N. Cox (ACRI-ST), R. Wesson (Cardiff University)



NASA Performance Foundations

Vision

Exploring the secrets of the universe for the benefit of all.

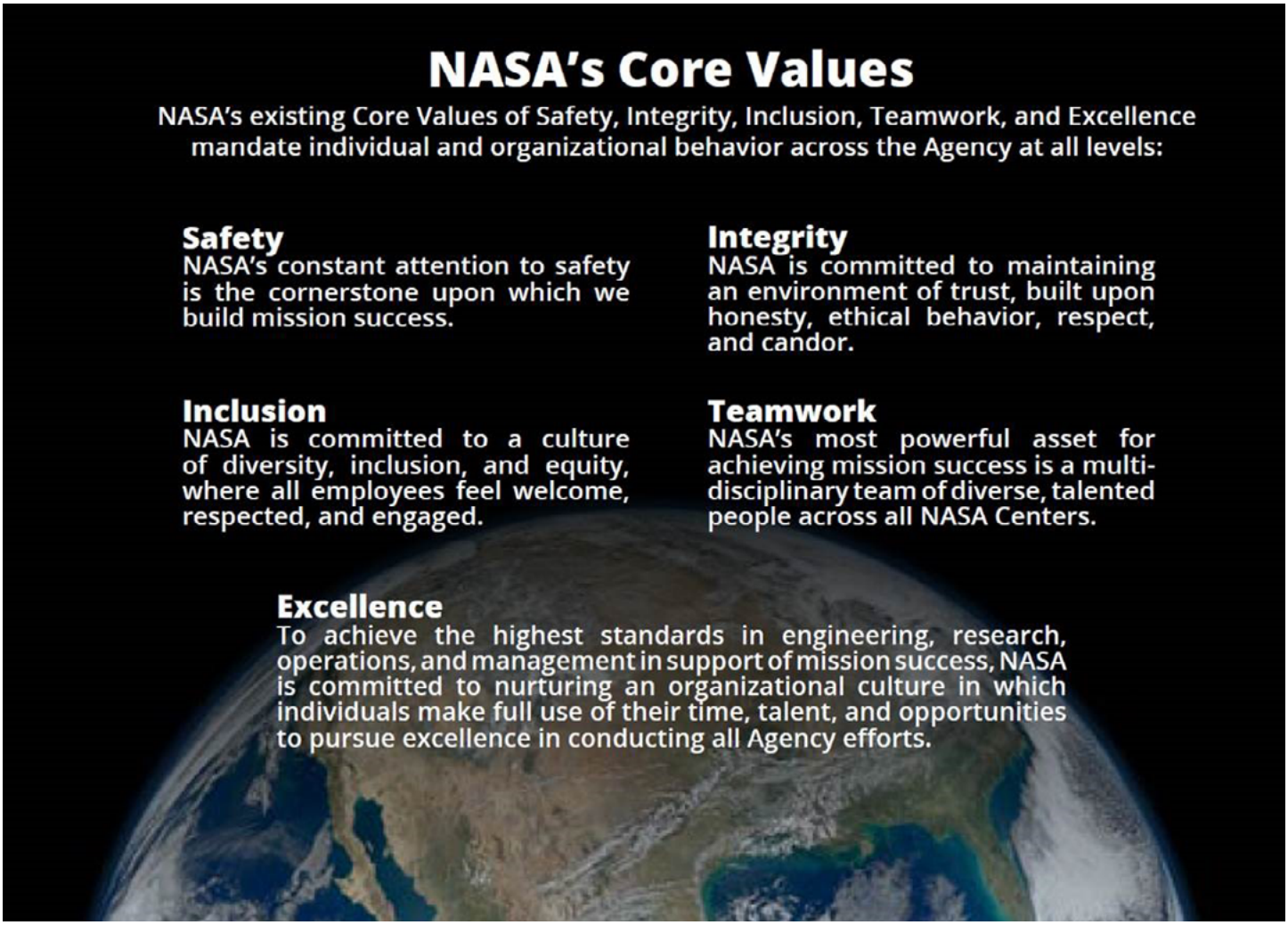
Mission

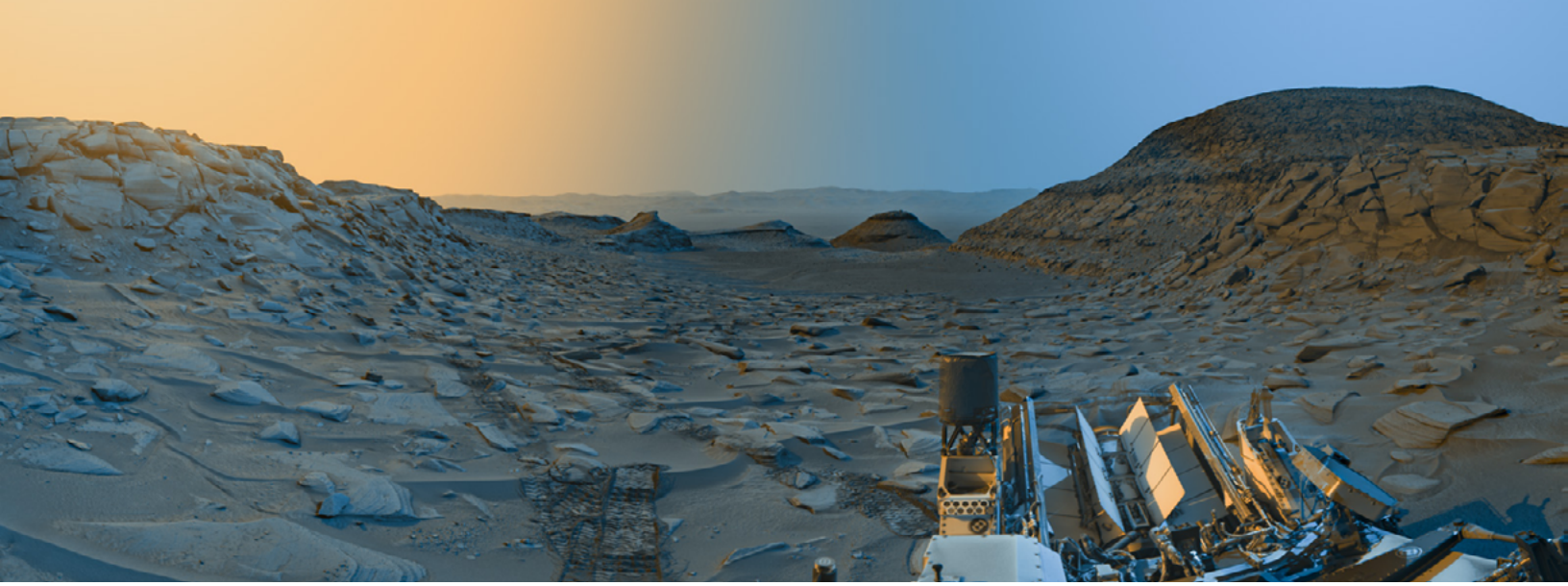
NASA explores the unknown in air and space, innovates for the benefit of humanity, and inspires the world through discovery.

Above: NASA astronaut and Expedition 68 Flight Engineer Nicole Mann is pictured in her Extravehicular Mobility Unit, or spacesuit, during her second spacewalk. She and fellow spacewalker Koichi Wakata (out of frame) of the Japan Aerospace Exploration Agency (JAXA) installed a modification kit on the International Space Station's starboard truss structure that will enable the future installation of the orbiting lab's next roll-out solar array. Image Credit: NASA

Since 1958, NASA has led the peaceful exploration of space by advancing knowledge of Earth while making discoveries about the furthest reaches of the universe. NASA research has advanced aeronautics, developed the commercial space industry, and strengthened the U.S. economy through innovative partnerships with American businesses. With the increasing threat of climate change, NASA's efforts to study and understand the Earth system are of critical global significance. NASA's partnerships with academic institutions support the development of a robust science, technology, engineering, and mathematics (STEM) workforce, and promote diversity, equity, and inclusion in the fields of science and technology.

NASA's long-term success will be determined by the strategic decisions and investments we make today, as well as committed adherence to our five guiding Core Values.



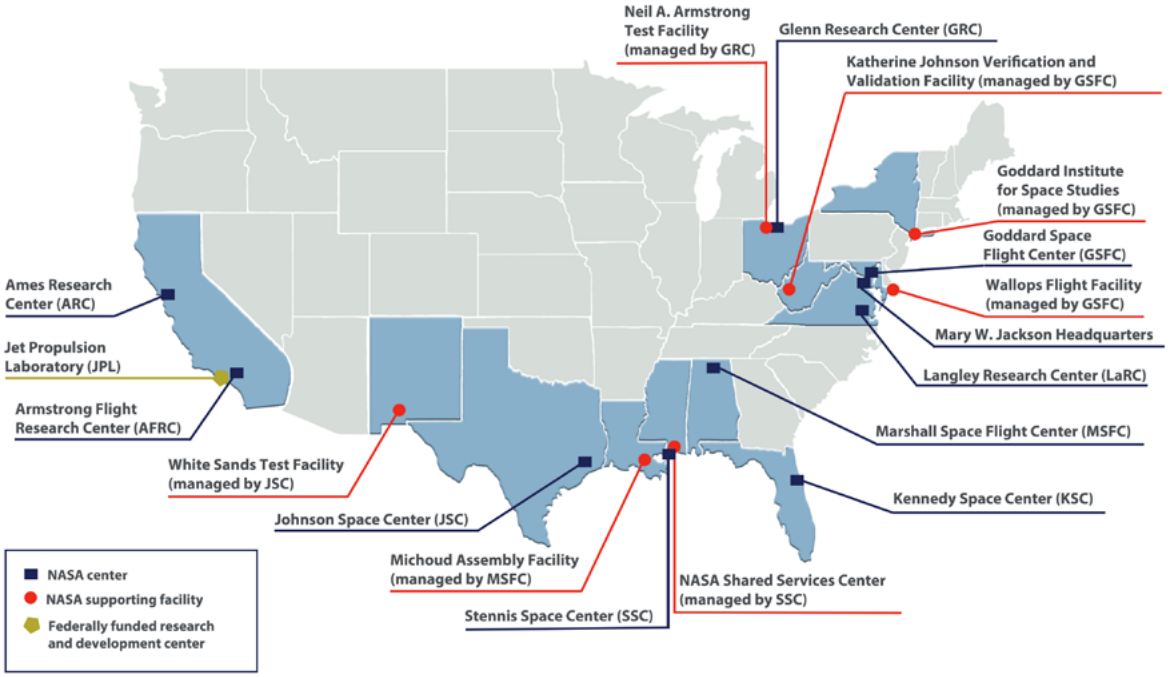


Organized for Success and Sustainability

NASA is organized for success, with a leadership model that optimizes strategic direction at the Agency level, facilitates management at the functional levels in the mission directorates and mission support offices, and enables a wide range of activities at centers and facilities. The distributed and diverse nature of our work is unified by an integrated performance culture that engages employees and stakeholders at all levels.

The innovative, responsive, and dynamic nature of our work benefits from the relationships within and between mission directorates, mission support offices, and centers. This organizational model ensures our leaders can take both a holistic and more narrowly-focused approach to programmatic, operational, business, and safety management.

Figure 1: Centers and Facilities Nationwide



Above: NASA's Curiosity Captures Martian Morning, Afternoon in New 'Postcard'. Lighting from two times of day was combined for a stunning view of terrain that the rover is leaving behind. After completing a major software update in April, NASA's Curiosity Mars rover took a last look at "Marker Band Valley" before leaving it behind, capturing a "postcard" of the scene. Image Credit: NASA

NASA's best asset for achieving mission success is a diverse, multidisciplinary, and skilled workforce across all Centers and facilities. NASA's approach to performance management is based on the premise that each team member brings unique experience and important expertise to projects. NASA is committed to nurturing an organizational culture in which individuals make full use of their time, talent, and opportunities to pursue the highest standards in engineering, research, operations, and management.

The NASA workforce of approximately 18,350 civil servants (including full-time, part-time, term appointment, student, and other non-permanent employees) is distributed across NASA Centers, facilities, and Headquarters (see Figure 1). A contractor workforce supports each location by providing technical and business operations services.

The Administrator and senior officials lead NASA by providing top-level strategy, policy, and direction. NASA's Office of the Chief Financial Officer leads the Agency's budget development, execution, and Agency-wide performance management activities.

Mission Directorates and Mission Support Offices at Headquarters manage decisions on programmatic investments and guide operations of the Centers. Provided below are brief descriptions of NASA's Mission Directorates and select offices.

The Aeronautics Research Mission Directorate (ARMD) conducts research to advance the safety, capacity, and efficiency of the air transportation system, reduce emissions, and sustain U.S. technological leadership in the aviation industry.

The Space Technology Mission Directorate (STMD) invests in transformational technologies that help offset future mission risk, reduce cost, advance capabilities that enable NASA's missions, and support space industry growth and high-quality job creation. STMD identifies and promotes research and technology development, demonstrates applicability, and supports the infusion of these technologies into NASA's exploration and science missions as well as commercial space activities.

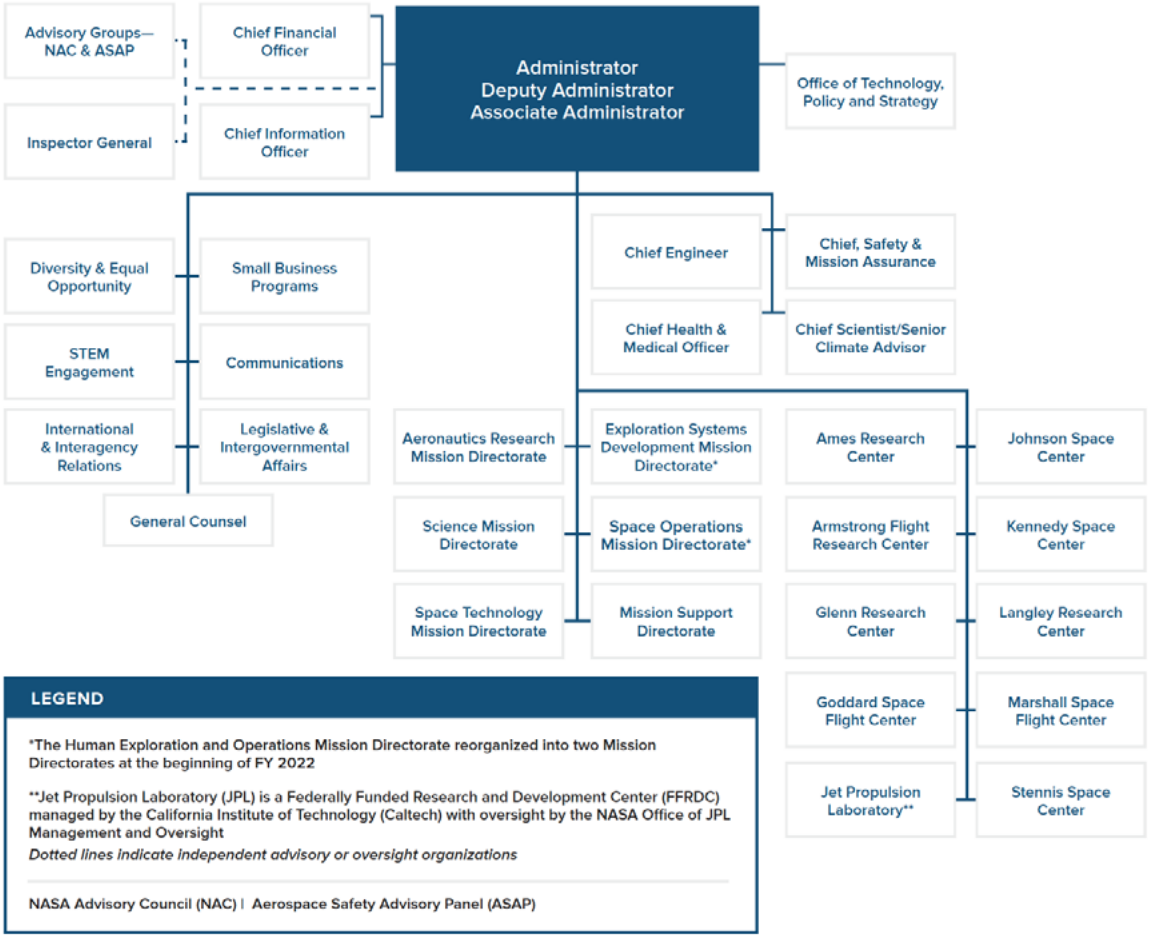
The Science Mission Directorate (SMD) conducts scientific exploration enabled by observatories that view Earth from space, observe, and visit other bodies in the solar system, and gaze out into the galaxy and beyond. NASA's science programs focus on three interdisciplinary objectives: discovering the secrets of the universe, searching for life in the solar system and beyond, and safeguarding and improving life on Earth.

The Exploration Systems Development Mission Directorate (ESDMD) defines and manages the systems development for programs critical to the Artemis lunar exploration initiatives. ESDMD is responsible for developing the Space Launch System, the Orion spacecraft, and Exploration Ground Systems. ESDMD also is responsible for developing technologies and capabilities to support sustainable human deep space exploration.

The Space Operations Mission Directorate (SOMD) focuses on launch and space operations, including launch services, space communications and navigation, and eventually, sustaining operations on and around the Moon. SOMD also manages the International Space Station (ISS) and commercial space capability development and on-going operations, such as commercial crew and cargo flights and the program to develop the commercial space stations that will replace the ISS.

The Mission Support Directorate (MSD) enables the Agency's missions by managing institutional services, capabilities, and critical mission support resources. MSD is actively reducing institutional risk to NASA's current and future missions by improving processes, stimulating efficiency, and providing consistency and uniformity across institutional standards and practices.

Figure 2: NASA Organizational Structure

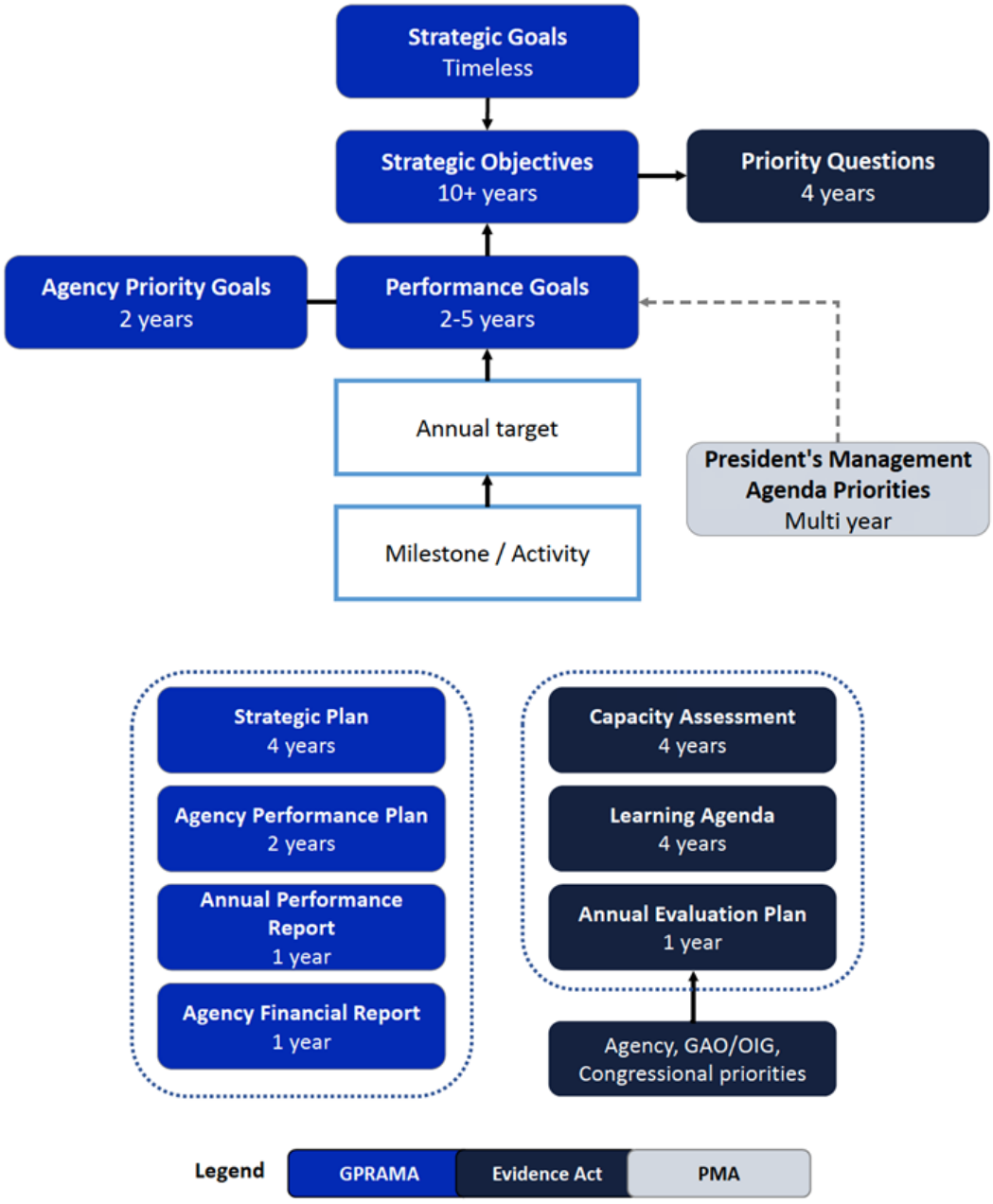


Performance-Evidence Framework

The Agency's success is supported by continually evolving and strengthening our performance management discipline. We use best practices from business and government to proactively establish expectations and assess and improve performance on an ongoing basis. We use data and evidence to inform investment decisions at all levels, ranging from day-to-day operations to selecting major missions and establishing the necessary infrastructure to pursue goals that may take a generation or longer to realize.

NASA aims to comply fully with the requirements on performance reporting and accountability, in accordance with the Government Performance and Results Act Modernization Act of 2010 (GPRAMA). NASA's commitment to performance reaches further than compliance, embedding our workforce culture with monitoring and improvement at the core. We are conducting evidence-building activities and making evidence-based decisions in accordance with the Foundations for Evidence-Based Policymaking Act of 2018 (Evidence Act). We have an ingrained culture of self-evaluation, using findings from studies and assessments to improve the Agency in the short-term and position NASA for long-term success. The framework of our Strategic Performance Evidence Framework is shown below.

Figure 3: NASA's 2023 Strategic Performance Evidence Framework



Strategic Plan

The NASA 2022 Strategic Plan outlines our plans for human and robotic space exploration, aeronautics, technology development, and Agency operations, providing a clear and unified direction for our programs and projects. The information reported in this document is aligned with the NASA 2022 Strategic Plan and the FY 2025 President's Budget Request, in accordance with the requirements of the GPRAMA and OMB Circular A-11.

Our quadrennial Strategic Plan outlines a framework that consists of Strategic Goals aligned to our Vision and Mission; Strategic Objectives describing our long-term strategies for achieving the Strategic Goals; and multiyear, outcome-oriented Performance Goals that propel NASA towards our Objectives. Annual targets and milestones allow NASA to measure and track incremental progress towards achieving the Performance Goals.

Learning Agenda, Capacity Assessment, and Annual Evaluation Plan

Congress signed the Evidence Act into law in January of 2019. The Evidence Act establishes a framework for agencies to organize evidence building, data management, and data access functions to ensure an integrated connection to data and evidence in decision-making. The NASA 2022 Strategic Plan included NASA's first-ever Learning Agenda and Capacity Assessment, both of which were required by the Evidence Act.

The Learning Agenda is a roadmap for NASA to systematically plan evidence-building activities that will allow the Agency to make evidence-based policy decisions. The Learning Agenda identifies a set of broad questions NASA sees as urgent to improving our operations and achieving our Mission over the next four years. When answered, these questions will help us work more effectively and efficiently, using evidence to make decisions relating to missions, programs, and investments.

The Capacity Assessment reviews NASA's ability to conduct evidence-building activities and identifies where resources are needed to develop and improve our capacity. Led by NASA's Evaluation Officer, in conjunction with the Statistical Officer and Chief Data Officer, five criteria guide NASA's evidence culture: coverage, quality, methods, effectiveness, and independence. This process supports the Agency's needs for learning and management, performance and strategic management, interagency and private sector coordination, and oversight and accountability.

The Annual Evaluation Plan document (see the Part 3 for the FY 2025 Annual Evaluation Plan) identifies specific evaluations that the Agency plans to undertake over the next fiscal year to create evidence for use by Agency leadership in decision-making. The annual plan cultivates data sharing and resources between NASA organizations and provides information to help support our evidence-driven culture.

Agency Performance Plan and Agency Performance Goals

NASA's Agency Performance Plan describes our multiyear Performance Goals (including annual targets consistent with program and project budget requests) and which Strategic Goals and Objectives they support. Every fiscal year, NASA reevaluates and updates, as needed, the existing Performance Goals and targets to ensure they accurately reflect NASA's budget, priorities, strategies, and programmatic plans.

Agency Priority Goals are a selected subset of Performance Goals that highlight high-priority, high-profile activities we plan to accomplish within a two-year timeframe. Agency Priority Goals are subject to a higher reporting threshold and highlight challenging areas with the potential for major technical, scientific, and societal benefit.

Performance Assessment Criteria

NASA's Performance Goals consist of outcome-based performance statements and the measurable performance targets to be achieved each fiscal year. To indicate progress over the previous performance year based on internal success criteria targets, we assign one of the color ratings described below.

Green Complete or On Target to Complete	NASA has completed or is on target to complete the Performance Goal/ Agency Priority Goal as planned.
Yellow Below Target	NASA is below target or behind schedule for the fiscal year but currently expects the work being measured to be completed as planned by the end of the Performance Goal's time frame.
Red Significantly Below Target/At Risk	NASA is significantly below target or behind schedule for the fiscal year. The work being measured is at risk of not being completed within the Performance Goal's time frame.
Gray Currently Unrated	NASA was unable to assess the Performance Goal/ Agency Priority Goal due to lack of data or changes to the associated work

The ratings discussed in Part 2 of this volume (Performance Planning and Reporting) are the final FY 2023 ratings assigned to each Performance Goal, and have been updated from the preliminary ratings summarized in NASA's FY

2023 Agency Financial Report, published before the final ratings were available.

Agency Priority Goals

NASA assesses progress toward achieving Agency Priority Goals every quarter, per GPRAMA guidance. In addition to reporting progress to Agency leadership, we report progress to external stakeholders via Performance.gov. The reporting cycle for the Agency's FY 2022-2023 two-year Agency Priority Goals closed at the end of FY 2023. A summary of the results is provided below while detailed progress is discussed in Part 2.

Agency Priority Goal Statement	FY 2023 Rating	Responsible Program
1.1.4: Use the global vantage point of space to advance our understanding of the Earth system, its processes, and changing climate. By September 30, 2023, NASA will advance climate change research by delivering two new observing systems and an upgrade to NASA's primary global Earth systems model.	Green (4 of 4 milestones completed)	Science Mission Directorate (Earth Science Division)
1.2.10: After launch, deployment, and start of science operations, the James Webb Space Telescope will study every phase in the history of our universe, ranging from the first luminous glows after the Big Bang, to the formation of other stellar systems capable of supporting life on planets like Earth, to the evolution of our own solar system. By September 30, 2023, NASA will complete commissioning of the James Webb Space Telescope, the most powerful and complex space telescope ever built, and begin Webb's Cycle 2 observations.	Green (4 of 4 milestones completed)	Science Mission Directorate (Cosmic Origins)
2.1.1: Advance America's goal to land the first woman and the first person of color on the Moon and pursue a sustainable program of exploration by demonstrating capabilities that advance lunar exploration. By September 30, 2023, NASA will launch Artemis I, deliver the Core Stage for Artemis II to Kennedy Space Center for processing, and have multiple companies under contract to develop systems for sustainable human lunar exploration.	Yellow (2 of 4 milestones completed)	Exploration Systems Development Mission Directorate (Common Exploration Systems Development and Artemis Campaign Development)
3.1.5: Ensure American global leadership in space technology innovations through increased partnering with industry and demonstrating key lunar surface and deep space technologies. By September 30, 2023: NASA will demonstrate leadership in space technology by: • Enhancing partnerships with industry through delivery or completion of milestones for at least 4 Tipping Point opportunities, and at least 3 critical small business technology transitions to develop capabilities that support NASA and commercial needs; • Delivering at least 3 new technologies that will be demonstrated on the lunar surface or in lunar orbit; and • Completing at least 2 major milestones for projects that increase the Nation's capabilities in deep space.	Yellow (0 of 4 milestones completed)	Space Technology Mission Directorate (Early Stage Innovation and Partnerships, Technology Demonstrations, Technology Maturation, and Small Business Innovation Research/Small Business Technology Transfer)

*See https://www.performance.gov/agencies/nasa/ for more information about our Agency Priority Goals.

The new reporting cycle for the Agency's FY 2024-2025 two-year Agency Priority Goals began on October 1, 2023, coinciding with the start of the new fiscal year. A summary of NASA's three recently established priority goals is provided below and more information is available on Performance.gov.

Earth System

1.1.4: Use the global vantage point of space along with the significant scientific knowledge acquired, to advance our

understanding of the Earth system and to curate actionable information to help the Nation understand, mitigate and adapt to climate change.

- By September 30, 2025, NASA will advance understanding of the Earth system and its climate by delivering three new observing systems; meeting development milestones for the Earth System Observatory (ESO); and maturing the interagency U.S. Greenhouse Gas Center.

Artemis

2.1.1: Advance America's goal to land the first woman and the first person of color on the Moon and pursue a sustainable program of exploration, support scientific discovery, and demonstrate capabilities that advance lunar exploration.

- By September 30, 2025, NASA will Launch Artemis II, the first crewed Artemis mission; demonstrate a key enabling technology by completing an on-orbit propellant transfer test in preparation for Artemis III; and deliver other key capabilities to enable deep space exploration.

Space Technology

3.1.5: Ensure American global leadership in space technology innovations through increased partnering with industry and demonstrating key lunar surface and deep space technologies.

By September 30, 2025, NASA will demonstrate leadership in space technology by:

- Enhancing partnerships with industry through delivery or completion of milestones for at least 3 Tipping Point opportunities, and at least 3 small business technology transitions;
- Advancing at least 2 new technologies demonstrated on the lunar surface or in lunar orbit; and
- Completing at least 4 major milestones for projects that increase the Nation's capabilities in deep space.

Alignment with Administration Priorities

The President's Management Agenda (PMA) defines government-wide management priorities for improving how Federal agencies operate and perform. The Biden-Harris Administration PMA, issued in November 2021, focuses on strategies to advance three core priorities: 1) Strengthening and empowering the Federal workforce; 2) Delivering excellent, equitable, and secure Federal services and customer experience; and 3) Managing the business of government to build back better.

The work of the PMA comprises sustained, multiyear, Federal government-wide efforts to advance each of the three PMA priorities, their supporting strategies, and Cross-Agency Priority Goals. Through the PMA, cross-Agency teams seek stakeholder input, define workstreams, set work plans and measures, advance collaborative efforts, and assess and measure progress across government organizations.

To ensure effective leadership and accountability across the Federal government, each priority has one senior leader within the Executive Office of the President, and another sitting within one or more of the key delivery agencies. Per GPRAMA's requirement to address Cross-Agency Priority Goals in the Strategic Plan, the Agency Performance Plan, and the Annual Performance Report, please refer to www.Performance.gov for our contributions to those goals and progress, where applicable. NASA is not a key delivery Agency but currently contributes to Priorities 1 and 3.

Following the passing of the Evidence Act, the Biden-Harris Administration published the inaugural PMA Learning Agenda in September 2022, identifying government-wide evidence gaps related to advancing PMA priorities. It not only reinforces a focus on learning, but also serves to bridge silos and catalyze innovation to stimulate coordination of evidence building across Federal agencies, state and local governments, tribal governing bodies, researchers, and practitioners from across the country.

The PMA Learning Agenda has three specific areas of focus which are, 1) Workforce, 2) Service Delivery, and 3) Equity. Each focus area has one main priority question and several sub-questions meant to guide evidence-building efforts. NASA is most closely aligned to focus areas 1 and 3. It is important to note that these areas of focus are not meant to be comprehensive and representative of all the evidence-building that is happening or needs to happen to

improve how the government operates and performs.

Performance Management in Action

NASA is committed to remaining a good steward of the taxpayer's numerous investments entrusted to our care. This includes maintaining a culture of data-driven performance management, evidence-building activities, and evaluation that continually improve our accountability, transparency, oversight, and decision-making. This approach supports evidence-based strategic and performance planning across organizations, leads to more consistent performance reporting, and ensures the optimal use of our resources.

NASA plans and evaluates performance in a continuous cycle, spanning multiple fiscal years, in conjunction with the annual planning, programming, budgeting, and execution process used to ensure that resource alignment supports mission and operational needs. This ongoing feedback loop ensures that plans reflect performance expectations and performance results inform planning decisions.

Annual Strategic Reviews

The annual Strategic Review process encompasses a comprehensive retrospective and prospective review of the strategies for achieving our 12 Strategic Objectives and the health of the contributing programs. NASA measures progress towards achieving each Strategic Objective through near-, mid-, and long-term success criteria for all supporting program portfolios. As of the publication of this document, at least 60% of the success criteria were quantitative. NASA also assesses:

- Available opportunities that could enable successful programs and projects;
- Approaches for addressing risks, including those identified through enterprise risk management capabilities (see Enterprise Risk Management below);
- Resources, including budget and workforce allocations; and
- Ongoing or planned program evaluations, performance measurement, policy analysis, and other evidence-building activities.

The lead organization and contributing programs conduct the analysis and recommend whether their Strategic Objective demonstrates noteworthy progress, satisfactory performance, or is a focus area for improvement. NASA's Performance Improvement Officer in conjunction with its Chief Performance Management Officer determine final ratings and next steps with the Agency Summary of Findings, reported to the Chief Operating Officer as part of the Baseline Performance Review (see Baseline Performance Review below). NASA then submits final ratings as part of the Strategic Review Summary of Findings to the Office of Management and Budget for review and comment.

The Strategic Review inputs, findings, and results inform our budget process and are inputs to the next performance planning cycle. In addition, NASA may adjust Strategic Objective strategy and supporting success criteria based on Strategic Review results.

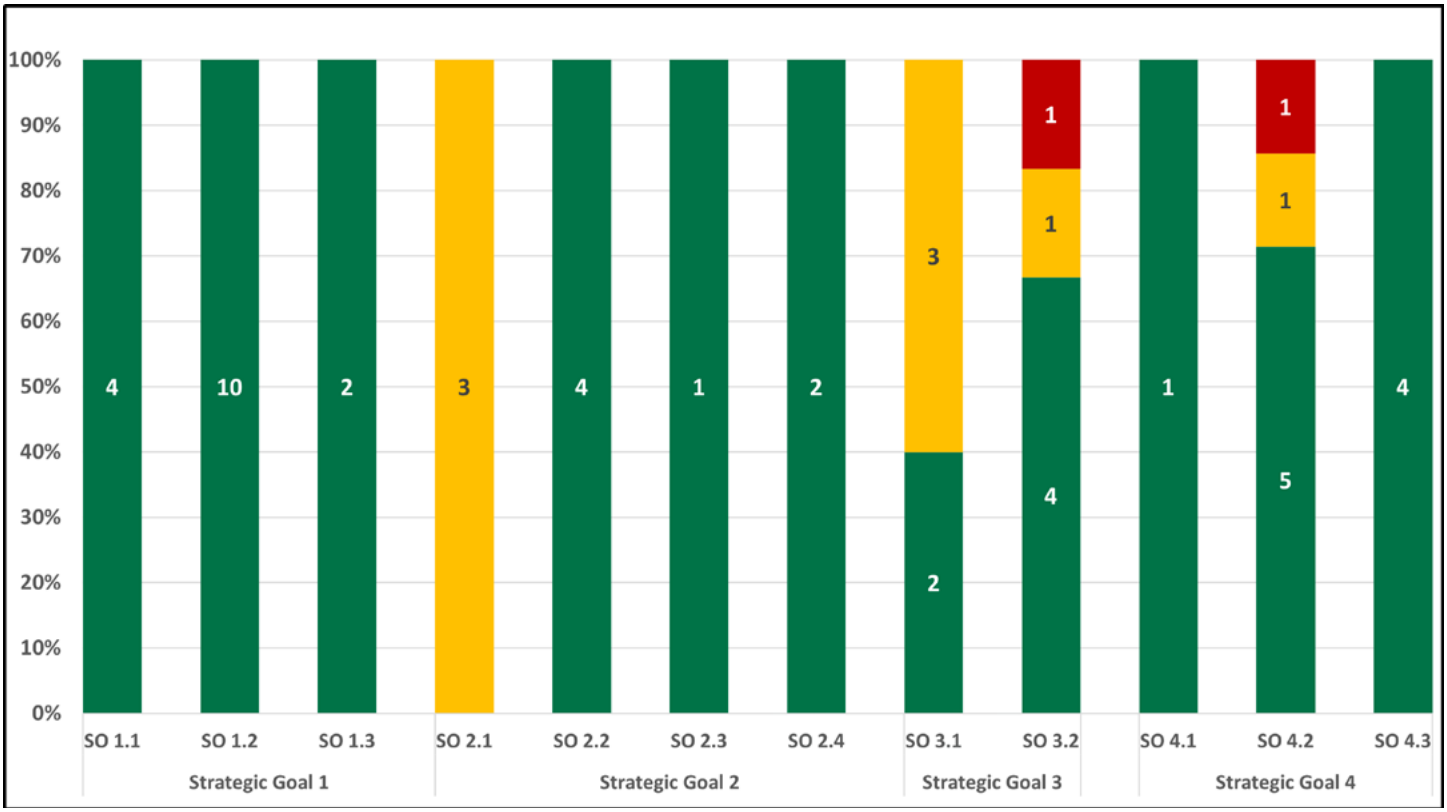
The ratings from this year's review cycle, and the Summary of Progress by Strategic Objective are provided in Part 2.

Annual Performance Assessments

During the third and fourth quarters of each fiscal year, NASA program officials assess progress towards achieving the Performance Goals listed in the Agency Performance Plan. They determine whether targets and any supporting milestones were met as anticipated, assign the appropriate rating, and provide an explanation to support the rating. NASA's Performance Improvement Officer reviews the performance assessment results and provides feedback and determines final ratings when needed.

Of the 49 Performance Goals in FY 2023, NASA rated 39 Green (80% achieved), 8 Yellow (16% missed annual target), and 2 Red (4% missed the annual target/at risk). Overall, NASA's performance was very similar to FY 2022 as 80% of the performance goals were achieved in both years. A slightly higher percentage of goals missed their annual targets. Part 2 of this volume presents the individual FY 2023 ratings and supporting performance explanations in further detail.

Figure 4: Summary of FY 2023 Performance Goal Ratings by Strategic Goal and Objective



Performance Management Goals and Mandates

Several key regulations and legislation have been issued or passed over the years that build on the GPRAMA's framework for performance management: the Evidence Act and it's guiding subsequent memorandums (M-19-23, M-20-12, M-21-27), the 2016 update on enterprise risk management (M-16-17) to OMB Circular A-123, and the 2018 update (M-18-19) to the Program Management Improvement Accountability Act of 2016 (PMIAA). Together these inform all aspects of performance management goals and mandates.

The 12 Strategic Objectives from the 2022 Strategic Plan are mapped to NASA's FY 2025 President's Budget Request in the table below. Detailed budget tables provided in Part 2 include the FY 2023 actual, FY 2024 enacted, and outyear budget numbers through FY 2029. The budget numbers for FY 2023 and FY 2024 represent actual budget authority (pending appropriations status) and the budget numbers for FY 2025 through FY 2029 are based on the requested budget.

Figure 5: FY 2025 Budget Request by Strategic Objective

Strategic Goals	Strategic Objectives	Requested ($M)
1. Expand human knowledge through new scientific discoveries	1.1 Understand the Earth system and its climate	$1,879.1
	1.2 Understand the Sun, solar system, and universe	$5,187.0
	1.3 Ensure NASA's science data are accessible to all and produce practical benefits to society	$499.5

Strategic Goals	Strategic Objectives	Requested ($M)
2. Extend human presence to the Moon and on towards Mars for sustainable long-term exploration, development, and utilization	2.1 Explore the surface of the Moon and deep space	$7,618.2
	2.2 Develop a human spaceflight economy enabled by a commercial market	$3,301.3
	2.3 Develop capabilities and perform research to safeguard explorers	$248.5
	2.4 Enhance space access and services	$840.0
3. Catalyze economic growth and drive innovation to address national challenges	3.1 Innovate and advance transformational space technologies	$1,181.8
	3.2 Drive efficient and sustainable aviation	$965.8
4. Enhance capabilities and operations to catalyze current and future mission success	4.1 Attract and develop a talented and diverse workforce	$118.2
	4.2 Transform mission support capabilities for the next era of aerospace	$3,343.1
	4.3 Build the next generation of explorers	$150.7

**Does not include Office of the Inspector General*

The funding amounts shown above encompass multiple programs and projects that together support the Strategic Objective. The budget numbers are rounded and will not add up to NASA's total budget request. Funds for the Office of Inspector General are not included in any Strategic Objective funding line.

Enterprise Risk Management

In July 2016, the Office of Management and Budget released a memorandum updating Circular A-123 Management's Responsibility for Internal Control to ensure that agencies manage risks arising from enterprise operations and activities that could affect achievement of Strategic Objectives. The memorandum required each Agency to implement an enterprise risk management capability in coordination with its strategic planning and Strategic Review processes. The enterprise risk management process provides insights on how to effectively prioritize and manage risks to mission delivery while also providing an enterprise-wide, strategically aligned portfolio view of organizational risks, challenges, and opportunities.

NASA has integrated enterprise risk management with the strategic planning and Strategic Review processes to provide an analysis of the risks and opportunities we face in accordance with Office of Management and Budget guidance. We have a program management integration function with matrixed support from the Office of the Chief Engineer and Office of the Chief Financial Officer that partner with the Mission Directorates and Centers. While we cannot mitigate all risks related to achieving our Strategic Goals and Objectives, we are using these risk-management strategies to identify, measure, and address challenges related to mission delivery to the greatest extent possible.

Improved Program and Project Management

In early 2022, NASA established the role of the Chief Program Management Officer (CPMO) in the Office of the Administrator to implement initiatives addressing the Agency's high-risk areas identified by the Government Accountability Office (see Strategies for Improvement).

The CPMO, who reports to NASA's Associate Administrator, collaborates across Mission Directorates and Centers to strengthen enterprise-wide oversight, management, and implementation of program management policies and best practices. The CPMO function continues to mature as it undertakes efforts, such as the reconstituted Program/Project Management Board and establishing communities of practice, mentoring, internship, and detail opportunities for the program management discipline.

Oversight and Accountability

In setting goals and establishing plans to achieve mission success, NASA leaders rely on information from multiple sources. Rigorous independent assessments, both internal and external to the Agency, are an essential tool in

ensuring the integrity of data necessary to make well-informed investment and program decisions. Independent verification and validation in planning and executing programs or projects provides greater confidence and improves expected outcomes. In many cases, these assessments include a routine measure of progress against a predetermined set of indicators, a baseline, or other targets that effectively establish an early warning system so that issues can be more quickly and easily identified and addressed.

Governance Councils

NASA uses four senior leadership councils to govern the Agency. Councils provide high-level oversight, set requirements and strategic priorities, and guide key assessments of the Agency. The council members evaluate issues and support decision authorities when issues involve or require high levels of difficulty, integration, visibility, and approval.

The Executive Council determines our strategic direction, assesses our progress toward achieving the NASA Vision, and serves as our senior decision-making body for Agency-wide decisions.

The Mission Support Council serves as our senior decision-making body regarding the integrated Agency mission support portfolio, and mission support plans and implementation strategies (including facility, infrastructure, workforce, and associated investments); and determines and assesses mission support requirements to enable successful accomplishment of our missions.

The Agency Program Management Council serves as our senior decision-making body regarding the integrated Agency mission portfolio; and baselines and assesses performance of NASA projects, programs, mission directorate portfolios, and the integrated Agency portfolio to ensure achievement of our Strategic Goals.

The Acquisition Strategy Council approves acquisition approaches for large, high-profile programs as recommended by the sponsoring Mission Directorate; decides work assignments to Centers and updates to Center roles; and evaluates mission needs and Agency workforce capacity.

Technical Authorities

Our Technical Authorities (Engineering, Safety and Mission Assurance, and Health and Medical) are a key part of NASA's overall system of checks and balances and provide independent oversight of programs and projects in support of safety and mission success.

Technical Authority originates with the Administrator, ensuring work on critical performance areas adheres to Agency policy, requirements, and standards. The fundamental aspects of Technical Authority are:

- Provide an independent view of program/project activities;
- Ensure direction to the program or project reflects the view of the Center or, where appropriate, the view of the NASA Technical Authority community;
- Adjudicate requests for relief (via waivers) from the Technical Authority technical baseline; and
- Implement the dissenting opinion process, to support full and open discussion of substantive disagreement with a decision or decisions regarding the Technical Authority's technical baseline.

Baseline Performance Reviews

The Baseline Performance Review (BPR) is a monthly forum in the Agency Program Management Council, where NASA's executive leadership track program and project performance against Agency plans and priorities. In FY 2022, NASA reformulated BPR to summarize key performance information, such as the portfolio risk profile and in-depth discussions about cost, schedule, technical, and programmatic risks for major projects.

BPR includes performance progress updates for Agency Priority Goals and Performance Goals. Each Mission Directorate or Mission Support Office provides a performance assessment of the activity it manages, and Agency-level analysts conduct independent assessments. NASA's Technical Authorities provide oversight and an additional level of control. We also conduct our annual Strategic Review at the BPR to take advantage of the existing top-level forum for performance discussion and decision-making.

Program and Project Key Decision Point Reviews

As aforementioned, NASA requires internal independent assessments on the progress of programs and projects through their programmatic life cycles. Senior leaders convene a series of formal key decision point reviews, requiring managers to provide assessments of how the programs and projects are performing in key areas, and outlining future plans. Such key decision points are specific milestones at which managers must provide Agency leadership with information about program maturity and readiness to progress to the next stage of the life cycle (see the figure below).

The mandatory reviews at key decision point milestones focus on the program or project's assessment of status, as well as that of the Standing Review Board or mission directorate independent review team. Multiple stakeholder organizations also weigh in on the information presented. Other reviews may be scheduled, in accordance with the lifecycle schedule of that project and depending on the formulation, development implementation, or construction plan. NASA regularly provides Congress, OMB, and the Government Accountability Office with cost and schedule updates for major projects with an estimated lifecycle cost of $250 million or greater.

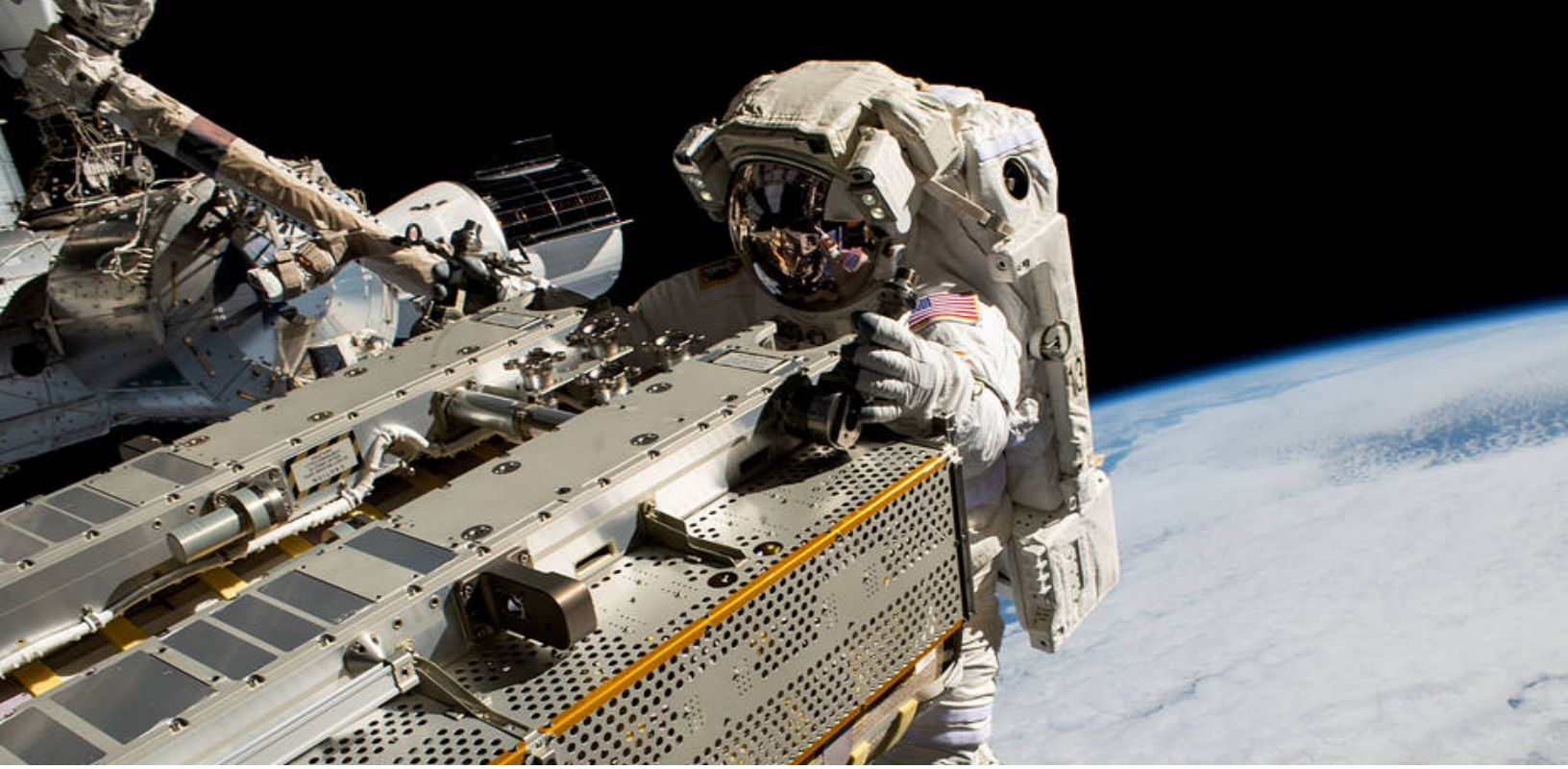
Figure 6: NASA Flight Project Lifecycle Phases, Key Decision Points, and Milestones

Key Decision Point (KDP) Review	Associated Milestone	Milestone Review Objectives	Overall Expected Maturity State at KDP
KDP-A	Mission Concept Review (MCR)	To evaluate the feasibility of the proposed mission concept(s) and its fulfillment of the program's needs and objectives. To determine whether the maturity of the concept and associated planning are sufficient to begin Phase A.	Project addresses critical NASA need. Proposed mission concept(s) is feasible. Associated planning is sufficiently mature to begin Phase A, and the mission can likely be achieved as conceived.
KDP-B	System Requirements Review (SRR)	To evaluate whether the functional and performance requirements defined for the system are responsive to the program's requirements on the project and represent achievable capabilities.	Proposed mission/system architecture is credible and responsive to program requirements and constraints, including resources. The maturity of the project's mission/system definition and associated plans is sufficient to begin Phase B, and the mission can likely be achieved within available resources with acceptable risk.
	Mission Definition Review (MDR) or System Definition Review (SDR)	To evaluate the credibility and responsiveness of the proposed mission/system architecture to the program requirements and constraints, including available resources. To determine whether the maturity of the project's mission/system definition and associated plans are sufficient to begin Phase B.	
KDP-C	Preliminary Design Review (PDR)	To evaluate the completeness/consistency of the planning, technical, cost, and schedule baselines developed during Formulation. To assess compliance of the preliminary design with applicable requirements and to determine if the project is sufficiently mature to begin Phase C.	Project's planning, technical, cost, and schedule baselines developed during Formulation are complete and consistent. The preliminary design complies with its requirements. The project is sufficiently mature to begin Phase C, and the cost and schedule are adequate to enable mission success with acceptable risk.
KDP-D	Critical Design Review (CDR)	To evaluate the integrity of the project design and its ability to meet mission requirements with appropriate margins and acceptable risk within defined project constraints, including available resources. To determine if the design is appropriately mature to continue with the final design and fabrication phase.	Project is still on plan. The risk is commensurate with the project's payload classification, and the project is ready for Assembly, Integration, & Test (AI&T) with acceptable risk within its Agency baseline cost.
	Production Readiness Review (PRR)	To evaluate the readiness of system developer(s) to produce the required number of systems within defined project constraints for projects developing multiple similar flight or ground support systems. To evaluate the degree to which the production plans meet the system's operational support requirements.	
	System Integration Review (SIR)	To evaluate the readiness of the project and associated supporting infrastructure to begin system AI&T, evaluate whether the remaining project development can be completed within available resources, and determine if the project is sufficiently mature to begin Phase D.	
KDP-E	Operational Readiness Review (ORR)	To evaluate the readiness of the project to operate the flight system and associated ground system(s) in compliance with defined project requirements and constraints during the operations/sustainment phase of the project life cycle.	Project and all supporting systems are ready for safe, successful launch and early operations with acceptable risk within the Agency baseline cost.
	Mission Readiness Review (MRR) or Flight Readiness Review (FRR)	To evaluate the readiness of the project and all project and supporting systems for a safe and successful launch and flight/mission.	
	Launch Readiness Review (LRR)	To evaluate a program/project and its ground, hardware, and software systems for readiness for launch.	

NASA Office of Inspector General and the Government Accountability Office

Two independent organizations, the NASA Office of Inspector General (OIG) and the Government Accountability Office (GAO), conduct both broadly and narrowly focused assessments of how well the Agency is achieving outcomes and performing to expectations. The assessments and reports span all types of NASA work including planning new initiatives, managing major programs, implementing necessary infrastructure modernization, and outlining potential impacts of legislation and policy.

The Office of Inspector General and contracted independent auditors are also employed to review the Agency's financial record keeping systems, compliance with requirements, and financial controls. We have received an unmodified "clean" opinion on our financial statements, with no reported material internal control weaknesses, for 13 consecutive years, as reported in the FY 2023 Agency Financial Report. We review the resulting reports, such as the annual auditor's report on NASA's financial statements and the OIG Report on NASA's Top Management and Performance Challenges, and provide feedback on how the Agency will take corrective actions or make improvements.



Strategies for Improvement

We've outlined the internal assessments and evaluations that NASA undertakes to aid in maintaining, managing, and improving operations and program performance.

Periodic external assessments also focus on areas of high risk or potential challenges for the Agency. The Government Accountability Office (GAO) and the NASA Office of Inspector General (OIG) conduct such external assessments, identifying areas for improvement and recommending how to address them. Issues raised by GAO and OIG represent high-priority areas for NASA management attention.

High Risk Areas Identified by the GAO

GAO assesses activities across the Federal government and identifies areas that carry a risk for fraud, waste, abuse, mismanagement, or otherwise requiring transformation. GAO's biennial High Risk List, which is issued publicly and delivered to each newly elected Congress, has included NASA's acquisition management since the inaugural report issued in 1990. GAO's evaluation criteria and a comprehensive list of all high risk areas, current ratings, and progress was published in GAO-23-106203. NASA's specific background and progress made to address acquisition management can be found in Appendix 32 of this report. NASA developed a new Corrective Action Plan (CAP) in 2022 with six major initiatives to address challenges with acquisition management. NASA's 2022 CAP builds upon the previous corrective action plans, which were developed in 2007, 2018, and 2020. The initiatives from those previous plans, including steps taken for closure on the initiatives, are detailed in an appendix of the 2022 Plan.

Management Challenges Identified by the OIG

Each fiscal year, NASA's OIG issues the Report on NASA's Top Management and Performance Challenges summarizing what the Inspector General considers to be NASA's most serious management and performance challenges, as well as a brief assessment regarding the Agency's progress in addressing those challenges. NASA leverages the results of this and other OIG recommendations to improve the overall efficiency and effectiveness of

Above: Spacewalker Woody Hoburg rides the Canadarm2 robotic arm while maneuvering a roll-out solar array toward the International Space Station's truss structure on June 9, 2023 Image Credit: NASA/Frank Rubio

our programs, projects, and functional activities.

NASA has implemented a comprehensive follow-up strategy intended to ensure that recommendations issued by the OIG are resolved and implemented in a timely, responsive, and effective manner. NASA's follow-up strategy is a key element in improving the overall efficiency and effectiveness of NASA's programs, projects, and operations. The Administrator's response to the OIG's recommendations is detailed in the Agency Response to OIG Report on NASA's Top Management and Performance Challenges (see the Appendix).

The seven challenges from the 2023 OIG report along with the relevant Performance Goals and significant evaluations are provided below:

Challenge 1: Returning Humans to the Moon

- Strategic Objective 2.1: Explore the Surface of the Moon and Deep Space

Challenge 2: Improving Management of Major Programs and Projects

- Strategic Objective 1.1: Understand the Earth system and its climate
- Strategic Objective 1.2: Understand the Sun, solar system, and universe
- Strategic Objective 2.1: Explore the surface of the Moon and deep space
- Strategic Objective 3.1: Innovate and advance transformational space technologies
- Strategic Objective 3.2 Drive efficient and sustainable aviation
- Cost and Schedule evaluation

Challenge 3: Sustaining a Human Presence in Low Earth Orbit

- Strategic Objective 2.2: Develop a human spaceflight economy enabled by a commercial market
- Strategic Objective 2.4: Enable space access and services

Challenge 4: Maturing Information Technology Management and Security

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

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

- Strategic Objective 3.1: Innovate and advance transformational space technologies
- Strategic Objective 4.2: Transform mission support capabilities for the next era of aerospace
- Cost and Schedule evaluation

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

- Strategic Objective 4.1: Attract and develop a talented and diverse workforce
- Minorities and Women in GS-14 and Higher Positions evaluation
- Strategic Objective 4.3: Build the next generation of explorers
- Internship Process and Retrospective evaluation

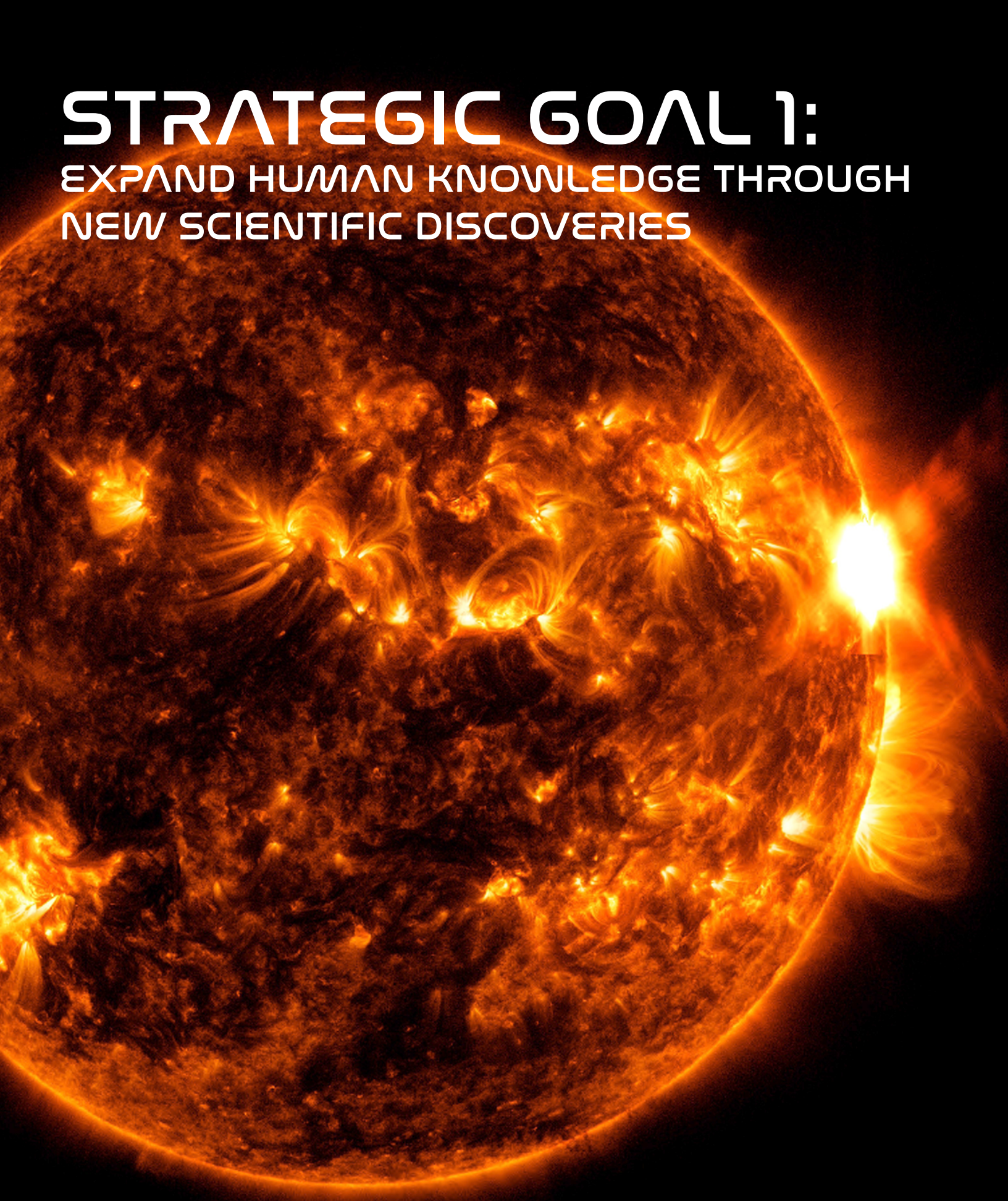
Challenge 7: Addressing NASA's Outdated Infrastructure and Facilities

- Strategic Objective 2.1: Explore the surface of the Moon and deep space
- Strategic Objective 2.4: Enhance space access and services
- Strategic Objective 4.2: Transform mission support capabilities for the next era of aerospace

PART 2:
PERFORMANCE PLANNING AND REPORTING

Seen here by Webb's Mid-Infrared Instrument (MIRI) is the galaxy M51, also known as NGC 5194. The gravity of its neighbor, the dwarf galaxy NGC 5195, is thought to be partially responsible for those prominent & distinct spiral arms! While MIRI brings out the web-like structure of the dust in the galaxy, NIRCam focuses more on ionized gas from newly formed star clusters. Image Credit: NASA

STRATEGIC GOAL 1:
EXPAND HUMAN KNOWLEDGE THROUGH NEW SCIENTIFIC DISCOVERIES



The Sun emitted a strong solar flare, peaking at 6:21 p.m. EDT on August 5, 2023. NASA's Solar Dynamics Observatory (SDO), which watches the Sun constantly, captured an image of the event. Image Credit: NASA/SDO

FY 2023 Performance Goals and Ratings Supporting Strategic Goal 1

Strategic Objective	Performance Goal	Description	Rating
1.1	**Understand the Earth System and its Climate**		
	1.1.1	Demonstrate progress in characterizing the behavior of the Earth system, including its various components and the naturally-occurring and human-induced forcings that act upon it	Green
	1.1.2	Demonstrate progress in enhancing understanding of the interacting processes that control the behavior of the Earth system, and in utilizing the enhanced knowledge to improve predictive capability	Green
	1.1.3	Achieve critical milestones for the Science Mission Directorate's Earth system major projects	Green
	1.1.4	Use the global vantage point of space to advance our understanding of the Earth system, its processes, and changing climate (**APG**)*	Green
1.2	**Understand the Sun, Solar System, and Universe**		
	1.2.1	Demonstrate progress in exploring and advancing understanding of the physical processes and connections of the Sun, space, and planetary environments throughout the solar system	Green
	1.2.2	Demonstrate progress in exploring and probing the origin, evolution, and destiny of the galaxies, stars, and planets that make up the universe	Green
	1.2.3	Demonstrate progress in exploring, observing, and understanding objects in the solar system in order to understand how they formed, operate, interact, and evolve	Green
	1.2.4	Demonstrate progress in discovering and studying planets around other stars	Green
	1.2.5	Demonstrate progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere, exploring and finding locations where life could have existed or could exist today, and exploring whether planets around other stars could harbor life	Green
	1.2.6	Demonstrate progress in developing the capability to detect and knowledge to predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth	Green
	1.2.7	Demonstrate progress in identifying, characterizing, and predicting objects in the solar system that pose threats to Earth or offer resources for human exploration	Green
	1.2.8	Demonstrate progress in understanding the properties of physical and biological systems in spaceflight environments to advance scientific knowledge, enable space exploration, and benefit life on Earth	Green
	1.2.9	Achieve critical milestones of Science Mission Directorate's heliophysics, planetary science, and astrophysics major projects	Green
	1.2.10	Complete deployment of the James Webb Space Telescope, the most powerful and complex space telescope ever built, and begin Webb's Cycle 2 observations (**APG**)*	Green
1.3	**Ensure NASA's Science Data are Accessible to All and Produce Practical Benefits for Society**		
	1.3.1	Accelerate the accessibility and use of NASA's science data and tools	Green
	1.3.2	Apply insights from Earth science to benefit the economy, health, quality of life, and environment around the globe	Green

*Agency Priority Goal

STRATEGIC OBJECTIVE 1.1

Understand the Earth System and its Climate

LEAD OFFICE
Science Mission Directorate (SMD)

GOAL LEADER
Karen Flynn, Deputy Associate Administrator for Management, SMD

BUDGET

	FY	$M
Op Plan	2023	$1,753.7
Enacted	2024	$1,771.7
Requested	2025	$1,879.1
Outyear	2026	$1,891.5
	2027	$1,927.9
	2028	$1,966.2
	2029	$2,011.7

As climate change makes its impact felt across the United States and the globe, NASA is rising to meet the challenge. Strategic Objective 1.1 directs NASA's capabilities in earth observation, data analysis, and research to support the effort to better understand and mitigate climate change.

One group of interlocking missions that are key to meeting this objective is the Earth System Observatory (ESO), which NASA is formulating based on recommendations in the most recent National Academies of Science, Engineering, and Medicine's Decadal Survey. The ESO will provide an unprecedented, holistic view of Earth – significantly advancing our ability to measure, predict, and respond to changes to our home planet.

NASA has made significant progress on the ESO in 2022 and 2023, including entering formulation for both Atmospheric Observing System (AOS) missions Surface Biology and Geology (SBG), and Mass Change (MC). In July 2022, NASA launched the Earth Surface Mineral Dust Source Investigation (EMIT) to the International Space Station. In addition to EMIT's planned mission of understanding how dust affects climate change, EMIT has also demonstrated the crucial capability of detecting the presence of methane, a potent greenhouse gas.

In December 2022, NASA launched the Surface Water and Ocean Topography (SWOT) mission, with first light images released in March 2023 that demonstrate SWOT's cutting-edge capabilities in surveying Earth's surface water. We also initiated the Landsat Next

Above: This February 3, 2023, enhanced-color image from Landsat 9 highlights a green and blue patchwork pattern in flooded rice fields in southwestern Louisiana. Image Credit: NASA

mission that will continue an over 50-year record of the global land surface observation. In early 2023, NASA delivered the NASA-Indian Space Research Organization (ISRO) Synthetic Aperture Radar (NISAR) to India in preparation for launch in 2024, and Investigation of Convective Updrafts (INCUS), Earth Venture Mission-3 (EVM-3) successfully passed Key Decision Point B (KDP-B). In April 2023, we launched Tropospheric Emissions: Monitoring of Pollution (TEMPO), NASA's first Earth Venture Instrument selection, which marks a new era in our ability to observe air pollution over North America. While some cost and schedule challenges arose, each of these accomplishments fulfilled criteria for strategic success in the near term.

Efforts supporting this strategic objective also face significant challenges including higher than anticipated inflation, supply chain issues, and workforce availability. However, with proactive management of these challenges and their impacts, NASA remains on track for the key mid- and long-term achievements supporting this objective. Nonetheless, increasing costs and greater budgetary pressure is expected to crowd out additional opportunities. To mitigate these challenges, SMD continues to pursue a number of opportunities, including expansion of international and domestic partnerships. Such partnerships allow for expansion of NASA's research portfolio, as they leverage the unique strengths of partners, allies, and international talent to drive scientific research and applications progress.

Based on SMD's strategy and accomplishments described in the above paragraphs, Strategic Objective 1.1 achieved a Green/Satisfactory rating during the 2023 Strategic Review Process.

1.1.1: Demonstrate progress in characterizing the behavior of the Earth system, including its various components and the naturally-occurring and human-induced forcings that act upon it

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	1 of 1	1 of 1	1 of 1
Result	1		
Rating	Green		

Critical milestones for FY 2023

1. Significant progress demonstrated as determined by annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.1.

Critical milestones for FY 2024

1. Significant progress demonstrated as determined by annual external expert review of published, peer-reviewed research contributing to Performance Goal 1.1.1.

Critical milestones for FY 2025

1. Significant progress demonstrated as determined by annual external expert review of published, peer-reviewed research contributing to Performance Goal 1.1.1.

Lead Organization: Science Mission Directorate (SMD)

FY 2023 Performance Progress

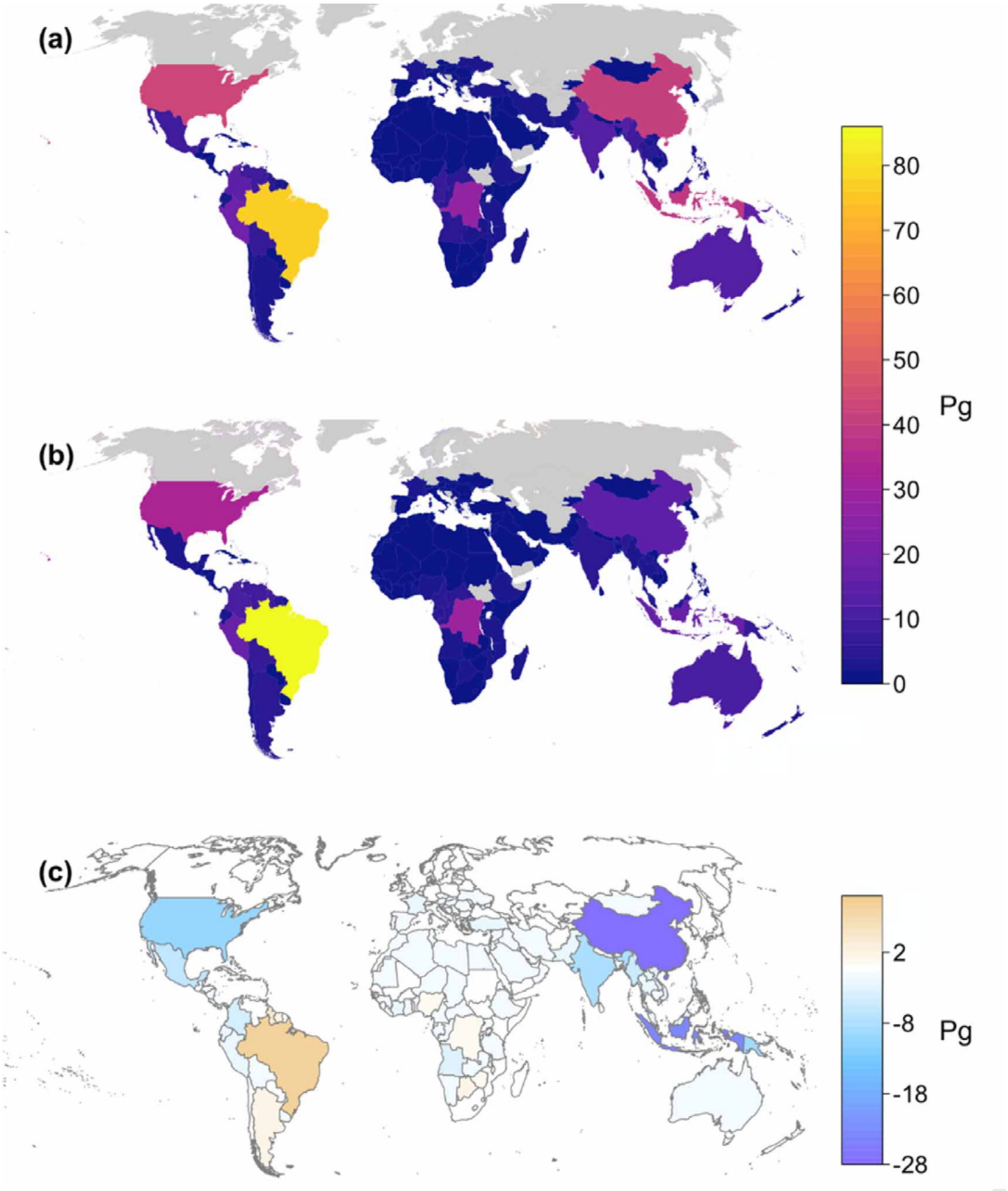
NASA achieved the FY 2023 target for this multiyear Performance Goal as determined by the Earth Science Advisory Committee in October 2023, leading to a Green Performance Goal rating. Below are examples of scientific progress reported in FY 2023.

A regional study of extremes applied a novel approach, leveraging terrestrial water storage observations from the Gravity Recovery and Climate Experiment (GRACE) and GRACE-Follow On (GRACE-FO) satellites to delineate and characterize 1,056 extreme events during 2002–2021. The largest event identified was an ongoing pluvial (heavy rain flooding) that began in 2019 and engulfed central Africa. The magnitude was such that Lake Victoria rose over 1 meter, with flooding in the surrounding region. The second largest event was a 2018-2021 pluvial over central and eastern North America. The third largest event was a 2011-2012 Australian pluvial that ended the Millennium Drought and even caused sea level to decline for a brief period. Scientists found the intensity of extreme water events was strongly correlated to high terrestrial soil temperatures, suggesting that continued warming will cause more frequent, more severe, longer and/or larger droughts and pluvials.

In a separate study, scientists used column carbon dioxide (CO_2) observations from Orbiting Carbon Observatory-2 (OCO-2) and OCO-3 missions on ten occasions from March 2017-June 2022 to quantify CO_2 emissions from Europe's largest fossil fuel power plant, the Bełchatów Power Station in Poland. They found that the space-based CO_2 emission changes with a trend consistent with the independently reported hourly power generation trend that results from both permanent and temporary unit shutdowns. OCO-2 and OCO-3 emission estimates agree with the bottom-up emission estimates within their respective 1 standard deviation uncertainties for nine of the ten occasions. These results demonstrate the ability of the missions to quantify emission reductions for a large facility, and their ability to quantify short-term emission changes to support verification of CO_2 emission reductions under the Paris Agreement.

Finally, NASA's Global Ecosystem Dynamics Investigation (GEDI) is a novel and powerful tool that is providing groundbreaking information on forest structure. GEDI is a spaceborne lidar hosted on the International Space Station (ISS) that was designed to provide measurements of vegetation structure in a way that enables quantitative measurements of aboveground biomass (AGB) across a variety of spatial scales. Applications of GEDI data include analyzing the effectiveness of protected areas (PA) for carbon sequestration. Establishing PAs represents an effective and important approach to forest conservation, but their contribution to climate change mitigation remains unquantified. Scientists used approximately 412 million GEDI lidar samples to estimate carbon sequestration in PAs, concluding that a total of approximately 19.7 Gt of additional above ground biomass (AGB) are associated with PA status. These higher carbon stocks are roughly equivalent to annual global fossil fuel emissions, underscoring the importance of conservation of high integrity, high biomass forests for avoiding carbon emissions and preserving future sequestration. (Figure 1)

Figure 1, Below: GEDI country-wide estimates of AGB as compared with in-country reports. (a) GEDI estimates. (b) Food and Agriculture Organization (FAO) estimates. (c) Difference (FAO—GEDI). GEDI estimates AGB across all land, not just forested land, while FAO estimates are focused on forests. The national forest inventories used as the basis of FAO's estimates vary widely in terms of framework, quantity, and quality. (Units of mass Pg: Petagram or 10^9 tones.) Image Credit: NASA



1.1.2: Demonstrate progress in enhancing understanding of the interacting processes that control the behavior of the Earth system, and in utilizing the enhanced knowledge to improve predictive capability

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	1 of 1	1 of 1	1 of 1
Result	1		
Rating	Green		

Critical milestones for FY 2023

1. Significant progress demonstrated as determined by annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.2.

Critical milestones for FY 2024

1. Significant progress demonstrated as determined by annual external expert review of published, peer-reviewed research contributing to Performance Goal 1.1.2.

Critical milestones for FY 2025

1. Significant progress demonstrated as determined by annual external expert review of published, peer-reviewed research contributing to Performance Goal 1.1.2.

Lead Organization: Science Mission Directorate (SMD)

FY 2023 Performance Progress

NASA achieved the FY 2023 target for this multiyear Performance Goal as determined by the Earth Science Advisory Committee in October 2023, leading to a Green Performance Goal rating. Below are examples of scientific progress reported in FY 2023.

NASA investigators offered a new mechanism for La Niña formation, proposing a new connection between the smoke from wildfires and climate, and arguing that extreme wildfires in Australia triggered a stronger than usual La Niña 2019-2020. Their analysis suggests that the Australian wildfires caused an increase in organic matter emission into the atmosphere, leading to more cloud cover and less sunlight reaching the Earth's surface, with subsequent decrease in humidity and temperatures, all triggering a "surprising" La Niña that lasted at least three years. The mechanism is similar to the impact of volcanic ash, which can temporarily mask global warming and even cause a dip in the global mean sea level, as was the case following the eruption of Mt. Pinatubo in 1991.

Recent studies analyzed wildfires caused by lightning in order to improve wildfire risk predictions, and to determine whether some types of lightning are more likely to cause fires. One study compared two potential wildfire outbreak days in California during August 2020. While both events had similar weather conducive to wildfire initiation and spread, only one day actually featured a wildfire initiation. Studying the differences between the days suggests that aerosol loading from prior fires may have played a factor in inhibiting lightning on the inactive day. These results suggest there is potential utility in considering aerosol concentration and depth while forecasting fire potential. Meanwhile, another study found that lightning density from wildfire-parent storms peaks near the wildfire ignition point, and that positive lightning flashes could be up to 60 times more efficient at igniting fires than negative flashes.

NASA researchers used a high-resolution, regional coupled modeling system to investigate the impacts of irrigation dataset selection on land–atmosphere coupling using a case study from the Great Plains Irrigation Experiment (GRAINEX) field campaign. Their results show that land-atmosphere coupling is sensitive to the choice of irrigation dataset and resolution. Furthermore, it shows that the irrigation impact on surface fluxes and near-surface meteorology can be dominant or minimal. A consistent finding across several analyses was that even a low percentage of irrigation fraction (i.e., 4 %–16 %) can have significant atmospheric impacts. This suggests that attempts to model the impacts of irrigated land on the atmosphere must pay particular attention to the representation of boundaries and heterogeneous areas within irrigated regions.

Finally, researchers demonstrated that Soil Moisture Active Passive (SMAP) retrievals of soil moisture, integrated with food prices, provide an early warning for food crises caused by droughts months in advance. They analyzed drought-induced food crises globally in the SMAP record (since 2015; approximately five per year). The change in soil moisture autocorrelation (i.e. correlation of values between successive time intervals) led to a dramatic improvement in anticipating the timing and intensity of food crises, with lead times of up to three to six months for every case. This significant advancement is the first documented analysis of a relationship between the autocorrelation indicator and the magnitude of change in food security, suggesting that in the future, the response could be predictively scaled to anticipate the size of the food crisis.

1.1.3: Achieve critical milestones for the Science Mission Directorate's Earth system major projects
(Performance Goal ending in FY 2023)

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	3 of 3	N/A	N/A
Result	3		
Rating	Green		

Critical milestones for FY 2023

1. Deliver the NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR) mission Integrated Radar Payload to ISRO.
2. Complete the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission Key Decision Point (KDP)-D review.
3. Launch the Tropospheric Emissions: Monitoring Pollution (TEMPO) mission.

Lead Organization: Science Mission Directorate (SMD)

FY 2023 Performance Progress

NASA achieved all three of the critical milestones identified for FY 2023, leading to a Green Performance Goal rating.

In February 2023, the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission completed the Key Decision Point (KDP)-D review, allowing the mission to move forward to observatory integration and testing ahead of its scheduled launch in early 2024. Once on orbit, PACE will help us better understand how the ocean and atmosphere exchange carbon dioxide, measure key atmospheric variables associated with air quality and Earth's climate, and monitor ocean health, in part by studying phytoplankton, tiny plants and algae that sustain the marine food web.

This was followed in March by the delivery of the Integrated Radar Payload for the NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR) mission. This science payload of two radar systems, one built by NASA and the other by ISRO, completed the journey from NASA's Jet Propulsion Laboratory in Southern California to ISRO's U R Rao Satellite Centre in Bengaluru, India, where teams began working to combine the radar systems with the satellite's body, or bus, ahead of testing for its scheduled launch in 2024. NISAR's payload will be the most advanced radar system ever launched as part of a NASA science mission. Once on orbit, NISAR will observe nearly all of Earth's land and ice surfaces twice every twelve days, measuring movements in extremely fine detail. The mission will measure Earth's changing ecosystems, dynamic surfaces, and ice masses, providing information about biomass, natural hazards, sea level rise, and groundwater, and will support a host of other applications.

In April, the Tropospheric Emissions: Monitoring Pollution (TEMPO) instrument launched from Cape Canaveral Space Force Station in Florida atop a SpaceX Falcon 9 rocket. From its fixed geostationary orbit above the equator, TEMPO is the first space-based instrument to measure air quality over North America hourly during the daytime and at spatial regions of several square miles – far better than previous limits of about 100 square miles in the U.S. TEMPO data will play an important role in the scientific analysis of pollution (including studies of rush hour pollution), the potential for improved air quality alerts, the effects of lightning on ozone, the movement of pollution from forest fires and volcanoes, and even the effects of fertilizer application.

1.1.4: Use the global vantage point of space to advance our understanding of the Earth system, its processes, and changing climate

Agency Priority Goal

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	4 of 4	4 of 5	4 of 5
Result	4		
Rating	Green		

This two-year Agency Priority Goal has been identified for inclusion in the FY 2024-2025 Agency Performance Plan.

(*1.1.3 in FY 2024 and FY 2025) By September 30, 2025, NASA will advance the understanding of the Earth System and its Climate by delivering three new observing systems; meeting development milestones for the Earth System Observatory (ESO); and establish (or mature) the interagency U.S. Government Greenhouse Gas Monitoring and Information Center.

Critical milestones for FY 2023

1. Q1 Develop and release Version 4 of the NASA GISS Model E Earth system model.
2. Q2 Complete the Libera Critical Design Review (CDR).
3. Q3 Launch the Surface Water Ocean Topography (SWOT) mission.
4. Q4 Deliver Polar Radiant Energy in the Far InfraRed Experiment (PREFIRE) CubeSats.

Critical milestones for FY 2024 (1.1.3)

1. Q1 Launch the web-based portal and information system of the US Greenhouse Gas Center.
2. Q2 Complete the Surface Biology and Geology (SBG) System Requirements Review (SRR).
3. Q3 Launch the Plankton, Aerosol, Cloud, and ocean Ecosystem (PACE) mission to extend key systematic ocean color, aerosol, cloud, and terrestrial climate data records.
4. Q3 Complete Earth System Explorers (ESE) Step-1 selection by competitively selecting initial proposals to proceed to concept studies as part of the Step-2 selection process to enable high-quality Earth system science investigations.
5. Q4 Launch the first Polar Radiant Energy in the Far-InfraRed Experiment (PREFIRE) mission cubesat.

Critical milestones for FY 2025 (1.1.3)

1. Q1 Prototype at least two of the three initial demonstration areas of the US Greenhouse Gas Center, in partnership with the Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA), and the National Institute of Standards and Technology (NIST).
2. Q1 Complete the Operational Readiness Review (ORR) of the NASA-Indian Space Research Organization (ISRO) Synthetic Aperture Radar (NISAR) mission which is the first global SAR mission and will capture the dynamics of Earth's flowing ice, deforming crust, and changing landscapes with unprecedented resolution and acuity.
3. Q2 Complete Landsat Next System Requirements Review (SRR) to enable the mission to advance closer to Phase B.
4. Q3 Launch the Total and Spectral Solar Irradiance Sensor-2 (TSIS-2) mission to continue the 42-year record of total solar irradiance (TSI) and 18-year record of full spectral solar irradiance (SSI) measurements which are integral for understanding solar influences on Earth's climate.
5. Q4 Complete the Gravity Recovery and Climate Experiment-Continuity (GRACE-C) Critical Design Review (CDR) to enable one of the Earth System Observatory (ESO) missions to advance further in Phase C.

Lead Organization: Science Mission Directorate (SMD)

FY 2023 Performance Progress

NASA has achieved this two-year priority goal, advancing climate change research by delivering two new observing systems and an upgrade to NASA's primary global Earth systems model. In early FY 2022, after completing on-orbit checkout, NASA commenced Landsat 9 operations and released first light images, delivering the first new observing system. Landsat 9 is providing users with essential information about crop health, irrigation use, water quality, wildfire severity, deforestation, glacial retreat, urban expansion, and more, with more sensitivity to observe subtle differences than previous Landsat missions. With Landsat 9 now providing this information alongside its predecessor Landsat 8, users such as city planners, farmers, and scientists can better manage agricultural practices, preserve precious resources, and respond more effectively to natural disasters.

NASA delivered a second new observing system on December 16, 2022, with the launch of Surface Water

Ocean Topography (SWOT), a collaborative mission with the French space Agency, Centre National d'Etudes Spatiales (CNES) (with contributions from the Canadian Space Agency (CSA) and the UK Space Agency). SWOT is surveying nearly all water on Earth's surface for the first time, measuring the height of the world's oceans, rivers, and lakes, helping scientists track how fresh and saltwater bodies change over time. The satellite is also helping scientists investigate how the oceans absorb atmospheric heat and carbon, moderating global temperatures and climate change. A global inventory of water resources will help scientists better understand where the water is, where it's coming from, and where it's going. The observations will help improve flood forecasts, improve the models used to monitor droughts, improve predictions for sea level rise, and benefit industries like shipping by providing measurements of water levels along rivers and information about tides, currents, and storm surges in the ocean.

NASA also completed a release of the Goddard Institute of Space Studies (GISS) Model E Earth system model Version 4 (ModelE4) in 2023. The GISS Model E is NASA's primary Earth system model for studies of Earth system change on decadal to multi-decadal timescales. GISS ModelE4 includes high resolution ocean and sea ice representations with eight times the detail of the previous ModelE3, combined with the ModelE3 representation of the atmosphere. The higher resolution allows superior model simulations of ocean currents and variability which are of critical importance to Earth system simulation. Further evaluation of these simulations and application of the model will be ongoing. GISS Model E is the NASA model used most extensively in assessments of climate change. This model configuration, with its better representation of ocean currents and mixing, will greatly enhance our ability to assess the impacts of climate change on the ocean circulation and sea level, and refine our understanding of the impacts of the ocean on climate change itself.

STRATEGIC OBJECTIVE 1.2

Understand the Sun, Solar System, and Universe

LEAD OFFICE
Science Mission Directorate (SMD)

GOAL LEADER
Karen Flynn, Deputy Associate Administrator for Management, SMD

BUDGET

	FY	$M
Op Plan	2023	$5,616.5
Enacted	2024	$5,543.4
Requested	2025	$5,187.0
Outyear	2026	$5,320.7
	2027	$5,425.2
	2028	$5,539.0
	2029	$5,645.9

Strategic Objective 1.2 represents NASA's commitment to advancing humanity's knowledge of astrophysics, heliophysics, biological and physical sciences, and planetary science. Guided by high-priority research questions established by the National Academies' Decadal Surveys, NASA's strategy implementation has focused on technology development to provide the foundation for new missions, to invent and use new space-based observing and sampling capabilities, and to create capabilities to interpret mission data.

NASA is on track to achieve nearly all near- and mid-term plans in support of this strategic objective, and in their most recent assessments, the relevant advisory committees rated NASA's progress toward all science goals as having met or exceeded expectations. The James Webb Space Telescope, the most powerful and complex space telescope ever built, completed its first year of observations in July. During that year, Webb gave us a more intricate understanding of galaxies, stars, and the atmospheres of planets outside of our solar system than ever before, laying the groundwork for NASA to lead the world in a new era of scientific discovery and the search for habitable worlds. SMD also completed the caching and deposit of Mars samples by the Perseverance Rover, as well as the tremendously successful Double Asteroid Redirection Test (DART), which demonstrated the ability to deflect a potentially hazardous asteroid in space. Furthermore, NASA continues to implement existing Decadal Survey priorities and to prepare for new Decadal Survey guidance in Heliophysics and in Biological and Physical Sciences. For instance, NASA has completed design work on the Roman Space Telescope, a priority of the Astrophysics Decadal Survey. The project is now building and exercising the engineering development and test units and is fabricating, testing, and assembling flight hardware.

Above: The sample return capsule from NASA's OSIRIS-REx mission is seen shortly after touching down in the desert, Sunday, September 24, 2023, at the Department of Defense's Utah Test and Training Range. The sample was collected from the asteroid Bennu in October 2020 by NASA's OSIRIS-REx spacecraft. Photo Credit: NASA/Keegan Barber

Strategic Objective 1.2 shares many of the same risks as 1.1: inflation, supply chain management, and safety of spaceflight due to orbital debris, which continue to impact technology development and operations. Furthermore, the Government Accountability Office (GAO) outlined several NASA management risks in cost, schedule, and procurement affecting the portfolio, such as cost overruns in Planetary Science testing budget reserves. These conditions have contributed to cost and schedule overruns that have put some short-term goals at risk. Accordingly, SMD is working to mitigate these risks, in part through Agency-wide efforts such as the Supply Chain Risk Working Group, coordinated by the Office of the Chief Engineer (OCE). Furthermore, the Chief Project Management Office (CPMO) plays a significant role by routinely interfacing with Mission Directorates, Centers, programs, projects, and technical authorities to identify challenges and opportunities with respect to program and project management using various channels that include the Program and Project Management Board, Project Management (PM) Coalition community of practice, and annual PM Symposium, among others. CPMO leverages these relationships to ensure Agency PM policies remain current and relevant and are appropriately adhered to in order to help ensure mission success. SMD also continues to pursue opportunities to further advance its strategic goals, including international and domestic partnerships and expansion of access to space.

Based on SMD's strategy and accomplishments described in the above paragraphs, Strategic Goal 1.2 achieved a Green/Satisfactory rating during the 2023 Strategic Review Process.

1.2.1: Demonstrate progress in exploring and advancing understanding of the physical processes and connections of the Sun, space, and planetary environments throughout the solar system

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	1 of 1	1 of 1	1 of 1
Result	1		
Rating	Green		

Critical milestones for FY 2023

1. Significant progress demonstrated as determined by annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.2.1.

Critical milestones for FY 2024

1. Significant progress demonstrated as determined by annual external expert review of published, peer-reviewed research contributing to Performance Goal 1.2.1.

Critical milestones for FY 2025

1. Significant progress demonstrated as determined by annual external expert review of published, peer-reviewed research contributing to Performance Goal 1.2.1.

Lead Organization: Science Mission Directorate (SMD)

FY 2023 Performance Progress

NASA achieved the FY 2023 target for this multiyear Performance Goal, as determined by the Heliophysics Advisory Committee in November 2023. Below are examples of scientific progress reported in FY 2023, leading to a Green Performance Goal rating. The selected results demonstrate significant progress in our understanding of the inter-connections shaping the space environment at Earth, at Mars, in interstellar space, and in the vicinity of exoplanets.

Progress has been made in understanding phenomena that are hundreds of times larger than the distance between the Sun and Earth, with the help of NASA's Interstellar Boundary Explorer (IBEX) mission.

IBEX remotely images the heliosphere, the distant "bubble" with a comet-like tail surrounding our solar system. As observed by the Voyager spacecraft, the heliosphere distorts the interstellar magnetic field as it moves through interstellar space. Interpretations of the data as the Voyager satellites move farther from the heliosphere have never been fully reconciled with models. A study this past year found previously unknown uncertainties with Voyager measurements using models constrained by IBEX data. Not only did this finally result in a unified picture of the interstellar magnetic field between observations and models, but also the capability to predict how far out future interstellar missions must travel before the spacecraft sample undisturbed interstellar space.

Just as a raft floating down a river is influenced by water currents and turbulence, particles that follow along Earth's magnetic field are influenced by electric currents and electromagnetic turbulence. Energy from the Sun is transferred to Earth's magnetic field, and NASA has made strides in understanding how that energy gets released in a process known as magnetic reconnection, as well as the interplay between turbulence and this energy release. This year, satellites from NASA's Magnetospheric Multiscale (MMS) mission obtained data from the space within Earth's invisible magnetic shell which directly confirmed that energy released during magnetic reconnection contributes to the growth of turbulence and that turbulence does not impede the release of energy by magnetic reconnection.

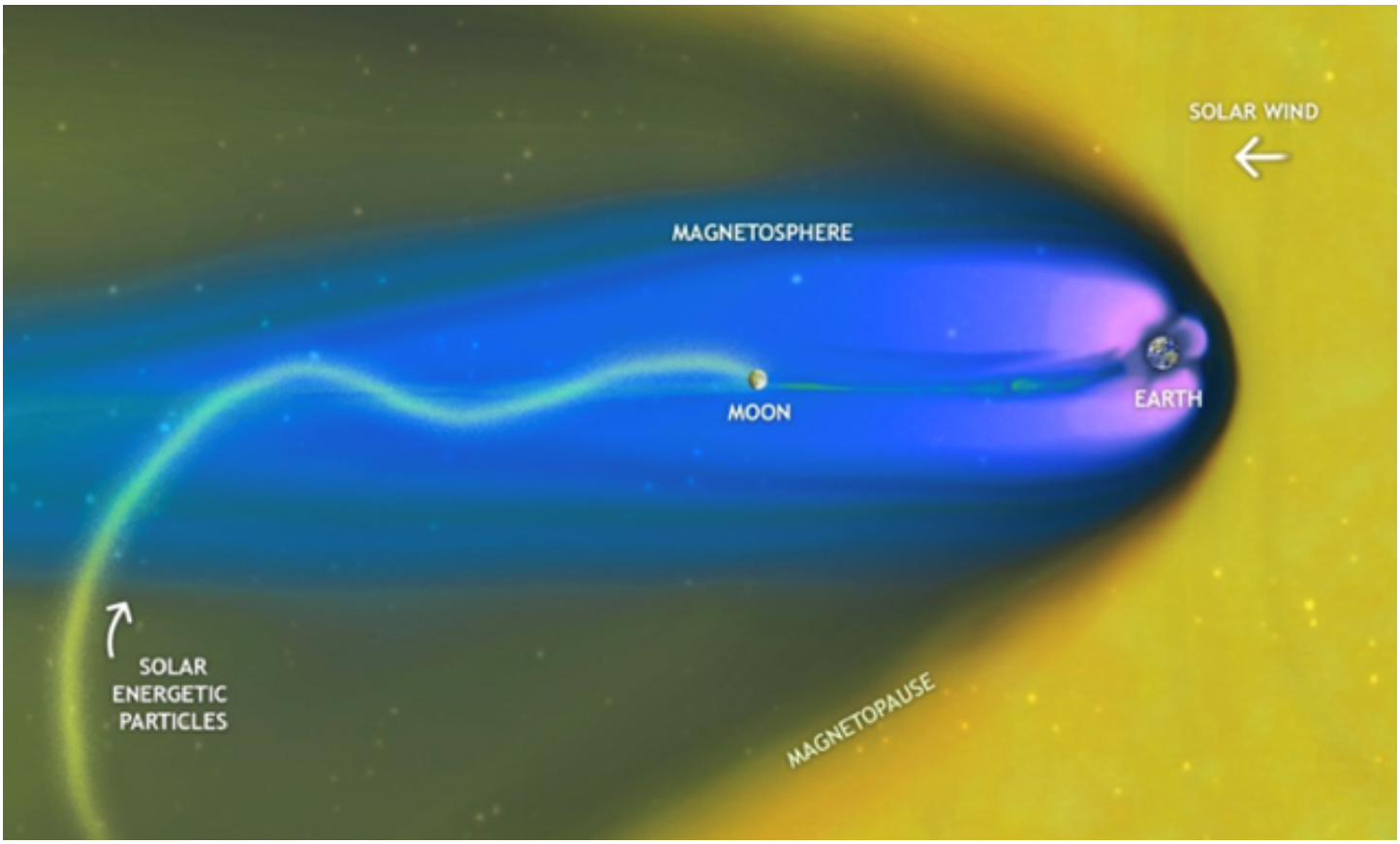
Earth's upper atmosphere is subject to energy and material input from both space and the lower atmosphere (i.e., interplanetary dust primarily from asteroid collisions or vaporized comet material and powerful global-scale waves propagating upward from the lower atmosphere). The NASA "Wind" mission revealed a strong annual variation of interplanetary dust when Earth is aligned with the direction of the flow in interstellar space. The dust collected in Earth's atmosphere shows an unexpected 22-year cycle, suggesting it is related to the solar cycle, over which the number of sunspots and the amount of solar activity vary. This relationship highlights the complex physics connecting the Sun, Earth, and the interplanetary environment.

NASA's Aeronomy of Ice in the Mesosphere (AIM) mission added crucial insights into the day-to-day variability of Earth's ionosphere driven by meteorological forcing. AIM observations revealed that coupling between the surface and the ionosphere is partially controlled by wind effects on vertically propagating buoyancy/gravity waves from the troposphere due to the stratospheric polar vortex (a large area of cold air surrounding Earth's poles). Because the stratosphere can be forecasted one week

ahead, understanding the connection between the stratosphere and ionosphere would help us to predict the condition of the ionosphere, which is important for radio communication.

The space environment of the Moon changes over the course of its orbit as it moves periodically into regions influenced by Earth's magnetic field, where it is expected to be shielded from energetic particles coming from the Sun or beyond. However, recent measurements from NASA's Wind and Acceleration, Reconnection, Turbulence and Electrodynamics of the Moon's Interaction with the Sun (ARTEMIS) mission show that these outside particles have just as much access to the Moon when it is situated behind Earth, deep in the magnetosphere. This is because particles sneak into Earth's magnetosphere well behind the Earth and Moon, where Earth's magnetic field strength is very low. Guided by Earth's magnetic field, the particles then travel back towards Earth, encountering the Moon. This work has implications for whether strong planetary magnetic fields truly shield planets from energetic events from the Sun.

Below: Artist's rendering of solar energetic particle entry pathway to the magnetosphere impacting the lunar environment even while the moon's orbit brings it within the protection of the Earth's magnetosphere. This has implications for astronaut safety as well as for whether strong planetary magnetic fields truly shield planets from energetic events from the Sun. Image Credit: Liuzzo et al., Unrestricted Solar Energetic Particle Access to the Moon While Within the Terrestrial Magnetotail



1.2.2: Demonstrate progress in exploring and probing the origin, evolution, and destiny of the galaxies, stars, and planets that make up the universe

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	1 of 1	1 of 1	1 of 1
Result	1		
Rating	Green		

Critical milestones for FY 2023

1. Significant progress demonstrated as determined by annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.2.2.

Critical milestones for FY 2024

1. Significant progress demonstrated as determined by annual external expert review of published, peer-reviewed research contributing to Performance Goal 1.2.2.

Critical milestones for FY 2025

1. Significant progress demonstrated as determined by annual external expert review of published, peer-reviewed research contributing to Performance Goal 1.2.2.

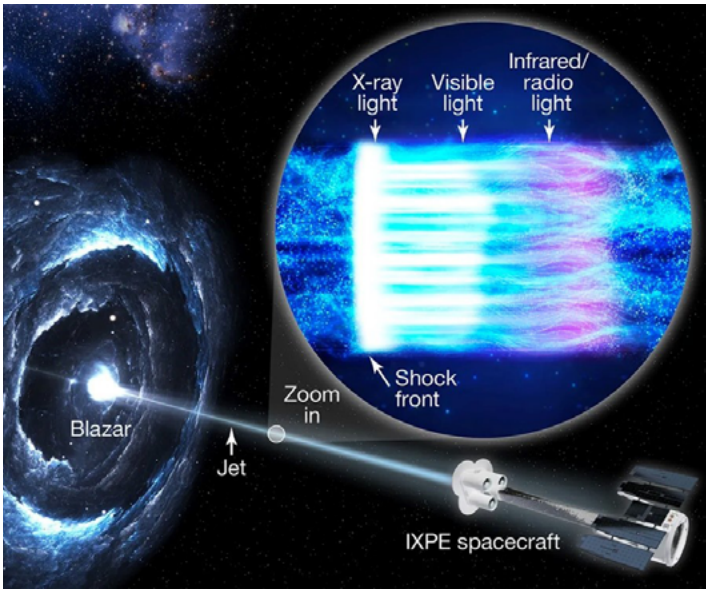
Lead Organization: Science Mission Directorate (SMD)

FY 2023 Performance Progress

NASA achieved the FY 2023 target for this multiyear Performance Goal as determined by the Astrophysics Advisory Committee in October 2023, leading to a Green Performance Goal rating. Below are examples of scientific progress reported in FY 2023.

NASA's recently launched James Webb Space Telescope is pushing the frontiers of space exploration, unveiling the early Universe and some of the youngest galaxies and supermassive black holes known to date. Webb has revealed that a surprisingly large number of luminous galaxies were already in existence during the first 600 million years after the Big Bang, when the Universe was less than one twentieth of its present age. Webb and the Chandra X-ray Telescope jointly made another groundbreaking discovery - that of an enormous black hole weighing over 100 million times the mass of the Sun, making it the youngest supermassive black hole known. These observations challenge our best theoretical models of how galaxies form their stars and grow their central black holes, and raise questions on the origin of our own Milky Way Galaxy.

NASA's Imaging X-ray Polarimetry Explorer (IXPE) spacecraft has uncovered new clues about particle acceleration in blazars by making the first X-ray polarization measurements of these powerful black hole jets. Pointing at the blazar Markarian 501, IXPE found the highest polarization in X-rays, followed by visible light and radio waves - yet the polarization aligned across wavelengths. This matches models where shock waves accelerate particles, which then emit light based on their energy - highest energy X-rays near the shock, with optical and radio farther out as interactions sap their energy. IXPE's unique X-ray vision provides an unprecedented close-up view of the extreme physics within these enigmatic cosmic jets.



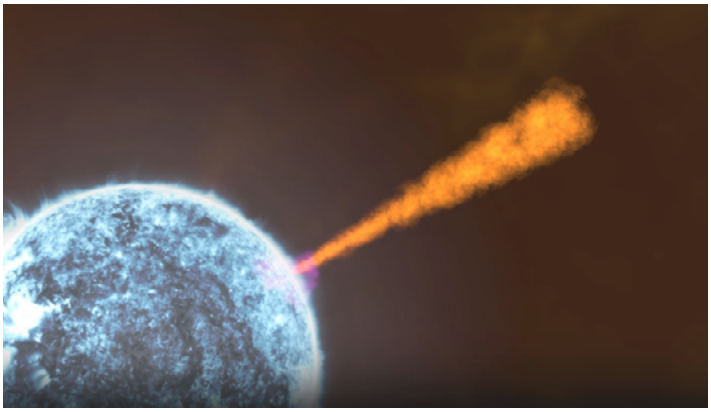
Above: This illustration depicts NASA's IXPE spacecraft observing the blazar Markarian 501. Blazars contain black holes launching energetic particle jets toward Earth. The inset shows particles hitting a shock wave in the jet, accelerating and emitting X-rays. Farther from the shock, interactions with turbulent magnetic fields cause the now less-energetic particles to emit visible, infrared, and radio light. Image Credit: NASA/Pablo Garciau

Webb has captured the activity of a pair of newly forming young stars in high-resolution near-infrared light, providing insight into how our own Sun and Solar System were born. This object, known as Herbig-Haro 46/47, is important to study because it is only a few thousand years old, compared to the millions of years that it takes stars to fully form. Observations like this give researchers insight into how much mass stars gather over time, potentially allowing them to model how our own Sun formed, along with its planetary system. The Webb infrared image shows intricate details of the star formation process, including structures caused by material shot out from the stars as they

repeatedly ingest and eject the gas and dust that immediately surround them. In millions of years, the fully formed stars in Herbig-Haro 46/47 will clear the scene of the multihued ejections visible in the image, and take center stage against a galaxy-filled background.

Above: NASA's James Webb Space Telescope has captured a tightly bound pair of actively forming stars, known as Herbig-Haro 46/47, in high-resolution near-infrared light. Look for them at the center of the red diffraction spikes. The stars are buried deeply, appearing as an orange-white splotch. They are surrounded by a disk of gas and dust that continues to add to their mass. Image Credit: NASA, ESA, CSA

Astronomers around the world were captivated by an unusually bright and long-lasting pulse of high-energy radiation that swept over Earth on October 9, 2022. The emission came from a gamma-ray burst (GRB) – the most powerful class of explosions in the universe – that ranks among the most luminous events known. Astronomers dubbed this GRB the brightest of all time, or BOAT. The signal, originating from the direction of the constellation Sagitta, had traveled an estimated 1.9 billion years. Astronomers think it represents the birth cry of a new black hole, one that formed in the heart of a massive star collapsing under its own weight. In these circumstances, a nascent black hole drives powerful jets of particles traveling near the speed of light. The jets pierce through the star, emitting X-rays and gamma rays as they stream into space. This unprecedented event was discovered by NASA's Fermi Space Telescope and shortly thereafter was triggered by NASA's Neil Gehrels Swift Observatory and Wind spacecraft, and then followed up by an international fleet: NASA's Nuclear Spectroscopic Telescope Array (NuSTAR) observatory, Neutron Star Interior Composition Explorer (NICER) X-ray telescope, IXPE observatory, Chandra, Hubble, and Webb telescopes, the Agency's Voyager 1 spacecraft, as well as the European Space Agency's Solar Orbiter and a Japanese detector called the Monitor of All-sky X-ray Image (MAXI). Excitingly, NASA's Mars Odyssey and MAVEN spacecraft at Mars detected the BOAT about 3.9 minutes after it was detected near Earth. The light from this ancient explosion brings with it new insights into stellar collapse, the birth of black holes, and the behavior and interaction of matter near the speed of light. Another GRB this bright may not appear for decades. Since this burst is much closer than typical GRBs, it allows us to detect many details that otherwise would be too faint to see.



Above: A jet of particles pierces a star as it collapses into a black hole during a typical gamma-ray burst, as depicted in this artist's concept. The jet created by gamma-ray burst 221009A had some unique features. Image Credit: NASA's Goddard Space Flight Center

The bright supergiant star Betelgeuse, the shoulder of the constellation Orion, underwent a historic dimming in 2020. To understand what was happening, a large consortium of telescopes aimed their instruments at Betelgeuse. Dupree et al., 2022, used data from many telescopes, including NASA's Hubble Space Telescope and Solar TErrestrial RElations Observatory-A (STEREO-A), which typically observes the Sun, to determine that the dimming was due to a phenomenon known as a Surface Mass Ejection (SME). This phenomenon is similar to the Coronal Mass Ejections (CMEs) that occur regularly on our own Sun. On the Sun, a CME occurs when the strong magnetic structures in the solar atmosphere above the visible surface go unstable and propel part of the coronal material out into the solar system. CMEs are critical to understand and predict to protect the Earth's fleet of satellites and communication systems. In the case of Betelgeuse, a combination of the star's natural pulsations and exceptionally strong convection motions caused a part of the outer shell of the star itself to be ejected. This ejected material rapidly cooled and obscured the star's southern hemisphere. Shocks from this event are still reverberating through Betelgeuse, disturbing its normal cyclic behavior. Surface mass ejections are an entirely new stellar phenomenon. Their very existence raises new questions about what happens to massive stars near the end of their life cycle. Betelgeuse is expected to become a supernova sometime in the next 100,000 years, and these observations may help astronomers better understand that process.

1.2.3: Demonstrate progress in exploring, observing, and understanding objects in the solar system in order to understand how they formed, operate, interact, and evolve

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	1 of 1	1 of 1	1 of 1
Result	1		
Rating	Green		

Critical milestones for FY 2023

1. Significant progress demonstrated as determined by annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.2.3.

Critical milestones for FY 2024

1. Significant progress demonstrated as determined by annual external expert review of published, peer-reviewed research contributing to Performance Goal 1.2.3.

Critical milestones for FY 2025

1. Significant progress demonstrated as determined by annual external expert review of published, peer-reviewed research contributing to Performance Goal 1.2.3.

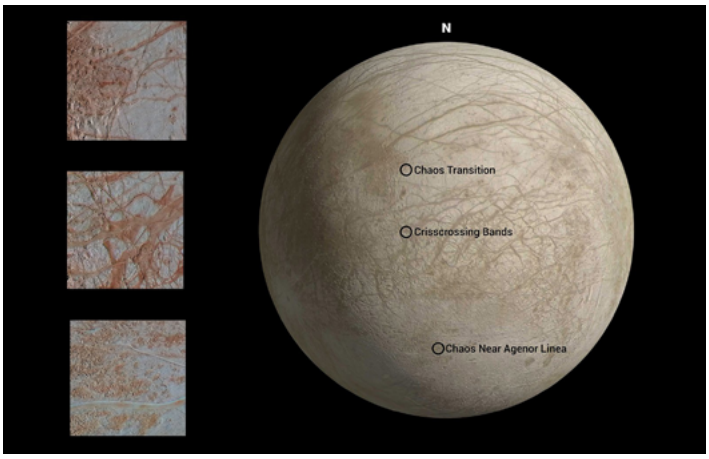
Lead Organization: Science Mission Directorate (SMD)

FY 2023 Performance Progress

NASA achieved the FY 2023 target for this multiyear Performance Goal as determined by the Planetary Science Advisory Committee in November 2023, leading to a Green Performance Goal rating. Below are examples of scientific progress reported in FY 2023.

At Mars, data from the InSight mission prompted a study that sought to answer the question: "What is the size and composition of the Martian core?" Seismic signals were analyzed from two marsquakes indicating a somewhat smaller and denser core compared to previous estimates, leaving the researchers to infer that Mars' core contains 20–22 weight percentage of light elements like sulfur, oxygen, carbon, and hydrogen. A precise determination of the light element budget of Mars' core is vital in comparing the processes at play during the formation of Earth and Mars.

In the outer solar system, the morphology of Europa's large chaos terrain and associated lenticulae (Latin for "freckles"; reddish spots on Europa's surface) suggest there may be reservoirs of saline liquid water 1–3 km beneath the surface. Previous investigations on the evolution of small shallow-water bodies (≤10^3 km^3) suggest that salts – such as $MgSO_4$ – that have a small effect on melting point can extend the lifetime of saline bodies by approximately 5% compared to freshwater reservoirs. More recent modeling demonstrates that NaCl – which may be a more relevant salt for Europa - has a significantly stronger impact on the freezing point, suggesting a further extension of liquid lifetimes by 60% over freshwater reservoirs. These results further support the presence of liquid water at shallow depths within Europa's ice shell today.



Above: The above map shows locations where each image, showcasing a variety of features, was captured by Galileo during its eighth targeted flyby of Jupiter's moon Europa. Image Credit: NASA/JPL-Caltech

The calcium–aluminum-rich inclusions (CAIs) from chondritic (unmelted) meteorites are the first solids formed in the solar system. Formation of a rim, or outer most layer, around CAIs marks a period in early solar system history when CAIs existed but had not yet been formed into chondritic parent bodies – the bodies that ultimately formed the rocky planets. New data suggests the relative ages of rims formed approximately 2–3 million years after CAIs, which implies that CAIs remained as free-floating objects in the solar nebula for this duration. Results from this work are consistent with chondritic materials accreting to form chondrite parent bodies later than the early-formed planetary embryos, and after the primary heat source, most likely the radioactive isotope ^{26}Aluminum, had mostly decayed away.

1.2.4: Demonstrate progress in discovering and studying planets around other stars

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	1 of 1	1 of 1	1 of 1
Result	1		
Rating	Green		

Critical milestones for FY 2023

1. Significant progress demonstrated as determined by annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.2.4.

Critical milestones for FY 2024

1. Significant progress demonstrated as determined by annual external expert review of published, peer-reviewed research contributing to Performance Goal 1.2.4.

Critical milestones for FY 2025

1. Significant progress demonstrated as determined by annual external expert review of published, peer-reviewed research contributing to Performance Goal 1.2.4.

Lead Organization: Science Mission Directorate (SMD)

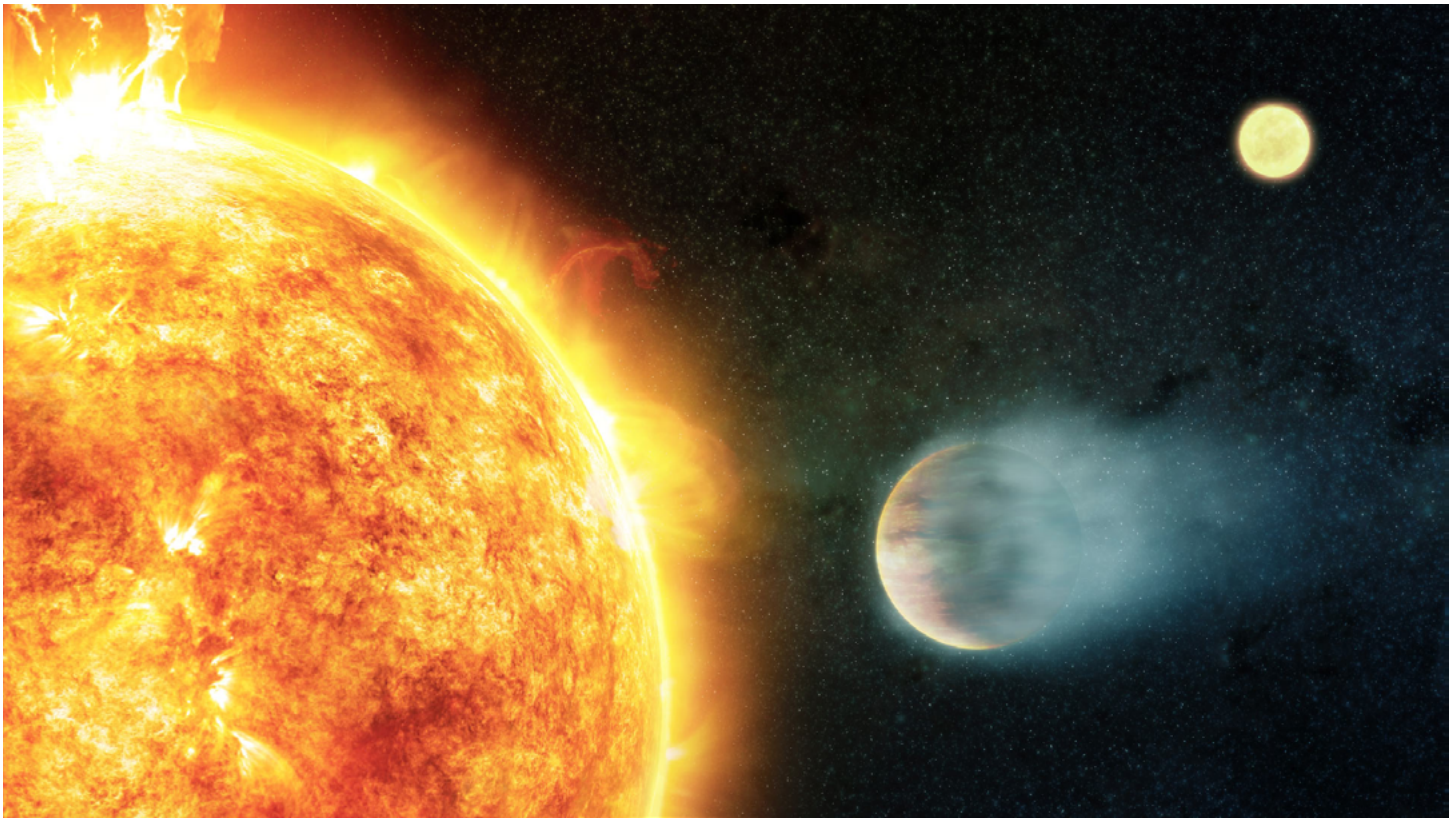
FY 2023 Performance Progress

NASA achieved the FY 2023 target for this multiyear Performance Goal as determined by the Astrophysics Advisory Committee in October 2023, leading to a Green Performance Goal rating. Below are examples of scientific progress reported in FY 2023.

Webb is making ground-breaking discoveries regarding the atmospheres of exoplanets, from giants down to rocky worlds. Webb's spectrum of WASP-39b (a Saturn-sized planet that is closer to its star than Mercury is to our Sun) shows detections of many atomic and molecular gases, including sulfur dioxide (SO_2), which provides the first clear evidence of photochemistry on an exoplanet. In another important discovery, Webb reported methane and carbon dioxide in the atmosphere of K2-18b, a sub-Neptune-sized planet in the habitable zone of a cool dwarf star. Past studies hypothesized that this exoplanet could be a Hycean world, characterized by a hydrogen-rich atmosphere and a water ocean-covered surface. Webb's latest findings lend further support to this hypothesis. Delving into even smaller planets, Webb recently placed strong constraints on the amount of CO_2 in the atmospheres of TRAPPIST-1 b and TRAPPIST-1 c, two of the seven exoplanets orbiting the nearby cool dwarf star TRAPPIST-1. With planet 'b' being most likely a bare rock and 'c' having at most a thin CO_2 atmosphere, Webb's results strongly suggest that the TRAPPIST-1 planets formed in a relatively volatile-poor environment.

Recent findings from NASA's Kepler space telescope and the Transiting Exoplanet Survey Satellite (TESS) have furthered the search for worlds beyond our solar system. Through analysis of Kepler's final dataset, a team of astrophysicists and citizen scientists identified three exoplanets between 2.6 to 4 times the size of Earth, with orbital periods of 6.5 to 13 days around low-mass M-dwarf stars. Additionally, examination of TESS data revealed an Earth-sized exoplanet, designated TOI 700 e, orbiting in the optimistic habitable zone of its host star TOI 700. At 95% of Earth's diameter, TOI 700 e completes an orbit every 28 days and may harbor liquid surface water under certain conditions. The discovery of these small, likely rocky planets in potentially life-supporting orbits contributes to our understanding of planetary system formation and evolution, including insights into the history of our own solar system. Even in their advanced operational stages, Kepler and TESS continue to further the search for and characterization of exoplanets through the invaluable contributions of science teams and public citizen scientists.
The dynamic interplay between a gas giant exoplanet (known as a "hot Jupiter" when it orbits its star at Mercury's distance or closer) and its host star has been shown by a team of scientists using data from NASA's Chandra X-ray Observatory and ESA's XMM-Newton to result in the host star spinning more quickly than if it did not have such a planet. This rapid rotation, resulting from the tidal forces between the planet and the star, can make the host star appear younger than it really is. The star is generally more active and produces more X-rays than it would if the planet were not present. While "hot Jupiters" have been known to have this effect on their host stars, the systematic approach taken in this study provides the best evidence to date of this age-defying phenomenon.

Below: This illustration shows a hot Jupiter exoplanet orbiting its highly active, younger-looking host star. A quiescent companion star, shown in the distance, acts as a control for the star with the hot Jupiter.
Image Credit: NASA/CXC/M.Weiss. X-ray: NASA/CXC/Potsdam Univ./N. Ilic et al.



1.2.5: Demonstrate progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere, exploring and finding locations where life could have existed or could exist today, and exploring whether planets around other stars could harbor life

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	1 of 1	1 of 1	1 of 1
Result	1		
Rating	Green		

Critical milestones for FY 2023

1. Significant progress demonstrated as determined by annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.2.5.

Critical milestones for FY 2024

1. Significant progress demonstrated as determined by annual external expert review of published, peer-reviewed research contributing to Performance Goal 1.2.5.

Critical milestones for FY 2025

1. Significant progress demonstrated as determined by annual external expert review of published, peer-reviewed research contributing to Performance Goal 1.2.5.

Lead Organization: Science Mission Directorate (SMD)

FY 2023 Performance Progress

NASA achieved the FY 2023 target for this multiyear Performance Goal as determined by the Planetary Science Advisory Committee in November 2023, leading to a Green Performance Goal rating. Below are examples of scientific progress reported in FY 2023.

Efforts to improve targeting for life-detection efforts on other planets have been aided by the creative utilization of machine learning. A team at the Search for Extraterrestrial Intelligence (SETI) Institute conducted an investigation of potential biosignatures at Salar de Pajonales, an extremely arid region in the Atacama Desert (northern Chile) analogous to evaporitic environments on Mars. This site was analyzed using novel predictive models and machine learning to improve life detection strategies on Mars. With the artificial intelligence-machine learning models, there was an 56.9-87.5% chance of finding life at the site, while a random search had a 9.2% probability over the same area, reducing the physical search space by 85-97%. These results significantly improve life detection efforts at the scale of microbial habitats, an equivalent scale to current Mars rovers, helping to optimize current and future search efforts on other terrestrial planets.

Recent discussions regarding the evolution of life have centered on the pivotal role nitrate (NO_3) may have played. Recent findings reveal an increase in biologically available nitrogen (N) during the time that marine eukaryotes (organisms whose cells have a nucleus) became dominant. This is important as eukaryotic cells evolved into multicellular organisms and are credited for ushering in a whole new era for life on Earth, including animals, plants, and fungi. Thus, the rise in biologically-available nitrate as documented here could have played a pivotal role in the evolution of life.

Astronomers using Webb detected super-hot water vapor in the planet forming region around a distant star known as PDS 70. The star in question shares a remarkable number of similarities with our own Sun; PDS 70 is roughly three-quarters the mass of our sun, and at 5.4 million years old, is relatively close to our Sun's age, which is roughly 4.6 billion years old. The water vapor, detected using Webb's mid-infrared instrument, was also found at a distance from the star similar to Earth's distance from the Sun (93 million miles), signaling that the area could be conducive to life.

1.2.6: Demonstrate progress in developing the capability to detect and knowledge to predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth

Number of critical milestones completed

Lead Organization: Science Mission Directorate (SMD)

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	2 of 2	2 of 2	2 of 2
Result	2		
Rating	Green		

Critical milestones for FY 2023

1. Significant progress demonstrated as determined by annual external expert review determination of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.2.6.
2. External expert review panel determination indicating whether expectations for research program have been fully met or exceeded in advancing scientific understanding of background solar wind, solar wind structures, and coronal mass ejections, which can be integrated into key models used to predict the arrival time and impact of space storms at Earth.

Critical milestones for FY 2024

1. Significant progress demonstrated as determined by annual external expert review determination of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.2.6.
2. External expert review panel determination indicating whether expectations for research program have been fully met or exceeded in advancing scientific understanding of background solar wind, solar wind structures, and coronal mass ejections, which can be integrated into key models used to predict the arrival time and impact of space storms at Earth.

Critical milestones for FY 2025

1. Significant progress demonstrated as determined by annual external expert review determination of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.2.6.
2. External expert review panel determination indicating whether expectations for research program have been fully met or exceeded in advancing scientific understanding of background solar wind, solar wind structures, and coronal mass ejections, which can be integrated into key models used to predict the arrival time and impact of space storms at Earth.

FY 2023 Performance Progress

NASA achieved the FY 2023 target for this multiyear Performance Goal as determined by the Heliophysics Advisory Committee in November 2023. Below are examples of scientific progress reported in FY 2023. The studies highlighted directly address the extreme space weather events that have the potential to cause substantial harm to national security, the economy, and crewed and unmanned space activities and support better understanding of background solar wind, solar wind structures, and coronal mass ejections.

In February 2022, 38 commercial satellites that were launched into a low Earth Orbit (LEO) in preparation for subsequent orbit-raising maneuvers were lost to premature reentry due to an unexpected increase in aerodynamic drag. While it was well-known that upper atmospheric densities, and therefore the aerodynamic drag forces on satellites, are highly variable, recent observations by NASA's Global-scale Observations of the Limb and Disk (GOLD) mission shed light on this specific event. The changes in upper atmospheric temperature and composition were studied. Not only did the instrument verify that there was a significant increase in upper atmospheric density for this time period, it provided details on the spatial and temporal response of the upper atmosphere to this specific solar eruption. These studies powerfully demonstrate the necessity to observe the upper atmospheric environment in order to advance the capability to detect and gain quantitative understanding of the space environment's response to external drivers and, ultimately, to develop the capability to create accurate forecasts.

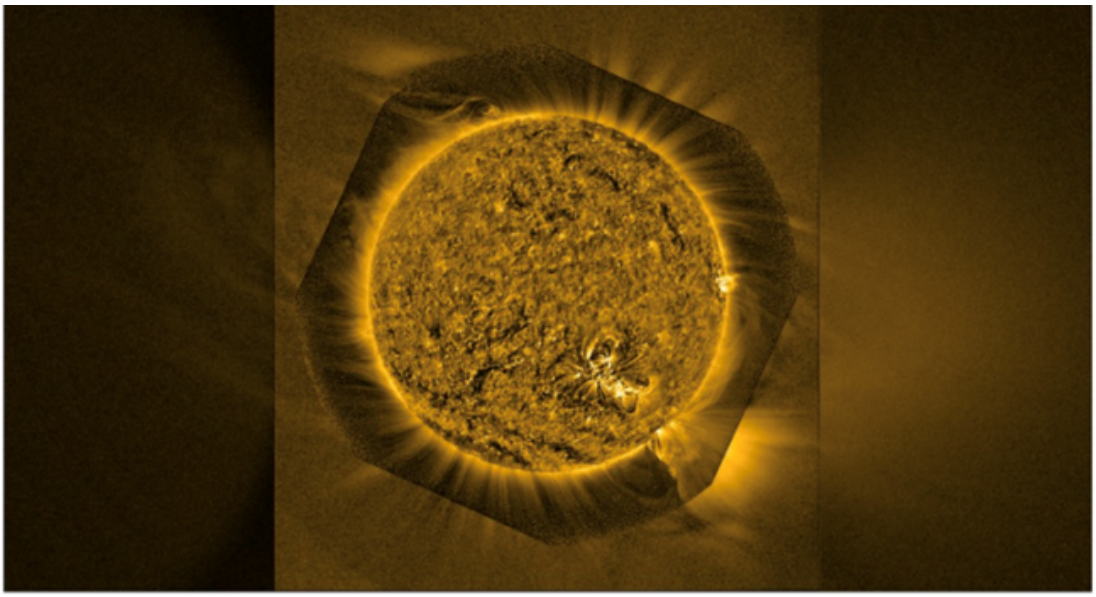
The solar wind, made up of energetic charged particles released into space from the Sun's atmosphere, imparts energy to the near-Earth environment, powering space weather. Just like wind-driven waves drive currents and transfer energy to Earth's oceans, solar wind-driven waves on the outer boundary of Earth's magnetic field transfer energy into the magnetosphere. These boundary waves, also known as Kelvin-Helmholtz waves, can cause rotational flows called vortices, which sometimes roll-up like steepened waves crashing on a seashore. A new statistical study of magnetopause boundary waves using data from NASA's Time History of Events and Macroscale Interactions during Substorms (THEMIS) mission covering an eleven-year period over which the Sun's magnetic field changes directions (a solar cycle) showed that the rate at which the waves

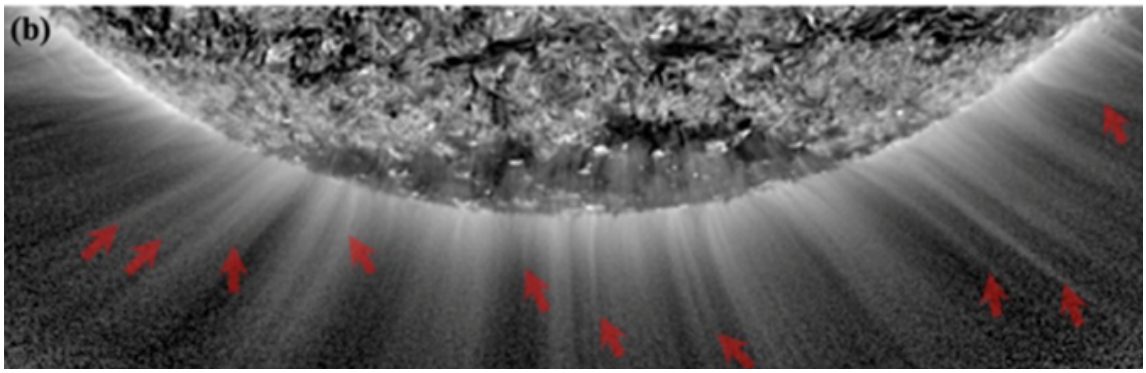
occur exhibit clear seasonal and daily variations. The variation is identical to reported variations of space weather intensity in Earth's space environment, as determined by ground magnetometers that measure the magnetic field strength at Earth's surface. These results suggest that the boundary waves contribute to space weather activity over solar-cycle periods, and therefore indicate the necessity for models to reconsider aspects of solar wind-magnetosphere energy coupling to predict near-Earth space weather.

The hot plasma (ionized gas) just beneath the Sun's surface moves in complex patterns. These plasma flows are a crucial aspect to the generation of magnetic fields that create sunspots, which in turn are the source of magnetic eruptions causing extreme space weather events which can impact humans on Earth and in space. The Helioseismic and Magnetic Imager (HMI) on NASA's Solar Dynamics Observatory (SDO) spacecraft has provided more than thirteen years of high-quality data that has been used to study the properties of the magnetic fields and plasma flows of the Sun. By using HMI data, researchers recently discovered oscillations of the global flows in the Sun's outer layer that were not known before. These results are important for determining how plasma flows on the Sun impact the magnetic fields and will help us understand the Sun's magnetic activity cycle. Understanding the origin of these variations is fundamental to the prediction of extreme conditions in space.

The mechanism that accelerates the solar wind from the Sun's atmosphere into interplanetary space has important implications for the prediction of space weather responses on Earth. Recent measurements from NASA's Parker Solar Probe (PSP) mission show evidence that magnetic reconnection, a process that can convert energy to accelerating particles, is a likely candidate for driving the solar wind. The implications of this affect our understanding of the source and properties of the solar wind passing by Earth and can be integrated into space weather modeling to better predict the impact of space weather at Earth.

Below: Recent measurements from NASA's Parker Solar Probe (PSP) mission and others show evidence that magnetic reconnection is a source of the solar wind. (a) Composite of SDO/Atmospheric Imaging Assembly (AIA) and GOES-R/SUVI 171 Å images showing the small-scale activity at the base of the solar corona and its extension to higher altitudes. The SUVI image maps the structures observed at the coronal base into the solar wind. (b) AIA image (171 Å) showing the jetlet structures as elongated features above the solar polar limb. Image Credit: L. Liuzzo, UCB and E. Masongsong, UCLA.





1.2.7: Demonstrate progress in identifying, characterizing, and predicting objects in the solar system that pose threats to Earth or offer resources for human exploration

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	2 of 3	2 of 2	2 of 2
Result	2		
Rating	Green		

Critical milestones for FY 2023

1. Significant progress demonstrated as determined by annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.2.7.
2. Identify and catalogue 10,700 near-Earth asteroids that are 140 meters in diameter or larger.
3. Complete the Double Asteroid Redirection Test (DART) mission success criteria.

Critical milestones for FY 2024

1. Significant progress demonstrated as determined by annual external expert review of published, peer-reviewed research contributing to Performance Goal 1.2.7.
2. Identify and catalogue 11,000 near-Earth asteroids that are 140 meters in diameter or larger.

Critical milestones for FY 2025

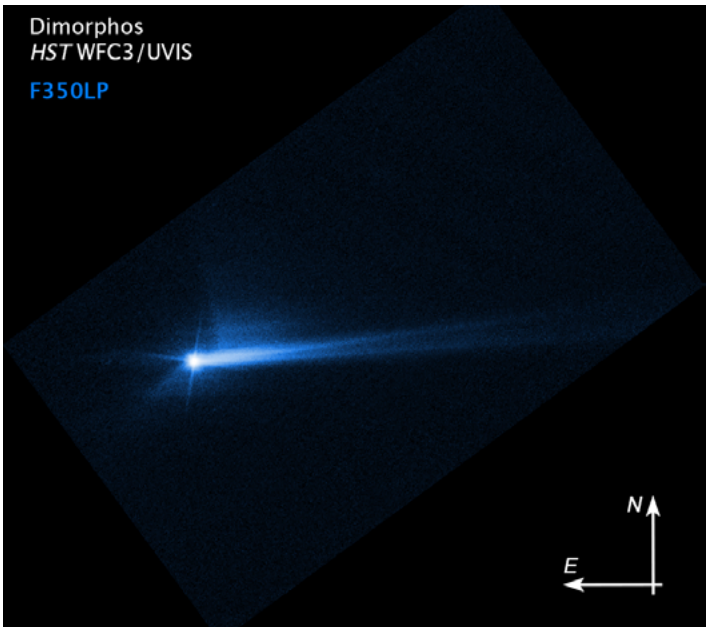
1. Significant progress demonstrated as determined by annual external expert review of published, peer-reviewed research contributing to Performance Goal 1.2.7.
2. Identify and catalogue a 11,400 amount of near-Earth asteroids that are 140 meters in diameter or larger.

Lead Organization: Science Mission Directorate (SMD)

FY 2023 Performance Progress

NASA achieved the FY 2023 target for this multiyear Performance Goal as determined by the Planetary Science Advisory Committee in November 2023, leading to a Green Performance Goal rating. Below are examples of scientific progress reported in FY 2023.

In September 2022, NASA's Double Asteroid Redirection Test (DART) mission intentionally collided with a known asteroid to demonstrate and validate one method of asteroid deflection. DART, about the size of a vending machine, navigated to 7 million miles away from Earth and autonomously collided with its target pyramid-sized asteroid at an approximate speed of 14,000 mph. Following DART's asteroid collision, an international team of astronomers utilized observatories around the world to better understand the effects imparted to the asteroid from DART's hypervelocity impact. DART's success marked humanity's first-ever demonstration of asteroid deflection.



Above: This imagery from NASA's Hubble Space Telescope from October 8, 2022, shows the debris blasted from the surface of Dimorphos 285 hours after the asteroid was intentionally impacted by NASA's DART spacecraft on September 26. Image Credit: NASA/ESA/STScI/Hubble

On January 26, a small near-Earth asteroid designated 2023 BU made a very close encounter with Earth, passing over the southern tip of South America about 2,200 miles (3,600 kilometers) above the planet's surface and well within the orbit of geosynchronous satellites. In advance of the event, NASA's "Scout" impact hazard assessment system, maintained by the Center for Near Earth Object Studies (CNEOS) at NASA's Jet Propulsion Laboratory in Southern California, predicted the close approach and proactively notified the planetary defense community of the forthcoming event.

A small, approximately 1-meter sized asteroid also entered the Earth's atmosphere over northwestern France on February 13, 2023. The asteroid, designated 2023 CX1, exploded upon impact with Earth's

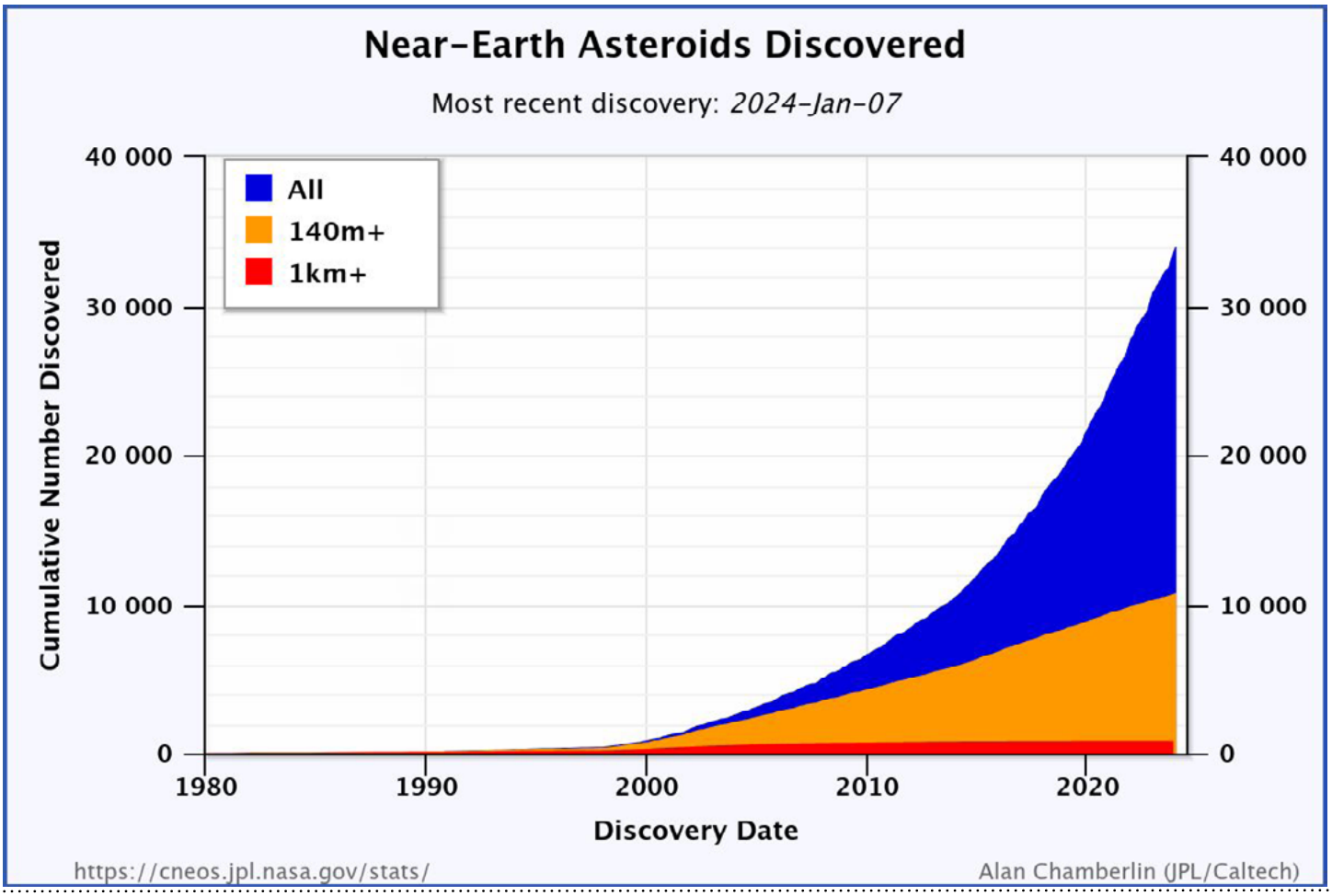
denser atmosphere and produced a bright fireball that was witnessed from regions of England, France, Belgium, Germany, and the Netherlands. NASA's Scout system provided advance notification of the event, marking the seventh asteroid discovery and accurate prediction prior to impact.

These events are significant as these very close approaches to Earth demonstrated that NASA's systems for predicting NEO impacts are properly working and provide benefit to the international planetary defense community.

In this fiscal year, asteroid search teams funded by NASA's Near-Earth Object Observations (NEOO) Program found an additional two asteroids larger than one km in size with orbits that can come within Earth's vicinity. These teams also found 2,383 smaller asteroids less than one kilometer in size. This brings the total known population of near-Earth asteroids to 32,418 along with 121 Near Earth Comets, as of August 15, 2023. The high-precision orbit predictions computed by the Center for Near-Earth Object Studies at NASA's Jet Propulsion Laboratory (JPL) show that none of these objects is likely to strike the Earth in the next century. However, 2,354 small bodies (of which 152 are larger than one km in size) are in orbits that could become a hazard in the more distant future and warrant continued monitoring.

Finally, NASA released its Planetary Defense Strategy and Action Plan earlier this year to guide the Agency's efforts to find, track, and better understand asteroids and comets that could pose an impact hazard to Earth. The release of NASA's planetary defense plan coincides with and complements the separate national planetary defense plan released by the White House Office of Science and Technology Policy. NASA's Planetary Defense Coordination Office was actively involved in the plan's creation alongside several other Federal agencies and offices. Together, the NASA and national level plans aim to further humanity's ability to safeguard Earth from asteroid and comet impacts over the next decade.

Below: This chart shows the cumulative number of known Near-Earth Asteroids (NEAs) versus time. Totals are shown for NEAs of all sizes, those NEAs larger than approximately 140m in size, and those larger than approximately 1km in size. Image Credit: NASA JPL



1.2.8: Demonstrate progress in understanding the properties of physical and biological systems in spaceflight environments to advance scientific knowledge, enable space exploration, and benefit life on Earth

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	1 of 1	1 of 1	1 of 1
Result	1		
Rating	Green		

Critical milestones for FY 2023

1. Significant progress demonstrated as determined by annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.2.8.

Critical milestones for FY 2024

1. Significant progress demonstrated as determined by annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.2.8.

Critical milestones for FY 2025

1. Significant progress demonstrated as determined by annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.2.8.

Lead Organization: Science Mission Directorate (SMD)

FY 2023 Performance Progress

NASA achieved the FY 2023 target for this multiyear Performance Goal as determined in December 2023 by an external panel of experts in the field of space sciences, leading to a Green Performance Goal rating. Below are examples of scientific progress reported in FY 2023.

Plants are an integral component to the future human exploration of space. Growing and optimizing plants under both ground and spaceflight conditions proved to be a major area of advancement this past year. NASA made important progress on the technology front, with notable highlights including the support of a critical evaluation of the most widely used ground-based microgravity analogs, development of approaches for biological sample preparation on orbit, and the application of state-of-the-art omics level approaches. For example, NASA facilitated a collaborative analysis of the patterns of gene expression caused by spaceflight in the small flowering plant, *Arabidopsis thaliana*. This study both capitalized on the complementary expertise of multiple research groups and aggregated data from current and past missions to increase the power of analyses. The team developed online tools making this work Open Science-enabled and allowing examination by as broad a community as possible to understand genetic responses.

NASA-funded studies in animal sciences also yielded significant results in animal sciences. Many of these involved findings that advanced our knowledge of muscle tissue loss in microgravity, as well as impacts to neurological, skeletal and vision systems. Several studies using invertebrate model systems, such as *D. melanogaster* and *C. elegans,* contributed to advances in knowledge of animal health in space by providing holistic, whole-body assessments under spaceflight and spaceflight-like conditions. Especially promising are studies that took a multi-system or genome-wide approach to understand the impact of spaceflight on animal physiology.

Work in the microbiology area was especially impactful, with influential and innovative research using comparative genomics, machine learning, and metagenomic approaches. These studies advanced knowledge in critical areas of space exploration for both low Earth orbit and exploration missions and benefited life on Earth by adding to our understanding of antimicrobial resistance and environmental microbial metagenomics. For example, significant strides were made in the exploration of mitigation strategies to prevent bacterial biofilms from growing in critical spacecraft systems. The discovery that the infusion of silicon oils on various materials could prevent potentially harmful biofilms during spaceflight was valuable to more fully understand how to protect crew as well as spacecraft materials.

Notable advances in the Physical Sciences included progress in the areas of multi-scale solidification and properties prediction for additive manufacturing. Researchers gained new insight into how grain boundaries emerge during the solidification process under microgravity environment and how that impacts their three-dimensional stability. This research provides a potential new direction for microgravity materials sciences.

The long-awaited Flow Boiling and Condensation Experiments on the International Space Station have been going strong, leading to at least six articles in

major scientific journals. The benchmark data set quantitatively identifies certain properties of forced multiphase heat transfer in fluids in a sustained microgravity environment that have been sought since the inception of spaceflight. Further tests are ongoing. The Zero Boil-Off Tank (ZBOT) series of cryogenic fluid phenomena experiments continue to provide valuable data for the fundamental and applied research of mission-enabling spacecraft fuels and propellant challenges.

Advances in the modeling of soft matter were made as magnetorheological fluids, which are materials that have a unique ability to change their viscosity and yield stress in response to a magnetic field, were examined in the absence of gravity. The lack of gravity enabled a new understanding of the physical behavior of these fluids, paving the path to improve computational modeling of these fluids for many space-based and terrestrial-based applications.

New insights into fundamental physics were derived from the Cold Atom Lab (CAL), which enables the generation and manipulation of Bose-Einstein condensates (BECs) in perpetual microgravity, allowing for the exploration of new states of matter. In recent experiments with CAL, new breakthroughs have been made in quantum-state engineering, enabling better control of the position, release velocity and expansion rates of quantum gases. These results have advanced the control protocols and increased the stability, thereby improving quantum engineering.

1.2.9: Achieve critical milestones of Science Mission Directorate's heliophysics, planetary science, and astrophysics major projects

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	6 of 8	7 of 9	8 of 10
Result	7		
Rating	Green		

Critical milestones for FY 2023

1. Complete the Volatiles Investigating Polar Exploration Rover (VIPER) Key Decision Point (KDP)-D review.
2. Initiate stacking and system-level tests of the integrated Europa Clipper spacecraft.
3. Complete the Dragonfly KDP-C review.
4. Complete the Mars Sample Return (MSR) Sample Retrieval Lander (SRL) Preliminary Design Review (PDR).
5. Complete the Interstellar Mapping and Acceleration Probe (IMAP) Mission Operations Review (MOR).
6. Complete the Nancy Grace Roman Space Telescope instrument carrier.
7. Initiate assembly of the Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer (SPHEREx) bus subsystem.
8. Award two Commercial Lunar Payload Services (CLPS) delivery task orders.

Critical milestones for FY 2024

1. Complete the Europa Clipper Pre-Ship Review (PSR).
2. Complete the Dragonfly mission instrument Critical Design Review (CDR).
3. Complete the Near-Earth Object (NEO) Surveyor instrument (telescope) Critical Design Review (CDR).
4. Deliver the Nancy Grace Roman Space Telescope (Roman) spacecraft Outer Barrel Assembly (OBA).
5. Complete the Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer (SPHEREx) System Integration Review (SIR).
6. Complete the Interstellar. Mapping and Acceleration Probe (IMAP) instrument deliveries
7. Complete the Multi-Slit Solar Explorer (MUSE) Preliminary Design Review (PDR).
8. Award a Commercial Lunar Payload Services (CLPS) delivery task order.
9. Complete assembly and test of the Payloads and Research Investigations on the Surface of the Moon (PRISM)-1b payloads.

Critical milestones for FY 2025

1. Launch Europa Clipper.
2. Complete the Dragonfly mission Critical Design Review (CDR).
3. Complete NEO Surveyor Spacecraft Critical Design Review (Spacecraft CDR).
4. Complete Nancy Grace Roman Telescope Key Decision Point (KDP)-D review.
5. Launch the Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer (SPHEREx).
6. Complete the Interstellar Mapping and Acceleration Probe (IMAP) Pre-Ship Review.
7. Complete the Multi-Slit Solar Explorer (MUSE) Critical Design Review (CDR).
8. Award a Commercial Lunar Payload Services (CLPS) delivery task order.
9. Complete Lunar Vulkan Imaging and Spectroscopy Explorer (Lunar-VISE) payload assembly and test.
10. Complete the Volatiles Investigating Polar Exploration Rover (VIPER) Pre-Ship Review.

Lead Organization: Science Mission Directorate (SMD)

FY 2023 Performance Progress

NASA achieved seven of the eight critical milestones identified for FY 2023, leading to a Green Performance Goal rating. Work in FY 2023 included hardware development and assembly, such as the instrument carrier for the Nancy Grace Roman Space Telescope, the assembly of the bus subsystem for the SPHEREx mission and stacking and system-level tests of the integrated Europa Clipper spacecraft, moving that mission toward its scheduled launch in late 2024.

Other critical missions successfully completed key review milestones including the Mission Operations Review for the IMAP mission, and the Key Decision Point-D review for the VIPER mission, which allowed VIPER to move forward to assembly, integration, and test. NASA completed the Dragonfly Key Decision Point-C review, which had been delayed due to a mission replan, in early FY 2024.

During FY 2023, NASA also awarded two CLPS delivery task orders, furthering the initiative's goal of enabling rapid, frequent, and affordable access to the lunar surface.

1.2.10: Complete deployment of the James Webb Space Telescope, the most powerful and complex space telescope ever built, and begin Webb's Cycle 2 observations

Agency Priority Goal (Performance Goal ending in FY 2023)

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	3 of 4	N/A	N/A
Result	4		
Rating	Green		

This two-year Performance Goal/Agency Priority Goal was completed on September 30, 2023, and NASA does not plan to develop a follow-up Agency Priority Goal for the FY 2024-2025 cycle. The James Webb Space Telescope will continue to support NASA's science strategies.

Areas for FY 2023

1. Q1 Make early release science products available in public archive.
2. Q2 Receive Cycle 2 proposals for second year of Webb operations.
3. Q3 Conduct review of Cycle 2 proposals.
4. Q4 Begin Cycle 2 observations.

Lead Organization: Science Mission Directorate (SMD)

FY 2023 Performance Progress

NASA has achieved this two-year priority goal, completing the launch, deployment, and commissioning of the James Webb Space Telescope, the most powerful and complex space telescope ever built, and beginning Webb's second year of science observations. Webb is now building on its first year of discoveries, with the 249 selected programs for Cycle 2 balanced across a wide range of science topics from asteroids and exoplanets to cosmology.

Built to study the early universe, Webb has already demonstrated the existence of galaxies up to redshift 13 (400 million years after the Big Bang), made robust measurements of metallicity and gas properties of galaxies up to 500 Myrs after the Big Bang, and discovered a quiescent galaxy at z=7.3 (700 Myrs after the Big Bang). Early observational signatures of even higher redshift (closer in time to the Big Bang) have been found and are being followed up in Cycles 2 and 3, showing that Webb will indeed find the most distant galaxies ever and take us to a time when the universe first began forming stars and galaxies.

While exploring worlds orbiting other stars, Webb has, for the first time, found molecules formed by ultraviolet light from the host star. This is thought to be fundamental for the evolution of planetary atmospheres, including habitable ones like the Earth. Computer models of exoplanet atmospheres, which include silicon dioxide (SO_2) in them, accurately explain the 4.05 micron spectral feature seen in Webb data. Discoveries like these herald a new epoch of exoplanet atmospheric science and weather studies.

The observatory continues to exceed all its mission level requirements for sensitivity, spatial resolution, ability to track moving targets, and expected mission lifetime. Approximately 1200 science papers using Webb data have been submitted for peer review as of the end of FY 2023.

Scientific discoveries based on Webb observations are shared with the public in the form of news releases, which report on results that have undergone peer review, and have been accepted for publication by a reputable scientific journal. However, because this process takes time, NASA also shares with the public observations and preliminary analyses as Early Highlights – a "sneak peek" into groundbreaking discoveries. Both the news releases and Early Highlights are available at https://webbtelescope.org/webb-science/early-highlights. The Webb operations site is available at https://webbtelescope.org/.

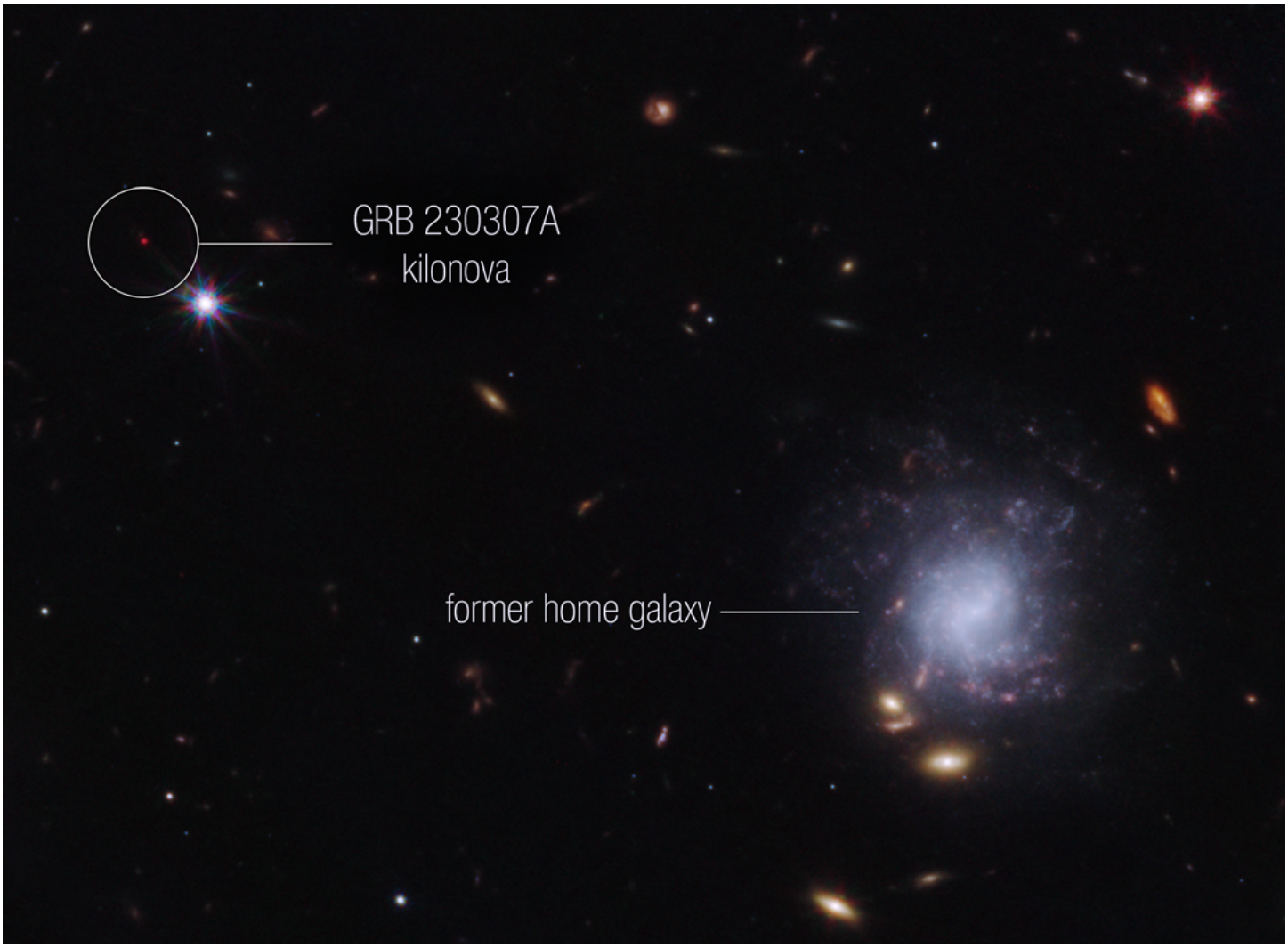
Highlights from FY 2023 include Webb's direct observations of plume materials from Saturn's moon Enceladus, and the detection of heavy neutron capture elements in a compact object merger.

Enceladus is an extraordinary moon that, even though it is located far from the classical habitable zone, harbors a sub-surface ocean. The presence of fractures on the surface of the moon's polar regions allows water mixed with other materials to escape into space, forming large plumes. Webb observations have shown that the water plumes surround the moon and extend far beyond it.

Webb used mid-IR imaging and spectroscopy of the exceptionally bright gamma-ray burst GRB 230307A, 29 and 61 days after the burst to detect very heavy element creation. This GRB is part of a class of long-duration gamma-ray bursts associated with compact object mergers and contains a kilonova. The spectroscopy shows an emission line at 2.15 microns interpreted as tellurium (atomic mass A=130), and a very red

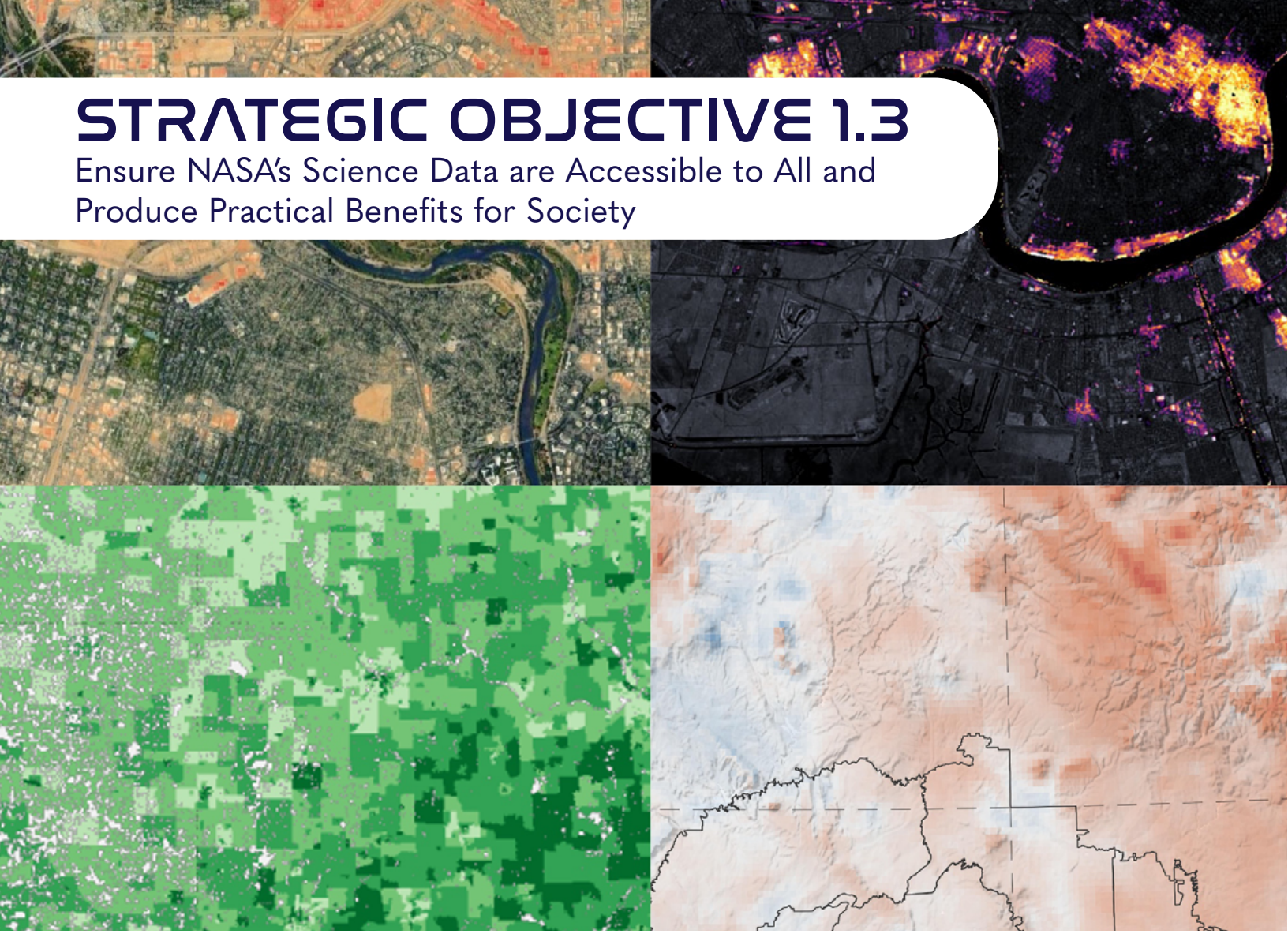
source emitting most of its light in the mid-IR due to the production of lanthanides. These observations demonstrate that nucleosynthesis in GRBs plays a central role in heavy element nucleosynthesis across the Universe.

Below: A team of scientists has used NASA's James Webb Space Telescope to observe an exceptionally bright gamma-ray burst, GRB 230307A, and its associated kilonova. Kilonovas—an explosion produced by a neutron star merging with either a black hole or with another neutron star—are extremely rare, making it difficult to observe these events. The highly sensitive infrared capabilities of Webb helped scientists identify the home address of the two neutron stars that created the kilonova.
This image from Webb's NIRCam (Near-Infrared Camera) instrument highlights GRB 230307A's kilonova and its former home galaxy among their local environment of other galaxies and foreground stars. The neutron stars were kicked out of their home galaxy and traveled the distance of about 120,000 light-years, approximately the diameter of the Milky Way galaxy, before finally merging several hundred million years later. Image Credit: NASA, ESA, CSA, STScI, Andrew Levan (IMAPP, Warw)



STRATEGIC OBJECTIVE 1.3

Ensure NASA's Science Data are Accessible to All and Produce Practical Benefits for Society



LEAD OFFICE
Science Mission Directorate (SMD)

GOAL LEADER
Karen Flynn, Deputy Associate Administrator for Management, SMD

BUDGET

	FY	$M
Op Plan	2023	$421.3
Enacted	2024	$479.9
Requested	2025	$499.5
Outyear	2026	$504.8
	2027	$518.2
	2028	$523.5
	2029	$531.7

NASA generates, analyzes, activates, and archives large amounts of data to support science objectives—putting this knowledge in the hands of consumers and creators is key to maximizing its impact across the nation and globe. Over the last year, NASA has leveraged educational programs, open data repositories, and grant-making processes, as well as interagency, international, and industry partnerships to ensure the accessibility and practical benefits of its scientific data.

The Agency has migrated the top 75 Earth Science datasets to the cloud, enabling researchers and commercial users to access them instantly, and through the Visualization, Exploration, and Data Analysis (VEDA) project, SMD has offered open-source tools for data processing, publishing, and visualization. NASA has implemented the Science Information Policy for the Science Mission Directorate, promoting open access to scientific publications, data, and software. Additionally,

Above: Examples of Environmental Justice applications of NASA Earth science data. Clockwise from upper left: Identifying vulnerable populations using remotely-sensed urban heat island data in Sacramento, CA; detecting power outages using nighttime lights imagery in New Orleans, LA; assessing Navajo Nation water resources using NASA's Drought Severity Evaluation Tool (DSET) in the U.S. Southwest; helping policy officials identify communities in need using U.S. Social Vulnerability Index data from NASA's Socioeconomic Data and Applications Center (SEDAC). Credit: NASA ESDS.

the Agency has created the Science Discovery Engine to enhance the discoverability of over one million datasets and publications and has awarded over twenty grants to support open-source scientific software and communities.

Educational programs continued to proactively expand the reach of NASA data. The Transform to Open Science (TOPS) initiative aimed to train 1,500 people through its Open Science 101 course by the end of 2023, with 350 individuals having already completed the first module. Similarly, NASA's Heliophysics Division has created the Heliophysics Digital Resource Library (HDRL) to expand use of observatory data by implementing metadata standards, and supporting data analysis, modeling, and computing.

Lastly, NASA has signed three new Space Act Agreements with cloud and computing partners, Nvidia, IBM, and Google Earth Engine. These agreements aim to accelerate discovery, access, and use of NASA science data by collaborating on common research problems and technology investigations. As a co-chair of the Subworking group on a Year of Open Science, NASA's TOPS collaborated with 11 Federal agencies to designate 2023 as a Federal Year of Open Science, further advancing the goal of making scientific knowledge accessible to all.

Risks to Strategic Goal 1.3 include increasing costs for cybersecurity, data storage, and processing that have risen with the growing amount of legacy data and increasing volume of new scientific observations each year. Secondly, SMD competes with private industry for high-skill technical talent, making workforce development a key strategic priority to preserve project timelines.

Based on SMD's strategy and accomplishments described in the above paragraphs, Strategic Goal 1.3 achieved a Blue/Notable rating during the 2023 Strategic Review Process.

1.3.1: Accelerate the accessibility and use of NASA's science data and tools

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	1 of 1	2 of 2	2 of 2
Result	1		
Rating	Green		

Critical milestones for FY 2023

1. Deploy an operational interdisciplinary science data search engine to allow users to discover 85 percent of NASA's scientific data.

Critical milestones for FY 2024

1. Continue work on an operational interdisciplinary science data search engine to allow users to discover at least 95 percent of NASA's scientific data.
2. Train 2,000 members of the scientific community in Open Science principles, practices, and tools.

Critical milestones for FY 2025

1. Continue work on an operational interdisciplinary science data search engine to allow users to discover at least 95 percent of NASA's scientific data.
2. Train 2,500 members of the scientific community in Open Science principles, practices, and tools.

Lead Organization: Science Mission Directorate (SMD)

FY 2023 Performance Progress

NASA released the beta version of an interdisciplinary science data search engine to the scientific community at the American Geophysical Union (AGU) 2022 Fall Meeting in December 2022. Known as the Science Discovery Engine (SDE), the SDE includes data and information from across the Science Mission Directorate: Astrophysics, Biological and Physical Sciences, Earth Science, Heliophysics, and Planetary Science. The December release featured an updated user interface that is customized to meet science user needs. Users can perform free-text searches and apply text-based facets to refine results based around science topical areas, data repository, source name, and document type. To support discovery within the SDE, a NASA science vocabulary extraction workflow was developed that leveraged over 50 glossaries, thesauri, and keywords across topical areas to generate term lists such as platforms, instruments, and missions. The first iterations of the term lists have been integrated as facets into the SDE to enable guided discovery for users. Over the course of FY 2023, there were over 9,000 unique user sessions in the beta SDE.

The SDE team also developed capabilities to enable data and information curation in the search capability to ensure the SDE includes high-quality, relevant content. The SDE team implemented a standardized curation workflow and built a customized application to streamline the curation process. This workflow was used to incorporate additional data documentation in the SDE and to curate documents already included in the SDE. In addition, the SDE team developed a standardized dataset landing page design for NASA science metadata to provide a cohesive data discovery experience for users.

At the conclusion of FY 2023, users could discover at least 85 percent of NASA's scientific data from all five science areas. In FY 2024, the total number of data documents included will continue to grow as NASA identifies new sources. The SDE will also complete planning to move out of the beta operational phase and into full operations. Last, the SDE will continue to foster greater use of the search capability by communicating more broadly with the scientific community and building customized scientific collections with the SDE itself.

1.3.2: Apply insights from Earth science to benefit the economy, health, quality of life, and environment around the globe

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	2 of 2	2 of 2	2 of 2
Result	2		
Rating	Green		

Critical milestones for FY 2023

1. 40 percent of Earth science applications projects advance one Applications Readiness Level (ARL) with 3 projects advancing to ARL 8 or 9, when an application has been incorporated into regular use and decision-making.
2. Engage 14,500 people across the Nation and around the world to build skills in applying Earth science information to benefit society.

Critical milestones for FY 2024

1. 40 percent of Earth science applications projects advance one Applications Readiness Level (ARL) with 3 projects advancing to ARL 8 or 9, when an application has been incorporated into regular use and decision-making.
2. Engage 15,500 people across the Nation and around the world to build skills in applying Earth science information to benefit society.

Critical milestones for FY 2025

1. 40 percent of Earth science applications projects advance one Applications Readiness Level (ARL) with 3 projects advancing to ARL 8 or 9, when an application has been incorporated into regular use and decision-making.
2. Engage 16,500 people across the Nation and around the world to build skills in applying Earth science information to benefit society.

Lead Organization: Science Mission Directorate (SMD)

FY 2023 Performance Progress

NASA Applied Sciences, which became part of the Earth Science Division's new Earth Action element in 2023, advanced uses of NASA data, information, and interdisciplinary expertise in Earth observations to address pressing issues related to climate and disaster resiliency, water resources, food security, natural resource management, ecological conservation, health and air quality, and environmental justice. The program's increasing impact is reflected in its close collaboration with decision makers, public and private sector partners, civil society groups, and communities. This is exemplified by ongoing work with the U.S. National Park Service on projects using Earth observations and data. https://appliedsciences.nasa.gov/our-impact/story/getting-satellite-data-hands-park-rangers

The ambitious program met its performance goal, with 47% of active projects increasing at least one Applications Readiness Level (ARL). Seven projects advanced to level 8 or 9, meaning the applications user has approved the application as complete and qualified it for their use (ARL 8) or that the partner fully integrated the application into their decision-making and is using it routinely (ARL 9). The Health and Air Quality program area demonstrated substantial reach and scale by enabling an updated air quality platform to support ozone and regional haze plans in six states around the Great Lakes, a new Saharan Dust Decision Support Tool operationalized in the Caribbean region, and an improved Malaria Decision Support product made available for sub-Saharan Africa. The Ecosystem and Conservation program areas continued to advance initiatives enabling geospatial tools to increase regional and global coverage for protection of biodiversity and targeted natural resource stewardship.

New cross-cutting programs were launched as part of Earth Action, including the Greenhouse Gas Center, Earth Information Center, and Wildland Fires. Geospatial platforms saw expanded demand and integrated use in decision-making, including its web-based Disaster portal and Wildfire hub for such events as the Maui wildfires. Increased transdisciplinary collaboration has improved the capture of lessons learned from field campaigns and the validation of innovative predictive modeling and frontier technologies in early warning and risk management. The online release of new environmental management applications from Water Resources, Agriculture and Ecological Conservation programs included a groundwater tool for the Central Valley of California, a regional water and food-balance dashboard for Africa, and a Sargassum Watch System for coastal waters of Intra-Americas Sea and Tropical Atlantic. The Disasters Program improved timely and integrated access to near real time environmental intelligence by establishing a Disaster Response Coordination System.

Dedicated to leading outreach activities serving environmental justice, indigenous communities and capacity building, the Applied Remote Sensing Training Program (ARSET) reached 14,345 individuals in FY 2023. The in-depth and ongoing engagement from global to regional scales has delivered on the Earth Action transformation, by enabling a more nimble and impactful response to user needs. The SERVIR program

(managed jointly with the U.S. Agency for International Development) conducted projects and trainings that reached 2,926 individuals engaging globally to capture effective practices in activities of lasting value. The DEVELOP Program, a workforce and early career initiative, engaged 546 young professionals. In total, through these efforts, as well as through the Community Action program element, Applied Sciences reached 19,353 individuals in FY 2023.

STRATEGIC GOAL 2:

EXTEND HUMAN PRESENCE TO THE MOON AND ON TOWARDS MARS FOR SUSTAINABLE LONG-TERM EXPLORATION, DEVELOPMENT, AND UTILIZATION

Above: NASA Names Astronauts to Next Moon Mission, First Crew Under Artemis
NASA and the Canadian Space Agency (CSA) announced the four astronauts who will venture around the Moon on Artemis II, the first crewed mission on NASA's path to establishing a long-term presence at the Moon for science and exploration through Artemis. The agencies revealed the crew members during an event at Ellington Field near NASA's Johnson Space Center in Houston. Image Credit: NASA

FY 2023 Performance Goals and Ratings Supporting Strategic Goal 2

Strategic Objective	Performance Goal	Description	Rating
2.1	**Explore the Surface of the Moon and Deep Space**		
	2.1.1	Advance America's goal to land the first woman and first person of color on the Moon by demonstrating capabilities that advance lunar exploration (APG)*	Yellow
	2.1.2	Develop the capabilities and infrastructure necessary to transport human missions from Earth to cislunar space	Yellow
	2.1.3	Complete the exploration activities that will support missions with human crew members to the lunar surface	Yellow
2.2	**Develop a Human Spaceflight Economy Enabled by a Commercial Market**		
	2.2.1	Expand commercial activities in low Earth orbit (LEO) and stimulate the human spaceflight economy, with a focus on deploying commercial LEO destinations that can be used by NASA and other customers	Green
	2.2.2	Provide support for and utilization of commercial facilities onboard the International Space Station (ISS) for NASA, other government agencies, and academic and industry users, including the ISS National Laboratory to expand the space economy	Green
	2.2.3	Provide operational resources to enable the closure of capability gaps in support of deep space exploration	Green
	2.2.4	Provide NASA crew transportation through commercial partners to the International Space Station (ISS) and low Earth orbit (LEO)	Green
2.3	**Develop Capabilities and Perform Research to Safeguard Explorers**		
	2.3.1	Identify activities that will mitigate the highest risks to crew health and performance	Green
2.4	**Enhance Space Access and Services**		
	2.4.1	Complete Launch Services Program (LSP) commercial non-crewed launch services objectives for NASA-Managed science, exploration, U.S. Government, and government-sponsored missions	Green
	2.4.2	Maintain the proficiency of Space Communications network services	Green

*Agency Priority Goal

STRATEGIC OBJECTIVE 2.1

Explore the Surface of the Moon and Deep Space

LEAD OFFICE
Exploration Systems Development Mission Directorate (ESDMD)

GOAL LEADER
Ned Penley, Deputy Associate Administrator for Management, ESDMD

BUDGET

	FY	$M
Op Plan	2023	$7,460.8
Enacted	2024	$7,468.9
Requested	2025	$7,618.2
Outyear	2026	$7,803.7
	2027	$7,959.8
	2028	$8,119.0
	2029	$8,281.4

The return of humanity to the surface of the Moon, including the first woman and first person of color, is the focus of Strategic Objective 2.1. NASA's Artemis campaign achieved several significant milestones over the last year. After extensive delays, NASA successfully demonstrated the integrated capability of the Space Launch System (SLS) rocket, Orion crew vehicle, and supporting ground systems during the Artemis I mission on November 16, 2022. Throughout 2023, NASA and our partners focused on collecting and evaluating lessons learned from the Artemis I mission, as well as preparing for Artemis II and Artemis III. The key hardware elements already in development for these missions demonstrates the strong commitment and integral collaboration between NASA and our commercial and international partners. Together, as a global team, NASA will continue to lead the development of the technology and systems required to live and work on the Moon in preparation for human missions to Mars.

To clarify its strategic approach, NASA developed and released a Moon to Mars (M2M) Strategy in April 2023. This document is a blueprint for sustained human

Above: A portion of the far side of the Moon looms large just beyond the Orion spacecraft in this image taken on the sixth day of the Artemis I mission by a camera on the tip of one of Orion's solar arrays. The spacecraft entered the lunar sphere of influence Sunday, November 20, making the Moon, instead of Earth, the main gravitational force acting on the spacecraft. On Monday, November 21, it came within 80 miles of the lunar surface, the closest approach of the uncrewed Artemis I mission, before moving into a distant retrograde orbit around the Moon. The darkest spot visible near the middle of the image is Mare Orientale. Image Credit: NASA

presence and exploration throughout the Solar System. NASA also conducted the first annual Architecture Concept Review (ACR) to review the Artemis strategy; the purpose of the ACR is to gain concurrence on the M2M architecture planning generally and specific systems and capabilities needed to accomplish the Agency's exploration objectives. The Agency also will use the ACR as an opportunity to assess the current state of technology, to ensure that the M2M architecture incorporates the latest technology in its plans.

Major procurements in support of future Artemis activities are underway. NASA's partner Axiom Space continues to develop a next generation Artemis spacesuit and supporting systems, and plan to demonstrate their use on the lunar surface during the Artemis III mission. On May 19, 2023 NASA announced the selection of Blue Origin to develop its Blue Moon lander for the Artemis V mission. Under the Appendix P contract award, Blue Origin will develop its human landing system to meet NASA's requirements for sustainable lunar exploration. Companies selected under this contract will be required to perform one uncrewed and one crewed lunar landing demonstration. The capabilities that will be provided by the HLS are integral to future exploration activities as the Agency works toward a regular cadence of Moon landings. Future procurement efforts are intended to be fixed-price contracts to mitigate budgetary uncertainty and prevent cost overrun risk to NASA.

Based on ESDMD's strategy and accomplishments described in the above paragraphs, Strategic Goal 2.1 achieved a Green/Satisfactory rating during the 2023 Strategic Review Process.

2.1.1: Advance America's goal to land the first woman and first person of color on the Moon by demonstrating capabilities that advance lunar exploration

Agency Priority Goal

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	4 of 4	4 of 4	4 of 4
Result	2		
Rating	Yellow		

This two-year Agency Priority Goal has been identified for inclusion in the FY 2024-2025 Agency Performance Plan.

By September 30, 2025, NASA will Launch Artemis II, the first crewed Artemis mission. Additionally, NASA will demonstrate a key enabling technology by completing an on-orbit propellant transfer test in preparation for Artemis III and it will deliver other key capabilities to enable deep space exploration.

Critical milestones for FY 2023

1. Q1 Complete Artemis II Booster Segment stacking.
2. Q2 Announce awards for sustaining lander development.
3. Q3 Deliver the Artemis II Core Stage to Kennedy Space Center.
4. Q4 Habitation and Logistics Outpost (HALO) systems Critical Design Review (CDR) closeout.

Critical milestones for FY 2024

1. Q1 Artemis II SLS Booster Segments Delivery to KSC.
2. Q2 Artemis III Integrated Sync Review #2 Kickoff.
3. Q3 EHP xEVAS Development Preliminary Design Review (PDR)-informed Sync Review complete.
4. Q4 Gateway HALO Habitable Element delivery.

Critical milestones for FY 2025

1. Q1 Start Vehicle Assembly Building (VAB) High Bay 4 Payload Environmental Access Room (PEAR) Design.
2. Q2 Complete Artemis III SLS Launch Vehicle Stage Adapter (LVSA).
3. Q3 Complete HLS Option A/SpaceX Propellant Flight Transfer technology test.
4. Q4 EHP xEVAS Development Critical Design Review (CDR)-informed Sync Review complete.

Lead Organization: Exploration Systems Development Mission Directorate (ESDMD)

FY 2023 Performance Progress

NASA continues to make significant progress towards returning humans to the Moon through the Artemis campaign, closing out two of the four milestones for performance goal 2.1.1. NASA successfully launched Artemis I on November 16, 2022 (the first quarter of FY 2023) closing out the remaining FY 2022 milestone. NASA's uncrewed 25.5-day Artemis I flight test proved the Space Launch System (SLS) rocket, Orion spacecraft, and the Exploration Ground Systems (EGS) needed for launch and recovery are ready for a crewed flight test, the next step towards flying astronauts on missions to the Moon.

For FY 2023, two of the four milestones planned on this priority goal have been closed. On May 19, NASA announced the selection of Blue Origin to develop its Blue Moon lander for the Artemis V mission. A request for proposals for sustaining lander development to carry astronauts between lunar orbit and lunar surface after Artemis III was released in March 2022 through a new NextSTEP Appendix P. Under the Appendix P contract award, Blue Origin will develop its human landing system to meet NASA's requirements for sustainable lunar exploration.

The Gateway program is comprised of several projects, including the Habitation and Lunar Outpost and the Power and Propulsion Element. NASA completed the Critical Design Review (CDR) for the Habitation and Logistics Outpost (HALO) in June 2023.

The remaining milestones identified for FY 2023 were delayed into FY 2024. NASA completed the mate of all five SLS core stage elements for Artemis II and installed all four engines. The core stage is in final integration and testing at the Michoud Assembly Facility in Louisiana. Delivery to Kennedy Space Center (KSC) is planned for early 2024, closing out one of the two remaining FY 2023 milestones. In September, the ten SLS solid booster segments were delivered to KSC to begin forming the twin five-segment solid rocket boosters, which produce more than 75% of the total thrust at Artemis II liftoff. Flight processing is currently underway and stacking of the booster segments is planned for FY 2024, posing no impact to the readiness for Artemis II launch. NASA also completed the Interim Cryogenic Propulsion Stage (ICPS) and the Launch Service Stage Adapter (LVSA). Both elements are in storage and ready for delivery to KSC in spring 2024 – closing out milestones related to the SLS Artemis II hardware.

2.1.2: Develop the capabilities and infrastructure necessary to transport human missions from Earth to cislunar space

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	4 of 5	4 of 5	4 of 4
Result	3		
Rating	Yellow		

Critical milestones for FY 2023

1. Artemis II Booster aft skirts ready for Acceptance Checkout.
2. Artemis II Launch Vehicle Stage Adapter complete.
3. Artemis III Crew Module Adapter (CMA) Complete.
4. Artemis IV Space Launch System Core Stage engines available.
5. Artemis III Core Stage Forward Skirt complete.

Critical milestones for FY 2024

1. Artemis II Crew Module (CM)/ Service Module (SM) Vacuum Performance Testing complete.
2. Mobile Launcher-1 ready for Artemis II crewed operations.
3. Artemis III Booster Aft Skirts ready for Acceptance Checkout.
4. Artemis III Crew Module initial power on.
5. Begin Artemis IV Exploration Upper Stage production.

Critical milestones for FY 2025

1. Artemis IV Crew Module Initial Power On.
2. Artemis III Launch Abort System Complete.
3. Pad 39B LN2 Construction Complete.
4. Begin Core Stage 3 Forward Join.

Lead Organization: Exploration Systems Development Mission Directorate (ESDMD)

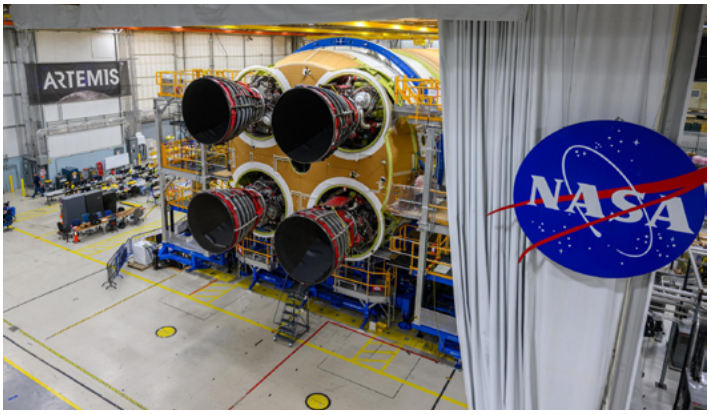
FY 2023 Performance Progress

During FY 2023, NASA completed three of the five capabilities and infrastructure milestones planned to support Artemis exploration missions from Earth to the area within the Moon's orbit, leading to a Yellow rating. These efforts, which include construction of system elements and infrastructure, support the activities described for Agency Priority Goal 2.1.1.

Artemis II is the first crewed mission on NASA's path to establishing a long-term lunar presence for science and exploration under Artemis. NASA continued progress towards Artemis II launch, with significant achievements on both Orion and SLS hardware. Assembly and test of the Crew Module (CM) and Service Module (SM) elements were nearing completion at the end of FY 2023 in preparation for mate into the Crew and Service Module (CSM). The CSM along with the Launch Abort System and adapter together form the Orion spacecraft for Artemis II. All SLS Artemis II flight hardware is either complete or near complete to support eventual delivery to Exploration Ground Systems at KSC.

NASA rolled the Mobile Launcher-1 to launch pad 39B on August 16, 2023 to initiate integrated testing of the Emergency Egress System, a new 1.4-million-gallon liquid hydrogen sphere that will increase launch availability and support the tanking needs of SLS Block 1B), and upgrades made to Environmental Control Systems (ECS) and Ignition Over Pressure/Sound Suppression. The ML-1 repair efforts continue and are on track to support Artemis II processing.

Production and build on Artemis III and IV Orion and SLS hardware are in various stages of manufacturing simultaneously. There are two remaining milestones for performance goal 2.1.2 that were delayed to FY 2024. These include the availability of the Artemis IV SLS Core Stage engines of which 2 of 4 engines were completed in FY 2023, the remaining 2 engines are planned to complete by early 2024; and Artemis III Core Stage Forward Skirt completion planned for summer 2024.



Above: NASA and industry partners Aerojet Rocketdyne and Boeing have installed all four RS-25 engines onto the SLS rocket core stage for the Agency's Artemis II mission, signaling the core stage is nearing completion. Once complete, the core stage will be shipped to NASA's Kennedy Space Center in Florida. During launch, the rocket's engines provide more than two million pounds of combined thrust. Image Credits: NASA

2.1.3: Complete the exploration activities that will support missions with human crew members to the lunar surface

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	4 of 5	4 of 5	4 of 5
Result	3		
Rating	Yellow		

Critical milestones for FY 2023

1. Complete the Human Landing System (HLS) Option A (SpaceX) incremental HLS design update.
2. Complete primary structure build for the Habitation and Logistics Outpost (HALO).
3. Conduct Exploration Extravehicular Activity Services (xEVAS) Certification Baseline Review.
4. Select and award Next Space Technologies for Exploration Partnerships (NextSTEP)-2 Appendix P: Sustaining Lunar Development contract.
5. Award the Lunar Terrain Vehicle (LTV) phase 1 contract(s).

Critical milestones for FY 2024

1. Complete HLS Option A (SpaceX) Starship Orbital Launch Architecture Assessment milestone.
2. Complete the Gateway MAXAR Power and Propulsion (PPE) Critical Design Review (CDR).
3. Complete xEVAS Artemis Suit Preliminary Design Review (PDR).
4. Complete HLS NextSTEP-2 Appendix P: Sustaining Lunar Development Preliminary Design Review (PDR).
5. Award LTV Phase 1 contract(s).

Critical milestones for FY 2025

1. Complete HLS Option A (SpaceX) Propellant transfer flight test.
2. Complete HLS Provider (SpaceX/Blue Origin) Sustaining Lander Preliminary Design Review(s).
3. Complete HLS Option A (SpaceX) Critical Design Review.
4. Complete the Lunar Terrain Vehicle (LTV) Phase 1 contract(s) design review milestone.
5. Complete xEVAS Artemis Suit Preliminary Design Review.

Lead Organization: Exploration Systems Development Mission Directorate (ESDMD)

FY 2023 Performance Progress

NASA completed 3 of 5 milestones and activities planned for FY 2023, resulting in a Yellow Performance Goal rating. NASA will follow the Artemis II crewed test flight with the first human lunar return mission on Artemis III. Manufacturing is underway on all SLS Artemis III hardware with a new core stage production flow planned to balance integration tasks between the Michoud Assembly Facility and the Kennedy Space Center. All solid rocket motor segments for Artemis III have been cast and are in storage in Utah. The ICPS was transferred to the United Launch Alliance (ULA) Delta Operations Center test cell, with forecasted completion of testing and checkout in early 2024. Other Artemis III SLS hardware, Launch Vehicle Stage Adapter and Orion Stage Adaptor (OSA) are in manufacturing and scheduled to be complete in 2024. Orion Artemis III hardware is also in production, the first crew module being built under the Orion Production and Operations Contract (OPOC) and European service module integration in progress in Bremen, Germany.

Gateway element manufacturing is underway, and the KDP-1 review—which establishes the Agency baseline commitment for lifecycle cost and schedule, as well as the technical parameters, for the Gateway program—was held and achieved final approval by the Agency in 2023. NASA began the Habitation and Logistics Outpost (HALO) primary structure build and is currently expected to be completed in December 2024.

SpaceX, on contract with NASA to provide the HLS for Artemis III, attempted a flight test of the integrated Starship/Super Heavy in April 2023 that ended prematurely approximately four minutes into the flight; a SpaceX-led investigation completed with Federal Aviation Administration (FAA) oversight and NASA participation ahead of a second planned test. SpaceX attempted a second flight test on November 18, 2023, which completed a stage separation and reached space, but ground crew lost telemetry after nine minutes. SpaceX Starship flight tests include ten launches of prototypes of the Starship spacecraft on suborbital and low-altitude tests, and two orbital trajectory flights of the entire Starship launch vehicle with the Starship prototype atop the Super Heavy first-stage booster. A third Starship flight is scheduled to take place in early 2024.

Axiom Space and Collins Aerospace are working to develop new, advanced spacewalking systems to work outside of the International Space Station (ISS) under the xEVAS contract. NASA completed the xEVAS Certification Baseline Review in June 2023.

On May 26, NASA released a request for proposals for a next-generation LTV that will allow astronauts to go farther and conduct more science than ever before as they explore the south polar region of the Moon during Artemis missions. NASA will contract LTV as a service from industry rather than owning the rover. Contracting services from industry partners allows NASA to leverage commercial innovation and provide the best value to U.S. taxpayers while achieving its human spaceflight scientific and exploration goals. Proposals for the LTV services contract were submitted on July 10, with the contract award scheduled for summer of 2024.

Right: The Artemis III spacesuit prototype, the AxEMU. Though this prototype uses a dark gray cover material, the final version will likely be all-white when worn by NASA astronauts on the Moon's surface. Image Credit: Axiom Space

STRATEGIC OBJECTIVE 2.2

Develop a Human Spaceflight Economy Enabled by a Commercial Market

LEAD OFFICE
Space Operations Mission Directorate (SOMD)

GOAL LEADER
Tonya McNair, Deputy Associate Administrator for Management, SOMD

BUDGET

	FY	$M
Op Plan	2023	$3,270.1
Enacted	2024	$3,262.4
Requested	2025	$3,301.3
Outyear	2026	$3,446.3
	2027	$3,538.9
	2028	$3,620.4
	2029	$3,692.8

NASA is uniquely situated to push the frontiers of exploration and simultaneously continue and expand the human presence in space. The growth of the commercial space economy represents not only an innovation boom to the American economy, but also a strategic partner for advancing all other NASA strategic objectives. NASA will expand the space economy by leveraging the International Space Station (ISS) to stimulate the growth of human spaceflight commercial activities and sustain a foundation of the Low Earth Orbit (LEO) ecosystem through commercial transportation systems and platforms via the Commercial Crew Program (CCP) and Commercial LEO Development Program (CLDP).

NASA continues to use the ISS and its capabilities to aid in the development of U.S. industry's ability to provide the necessary platforms and services in LEO. In FY

Above: NASA's SpaceX Crew-5 Splashdown
Roscosmos cosmonaut Anna Kikina, left, NASA astronauts Josh Cassada and Nicole Mann, and Japan Aerospace Exploration Agency (JAXA) astronaut Koichi Wakata, right, are seen inside the SpaceX Dragon Endurance spacecraft onboard the SpaceX recovery ship Shannon shortly after having landed in the Gulf of Mexico off the coast of Tampa, Florida, Saturday, March 11, 2023. Mann, Cassada, Wakata, and Kikina are returning after 157 days in space as part of Expedition 68 aboard the International Space Station.
Image Credit: NASA/Keegan Barber

2023, NASA is continuing to support the eight proposals selected in FY 2022 enabling U.S. businesses and institutions of higher learning to raise the technological readiness level of their manufacturing technologies and products for In-Space Production Applications.

NASA is continuing to prepare for the retirement of the ISS in 2030 and the transition to relying on commercial space stations after this time.

- NASA conducted a study reviewing potential models for a future National Laboratory post-ISS, also known as a LEO National Lab. The report was finalized in FY 2023, and will be released in FY 2024, to align with the LEO National Lab Strategy report release.
- Within the CLD Program, three providers under a Space Act Agreement with NASA have successfully achieved their contracted milestones for FY 2024 to provide a commercial destination to succeed the ISS with no gap in LEO capability.
- The combination of a sustaining destination and research demand enables a private market to sustain the commercial transportation systems used on the ISS today.

Based on SOMD's strategy and accomplishments described in the above paragraphs, Strategic Objective 2.2 achieved a Green/Satisfactory rating during the 2023 Strategic Review Process.

2.2.1: Expand commercial activities in low Earth orbit (LEO) and stimulate the human spaceflight economy, with a focus on deploying commercial LEO destinations that can be used by NASA and other customers

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	3 of 4	2 of 2	2 of 2
Result	4		
Rating	Green		

Critical milestones for FY 2023

1. Release Commercial LEO Development (CLD)-related white papers to industry through NASA Request for Information process.
2. Execute a private astronaut mission to the International Space Station.
3. Complete one major milestone for Commercial Destinations on ISS (CDISS).
4. Complete three major milestones--one on each of the Commercial Destinations Free Flyers (CDFF) Space Act Agreements (SAAs).

Critical milestones for FY 2024

1. Release initial set of CLD Requirements.
2. Complete two major milestones, one on each of the CDFF SAA.

Critical milestones for FY 2025

1. Define NASA CLD top-level requirements for CLDs to host future NASA crew.
2. Complete two major milestones, one on each of the CDFF SAA.

Lead Organization: Space Operations Mission Directorate (SOMD)

FY 2023 Performance Progress

NASA focused on developing a firm foundation for commercial activities in FY 2023 and completed all milestones, achieving a Green rating for this Performance Goal.

NASA's Commercial LEO Program released essential whitepapers to both communicate intended outcomes for future LEO destinations and act as a catalyst to promote discussion within the community. These documents mark significant accomplishments for the program as the concept of operations and capabilities of interest and resources needed whitepapers were published on February 13, 2023 and March 6, 2023 respectively.

In support of this Performance Goal, Axiom Mission 2 (Ax-2), the second private astronaut mission to the ISS, launched on May 31, 2023. The SpaceX Dragon spacecraft docked with the ISS on May 22, one Axiom astronaut and three international astronauts spent nine days aboard the space station. In March, NASA and Axiom Space signed a mission order for a second private mission, planned for FY 2024.

As future sustainability of this performance goal is to maintain uninterrupted U.S. presence in LEO, NASA is partnering with the commercial space sector to develop one or more platforms to serve as a CDISS, and follow-ons to the CDFF.

Several milestones were accomplished in FY 2023 under NASA's Space Act Agreement partners which include key programmatic milestones:

- Axiom completed their habitat (Ax-Hab1) Critical Design Review (CDR) in February 2023. In this three week-long review, the NASA and Axiom teams reviewed the progress of assembly level designs against Axiom Segment and Ax-Hab1 module level requirements and the NASA Commercial Element Requirements Document (CERD) to safely mature the subsystem concepts as Axiom begins production of their designs for the CDISS.
- Blue Origin completed Milestone #5 of their Space Act Agreement which was the Large Integrated Flexible Environment (LIFE) module Creep Test on May 24.
- Nanoracks completed Milestone #5 of their Space Act Agreement which was the Metallic Habitat Material/Manufacturing Demonstration on May 24.
- Northrop Grumman completed Milestone #7 of their Space Act Agreement which was the Element 1 System Requirements Review (SRR) Closeout on May 3.

2.2.2: Provide support for and utilization of commercial facilities onboard the International Space Station (ISS) for NASA, other government agencies, and academic and industry users, including the ISS National Laboratory to expand the space economy

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	1 of 1	2 of 2	2 of 2
Result	1		
Rating	Green		

Critical milestones for FY 2023

1. Launch 20 commercial facilities to the ISS and conduct experiments.

Critical milestones for FY 2024

1. Conduct at least 45 experiments using commercial facilities on the ISS.
2. Sponsor at least 15 investigations focused on in space production areas, such as biomanufacturing and advanced materials.

Critical milestones for FY 2025

1. Conduct at least 45 experiments using commercial facilities on the ISS.
2. Sponsor at least 15 investigations focused on in space production areas, such as biomanufacturing and advanced materials.

Lead Organization: Space Operations Mission Directorate (SOMD)

FY 2023 Performance Progress

During FY 2023, approximately 20 commercial facilities were operational on the ISS, leading to a Green rating for this Performance Goal. In support of commercial goals, the Center for the Advancement of Science in Space (CASIS) solicited commercial flight projects through a Cooperative Agreement with NASA. Examples of these facilities include the following:

- The Materials ISS Experiment Flight Facility (MISSE FF), owned by Aegis Aerospace, is attached to the outside of the ISS, allowing researchers to test materials (e.g., paints, coatings, polymers) or other larger experiments in the extreme environment of space. Samples are exposed to extreme temperature variations, vacuum, unfiltered ultraviolet radiation, atomic oxygen, and electromagnetic radiation, and micro-meteoroids in low Earth orbit.
- The Space Automated Bioprocessing Lab (SABL), owned by Bioserve, is an incubator and freezer designed to support a wide variety of investigations in the life, physical, and materials sciences, with a focus on supporting research in biological systems and process. SABL also can support secondary functions, such as physical science experiment support and food storage.
- The Multi-use Variable-gravity Platform (MVP), owned by Techshot, is designed for research with different kinds of organisms and cell types, such as fruit flies, flatworms, plants, fish, and protein crystals. MVP includes two carousels that can produce up to 2g of artificial gravity, while controlling for temperature, light cycles, and humidity.

2.2.3: Provide operational resources to enable the closure of capability gaps in support of deep space exploration

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	1 of 1	1 of 1	1 of 1
Result	1		
Rating	Green		

Critical milestones for FY 2023

1. Initiate and operate at least 5 technology demonstrations on the International Space Station (ISS) to advance deep space exploration.

Critical milestones for FY 2024

1. Initiate and operate at least 5 technology demonstrations on the ISS to advance deep space exploration.

Critical milestones for FY 2025

1. Initiate and operate at least 5 technology demonstrations on the ISS to advance deep space exploration.

Lead Organization: Space Operations Mission Directorate (SOMD)

FY 2023 Performance Progress

NASA is using the ISS to develop and test new technologies that will support exploration beyond low Earth orbit. During FY 2023, NASA initiated five technologies aboard the ISS leading to a Green rating: CapiSorb Visible System (CVS); Urine Processor Assembly (UPA) Purge Pump and Separator Assembly (PPSA); Exploration Potable Water Dispenser (xPWD); BioMole Water Filtration Kit; and MinION MK1C.

- The CVS, launched on SpX-27, demonstrates replacing gravity with capillary forces to control liquids that can absorb carbon dioxide. Data from the experiment could directly inform design of new carbon dioxide removal systems for future crewed missions to the Moon and Mars.
- The UPA, launched on SpX-26, is an essential component of the Water Recovery System onboard the ISS and will be a core component of deep space life support systems.
- In FY 2023, the UPA PPSA, launch on NG-19, was delivered and installed to improve efficiency compared to the previous UPA pump assembly.
- The Exploration Potable Water Dispenser, launched on NG-19, provides drinkable water at the proper temperature for both food and beverage rehydration, advancing the existing ISS Potable Water Dispenser by adding UV disinfection to eliminate a consumable filter and reducing the potential for microbial growth during periods of dormancy. An efficient and reliable potable water dispensation system is essential for long duration human spaceflight missions.
- BioMole and MinION M1KC, both launched on NG-19, together called the BioMole MinION 2.0 payload, supports sample preparation and sequencing onboard the ISS and is being used to better understand the evolution of microbial environments in microgravity. For long duration missions, technology will be needed to analyze and monitor microbial environments to protect crew health.

Above: NASA astronaut and Expedition 69 Flight Engineer Jasmin Moghbeli collects water samples for microbial analysis inside the International Space Station's Destiny laboratory module. Image Credit: NASA

2.2.4: Provide NASA crew transportation through commercial partners to the International Space Station (ISS) and low Earth orbit (LEO)

Number of Commercial Crew missions launched

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target # Missions	2 of 2	2 of 2	2 of 2
Result	3		
Rating	Green		

Critical milestones for FY 2023

1. Launch 2 new Commercial Crew missions.

Critical milestones for FY 2024

1. Launch 2 Commercial Crew missions.

Critical milestones for FY 2025

1. Launch 2 Commercial Crew missions.

Lead Organization: Space Operations Mission Directorate (SOMD)

FY 2023 Performance Progress

NASA has contracted for commercial crew transportation to the ISS and returning safely to Earth with SpaceX and Boeing. In FY 2023, SpaceX launched three crewed missions to the ISS for NASA's Commercial Crew Program, leading to a Green rating. Despite delays due to parachute and wiring verifications, Boeing's capabilities continue to mature in anticipation of an FY 2024 first crewed flight performed by NASA astronauts Suni WIlliams and Barry "Butch" Wilmore.

The SpaceX Crew-5 mission launched on October 5, 2022, carrying NASA astronauts Nicole Mann and Josh Cassada, as well as Japan Aerospace Exploration Agency (JAXA) astronaut Koichi Wakata and Roscosmos cosmonaut Anna Kikina. On March 12, 2023, the Crew-5 astronauts safely returned to Earth aboard the SpaceX Dragon spacecraft.

The SpaceX Crew-6 mission launched on March 2, 2023, carrying NASA astronauts Stephan Bowen and Warren Hoburg, as well as Mohammed bin Rashid Space Centre (MBRSC) astronaut Sultan Al Neyadi and Roscosmos cosmonaut Andrey Fedyaev. On September 4, 2023, the Crew-6 crew safely returned to Earth about the SpaceX Dragon spacecraft.

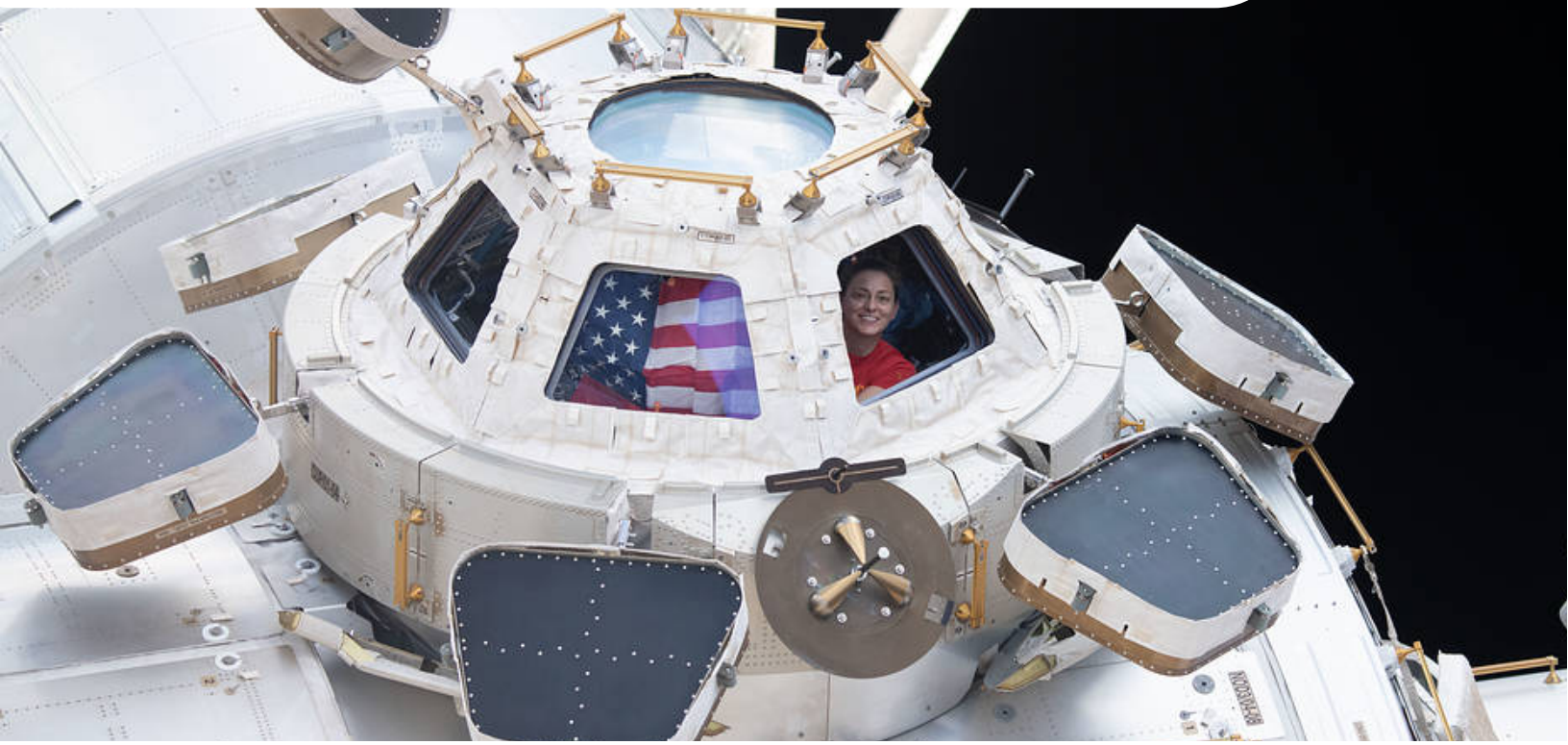
The SpaceX Crew-7 mission launched on August 25, 2023, carrying NASA astronaut Jasmin Moghbeli, as well as European Space Agency (ESA) astronaut Andreas Mogensen, Japan Aerospace Exploration Agency (JAXA) astronaut Satoshi Furukawa, and Roscosmos cosmonaut Konstantin Borisov. The crew is currently on their 6-month mission aboard the International Space Station and plan to return to Earth in the Spring of 2024 aboard the SpaceX Dragon spacecraft.

Boeing—NASA's second provider for commercial crew services—is preparing for their first crewed test flight (CFT-1) to launch in the Spring of 2024.

Above: The four crew members that comprise the SpaceX Crew-6 mission are pictured in front of the SpaceX Dragon crew ship during a crew equipment integration test at SpaceX headquarters in Hawthorne, California. From left, in their pressure suits are, Mission Specialist Andrey Fedyaev of Roscosmos; Pilot Warren "Woody" Hoburg and Commander Stephen Bowen, both from NASA; and Mission Specialist Sultan Alneyadi from the Mohammed bin Rashid Space Centre. Image Credit: SpaceX

STRATEGIC OBJECTIVE 2.3

Develop Capabilities and Perform Research to Safeguard Explorers



LEAD OFFICE
Space Operations Mission Directorate (SOMD)

GOAL LEADER
Tonya McNair, Deputy Associate Administrator for Management, SOMD

BUDGET

	FY	$M
Op Plan	2023	$252.7
Enacted	2024	$255.5
Requested	2025	$248.5
Outyear	2026	$261.3
	2027	$261.3
	2028	$262.4
	2029	$267.5

Strategic Objective 2.3 centers on the work of NASA's Human Research Program (HRP) to ensure that astronauts are adequately protected from the hazards of space. Over the last year, HRP has achieved high-impact results using modest investment to address the risks identified in the human exploration plan, Moon to Mars Program, and the Office of the Chief Health and Medical Officer. In addition to conducting several studies regarding the physical and mental health risks, HRP signed agreements to enhance academia, industry, U.S. Government, and international collaboration and funding for these activities.

HRP is successfully implementing crew health and performance risk mitigation activities for upcoming Artemis missions under the ISS flight research plan. The ISS is a critical facility that can uniquely accommodate long-duration human research activities. HRP and NASA face a significant risk to be able to perform these research activities as the ISS is decommissioned at the end of the decade and NASA requires an operational commercial destination to continuing these risk reduction capabilities.

HRP is working in collaboration with the Exploration Systems Development Mission Directorate (ESDMD) to prioritize the highest engineering, health, and behavioral health integrated research needs for Artemis mission success. Additionally, NASA is balancing on-going research activities with the increasing mission support activities required by the NASA exploration program. NASA continues to identify and successfully execute

Above: NASA astronaut and Expedition 68 Flight Engineer Nicole Mann peers through one of the seven windows in the cupola, the International Space Station's "window to the world" on January 2, 2023. Image Credit: NASA

collaborations with a broad spectrum of partners across academia, industry, the U.S. Government, and international partners. These include advanced food and nutrition studies with the Department of Defense, behavioral and physiological studies at National Science Foundation polar facilities, isolation and confinement studies with Russian laboratories, bed rest studies at the German Space Agency's (DLR) envihab facility, and new joint flight research and data sharing agreements with international partners. Through HRP's Translational Research Institute for Space Health (TRISH) cooperative agreement, NASA planned a suite of experiments for private spaceflight participants to execute, setting a precedent for commercial space companies to offer NASA research as experiences to their customers. Strategically, this partnership opens additional platforms and research subjects that will help HRP accelerate its research findings for buying down exploration mission risks.

Results collected by HRP from ISS flight and terrestrial analog studies have been accepted by multiple programs throughout NASA and are now being integrated to benefit Artemis including Human Landing System acceleration requirements, motion sickness countermeasures, and manual control countermeasure and EVA Suit emergency CO2 limits and in-suit nutrition trade study (and other NASA activities such as ISS and use in terrestrial medicine). HRP research results are publicly available through peer reviewed publications (many in high impact journals) and through NASA Life Sciences Data Repositories.

Based on SOMD's strategy and accomplishments described in the above paragraphs, Strategic Objective 2.3 achieved a Blue/Noteworthy rating during the 2023 Strategic Review Process.

2.3.1: Identify activities that will mitigate the highest risks to crew health and performance

Number of funded investigations and published papers

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target Investigations	5	5	5
Target Papers	150	150	150
Result	6, 186		
Rating	Green		

Critical milestones for FY 2023

1. 5 new investigations funded.
2. 150 peer-reviewed papers published.

Critical milestones for FY 2024

1. 5 new investigations funded.
2. 150 peer-reviewed papers published.

Critical milestones for FY 2025

1. 5 new investigations funded.
2. 150 peer-reviewed papers published.

Lead Organization: Space Operations Mission Directorate (SOMD)

FY 2023 Performance Progress

The NASA Human Research Program conducts ground- and space-based research to support safe, productive human space travel. Over the past year, NASA surpassed the FY 2023 target of 150 peer-reviewed papers for this Performance Goal by publishing more than 180 papers and funding six new investigations, leading to a Green rating.

Below: Astronauts can now volunteer for a new suite of experiments called the Complement of Integrated Protocols for Human Exploration Research (CIPHER), which aims to unlock how extended time in space affects the human body. As part of CIPHER, these astronauts will wear a specialized shirt, like the one seen here on Canadian Space Agency astronaut David Saint-Jacques. The shirt measures heart rate and respiration and is worn periodically before, during, and after missions for two days at a time. Image Credit: NASA

STRATEGIC OBJECTIVE 2.4

Enhance Space Access and Services

LEAD OFFICE
Space Operations Mission Directorate (SOMD)

GOAL LEADER
Tonya McNair, Deputy Associate Administrator for Management, SOMD

BUDGET

	FY	$M
Op Plan	2023	$730.7
Enacted	2024	$732.1
Requested	2025	$840.0
Outyear	2026	$790.0
	2027	$787.4
	2028	$796.7
	2029	$812.6

Space is difficult to reach and operate within. Strategic Objective 2.4 represents NASA's commitment to affordable and reliable space launch capabilities for new missions and a robust communications and navigation infrastructure to support ongoing missions.

As the launch agent for the U.S. civil space sector, NASA relies on the Launch Services Program (LSP) to certify new commercial launch vehicles for readiness to fly high-value spacecrafts, and direct vital launch mission assurance efforts to ensure the greatest probability of launch mission success. LSP is the Agency's recognized experts in all aspects of commercial launch services, including acquisition, certification, and mission management, Over the last year, LSP successfully managed and launched two science missions. To make these missions possible, the Space Communication and Navigation (SCaN) program has overcome obstacles to maintain capability, including a natural disaster that destroyed the Guam communications facility, while focusing on priority investments needed to support and buy-down risks for future NASA human and robotic missions.

SCaN exceeded its Performance Goal of 95.0% network proficiency for FY 2023, with an average proficiency of 99.47%. SCaN has also released a request for proposal (RFP) for Near Space Network (NSN) services in Q2 2023, with a focus on enabling commercial services to take a leading role. The Spring 2023 SCaN Program Implementation Review (PIR) noted challenges in operational capability, underfunding in critical

Above: A SpaceX Falcon 9 rocket with the Surface Water and Ocean Topography (SWOT) spacecraft onboard is seen as preparations for launch continue, Wednesday, December 14, 2022, at Space Launch Complex 4E at Vandenberg Space Force Base in California. Image Credit: NASA/Keegan Barber

investment areas, and strategy challenges transitioning technology to operations. SCaN has worked to improve the robustness of its risk, schedule, budget and technical, management/review processes to ensure prioritization of investments.

SCaN is working aggressively to address the concerns raised by the PIR with a goal of implementing a series of process, organization, roles/responsibilities, and other changes, in FY 2024. SCaN is currently conducting an internal review of its organizational structure, which is evaluating SCaN's core objectives and alignment toward those objectives in terms of resources, workforce, and strategic and technical direction. SCaN will have a follow-up PIR to assess progress in the fall of 2024. To continue its current performance while implementing new capabilities and increased capacity (commercial and government owned/operated) to support both human spaceflight activities at the Moon and as well as a growth in the robotic missions from LEO to the outer solar-system, SCaN will need to have the tools and processes in place to clearly capture customer requirements, prioritize/time-phase investment strategies, provide strong program management and risk management oversight of operational and development activities, and ensure the timely development/insertion of advanced communication/navigation technologies.

Based on SOMD's strategy and accomplishments described in the above paragraphs, Strategic Objective 2.4 achieved a Yellow/Focus Area for Improvement rating during the 2023 Strategic Review Process.

2.4.1: Complete Launch Services Program (LSP) commercial non-crewed launch services objectives for NASA-Managed science, exploration, U.S. Government, and government-sponsored missions

Percentage of launch objectives met

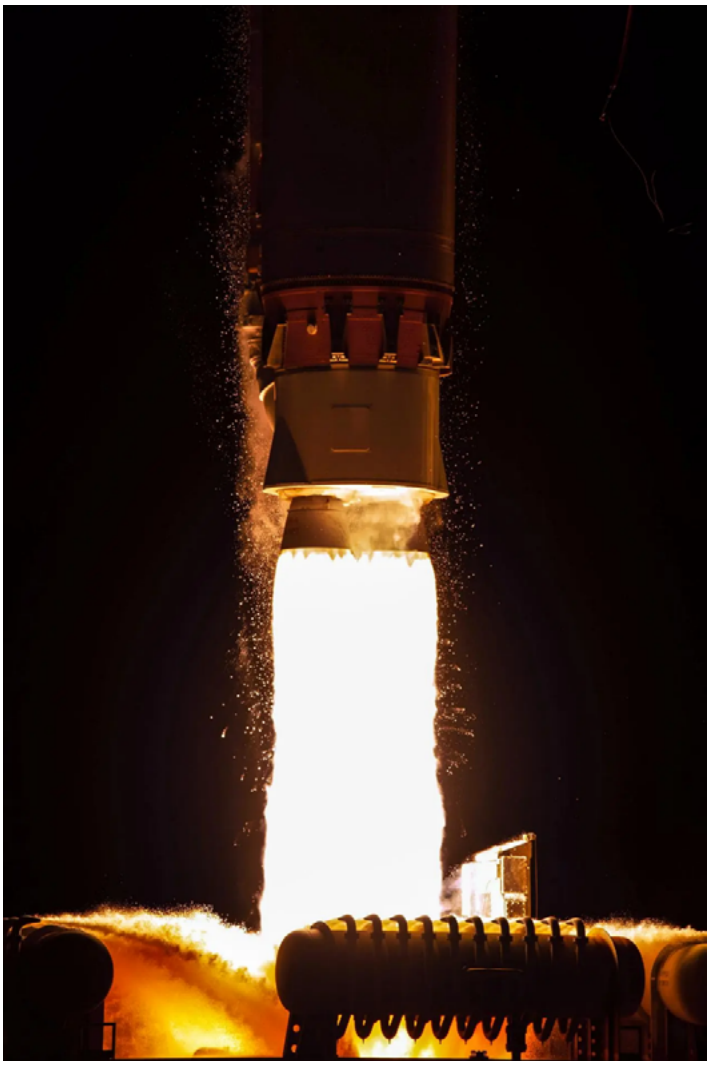
	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	100%	100%	100%
Result	100%		
Rating	Green		

Lead Organization: Space Operations Mission Directorate (SOMD)

FY 2023 Performance Progress

NASA achieved all launch objectives in FY 2023, leading to a Green rating. Specifically, NASA successfully launched 2 planned science missions over the past fiscal year:

- The Joint Polar Satellite System-2 (JPSS-2) and Low-Earth Flight Test of an Inflatable Decelerator (LOFTID) missions launch on November 10, 2022, from Space Launch Complex 3 at Vandenberg Space Force Base, California.
- The Surface Water and Ocean Topography (SWOT) mission launched on December 15, 2022, from Space Launch Complex 4E at Vandenberg Space Force Base, California.



Right: A United Launch Alliance Atlas V 401 rocket lifts off from Space Launch Complex 3 at Vandenberg Space Force Base in California on November 10, carrying the National Oceanic and Atmospheric Administration's (NOAA) Joint Polar Satellite System-2 (JPSS-2) and NASA's Low-Earth Orbit Flight Test of an Inflatable Decelerator (LOFTID) technology demonstration. Liftoff was at 2:25 a.m. PDT. JPSS-2 is the third satellite in the polar satellite series and is expected to capture data to improve weather forecasts, helping scientists predict and prepare for extreme weather events and climate change. Credits: USSF 30th Space Wing/Joe Davila

2.4.2: Maintain the proficiency of Space Communications network services

Percentage of network proficiency

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	95%	95%	95%
Result	99.5%		
Rating	Green		

Lead Organization: Space Operations Mission Directorate (SOMD)

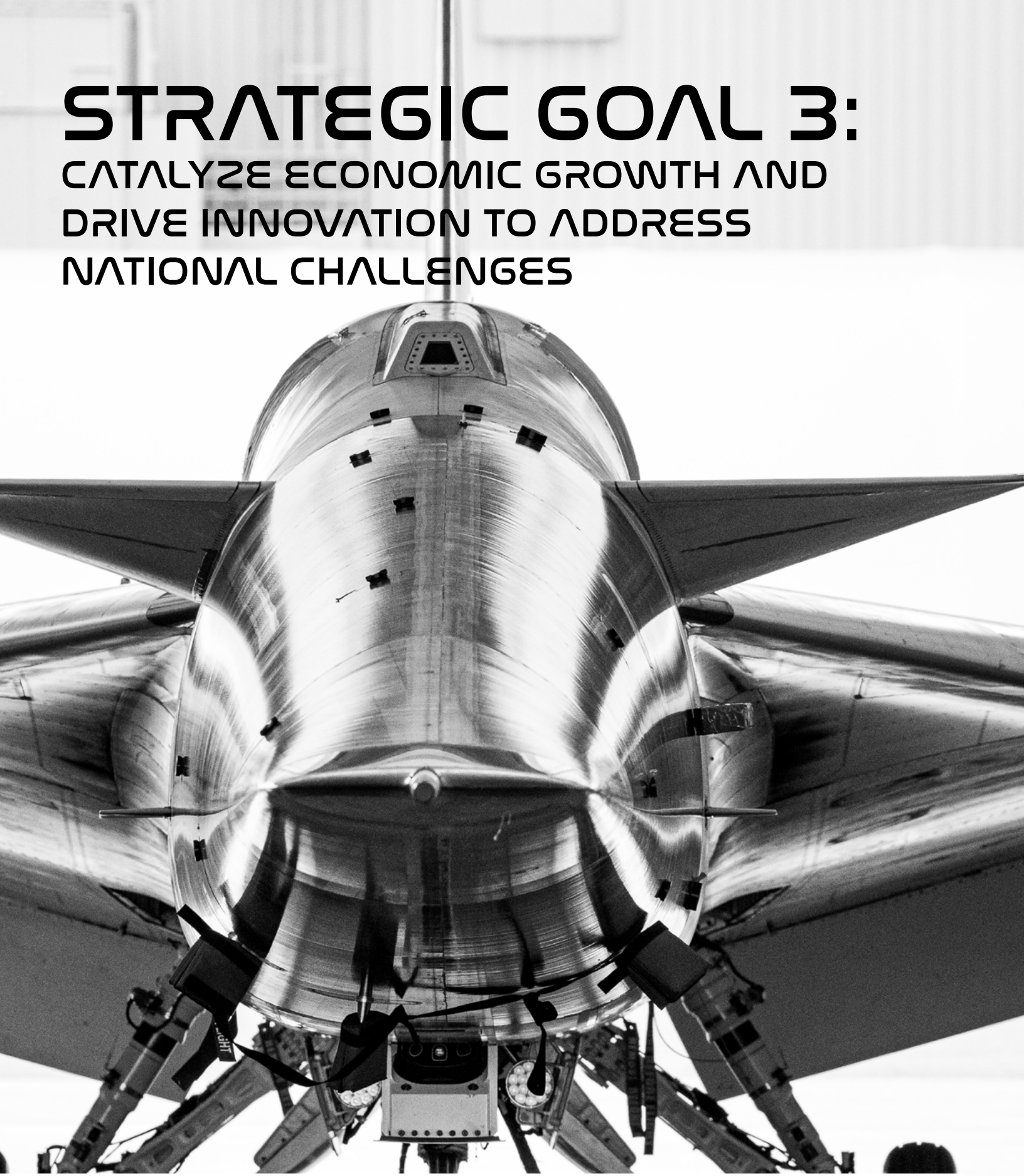
FY 2023 Performance Progress

NASA's communications networks—the Deep Space Network (DSN) and the Near Space Network (NSN), which has relay and direct-to-Earth (DTE) components—achieved 95 percent service delivery, achieving the FY 2023 target of a minimum 95 percent network proficiency, leading to a Green rating.

NASA's communications networks serve more than 100 NASA and non-NASA missions. The DSN enables missions that explore the furthest points of our solar system, utilizing three ground stations located approximately 120 degrees apart on Earth. The NSN provides services for near-Earth missions, including DTE services and relay capabilities.

Below: The map of SCaN facilities shows ground stations for the Near Space Network and the Deep Space Network. Image Credit: NASA

STRATEGIC GOAL 3:
CATALYZE ECONOMIC GROWTH AND DRIVE INNOVATION TO ADDRESS NATIONAL CHALLENGES



NASA's X-59 research aircraft moves from its construction site to the flight line – or the space between the hangar and the runway – at Lockheed Martin Skunk Works in Palmdale, California, on June 16, 2023. This milestone kicks off a series of ground tests to ensure the X-59 is safe and ready to fly.
Image Credit: Lockheed Martin Photography by Garry Tice

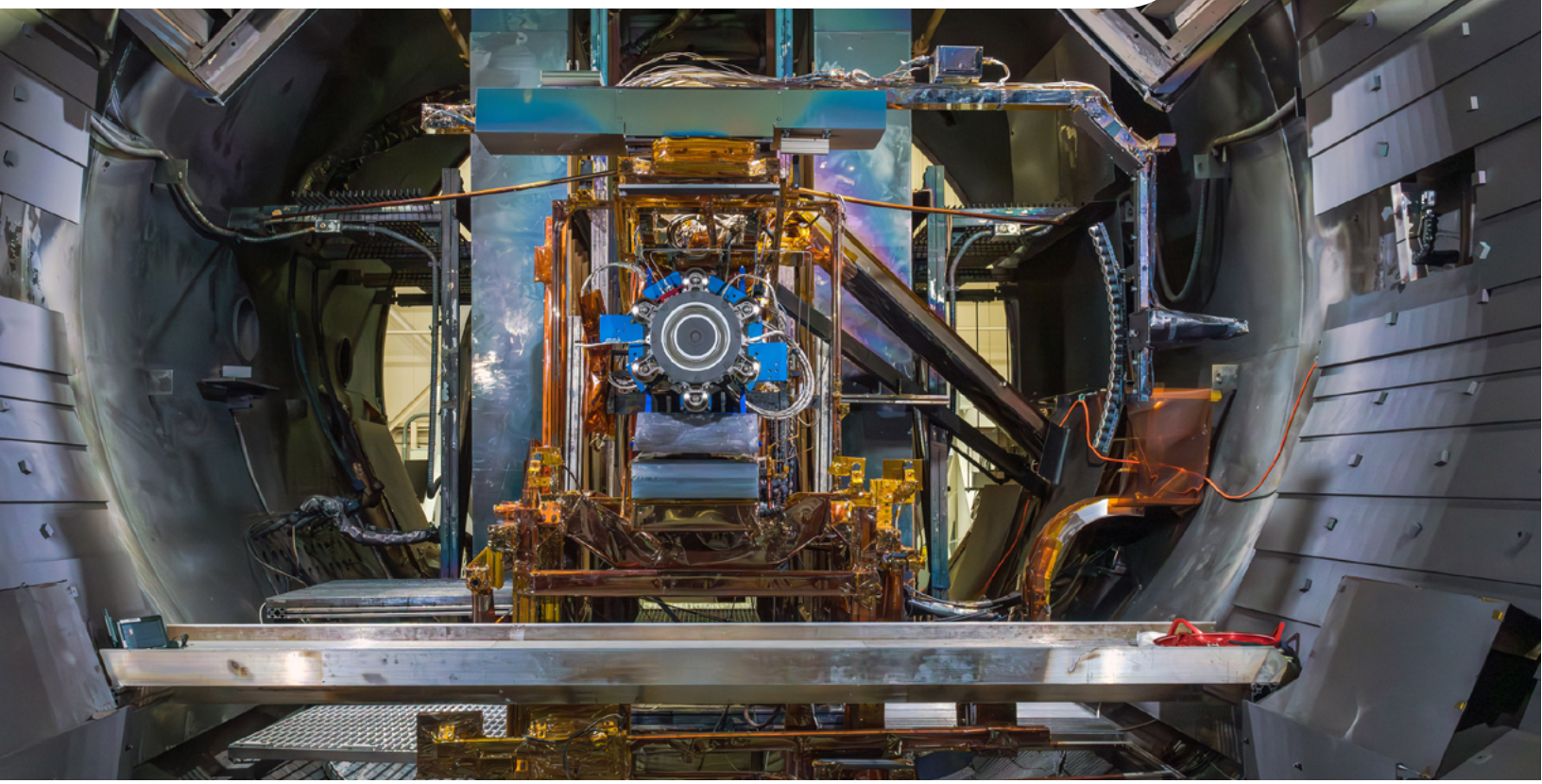
FY 2023 Performance Goals and Ratings Supporting Strategic Goal 3

Strategic Objective	Performance Goal	Description	Rating
3.1	**Innovate and Advance Transformational Space Technologies**		
	3.1.1	Foster a diverse U.S. engineering and technology talent base, expand commercial opportunities in the space industry, and advance innovative technology solutions	Green
	3.1.2	Mature technology projects that offer significant improvement to existing solutions or enable new capabilities	Yellow
	3.1.3	Rapidly develop and demonstrate technologies for exploration, discovery, and the expansion of space commerce through partnership with U.S. industry and academia	Yellow
	3.1.4	Demonstrate new technologies and cross-cutting capabilities that are of direct interest and use to NASA missions and the commercial space sector	Green
	3.1.5	Ensure American global leadership in space technology innovations through increased partnering with industry, broadening the base of innovation, and demonstrating key lunar surface and deep space technologies (APG)*	Yellow
3.2	**Drive Efficient and Sustainable Aviation**		
	3.2.1	Develop solutions that will enable the integration of a diverse range of non-traditional vehicles and operations into the National Airspace System by means of a scalable, service-oriented architecture	Green
	3.2.2	Demonstrate the ability to reduce the perceived loudness of sonic booms and enable future industry innovation in commercial supersonic aircraft	Red
	3.2.3	Advance airframe and engine technologies to enable the development of future generations of ultra-efficient air vehicles that minimize environmental impact including electric aircraft propulsion concepts	Yellow
	3.2.4	Advance airframe and propulsion technologies to enable the development of vertical take-off and landing (VTOL) vehicles that minimize noise and maximize safety	Green
	3.2.5	Define and demonstrate solutions that predict, identify, and mitigate emerging safety risks and address the national need to safely transform the National Airspace System	Green
	3.2.6	Contribute toward the safe introduction of on-demand Urban Air Mobility (UAM) and other emerging operations by developing, applying, demonstrating, and validating advanced autonomy and automation technologies and providing methods or research results that support certification of autonomous systems	Green

*Agency Priority Goal

STRATEGIC OBJECTIVE 3.1

Innovate and Advance Transformational Space Technologies



LEAD OFFICE
Space Technology Mission Directorate (STMD)

GOAL LEADER
Mike Green, Deputy Associate Administrator for Management, STMD

BUDGET

	FY	$M
Op Plan	2023	$1,193.0
Enacted	2024	$1,200.0
Requested	2025	$1,181.8
Outyear	2026	$1,205.4
	2027	$1,229.5
	2028	$1,254.1
	2029	$1,279.2

As NASA explores the final frontier, opportunities exist to mature and demonstrate revolutionary, high-payoff space technologies and broaden the base of innovation. Strategic Objective 3.1 enshrines NASA's commitment to ambitious technology development to transform NASA missions and ensure American leadership in the space economy. While there are issues caused by appropriations below the President's Requests, as well as cost growth and schedule delays in some projects, a clear strategy has been developed and STMD is on track for achieving long-term success.

STMD investments continue to serve as a catalyst for the new technology required for the varied mission architecture needs of multiple stakeholders. In FY 2022, STMD has made significant progress by developing and delivering new technologies and capabilities. Examples include the successful launch, test, and retrieval of Low-Earth Orbit Flight Test Inflatable Decelerator (LOFTID); launch and successful completion of the power-on and check out activities of Laser Communications Relay Demonstration (LCRD); launch of CAPSTONE; and numerous significant technology transitions and infusions. STMD received a Yellow rating for the Agency Priority Goal in this area, and also achieved three of the four FY 2022 NASA Performance Goals under Objective 3.1 and achieved similar results (three of five) in FY 2023.

In FY 2022, the Prizes, Challenges, and Crowdsourcing (PCC) Program offered 69 new opportunities to broaden NASA's innovation community through activities to

Above: The Advanced Electric Propulsion System qualification thruster from the Solar Electric Propulsion project is shown inside one of the vacuum chambers at NASA Glenn's Electric Propulsion and Power Laboratory. Image Credit: NASA/GRC/Jef Janis

advance research and development challenges. PCC has conducted 45 opportunities through Q3 FY 2023. Furthermore, 86% of Space Technology Research Grants (STRG) program included at least one knowledge transition for projects closed out in FY 2022. In the long-term, STMD has identified 14 long-term technical outcomes and three long-term socioeconomic outcomes as priority areas of focus as described in our long-term success criteria.

Risks to Strategic Objective 3.1 mainly center around cost and workforce factors. Progress developing nuclear propulsion advancements have been slow as the 22% appropriations shortfall below recent STMD President's Budget Requests (PBR) has reduced scope of future technology development partnerships. Supply chain disruptions are improving through project re-plans and prioritizing investments. From a workforce perspective, STMD notes that retirements for highly skilled positions exceeded the pace of hiring and training, necessitating continued effort and vigilance.

While some STMD projects are experiencing cost, schedule, technical, and/or programmatic challenges, overall, the STMD portfolio has strategies in place to meet its strategic objective and has several technology demonstrations planned in the coming years.

Based on STMD's strategy and accomplishments described in the above paragraphs, Strategic Objective 3.1 achieved a Green/Satisfactory rating during the 2023 Strategic Review Process.

3.1.1: Foster a diverse U.S. engineering and technology talent base, expand commercial opportunities in the space industry, and advance innovative technology solutions

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	4 of 5	4 of 5	4 of 5
Result	5		
Rating	Green		

Critical milestones for FY 2023

1. Achieve at least 1 knowledge transition for a minimum of 75% of research grants.
2. Offer 50 new opportunities to broaden NASA's innovation community through prizes, challenges, and crowdsourcing.
3. Achieve 60 innovative Small Business Technologies that receive external funding to further advance technologies.
4. Achieve 3,600 licenses and software usage agreements.
5. Conduct 15 strategic engagement opportunities to underserved and underrepresented communities.

Critical milestones for FY 2024

1. Achieve at least 1 knowledge transition for a minimum of 75% of research grants.
2. Achieve 90% of project owners/subject matter experts in PCC reporting that the solutions submitted to their projects made a difference in meeting their technology objectives.
3. Obtain 100 commitments from external partners for funding to further advance small business technologies.
4. Achieve 4,000 licenses and software usage agreements.
5. Conduct 15 strategic engagement opportunities to underserved and underrepresented communities.

Critical milestones for FY 2025

1. Achieve at least 1 knowledge transition for a minimum of 75% of research grants.
2. Achieve 90% of project owners/subject matter experts in PCC reporting that the solutions submitted to their projects made a difference in meeting their technology objectives.
3. Obtain 100 commitments from external partners for funding to further advance small business technologies.
4. Achieve 4,000 licenses and software usage agreements.
5. Conduct 15 strategic engagement opportunities to underserved and underrepresented communities.

Lead Organization: Space Technology Mission Directorate (STMD)

FY 2023 Performance Progress

NASA exceeded the FY 2023 target for this multi-year Performance Goal as the Agency continued to foster, expand, and advance the U.S. space technology economy. NASA achieved the FY 2023 target for this Performance Goal by meeting the targets for all five milestones leading to a Green rating overall. These investments and activities ensure a healthy base of promising early-stage solutions for further development by other programs and organizations.

NASA's Space Technology Research Grants (STRG) Program continued to challenge academic researchers, from graduate researchers to senior faculty members, to contribute to NASA's goal of creating innovative new space technologies, specifically in areas where academia is ideally suited to provide significant innovations. Of the 81 projects that were part of the 2018 cohort planned to have close-out reviews in FY 2023, 76 were completed as of the end of the fiscal year. Five projects were given no-cost extensions and were therefore not completed. All 81 projects were assessed and 78% (63 projects) achieved at least one knowledge transition. These knowledge transitions capture the technologies, ideas, and expertise created by these projects for use by NASA, other Federal agencies, and industry; they include published journal articles, patents, licensing, new technology reports (NTRs), open source software, and NASA Space Technology Graduate Research Opportunities (NSTGRO) researcher hiring.

NASA started 73 new Prize, Challenge, and Crowdsourcing (PCC) activities in FY 2023. Exciting public challenges that started in FY 2023 included Phase 3 of the Break the Ice Lunar Challenge designed to help NASA excavate ice on the Moon; Phase 3 of the Deep Space Food Challenge in partnership with the Canadian Space Agency to help bring innovative food production technologies to space and here on Earth; the Power to Explore K-12 Challenge and the third running of the NASA TechRise Student Challenge in partnership with the Flight Opportunities program.

NASA provided opportunities for small, highly innovative companies and research institutions through the Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) program. The Agency created 113 post-Phase II opportunities, compared to the targeted 60 opportunities, including 37 Phase II-E awards, three Civilian Commercialization Readiness Pilot Program opportunities, five Sequential Phase II awards, and 68 Phase III awards. These follow-on awards prove that STMD supports the development of innovative technologies that are sought by and resonate with other programs.

NASA continues to ensure that technologies developed for missions in exploration and discovery are broadly available to the public though through its Technology Transfer Program. We have continued to exceed our target of 3,600 licenses and software usage agreements made by executing 146 patent licenses and 10 copyright licenses and 5,133 new software usage agreements.

This year, NASA's Early Stage Innovations and Partnerships (ESIP) portfolio began implementing lessons learned from the Diversity, Equity, Inclusion, and Accessibility (DEIA) assessment and DEIA data benchmarking work completed in FY 2022. New this year, STMD began tracking the number of strategic engagement opportunities made with underserved and underrepresented communities. STMD programs must take meaningful participatory roles in the activities to inform, consult, involve, collaborate, and empower individuals, this year targeting 15 such opportunities. NASA has exceeded this goal, participating in 29 opportunities focusing on addressing and removing barriers commonly experienced by underserved and underrepresented communities.

3.1.2: Mature technology projects that offer significant improvement to existing solutions or enable new capabilities

Percentage of planned key performance parameters that met requirements

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	60%	60%	60%
Result	49%		
Rating	Yellow		

This program tracks dozens of key performance parameters every fiscal year. For example, the program is tracking 75 key performance parameters that plan to close during FY 2023. They include but are not limited to the following:

- COLDArm: COLDArm Actuator Min Operational Temp
- COLDArm: Cold Motor Drivers Minimum Operating Temperature
- COLDArm: Actuator Heater Energy
- Hopper-TP: Excursion Data Downlinked (1)
- Hopper-TP: Longest Flight Capability
- Hopper-TP: PSR Survival Limits
- Hopper-TP: Landing Capability (2)
- Hopper-TP: Power Margin (3)
- PRIME-1: Regolith sample-depth resolution
- PRIME-1: Volatile species identification
- PRIME-1Water detection accuracy for regolith
- TALOS Axial Propellant Operating Temp (C)
- TALOS Axial Minimum Impulse Bit (N-sec)
- TALOS Axial Thrust to Weight (ratio)
- TALOS ACS Thrust to Weight (ratio)
- TALOS ACS Propellant Operating Temp (C)

Lead Organization: Space Technology Mission Directorate (STMD)

FY 2023 Performance Progress

NASA did not achieve this performance goal target (i.e., 60 percent of planned key performance parameter (KPP) events) due to launch and testing delays, lingering budget shortfalls resulting in project de-scope, re-direction and cancellations, as well as a combination of project-specific development challenges and facility constraints. This Performance Goal is therefore rated Yellow. Despite this, the KPPs' thresholds that NASA met or exceeded during FY 2023 each represent technology advancement that may lead to entirely new mission approaches and provide solutions to national needs.

NASA met KPPs in 11 of its Game Changing Development (GCD) projects such as Cold Operable Lunar Deployable Arm (COLDArm), Polar Resources Ice Mining Experiment-1 (PRIME-1), Entry Systems Modeling (ESM), and Rapid Analysis and Manufacturing Propulsion Technology (RAMPT), among others. This year, NASA significantly advanced the PRIME-1 mission, the first in-situ resource demonstration on the Moon and first time NASA will robotically sample and analyze ice from below the lunar surface. As part of this mission, GCD successfully completed testing and lander delivery of the Mass Spectrometer Observing Lunar Operations (MSolo) and mounted the Regolith and Ice Drill for Exploring New Terrain (TRIDENT), the two major components of PRIME-1. TRIDENT was developed via NASA's Small Business Innovative Research (SBIR) program by Honeybee Robotics in 2016.

The Distributed Spacecraft Autonomy (DSA) experiment is one of four technology demonstrations that will be tested in orbit on the Small Spacecraft Technology (SST) Starling mission, which launched summer 2023. DSA will demonstrate the ability of a swarm of spacecraft to collect and analyze science data onboard and cooperatively optimize data collection in response. The satellites will monitor Earth's ionosphere – part of the upper atmosphere – and when one detects interesting phenomena, other satellites in the constellation will be tasked to join its observations.

While NASA's Technology Maturation Portfolio made significant advancements on a variety of technology projects, it did face challenges that lead to a yellow rating for this Performance Goal. For example, the LTE Proximity Communications Tipping Point (LTE-TP) had 11 KPPs planned to complete in FY 2023. None have met their threshold as a result of delays to Intuitive Machines IM-2 mission. A total of 18 KPPs across five projects have been delayed due to issues with CLPS launch providers. Additionally, multiple projects have faced delays due to limited testing capacity, facilities, and workforce issues. NASA personnel working on Integrated System for Autonomous and Adaptive Caretaking (ISAAC) have been temporarily reassigned to SMD's Volatiles Investigating Polar Exploration Rover (VIPER). ISAAC had planned on achieving 3 KPPs in FY 2023. Other programs like Luna-TP, RPCD-TP and SynBio are awaiting testing. Overall, 18 KPPs across eight projects suffered from schedule delays. Additional descopes and redirections resulting from budget shortfalls resulted in two missed KPPs on the Thruster for the Advancement of Low-temperature Operation in Space (TALOS) and RAMPT. Although these challenges caused a Yellow rating for the year, NASA continued to make significant progress towards its goal of maturing technologies that will revolutionize space exploration.

3.1.3: Rapidly develop and demonstrate technologies for exploration, discovery, and the expansion of space commerce through partnership with U.S. industry and academia

Number of technologies tested suborbitally or orbitally

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	45	30	30
Result	25		
Rating	Yellow		

Lead Organization: Space Technology Mission Directorate (STMD)

FY 2023 Performance Progress

NASA fell short of its 45 targeted flight-tested technologies, having tested 25, leading to an overall Yellow rating for this Performance Goal. Several commercial flight providers faced challenges in FY 2023 that impacted the flight rate of NASA supported payloads. Despite this, NASA's Flight Opportunities and Small Spacecraft Technology (FO/SST) programs continue to foster the U.S. commercial spaceflight industry by testing new technologies using emerging commercial spaceflight capabilities.

Among the technologies tested in FY 2023 were several aboard the Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) mission which entered lunar orbit on November 13, 2022, becoming the first CubeSat and commercial mission to fly to and operate at the Moon. In April 2023, the TeraByte InfraRed Delivery (TBIRD) communications system achieved 200 gigabit per second (Gbps) throughput on a space-to-ground optical link between a satellite in orbit and Earth, the highest data rate ever achieved by space based optical communications technology. Additional technologies were tested as part of the CubeSat Infrared CrossLink A (CLICK) mission and the Starling distributed spacecraft technology demonstration mission.

FO/SST also employs suborbital flights to test new technologies. As one example, researchers at the University of Central Florida developed Ejecta STORM (Sheet Tracking, Opacity, and Regolith Maturity) a laser-based instrument tested aboard Astrobotic's Xodiac rocket-powered lander vehicle. The instrument is designed to measure the size and speed of surface particles kicked up by the exhaust from a Moon or Mars lander. In addition, the three winners of the inaugural NASA TechLeap Prize, the Autonomous Observation Challenge No. 1, were provided a second flight on Aerostar high-altitude balloon flights to enable a "fly-fix-fly" approach to further advance their technologies.

Several Flight Opportunities-supported technologies transitioned from suborbital testing to orbital and terrestrial uses. The dual-spinning CubeSat bus developed at the Massachusetts Institute of Technology (MIT) is now a key element in NASA's TROPICS mission, which launched in May 2023. TROPICS is a four CubeSat constellation that is observing tropical cyclones from space. The MIT-developed technology, which was tested on parabolic flights supported by FO has now enabled the use of microwave radiometers—previously used only on large satellites—on small spacecraft.

While the FO/SST portfolio advanced several critical technologies in FY 2023, the programs fell short of their targeted number of tested technologies. The portfolio relies on commercial flight providers who in turn faced challenges such as flight anomalies and other events. In all, more than 25 payloads slated for testing with commercial providers in FY 2023 have been delayed.

3.1.4: Demonstrate new technologies and cross-cutting capabilities that are of direct interest and use to NASA missions and the commercial space sector

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	8 of 11	5 of 7	6 of 8
Result	8		
Rating	Green		

Critical milestones for FY 2023

1. Low-Earth Orbit Flight Test of an Inflatable Decelerator (LOFTID) Launch Readiness Date (LRD).
2. On-orbit Servicing, Assembly, and Manufacturing (OSAM)-1 servicing payload integration start.
3. ULA 2020 Tipping Point Preliminary Design Review (PDR).
4. Radio Frequency Mass Gauge (RFMG) launch on Commercial Lunar Payload Services (CLPS).
5. SpaceX 2020 Tipping Point demonstration.
6. OSAM-1 spacecraft delivery to Goddard Space Flight Center.
7. Solar Electric Propulsion (SEP) Key Decision Point (KDP)-D.
8. Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE) operations complete.
9. Cryogenic Fluid Management (CFM) annual assessment review.
10. Eta Space Tipping Point payload delivery to spacecraft integration.
11. Fission Surface Power Phase I Interim Reviews.

Critical milestones for FY 2024

1. Solar White Project Close-Out.
2. Deep Space Optical Communications (DSOC) Post-Launch Assessment Review (PLAR).
3. Lockheed Martin Cryogenic Fluid Management (CFM) 2020 Tipping Point Technology Maturation Review (TMR-7).
4. United Launch Alliance (ULA) Cryogenic Fluid Management (CFM) 2020 Tipping Point Critical Design Review (CDR).
5. Cryogenic Fluid Management (CFM) 20k 20 Watt Cryocooler characterization test start.
6. Solar Electric Propulsion (SEP) Qualification Model 2 (QM-2) assembly complete.
7. Cryogenic Fluid Management (CFM) portfolio annual review.

Critical milestones for FY 2025

1. Fission Surface Power (FSP) Phase 1A Final Review.
2. Fission Surface Power (FSP) Mission Concept Review (MCR).
3. United Launch Alliance (ULA) Cryogenic Fluid Management (CFM) Tipping Point "Do No Harm" review.
4. Deep Space Optical Communications (DSOC) post-conjunction operations start.
5. Lockheed Martin Cryogenic Fluid Management (CFM) 2020 Tipping Point Launch Reediness Date (LRD).
6. Fission Surface Power (FSP) Acquisition Strategy Meeting (ASM).
7. Solar Electric Propulsion (SEP) qual 4500 hour wear test complete.
8. Cryogenic Fluid Management (CFM) portfolio annual review.

Lead Organization: Space Technology Mission Directorate (STMD)

FY 2023 Performance Progress

During FY 2023, NASA had several impactful successes in its technology demonstration portfolio, and met eight major milestones in Technology Demonstration Missions (TDM) out of 11, leading to a Green rating for this performance goal.

In FY 2023, Low Earth Orbit Flight Test of an Inflatable Decelerator (LOFTID) made its launch readiness date and was successfully flown and demonstrated on November 10, 2022. The LOFTID technology demonstration is helping to transform the way NASA and industry deliver substantial payloads to planetary destinations with atmospheres in support of human exploration and commercial applications from low Earth orbit.

TDM's contribution to the Mars 2020 Perseverance Rover, The Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE) completed its 17th and final oxygen generation run on Mars this year. Since arriving on the Red Planet in 2021, MOXIE has produced 122 grams of oxygen over a total of 20 hours of operation. MOXIE successfully converted the thin, carbon dioxide-rich Martian atmosphere into oxygen, paving the way for isolating and storing oxygen on Mars to help power rockets that could lift astronauts off the planet's surface and provide them breathable air. MOXIE was named by TIME as one of 2023's best inventions.

TDM has made progress on its largest projects, despite challenges. On-Orbit Servicing and Manufacturing 1 (OSAM-1) began integration of its servicing payload, and after numerous delays, the spacecraft bus was delivered from Maxar in California to Goddard Space Flight Center

in Maryland in late FY 2023. In parallel to these major milestones, two of OSAM-1's most crucial systems, the Robotic Servicing System (RSS) and Light Detection and Ranging (LiDAR), have progressed through component build and box-level testing. Both systems saw struggles in component manufacturing and assembly throughout FY 2023, delaying their flight hardware deliveries into FY 2024. Solar Electric Propulsion (SEP) made significant progress this year, completing the build of Qualification Module-1 (QM-1), and passing KDP-D in May 2023. This milestone marks the beginning of the project's environmental qualification testing and eventual launch of three thrusters aboard Gateway's Power and Propulsion Element (PPE) in 2025.

The Cryogenic Fluid Management (CFM) portfolio continues to make significant progress in its projects, successfully completing the United Launch Alliance (ULA) 2020 Tipping Point PDR, and the portfolio Annual Assessment Review. Two CFM milestones were not met, however, due to issues outside of the project's control—one Tipping Point partnership experienced delays in launch vehicle readiness, while the other, the Radio Frequency Mass Gauge (RFMG), was installed on the CLPS IM-1 mission, which has delayed its launch until the first half of FY 2024. A third CFM milestone for Eta Space Tipping Point payload delivery for spacecraft integration has been delayed until FY 2024. Fission Surface Power (FSP) also successfully completed its Phase 1 interim reviews. The FSP project continued to implement their Phase 1 industry contracts for the design of an integrated FSP system and is working towards Phase 2 during which it will refine the lunar demonstration's requirements and goals.

Space Nuclear Propulsion (SNP) received Authority to Proceed (ATP) to formulation for the Demonstration Rocket for Agile Cislunar Operations (DRACO). DRACO is a partnership between NASA and the Defense Advanced Research Projects Agency (DARPA) to design, build, launch, and demonstrate the first in-space Nuclear Thermal Rocket Engine (NTRE). Such propulsion systems may be crucial in enabling future crewed exploration of Mars and beyond.

Below: The Low-Earth Orbit Flight Test of an Inflatable Decelerator, or LOFTID, spacecraft is pictured after its atmospheric re-entry test in November 2022. Through a new Tipping Point partnership, United Launch Alliance will continue development of the inflatable heat shield technology demonstrated by LOFTID. Image Credit: NASA/Greg Swanson

3.1.5: Ensure American global leadership in space technology innovations through increased partnering with industry, broadening the base of innovation, and demonstrating key lunar surface and deep space technologies

Agency Priority Goal

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023 Agency Priority Goal	FY 2024	FY 2025
Target	4 of 4	4 of 4	4 of 4
Result	0		
Rating	Yellow		

This two-year Agency Priority Goal has been identified for inclusion in the FY 2024-2025 Agency Performance Plan.

Critical milestones for FY 2023

1. Q1. Transition 3 SBIR/STTR sequentials planned to be completed in CY 2023 to stakeholder programs for planned follow-on use/development and integration into future systems and demonstrations.
2. Q2. Deliver the LTE Proximity Communications Tipping Point with Nokia to Intuitive Machines for integration to their CLPS Lander.
3. Q3. Deliver the Cooperative Autonomous Distributed Robotic Explorers (CADRE) to the CLPS vendor for integration.
4. Q4. Initiate primary mission operations of the Deep Space Optical Communications (DSOC).

Critical milestones for FY 2024

1. Q1. Complete kickoff of the Consortium for Space Mobility and ISAM Capabilities (COSMIC).
2. Q2. Achieve "first light" of the Deep Space Optical Communications (DSOC) while on-orbit.
3. Q3. Publish Request for Proposal (RFP) for Candidate Technologies 1 (CT-1) CLPS demonstration.
4. Q4. Complete 3 design milestones for TDM led-tipping point projects.

Critical milestones for FY 2025

1. Q1. Complete environmental qualification testing of the Solar Electric Propulsion project.
2. Q2. Moon to Mars Planetary Autonomous Construction Technology (MMPACT) completes ground demonstration of engineering development hardware.
3. Q3. Transition 3 SBIR/STTR sequentials planned to be completed in CY 2024 to stakeholder programs for planned follow-on use/development and integration into future systems and demonstrations.
4. Q4. High Performance Spaceflight Computing (HSPC) project delivers first release of processor evaluation board.

Lead Organization: Space Technology Mission Directorate (STMD)

FY 2023 Performance Progress

While NASA fell short of its milestones set for FY 2023, significant progress was made towards all four goals with final progress blocked by launch delays and other challenges, overall resulting in a Yellow rating for this performance goal.

NASA transitioned two SBIR/STTR sequentials to stakeholder programs for planned follow-on use/development and integration into future systems and demonstrations, with technologies now being infused into NASA's VIPER mission and Gateway Vehicle System Manager. Despite falling short of the targeted three, each transition represents a new technological innovation that would not have otherwise been advanced.

While the LTE Proximity Communications Tipping Point with Nokia is ready for delivery to Intuitive Machines, NASA was unable to deliver the mission due to launch delays stemming from the CLPS provider. Intuitive Machines re-baselined the launch of the IM-2 mission to November 2023. LTE-TP is currently awaiting delivery in FY 2024 to meet new schedule requirements for integration testing.

Delivery of the Cooperative Autonomous Distributed Robotic Explorers (CADRE) has been delayed until December 2023. Delays to the schedule were the result of multiple challenges facing NASA including scope growth from added lander interface requirements, reduced mass allocation, parts availability/supply chain issues, workforce/skillset availability, and system maturation.

The Psyche mission, which hosts the Deep Space Optical Communications (DSOC) technology demonstration, was delayed by one year, with NASA successfully launching Psyche and DSOC on October 13, 2023. DSOC was approved for operations, passing KDP-E on September 6, 2023, and will initiate primary mission operations in the first half of FY 2024 with two years of demonstration activities taking place as the spacecraft spirals out to Mars and beyond.

STRATEGIC OBJECTIVE 3.2

Drive Efficient and Sustainable Aviation

LEAD OFFICE
Aeronautics Research Mission Directorate (ARMD)

GOAL LEADER
William Harrison, Director of the Portfolio Analysis & Management Office, ARMD

BUDGET

	FY	$M
Op Plan	2023	$935.0
Enacted	2024	$935.0
Requested	2025	$965.8
Outyear	2026	$985.1
	2027	$1,004.8
	2028	$1,024.9
	2029	$1,045.4

NASA's charge to create a future of aviation that is safer, cleaner, more efficient, and accessible, as well as to provide more versatile mobility rests within Strategic Objective 3.2. Major emphases include airspace and safety technologies, ultra-efficient alternative subsonic airframe and propulsion systems including electrification and potential use of non-carbon-based fuels, supersonic flight over land, automation, and autonomy, fostering new aviation applications in Advanced Air Mobility (AAM), and fundamental research involving hypersonic flight well above the speed of sound. Collectively, these efforts, other technologies, and a focus on technology convergence will develop transformative solutions towards the goal of a safe, efficient, adaptable, and environmentally sustainable global aviation system.

Over the last year, ARMD demonstrated good progress against its near-, mid-, and long-term success measures. For example, ARMD completed Low Boom Flight Demonstration (LBFD) shock tests, its assessment of Urban Air Mobility (UAM) Gen-2 vehicle noise testing, and wind tunnel tests of the Transonic Truss Braced Wing (TTBW). Furthermore, it issued a funded Space Act Agreement to Boeing for the Sustainable Flight Demonstration project. Since FY 2019, ARMD has achieved green rating for 71% of its Performance Goals and 67% of its annual milestones, with some completion dates trailing into the next quarter or fiscal year.

At the same time, cost and schedule pressures on major development programs were pronounced. In 2022, 13% of its strategic success criteria were rated "at risk." Most significantly, construction on the LBFD was delayed by performance issues with the project's prime contractor, Lockheed Martin, which pushed back the first flight and testing cadence. This resulted in cost overruns and missing one of ARMD's annual Performance Goals. A key part of ARMD's strategic planning has been the mitigation of these development risks through replanning, scope changes, and direct engagement with contractors.

Overall, ARMD's results speak to a focused, disciplined approach to current activities, a clear capability to continue moving toward ambitious long-term goals, and active mitigation efforts in place to address current risks.

Based on ARMD's strategy and accomplishments described in the above paragraphs, ARMD achieved a Green/Satisfactory rating during the 2023 Strategic Review Process.

Above: Image of the X-59's 13-foot General Electric F414 engine as the team prepares for a fit check. Making sure components, like the aircraft's hydraulic lines, which help control functions like brakes or landing gear, and wiring of the engine, fit properly is essential to the aircraft's safety. Image Credit: Lockheed Martin Photography by Garry Tice

3.2.1 Develop solutions that will enable the integration of a diverse range of non-traditional vehicles and operations into the National Airspace System by means of a scalable, service-oriented architecture

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	1 of 1	3 of 3	2 of 2
Result	1		
Rating	Green		

Critical milestones for FY 2023

1. Research, develop, test and evaluate a UAM arrival/departure scheduler.

Critical milestones for FY 2024

1. Evaluation of Cooperative Operating Practices for interactions of diverse aircraft in Upper Class E airspace.
2. Integrate and demonstrate multiple UAM mission-types, integrated into multiple high-fidelity Air Traffic Service (ATS) environments, representative of moderate levels of complexity, diversity, and scale associated with midterm operations as defined in UAM ConOps v2.0.
3. Complete an initial draft of a wildland firefighting concept of operation developed through inter-Agency collaboration.

Critical milestones for FY 2025

1. Evaluation of trajectory management automation for routine increasingly autonomous operations.
2. Collect operational performance data for an eVTOL/UAM vehicle representing multiple phases of flight scenarios.

Lead Organization: Aeronautics Research Mission Directorate (ARMD)

FY 2023 Performance Progress

NASA achieved the FY 2023 milestones for this Performance Goal, earning a green rating. During the year, the NASA Urban Air Mobility (UAM) Airspace Management Subproject team completed a Concept of Use (ConUse), a Cooperative Conflict Management (CCM) Concept, a trade study assessment, and tabletop exercises with key stakeholders. The team also developed and tested an initial UAM arrival/departure scheduler prototype to validate requirements for UAM sequencing and scheduling capability, and conducted studies and analyses on conflict management and throughput estimation.

The ConUse was completed in October 2022, which describes a focused use case for airport transfer along with the strategic and tactical capabilities needed for airspace management of mid-term UAM operations. The use case, initially developed and vetted through partnership with the Federal Aviation Administration (FAA), leverages joint capabilities designed to increase operational realism of the associated scenarios. While initial UAM operations will conform to current rules and procedures and receive air traffic services, mature UAM operations are expected to require new air traffic management paradigms to accommodate higher demand levels.

The CCM introduces a notion of cooperation among operators to perform conflict management functions and assume responsibility for separation. A trade study assessment was conducted in November 2022, which presents the results of a comparison analysis of candidate Strategic Conflict Management (SCM) strategies as applied to UAM operations. The comparison evaluated SCM strategies' effectiveness in reducing the need for the tactical conflict management layer actions and looked at the metrics of unmitigated losses-of-separation, flight delays imposed by strategic planning, and throughput of the overall airspace. The results in this study indicate that an air traffic system should attempt to implement mechanisms appropriate for reducing uncertainty where possible in order to increase the chances for scalability.

A preliminary analysis of Tactical Conflict Management (TCM) impact on safety and operational suitability of UAM operations using a fast-time simulation was conducted in March 2023 to assess conflict severity mitigation impact based on use of strategic deconfliction and onboard TCM system. A set of different separation standards for the proposed UAM operations in the Dallas/Fort Worth (DFW) region using safety and operational suitability metrics was evaluated. A study on throughput analysis in the DFW metropolitan area was completed in June 2023. The study informs development of future UAM ecosystem towards the higher level of operational density and complexity in a given location. The results of the study were published in a 2023 American Institute of Aeronautics and Astronautics (AIAA) Aviation conference paper titled "Estimating Throughput for Urban Air Mobility Operations."

From June to August 2023, the UAM Subproject team conducted internal simulations to assess different methods of strategic deconfliction, which includes demand/capacity balancing as well as sequencing and scheduling. The results of the simulation will inform

and validate functional requirements for strategic conflict management in the federated architecture. These services are being integrated with the Provider of Services for UAM (PSU) and fleet management software, as part of the overall UAM system architecture, that can support future airspace research and simulation activities.

3.2.2: Demonstrate the ability to reduce the perceived loudness of sonic booms and enable future industry innovation in commercial supersonic aircraft

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	1 of 1	1 of 1	2 of 2
Result	0		
Rating	Red		

Critical milestones for FY 2023

1. F-15 platform ready to support X-59 high altitude and high-speed flights.

Critical milestones for FY 2024

1. Complete Flight Readiness Review (FRR) of the Low Boom Flight Demonstrator aircraft.

Critical milestones for FY 2025

1. Complete System Acceptance Review for the X-59 aircraft.
2. Collect requested airborne near-, mid-, and far-field shock sensing critical to the effort to validate the predictive tools for shock propagation and ground loudness.

Lead Organization: Aeronautics Research Mission Directorate (ARMD)

FY 2023 Performance Progress

NASA did not achieve the FY 2023 milestones for this Performance Goal. While on track to support X-59, the F-15 platform was not ready by the end of FY 2023. Control surface rigging and system checks were completed on F-15D Tail Number (TN) 884 following required structural fatigue repairs. The aircraft completed its final Functional Check Flight in November 2023. F-15D instrumentation subsystems are ready for aircraft integration. Furthermore, the F-15B TN836 was fitted with an upgraded life support system that increased its max aircraft service altitude from 50k to 60k feet to support X-59 high-altitude flights and the in-flight system calibration is complete. F-15D TN897 longeron replacement funding was secured and maintenance is scheduled for completion in January 2024.

Below: Two of NASA's F-15 research aircraft take off in support of the Agency's Shock-Sensing Probe (SSP) research flight series at the Armstrong Flight Research Center in Edwards, California. Image Credit: NASA/Carla Thomas

3.2.3: Advance airframe and engine technologies to enable the development of future generations of ultra-efficient air vehicles that minimize environmental impact including electric aircraft propulsion concepts

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	5 of 5	4 of 4	6 of 6
Result	4		
Rating	Yellow		

Critical milestones for FY 2023

1. Design, build, test, and evaluate a suite of electrified aircraft propulsion (EAP) components to TRL-6 that are relevant for demonstrators and small EAP aircraft.
2. Design, build, and evaluate a suite of novel manufacturing technologies to TRL-4 that are relevant for high-rate, lightweight metallic fuselage manufacturing.
3. Critical Design Review (CDR) complete of at least one integrated, 1MW class electric powertrain flight demonstration.
4. Award of the Funded Space Act Agreement (FSAA) for the SFD aircraft design, development, and flight tests.
5. Develop and flight test a mission-controlled deployable and retractable Shape Memory Alloy Reconfigurable Technology-Vortex Generator (SMART-VG) "2nd Generation" system that demonstrates drag reduction and commensurate fuel savings and economic benefits on a commercial transport-class aircraft.

Critical milestones for FY 2024

1. Develop, test, and apply a model-based systems analysis & engineering (MBSA&E) framework for integrated, multi-fidelity vehicle concept design optimization and technology assessments.
2. Design and fabricate a wing/truss junction model section for the Subsonic Ultra Green Aircraft Research (SUGAR) Transonic Truss Braced Wing (TTBW) configuration, conduct a wind tunnel test in the GRC Icing Research Tunnel to investigate the icing exposure on this area of the TTBW configuration, and provide preliminary highlight of experimental and computational results of ice accretion.
3. Successful completion of the Electrified Powertrain Flight Demonstration (EPFD) project Integrated Baseline Review (IBR).
4. Successful completion of the Sustainable Flight Demonstrator (SFD) System Requirements Review (SRR).

Critical milestones for FY 2025

1. Enable revolutionary unducted propulsor for 2030's EIS through public-private partnership to collect experimental data supporting aeromechanics and aeroacoustics risk reduction and validating aerodynamic performance showing a step-change in fuel efficiency.
2. Develop noise estimates from high-fidelity simulations of the Transonic Truss-Braced Wing (TTBW) with the high-lift devices deployed in the landing phase of flight so that wind tunnel scaling effects can be evaluated as well as ranking the primary and secondary noise sources for this new configuration.
3. Design, build, test, evaluate a suite of composite manufacturing technologies at technical and manufacturing readiness level of 4 (TRL/MRL 4) that are relevant to high-rate, low-cost manufacturing of lightweight large composite airframe structures.
4. Assess the Phase 1 TRL 4/5 high-power density-core engine technologies contribution toward HyTEC's technical performance metrics.
5. Successful completion of the Sustainable Flight Demonstrator Preliminary Design Review (PDR).
6. Develop shape memory alloy (SMA) vortex generators (VGs) for noise reduction for transport aircraft high lift systems.

Lead Organization: Aeronautics Research Mission Directorate (ARMD)

FY 2023 Performance Progress

NASA partially achieved the FY 2023 milestones for this Performance Goal, earning a yellow rating. In FY 2023, NASA showcased advanced forming and joining techniques in a lightweight metallic fuselage at technology readiness level (TRL) 4. The work featured single-piece forming of stiffened cylinders and refill friction stir spot welding, eliminating hundreds of thousands of rivets. This improved fuselage performance by reducing weight, drag, and crack initiation sites. Trade studies predicted a 2% cost reduction and a 10% weight reduction compared to conventional aluminum aircraft construction. These technologies benefit U.S. industry by improving performance, doubling manufacturing rates, and enhancing sustainability through reduced fuel burn and waste, along with aluminum recyclability.

Furthermore, NASA demonstrated flight-ready electrified aircraft components at TRL 6. The team designed, built, and tested megawatt-class inverters, machines, and advanced circuit breakers for near-term flight demonstration. Achievements include a full-scale design of a megawatt machine, an altitude test of General Electric's SLIM inverter and machine, and three advanced circuit breakers that met all goals. The work advances the state-of-the-art and confirms the feasibility of high-power, low-loss components for safe flight operation. By progressing megawatt components—the building blocks for electrified regional and transport-class vehicles—the effort enables fuel burn reduction through electrification.

In FY 2023, NASA completed four Shape Memory Alloy Reconfigurable Technology Vortex Generators (SMART VG) modes of operation on 24 flights on the Boeing eco-Demonstrator 777-200ER, which seeks to make aviation more sustainable and fuel-efficient by decreasing drag in flight that could reduce aviation's environmental impact. The completed test results displayed favorable test conditions at a multi-speed of range operational conditions, confirming a computational fluid dynamic drag benefit reducing overall drag on the airplane more than 0.2%, in turn allowing engines to work more efficiently, saving fuel, and releasing fewer emissions.

In FY 2023, NASA has made significant progress with both Electrified Powertrain Demonstration Partners, GE and magniX; however, the plan of achieving one Critical Design Review (CDR) in FY 2023 was not achieved. The GE CDR shifted from summer of 2023 to early 2024 to mature Boeing Aurora Flight Sciences (GE Partner) aircraft interface control documentation needed to inform detailed design ahead of the CDR. In addition, new analysis revealed the need to update the wing leading edge design and perform additional arc-flash testing thereby moving the detailed design review from September to December 2023. magniX CDR is planned for late 2024 following a 15 month delay in preliminary design needed to mature their energy storage system and validate design considerations based on their unmodified D-7 demonstration vehicle. The 2023 Canadian wildfires significantly delayed ferry of the D-7 from a maintenance facility in Canada to magniX's aircraft integrator, AeroTEC, in Moses Lake, Washington. The D-7 is now with AeroTEC and magniX has proceeded toward PDR planned for late January 2024.

Finally, on January 18, 2023, NASA awarded a Funded Space Act Agreement (FSAA) to The Boeing Company for their Transonic Truss-Braced Wing (TTBW) aircraft design and flight tests. NASA is providing $425M in phased payments to Boeing contingent upon completing established FSAA milestones. NASA is also providing labor and facility resources. Boeing is providing an estimated $725M in the agreement. Since award, the Sustainable Flight Demonstrator achieved X-plane designation, X-66. Furthermore, the project has completed several key FSAA milestones to include baselining the airworthiness approach, completing MD-90 reactivation (basis for future X-66 modifications), and completing the Concept Design Review.

Below: GE Aerospace and magniX have revealed the paint schemes of the hybrid electric aircraft they will fly as part of NASA's Electrified Powertrain Flight Demonstration (EPFD) project. Image Credit: NASA, GE Aerospace, magniX

3.2.4: Advance airframe and propulsion technologies to enable the development of vertical take-off and landing (VTOL) vehicles that minimize noise and maximize safety

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	1 of 1	1 of 1	1 of 1
Result	1		
Rating	Green		

Critical milestones for FY 2023

1. Conduct a workshop open to US industry to foster transition and provide training for best-practice use of NASA-developed toolchain for Advanced Air Mobility (AAM) and Urban Air Mobility (UAM) aeromechanics and acoustic analysis.

Critical milestones for FY 2024

1. Apply and document reliability prediction for high reliability motor concept.

Critical milestones for FY 2025

1. Document capability to adequately model electric VTOL composite airframes under impact conditions.

Lead Organization: Aeronautics Research Mission Directorate (ARMD)

FY 2023 Performance Progress

NASA achieved the FY 2023 milestones for this Performance Goal, earning a green rating. In FY 2023, NASA completed the documentation of a workshop that was conducted in August 2022, that provided background, examples, and hands-on training for use of a NASA-developed toolchain for Advanced Air Mobility (AAM) and Urban Air Mobility (UAM) aeromechanics and acoustic analysis.

The Conceptual Design team of the NASA Revolutionary Vertical Lift Technology (RVLT) Project hosted a hybrid-format workshop at NASA Ames Research Center. Overviews of analysis tools were presented virtually, and hands-on training of tools was provided in-person. Workshop attendees were guided through the use of NASA-provided laptop computers to execute the toolchain for the NASA 6-occupant quadrotor Urban Air Mobility (UAM) reference vehicle, including rotor analysis, conceptual sizing, and noise prediction. A total of 107 people registered for the workshop: 38 government and 69 non-government. Industry registrants included representatives from Joby, Wisk, Archer, Boeing, Raytheon, and Elroy. Presentations from this workshop - and the previous two workshops - are archived on the RVLT Conceptual Design Toolchain website which remains available to registrants.

The workshop generated approximately 49 new Software Usage Agreements for the NASA Design and Analysis of Rotorcraft (NDARC, approximately 14), Rotorcraft Optimization Tools (RCOTOOLS, approximately 18), and Aircraft Noise Prediction Program/AeroAcoustic Rotor Noise (ANOPP2/AARON, approximately 17).

Ultimately, the ability to use advanced analysis tools for calculation of AAM and UAM vehicle design, performance, noise, flight dynamics and propulsion systems by the US industry will accelerate the integration of the AAM and UAM vehicles into the community.

3.2.5: Define and demonstrate solutions that predict, identify, and mitigate emerging safety risks and address the national need to safely transform the National Airspace System

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	1 of 1	1 of 1	1 of 1
Result	1		
Rating	Green		

Critical milestones for FY 2023

1. Analyze aircraft data and make recommendations for applying NASA's developed monitoring, assessment, and mitigation techniques to future aviation operations.

Critical milestones for FY 2024

1. Complete final testing and provide summary findings and recommendations to external stakeholders on implementation of In-Time System-Wide Safety Assurance data architecture to achieve required assurance levels.

Critical milestones for FY 2025

1. Complete a design space evaluation of In-Time Aviation Safety Management System (IASMS) architecture characteristics and requisite services, functions and capabilities to enable emergency response operations.

Lead Organization: Aeronautics Research Mission Directorate (ARMD)

FY 2023 Performance Progress

NASA achieved the FY 2023 milestones for this Performance Goal, earning a green rating. Work was successfully completed to define and demonstrate solutions that predict, identify, and mitigate emerging safety risks and address the national need to safely transform the National Airspace System during FY 2023.

Success criteria for this work was stated as "Analysis of flight and simulated test data. Report on relevance and application to future aviation operations."
Multiple conference papers have been published with others submitted to document analysis results by the System Wide Safety (SWS) Project. These included presentations at the American Institute of Aeronautics and Astronautics (AIAA) Aviation Forum (June 2023). During this international forum, NASA worked with AIAA planners to organize and conduct two invited sessions (10 papers) on SWS progress and results. Presentations were well received and generated a good amount of interest from the participants. Also, an article was published in the AIAA Air Transportation Journal analyzing the effect of wind on trajectory deviation during future urban flight operations. Additional documentation is in the form of NASA technical reports and pending conference papers.

The SWS Project team has also developed new machine learning algorithms to identify and help explain safety issues and a platform to depict the level of risk in flights. An early version of this platform was demonstrated at the Aviation Safety InfoShare Workshop in March 2023 and the final version, as well as the new machine learning algorithms, were demonstrated July 18, 2023 as part of a subproject closeout event.

3.2.6: Contribute toward the safe introduction of on-demand Urban Air Mobility (UAM) and other emerging operations by developing, applying, demonstrating, and validating advanced autonomy and automation technologies and providing methods or research results that support certification of autonomous systems

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	3 of 3	3 of 3	2 of 2
Result	3		
Rating	Green		

Critical milestones for FY 2023

1. Develop a prototype Digital Information Platform that will improve access to aviation data critical for the development of machine learning and artificial intelligence services that can improve the sustainability of aviation operations.
2. Demonstrate algorithms for checking safety standards for systems relying on untrusted components for autonomous surface operations and autonomous drone flight operations.
3. Demonstrate automated aircraft vertiport operations using operational scenarios through the Scalable Autonomous Operations simulation and flight test execution.

Critical milestones for FY 2024

1. Demonstrate an aviation service that applies machine learning to improve the sustainability of aviation operations.
2. Delivery of final evidence and recommendations for the FAA, UAST, and Flight Safety Foundation on a process for certification of learning-enabled components in aerospace systems.
3. Demonstrate automated integrated aircraft/airspace operations using operational scenarios in the Integrated Automation Systems-1 (IAS-1) flight test.

Critical milestones for FY 2025

1. Evaluation of an aviation service for routine and scalable increasingly autonomous operations.
2. Perform an evaluation of assurance methodologies necessary to assure machine-learning enabled In-Time Aviation Safety Management System (IASMS) services, functions and capabilities (SFC) that enable emergency response operations.

Lead Organization: Aeronautics Research Mission Directorate (ARMD)

FY 2023 Performance Progress

NASA achieved the FY 2023 milestones for this Performance Goal, earning a green rating. The Air Traffic Management Exploration Project team continued development of a cloud-based reference Digital Information Platform (DIP) and progress toward demonstrating an aviation service that uses machine learning (ML) to identify pre-departure reroutes that save fuel, reduce emissions, and improve sustainability of aviation operations.

A cohort of five airlines signed a collaborative agreement to support the digital information platform development and sustainable aviation demonstrations. Features that have been added to the digital information platform include information streaming leveraging the Federal Aviation Administration's (FAA's) Flight Information eXchange Model (FIXM) format, access to archived historic data to facilitate training of artificial intelligence/machine learning (AI/ML) models, the ability to search and discover services hosted on the platform, and the ability to report and visualize key performance metrics.

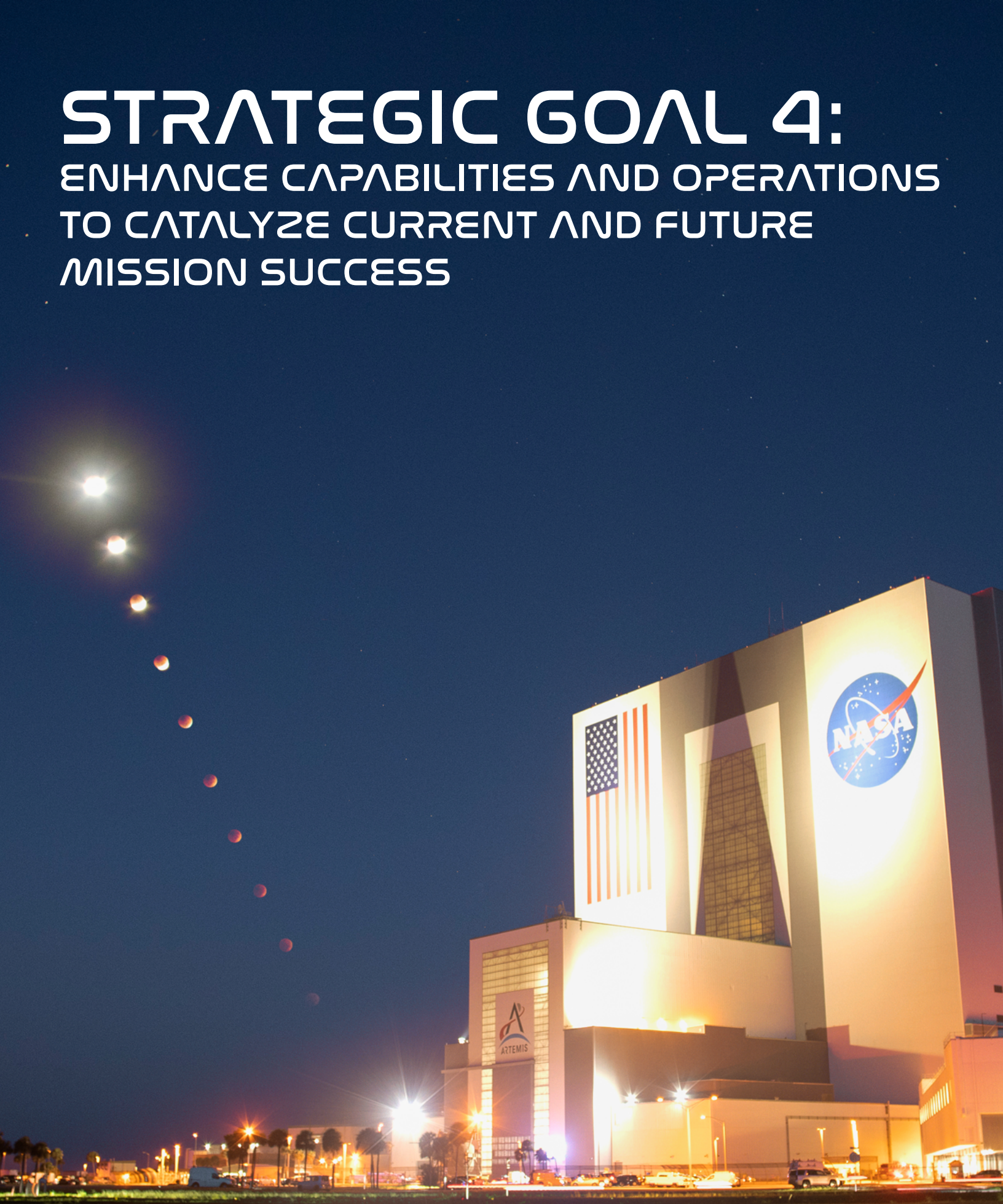
Public access to the DIP platform and specific services was granted in September 2023, giving government agencies, academic research groups, and industry an opportunity to use the aviation data provided by DIP's and provide quick feedback to inform information sharing requirements. Additionally, the cloud deployment of the Collaborative Digital Departure Re-route (CDDR) service was successfully completed in April 2023. The cloud-based service is being tested at the North Texas Research Station, where the machine learning model performance is being captured and monitored along with the performance of the digital information platform. A service reporting dashboard is being used to monitor and track the performance of the machine learning based services currently available on the platform. A novel machine learning approach was also implemented to make it easier to adapt the service to new airports, resulting in reduced time to scale the service to new locations.

NASA's System Wide Safety Project team published and received recognition for techniques that allow for a mathematical analysis of machine learning techniques, in particular, deep neural networks. The research has demonstrated safety analysis techniques for systems including machine learning (ML)-enabled components. The results are aiming to support the development of standards for ML-enabled components in FY 2024. To this effect, coverage metrics (similar to what is currently in the DO-178C standard) for neural networks have

been studied and developed. The NASA team has also demonstrated algorithms to verify assurance at the component level and then at the system level using a compositional framework.

The High Density Vertiplex (HDV) Sub-project team within the Advanced Air Mobility Project completed the Scalable Autonomous Operations (SAO) Prototype Assessment Operations (PAO) flight test. The SAO-PAO flight test included representative systems including Onboard Autonomy, Airspace Management, Ground Control and Flight Management, and Vertiport Automation capabilities. The HDV team completed all their planned tests and test cards, running over 60 operations per hour. They received their Certificate of Authorization (COA) for beyond visual line of sight operations from the FAA and were able to complete their test plans with vehicles beyond visual line of sight for the pilot.

STRATEGIC GOAL 4:
ENHANCE CAPABILITIES AND OPERATIONS TO CATALYZE CURRENT AND FUTURE MISSION SUCCESS



This composite made from ten images shows the progression of the Moon during a total lunar eclipse above the Vehicle Assembly Building (VAB) November 8, 2022, at NASA's Kennedy Space Center in Florida. Standing 525 feet tall and containing 130 million cubic feet of interior space, the VAB is NASA's VAB is one of the largest buildings in the world. Visible trailing the Moon in this composite is Mars. Image Credit: NASA/Joel Kowsky

FY 2023 Performance Goals and Ratings Supporting Strategic Goal 4

Strategic Objective	Performance Goal	Description	Rating
4.1	**Attract and Develop a Talented and Diverse Workforce**		
	4.1.1	Decrease overall Agency time to hire	Green
4.2	**Transform Mission Support Capabilities for the Next Era of Aerospace**		
	4.2.1	Minimize the number and severity of employee injuries and illnesses to support the next era of aerospace	Green
	4.2.2	Reduce damage to NASA assets (excluding launched flight hardware)	Green
	4.2.3	Ensure the health and safety of NASA astronauts and pilots	Green
	4.2.4	Safeguard NASA's information resources through critical enhancements to confidentiality, integrity, and availability	Red
	4.2.5	Demolish or eliminate obsolete/unneeded facilities to reduce the Agency's infrastructure footprint	Green
	4.2.6	Improve NASA's ability to operate facilities sustainably and reduce overall resource demands	Green
	4.2.7	Demonstrate increased facility reliability for current and future mission needs through investments in preventative maintenance that reduce unscheduled maintenance	Yellow
4.3	**Build the Next Generation of Explorers**		
	4.3.1	Create unique opportunities for a diverse set of students to contribute to NASA's work in exploration and discovery	Green
	4.3.2	Build a diverse future STEM workforce by engaging students in authentic learning experiences with NASA's people, content, and facilities	Green
	4.3.3	Attract diverse groups of students to STEM through learning opportunities that spark interest and provide connections to NASA's mission and work	Green
	4.3.4	Promote equal opportunity compliance and encourage best practices among NASA grant recipient institutions to ensure that grantees are providing equal opportunity regardless of race, color, national origin, sex (including pregnancy, sexual orientation, gender identity), age, or disability	Green

STRATEGIC OBJECTIVE 4.1

Attract and Develop a Talented and Diverse Workforce

LEAD OFFICE
Mission Support Directorate (MSD), Office of the Chief Human Capital Officer (OCHCO), and Office of Diversity and Equal Opportunity (ODEO)

GOAL LEADER
Bob Gibbs, Associate Administrator, MSD; Elaine Ho, Associate Administrator for Diversity and Equal Opportunity; Kelly Elliott, Chief Human Capital Officer

BUDGET

	FY	$M
Op Plan	2023	$106.4
Enacted	2024	$110.8
Requested	2025	$118.2
Outyear	2026	$120.6
	2027	$123.0
	2028	$125.4
	2029	$128.0

NASA is committed to cultivating an excellent and inclusive team to accomplish its goals. Strategic Objective 4.1 outlines NASA's plans to improve its human resource management and implement its Equity Action Plan for diversity, equity, inclusion, and accessibility (DEIA). Over the last year, the Agency took significant steps forward by inaugurating multiple barrier analyses and impact assessments to identify and guide its efforts.

Streamlining the NASA hiring process to bring in top talent remains a priority for the Agency. Time to hire, for all hires, excluding Senior Executive Service (SES) and Pathways, has been reduced from 99 to 75 days in FY 2023 (Target: 80 days – OPM benchmark), and NASA is currently taking steps to gain efficiency through multiple initiatives, such as using existing certificates to reduce the time and resources required to acquire new hires. In Q4 FY 2023, NASA had 56% of its selections come from existing certificates. These efforts are paramount for NASA attracting technical talent in a hyper competitive labor market in a growing aerospace industry.

A significant portion of Strategic Objective 4.1 is mapped to the NASA Equity Action Plan. The last year saw significant steps forward in launching assessments and completing steps of the plan, most notably an Agency-wide anti-harassment self-assessment in 2023. At the same time, ambitious action demonstrated that ODEO does not have the staff to conduct the 10 Civil Rights Compliance checks a year, as required by the NASA Equity Action Plan. Looking forward, NASA expects to make progress toward this Strategic Objective.

The Agency initiated a DEIA Index within the Federal Employee Viewpoint Survey for the FY 2022 survey. This index is a collection of 12 questions that focus on employee perceptions of various DEIA elements throughout the Agency. In FY 2023, NASA registered negative responses at 14.4% percent. ODEO and OCHCO are partnering to seek ways to address the issues raised by the negative responses and improve this metric in future years, demonstrating the commitment the Agency has to this vital initiative.

Based on MSD, OCHCO, and ODEO's strategy and accomplishments described in the above paragraphs, Strategic Objective 4.1 achieved a Green/Satisfactory rating during the 2023 Strategic Review Process.

Above: On International Women's Day, March 8, 2023, NASA celebrated the women responsible for helping return humanity to the Moon, including the first woman and first person of color under NASA's Artemis missions. Artemis launch director – and NASA's first woman launch director – Charlie Blackwell-Thompson leads her launch team, which is composed of about 30% women, into a new era of space exploration. Image credit: NASA/Kim Shiflett

4.1.1: Decrease overall Agency time to hire

Time between hiring need validation date and enter on duty date for all hires, excluding Pathways and Senior Executive Service (SES) hires, from the FY 2021 baseline of 104 days to a long-term goal of 80 days. Decrease of 5% or more from FY 2022 actual (85 days).

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	<81	<80	<80
Result Average	75		
Rating	Green		

Lead Organization: Office of the Chief Human Capital Officer (OCHCO)

FY 2023 Performance Progress

NASA achieved a Green rating for this Performance Goal for FY 2023, surpassing the target of 81 days, which was a 5% reduction from the FY 2022 baseline of 85 days. NASA finished FY 2023 with an average time to hire of 75 days, which is 6 days less than the target. In addition to the FY 2023 target of 81 days, NASA also achieved the long-term target of 80 days while experiencing a 20% increase in the number of hires over FY 2022. The Agency's FY 2023 improvement in time to hire is the result of concentrated communication efforts to increase the number of selections from existing certificates, an increased emphasis on hiring managers planning to make selections quickly and improvements in approving hiring incentives.

NASA will strive to maintain the average overall time to hire at or below 80 days in FY 2024. To minimize time to hire, NASA will focus on increasing the awareness and use of non-competitive hiring authorities, partnering across the Agency to continue improvement with our use of workforce planning data to better project both short-term and long-term hiring needs in an effort to maximize recruitment efforts while maintaining our successful strategies of increasing selections made from existing certificates, implementing various efficiencies, and streamlining the end-to-end hiring processes.

A key tool in the Agency's improvement in time to hire has been NASA's use of government-wide and Agency specific direct hire authority (DHA). DHA enables Federal agencies to fill vacancies in specific occupations, grade levels, and locations when it can be proven that there is a critical hiring need or a severe shortage of candidates, aiding the agility of NASA's hiring processes. These authorities expire in 2024. NASA will continue to seek DHA and other flexibilities that will help maintain NASA's competitiveness in our market and develop options for hiring critical positions.

We must be able to successfully compete for the skills and the diverse talent essential to deliver on our missions in a highly competitive market with a growing commercial aerospace sector. Our success in continuing to reduce time to hire is critical to staying competitive in the labor market.

4.1.2: Decrease percentage of negative rating on NASA Federal Employee Viewpoint Survey (FEVS) DEIA (Diversity, Equity, Inclusion, and Accessibility) index (new Performance Goal beginning in FY 2024)

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	N/A	88%	89%
Result	N/A		
Rating	N/A		

Lead Organization: Office of the Chief Human Capital Officer (OCHCO) and Office of Diversity and Equal Opportunity (ODEO)

4.1.3: Conduct an Agency-wide Full Workforce Barrier Analysis via a multi-phase evaluation of barriers. The barrier analysis will address NASA's overall workforce across the Agency and will examine four key identities: 1) race/ethnicity, 2) gender, 3) disability status, 4) LGBTQIA+* and include a component addressing NASA's leadership pipeline (new Performance Goal beginning in FY 2024)

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	N/A	3 of 3	3 of 3
Result	N/A		
Rating	N/A		

Lead Organization: Office of the Chief Human Capital Officer (OCHCO) and Office of Diversity and Equal Opportunity (ODEO)

*Lesbian, Gay, Bisexual, Transgender, Queer, Intersex, Asexual

Critical milestones for FY 2023

1. N/A

Critical milestones for FY 2024

1. Phase 1 - Personnel Data Analysis
2. Phase 2- Shareholder Interviews
3. Phase 3- Quantitative Survey

Critical milestones for FY 2025

1. Phase 4- Focus Groups
2. Phase 5- Barrier Identification
3. Phase 6- Barrier Mitigation

STRATEGIC OBJECTIVE 4.2

Transform Mission Support Capabilities for the Next Era of Aerospace

LEAD OFFICE
Mission Support Directorate (MSD)

GOAL LEADER
Bob Gibbs, Associate Administrator, MSD; Joel Carney, Associate Administrator for OSI; Jeff Seaton, Chief Information Officer, OCIO

BUDGET

	FY	$M
Op Plan	2023	$3,435.8
Enacted	2024	$3,425.4
Requested	2025	$3,343.1
Outyear	2026	$3,356.7
	2027	$3,423.8
	2028	$3,492.2
	2029	$3,562.0

NASA's ambitious plans of exploration and innovation in air and space are underpinned by expertise, infrastructure, and workforce on Earth. Strategic Objective 4.2 is divided in to three priority areas to track NASA's progress in sustaining each of these mission support areas: 1) Agency Technical Authorities overseeing mission safety, 2) infrastructure modernization efforts, and 3) information technology. Facing continued budgetary shortfalls, NASA's support activities are divided between those that are creating successes under difficult conditions, and those that are focus areas for improvement. Efforts to optimize resources continue to be intensely studied and implemented, such as innovations in information technology and maintenance techniques.

PRIORITY AREA 1: Strengthen NASA's Agency Technical Authorities (ATA)

NASA technical authorities support safety and mission success by providing independent engineering, health and medical, and safety oversight to programs to support successful launch and execution of the Agency's missions and activities. NASA's 2023 Strategic Review determined that the Agency's ambitious program of manned and unmanned exploration presents an increased demand on Agency Technical Authority (ATA) resources, including assessment capacity by the NASA Engineering and Safety Center (NESC), but that the

Above: NASA conducted an RS-25 hot fire test on the Fred Haise Test Stand - one of several test stands - at NASA's Stennis Space Center in south Mississippi on June 22, 2023. With this NASA achieved a key milestone, completing an initial certification test series designed to pave the way for production of new RS-25 engines to help power NASA's SLS (Space Launch System) rocket on future Artemis missions to the Moon,beginning with Artemis V. Image Credit: NASA

ATA's had satisfactory strategies and performance. In addition to the progress described below in the sections on Performance Goals 4.2.1, 4.2.2 and 4.2.3, the ATAs have released updated requirements, standards, and guidance critical to safety and mission success:

- a two-volume update to "NASA Spaceflight Human-System Standard" (NASA-STD-3001), released in September 2023, outlining the Agency-level technical requirements, established by the Office of the Chief Health and Medical Officer, directed at minimizing health and performance risks for flight crews in human spaceflight programs;
- a new Nuclear Flight Safety Handbook (NASA-HDBK-8715.26) "Information and Best Practices Related to NASA Nuclear Flight Safety for Space Flights Involving Space Nuclear Systems";
- and "Wind Tunnel Model Systems Criteria" (NASA-STD-8719.28), which replaces individual Center wind tunnel standards with an Agency standard to ensure test models can move seamlessly from one Center to another.

PRIORITY AREA 2: Modernize infrastructure and technical capabilities

NASA's program of research and discovery requires a strong foundation of physical and technical infrastructure for our engineering, research, support, and safety activities. Ensuring this infrastructure is modern and reliable is therefore key. Overall, 83% of NASA's 5,523 buildings/structures are past their design life. Unplanned maintenance criticalities have continued to rise each year. However, progress implementing Performance Goals has continued apace, aligns them with current and future Agency needs, and prioritizes maintenance and demolition. Over the last year, significant mitigation efforts have yielded valuable results: the implementation of condition-based maintenance study has increased maintenance cost avoidance by 20%. Furthermore, the Agency was able to decrease its infrastructure footprint and resource demands in FY 2023 by eliminating 40 obsolete and/or unneeded facilities, reducing energy intensity by 40% since 2003, and decreasing water intensity by 33% since 2007. Unscheduled maintenance still remains an issue for the Agency as our equipment ages. The Agency has deployed a tiered maintenance plan to mitigate this issue.

PRIORITY AREA 3: Support our workforce with secure, innovative technology

NASA continues to experience higher demand for digital capabilities and an increasing backlog of IT modernization needs. This dynamic IT environment requires continuous attention to address IT infrastructure obsolescence, resourcing, and cybersecurity risks to effectively support NASA's missions. NASA is continuing transition to an enterprise operating model for IT. Revitalized roadmaps are facilitating planning and execution of the forthcoming NASA IT Strategic Plan, and IT is transforming how the Agency achieves our missions. The OneNASA intranet enhanced Agencywide information sharing, consolidating 109 websites. NASA's modernized public website, in beta testing, enables missions to communicate more effectively, including improved accessibility for people with disabilities. NASA's cybersecurity scorecard rating remains an issue for the Agency, as we did not achieve our internal target. NASA's strategy for rectifying this complicated issue focuses on enhancing the Agency's capabilities around Multi-Factor Authentication, Data-at-Rest encryption, and Data-in-Transit encryption.

Based on MSD, OSI, and OCIO's strategy and accomplishments described in the above paragraphs, Strategic Objective 4.2 achieved a Yellow/Focus Area for Improvement rating during the 2023 Strategic Review Process.

4.2.1: Minimize the number and severity of employee injuries and illnesses to support the next era of aerospace

Number of Occupational Safety and Health Administration (OSHA) recordable injuries or illnesses per 100 employees (i.e., Total Case Rate) and number of injuries or illnesses per 100 employees that result in days away from work or restricted duty (i.e., Days Away, Restricted, or Transferred Case Rate) compared to Federal and industry standards.

Metric assessed by Centers above 12-month Total Case Incident Rate (TCIR)/ days away from work or restricted duty (DART) North American Industry Classification System (NIACS) industry rates, and 12-month Agency-wide TCIR/DART rates against industry averages.

Target of staying below 4 Centers exceeding TCIR/DART rates. For 2023, 0 Centers exceeded TCIR/DART rates.

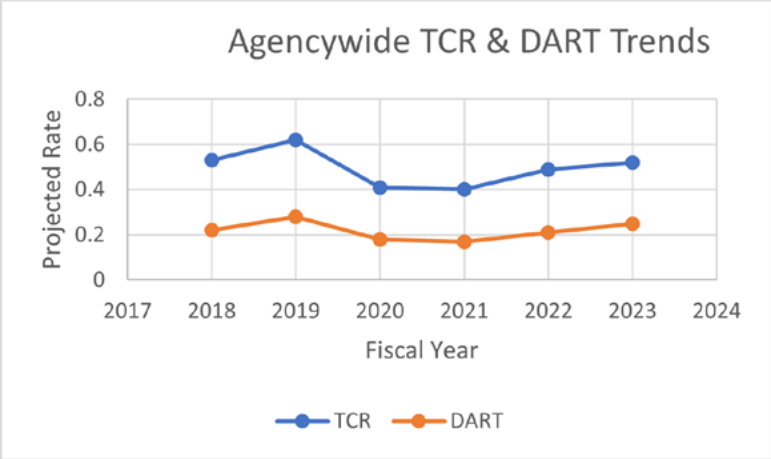
	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target per 100 Employees	<0.7 TCIR <0.3 DART	<0.9 TCIR <0.3 DART	TBD
Result	0.45 TCIR 0.21 DART		
Rating	Green		

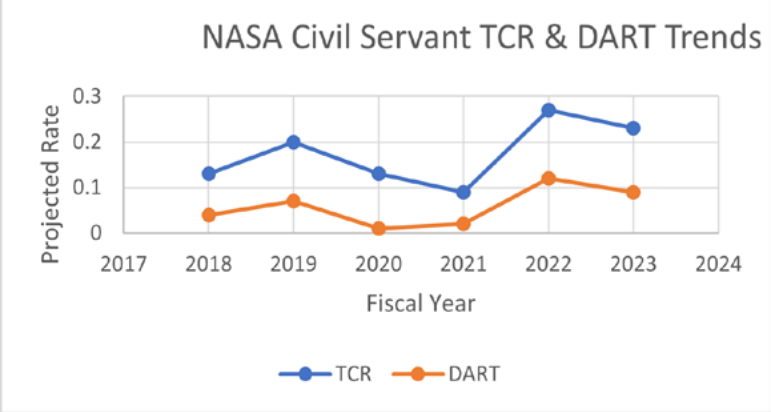
Lead Organization: Agency Technical Authorities

FY 2023 Performance Progress

NASA measures its ability to minimize employee injury and illness by assessing its total number of OSHA-recordable injuries or illnesses TCIR and those which result in DART compared to industry averages. Agency rates are averaged across 10 NASA Centers and include both civil servants and contractor employees. The Agency's FY 2023 TCIR of 0.45 and DART of 0.21 as of the end of the fiscal year are well below industry average targets of 0.7 and 0.3, respectively. For Agency civil servants, the rates were 0.20 TCIR and 0.03 DART. NASA maintains a world-class occupational safety and health program and is a result of NASA planning and executing a very strong occupational safety and health program. NASA achieved the FY 2023 milestones for this Performance Goal leading to a Green rating.

Below Top: Historical Trends for Agencywide TCR and DART data (Source: NASA)
Below Bottom: Civil Servant-only TCR and DART Trends (Source: NASA).





4.2.2: Reduce damage to NASA assets (excluding launched flight hardware)

Cost of mishaps to NASA assets (excluding launched/ operational flight hardware) compared to 5-year median*.

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	<$4.00 mil	<$3.52 mil	TBD
Result	$3.84 mil		
Rating	Green		

*The NASA Safety Center analyzes damage mishaps (excluding launched/operational flight hardware reported by Centers to the NASA Mishap Information System. NASA's analysis includes NASA assets onsite at a Center or involving NASA assets on grounds outside Center property (i.e., including contractor sites) as described in NASA Procedural Requirements 8621.1D, "NASA Procedural Requirements for Mishap and Close Call Reporting," Investigating, and Recordkeeping. Assets in flight or in space operations are not included.

Lead Organization: Agency Technical Authorities

FY 2023 Performance Progress

Over FY 2023, NASA's non-mission related damage costs were $3.84 million, below FY 2022's total of $4.95 million. Damage costs were primarily spread across multiple events as a result of facility system failures. As a performance metric, NASA measures the previous 12-month total damage cost against the annual average across the previous five years, which as of the end of FY 2023 measured $4 million. With the $3.84 million total below the 5-year average, this Performance Goal received a Green rating for FY 2023.

Below: Launch Equipment Test Facility Image Credit: NASA

4.2.3: Ensure the health and safety of NASA astronauts and pilots

Number of non-concurrence determinations by the Health and Medical Technical Authority (HMTA) and percentage of program variances from health and medical policies and standards*.

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	0 non-concurrences 5% or fewer variances	0 5%	0 5%
Result	0 non-concurrences 5% or fewer variances		
Rating	Green		

*Continuous measurement of the ability to accomplish the human space flight manifest. Successful execution of the flight manifest indicates successful support for NASA flight programmatics through ongoing observation and documentation of flight activities and evaluation processes, as well as effective implementation of Health and Medical standards and operations.

A concurrence is a documented agreement by the HMTA that a proposed course of action associated with a program or project position, issue resolution, request for relief from HMTA standards, or program or project level requirements is acceptable.

For every NASA program with a potential impact to humans, the HMTA coordinates with the cognizant program to provide the applicable flow-down of health and medical standards into program requirements. The HMTA discusses with programs any non-concurrences it issues at milestone and Key Decision Point reviews and Joint Cost and Schedule Confidence Level (JCL) meetings.

A variance is any authorized and documented change from prescribed technical requirements for a program or project.

Lead Organization: Agency Technical Authorities

FY 2023 Performance Progress

In FY 2023, the Health and Medical Technical Authority (HMTA) issued no non-concurrences with respect to major program milestones. In addition, the HMTA issued no program variances from the technical standards, leading to a Green Performance Goal rating. Meeting these targets furthers NASA's commitment mission safety. The HMTA's mission is to prevent or mitigate adverse health and medical events and provide for the human performance. HMTA work has proven critical in the development of appropriate standards, as well as insight and oversight across multiple Programs.

In FY 2023 HMTA continued to apply prioritized, time-critical resources amongst and between Programs and in the evaluation of requests for waiver or risk mitigations, as well as the approval of baselined adjudicated requirements.

4.2.4: Safeguard NASA's information resources through critical enhancements to confidentiality, integrity, and availability

Scoring is based on Cybersecurity Scorecard data collected from multiple Agency sources and also feeds the Federal Cybersecurity Dashboard. NASA's cybersecurity scorecard metric is taken from the average of the 20 individual overall scores that span the Missions, corporate organizations, and Centers/ Federally Funded Research and Development Centers (FFRDCs) and is supported by 95 "child" metrics.

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	85%	90%	94%
Result	67.2%		
Rating	Red		

Lead Organization: Office of the Chief Information Officer (OCIO)

FY 2023 Performance Progress

NASA updated our cybersecurity performance goal for FY 2023 to address OMB's revised criteria for cybersecurity. These criteria drive performance across a broad set of key indicators including Operating System Management, Security Plan Management, Vulnerability Management, and Protection capabilities. Scoring for this performance goal is based on NASA's Cybersecurity Scorecard, launched in late FY 2022. Scorecard data is collected from multiple Agency sources and feeds the Federal Cybersecurity Dashboard. NASA's cybersecurity score is obtained from the average of the individual overall scores that span the mission directorates, corporate organizations, and FFRDCs and is supported by numerous underlying metrics.

NASA made progress in FY 2023 across mission directorates, corporate organizations, and Centers/ FFRDC to improve the Agency's cybersecurity posture as measured through this internal scorecard. However, NASA's overall score was 67.2%, a Red rating since the Agency did not achieve its internal target of 85% for FY 2023. NASA's cybersecurity efforts included focus on the government-wide action from the National Security Council (NSC) to strengthen three specific capabilities in the scorecard: Multi-Factor Authentication, Data-at-Rest encryption, and Data-in-Transit encryption. NASA's FY 2023 score reflects increased visibility into a significant number of devices across the Agency that were added to the scorecard. These were largely systems that required a risk-based decision, and NASA implemented other risk mitigating controls.

4.2.5: Demolish or eliminate obsolete/unneeded facilities to reduce the Agency's infrastructure footprint

Annual reduction in square footage or number of facilities

*Performance Goal titled 4.2.6 in FY 2024 and FY 2025

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	471,000 sq ft 20 facilities	471,000 sq ft	471,000 sq ft
Result	457,000 sq ft 40 facilities		
Rating	Green		

Measure of the amount of obsolete and/or unneeded space (square footage or facilities) that is either demolished or otherwise eliminated (through Real Property actions) from NASA's portfolio and will no longer require funds for maintenance.

This is calculated through the sum of square footage demolished or otherwise eliminated in the period, as recorded in the Real Property Management System.
Lead Organization: Office of Strategic Infrastructure (OSI)

FY 2023 Performance Progress

This Performance Goal received a Green rating. By eliminating inactive and obsolete facilities, we improve energy efficiency, reduce the Agency's footprint, eliminate safety and environmental liabilities, and make room for new construction that fits NASA's current and future needs. During FY 2023, we eliminated $44.7 million of deferred maintenance and avoided $1.4 million in maintenance and operations costs. In addition, we reduced the current replacement value by $224.2 million.

4.2.6: Improve NASA's ability to operate facilities sustainably and reduce overall resource demands

Percentage of sustainability goals met annually in the OMB Scorecard for Efficient Federal Operations/ Management*

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	80%	80%	80%
Result	88%		
Rating	Green		

Measure of NASA's performance in seven distinct sustainability efficiency areas: energy intensity usage, efficiency opportunities, use of renewable energy, water intensity, high performance sustainable buildings, fleet's fuel use, and sustainable acquisitions.

*A fiscal year's OMB Scorecard for Efficient Federal Operations/Management is released more than 6 months after the close of that fiscal year. Therefore, NASA will use the previous fiscal year's results to assess progress.

Target represents the long-term exemplar for this Performance Goal. NASA assesses annual progress based on an interim target of 80% for both FY 2023 and FY 2024.

Lead Organization: Office of Strategic Infrastructure (OSI)

FY 2023 Performance Progress

The Office of Management and Budget released NASA's FY 2022 Scorecard during the fourth quarter of FY 2023. NASA met or exceeded 7 out of 8 (88%) of sustainability goals in the OMB Scorecard, including reducing energy intensity by 40% from 2003, exceeding the goal of 30%; and reducing water intensity by 33% from 2007, exceeding the goal of 20%. The report recognized NASA for being in top 25% of Federal agencies in completing facility evaluations as required by the Energy Independence and Security Act (EISA) of 2007 and for exceeding requirements for performance contracting investments in energy/water efficiency.

NASA did not add new light duty zero emissions vehicles (LD-ZEV) to its fleet in FY 2023 however, this was part of the Agency's strategy to direct investments to infrastructure before increasing its LD-ZEV fleet. As a result of this investment, the Agency increased its number of charging ports by 23%.

Total Existing EVSE Ports in FY22	441
EVSE Ports added in FY23	101
Total EVSE Ports in FY23	542
Percentage Increase of Ports from FY22 to FY23	23%

4.2.7: Demonstrate increased facility reliability for current and future mission needs through investments in preventative maintenance that reduce unscheduled maintenance

Percentage of maintenance funds dedicated to unscheduled maintenance

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	<20%	<20%	<20%
Result	20.4%		
Rating	Yellow		

Lead Organization: Office of Strategic Infrastructure (OSI)

FY 2023 Performance Progress

NASA achieved a ratio of 20.4% unscheduled to total maintenance costs for FY 2023, above the annual target of 20%, leading to a Yellow rating for this Performance Goal.

NASA performs scheduled maintenance on its equipment to keep it in good operating condition. When equipment fails, we must perform unscheduled maintenance to repair it. The percentage of unscheduled maintenance spending to total maintenance spending is an indicator of the overall condition of the equipment. More unscheduled maintenance indicates that the equipment has become unreliable and unplanned failures and outages become more frequent, which can delay mission activities, such as manufacturing and testing. We continue deployment of tiered maintenance and condition-based maintenance processes across the Agency, which helps to reduce unplanned downtime and equipment failures.

The Office of Strategic Infrastructure's Facilities and Real Estate Division, is also tracking increased risk within the Infrastructure and Technical Capabilities, Facility Services Account related to growth of percent unscheduled maintenance.

Historical comparison of unscheduled versus total maintenance cost, FY 2019-2023

2019	24.7%
2020	21.3%
2021	19.0%
2022	20.4%
2023	20.4%

4.2.8*: Increase the cumulative annualized person hours saved through automation (new Performance Goal beginning in FY 2024, *will be 4.2.5)

Number of cumulative person hours saved

Lead Organization: Office of the Chief Information Officer (OCIO)

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	N/A	45,000	N/A
Result	N/A		
Rating	N/A		

4.2.5*: Maximize the availability of the Space Environment Testing Management Office (SETMO) portfolio of assets to meet NASA's current and future test facility needs. (*Sunset Performance Goal in FY 2022)

Lead Organization: Office of Strategic Infrastructure (OSI)

FY 2023 Performance Progress

NASA maintained mission critical test availability for the SETMO Tier 1 assets, which included flight simulation, space environments testing, high-enthalpy simulation and testing, and the Thermal Vacuum Test Chamber B at the Johnson Space Center in Houston. In turn, this Performance Goal received a Green rating.
NASA's workforce performs essential preventive maintenance to ensure that key capabilities and critical assets are available on-time when needed and will continue to be available in the future to support the missions that require them.

STRATEGIC OBJECTIVE 4.3

Build the Next Generation of Explorers

LEAD OFFICE
Office of Science, Technology, Engineering, and Math (OSTEM)

GOAL LEADER
Kris Brown, Deputy Associate Administrator for STEM Engagement, OSTEM

BUDGET

	FY	$M
Op Plan	2023	$152.2
Enacted	2024	$151.0
Requested	2025	$150.7
Outyear	2026	$153.8
	2027	$156.8
	2028	$160.0
	2029	$163.1

NASA makes vital investments toward building a diverse STEM workforce. The scope of our STEM engagement comprises all endeavors to attract, engage, and educate students and to support educators and educational institutions. NASA's STEM engagement investments are intended to build a diverse, skilled future STEM workforce–our next generation of explorers who possess the technical skills needed to advance our Nation's vital mission and work in aeronautics and space into the future. The national STEM ecosystem will benefit from NASA's contributions to attract and retain students on STEM pathways with increased attention on underserved and underrepresented students.

Over the last year, NASA's STEM outreach and engagement efforts have achieved all its Performance Goals within cost and schedule constraints. In FY 2022, OSTEM supported 25 active national partnerships via Space Grant and 21 informal collaborations to share student content, such as with Nickelodeon, Discovery, LEGO, and Girl Scouts. Furthermore, the creation of a consolidated, Agency-wide cloud service contract has helped save on personnel and administrative costs.

NASA has a long history of investing in and inspiring new talent to join the STEM workforce. OSTEM's rigorous strategy aims to focus these efforts an evidence-based approach. Furthermore, there are clear strategies in place to continue to achieve strategic objectives. OSTEM's FY 2023-2024 Learning Agenda poses questions that will prepare the Agency for the future of its STEM engagement initiatives. OSTEM completed two assessments from its learning agenda and is making progress on two more evaluations, including assessment of NASA internship outcomes regarding NASA/industry employment and Phase 2 of the K-12 Student Outcome Study (expected before the end of FY 2023).

Based on OSTEM's strategy and accomplishments described in the above paragraphs, Strategic Objective 4.3 achieved a Blue/Noteworthy rating during the 2023 Strategic Review process.

Above: NASA's SpaceX Crew-3 astronaut Tom Marshburn participates in a STEM demonstration during a visit to Amidon-Bowen Elementary School, December. 8, 2022, in Washington. Image Credit: NASA/Keegan Barber

4.3.1: Create unique opportunities for a diverse set of students to contribute to NASA's work in exploration and discovery

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	2 of 2	2 of 2	1 of 1
Result	2		
Rating	Green		

Critical milestones for FY 2023

1. Advance higher education students' STEM skills by supporting the release of at least 2000 paper presentations and peer-reviewed research publications through STEM engagement investment.
2. Conduct a MUREP Outcome Assessment.

Critical milestones for FY 2024

1. Measure the number of paper presentations and peer-reviewed research publications resulting from higher education students' engagement in STEM engagement investments (2,200).
2. Complete milestone of Space Grant Program-Level Evaluation.

Critical milestones for FY 2025

1. Measure the number of paper presentations and peer-reviewed research publications resulting from higher education students' engagement in STEM engagement investments (2,200).

Lead Organization: Office of STEM Engagement (OSTEM)

FY 2023 Performance Progress

NASA met the target for Performance Goal 4.3.1. resulting in a Green rating. Results indicate that NASA achieved this performance goal with a reported total of 3,613 peer-reviewed publications, technical papers, and presentations, exceeding the target of 2,000. NASA's performance in providing opportunities for students to contribute to NASA's aeronautics, space, and science missions and work was assessed across peer-reviewed publications, non-peer-reviewed technical publications, and invited and self-submitted paper presentations directly resulting from research funded by NASA STEM Engagement grants and awards to higher education institutions. As a direct result of NASA STEM Engagement investments, Space Grant, Established Program to Stimulate Competitive Research (EPSCoR), Next Gen STEM, and Minority University Research and Education Project (MUREP), grantee and awardee institutions published and submitted 982 peer-reviewed papers, published or presented 330 technical papers, and delivered 2,301 invited or self-submitted paper presentations. Notably, students authored or co-authored 47 percent of the peer-reviewed publications. Additionally, 22 patents and technology transfers were awarded to higher education institutions as a direct result of their NASA STEM Engagement grants or cooperative agreements. The MUREP Outcome Assessment was also conducted including completion of data collection and analysis and the development of an evaluation report, including findings and recommendations, of MUREP investments.

4.3.2: Build a diverse future STEM workforce by engaging students in authentic learning experiences with NASA's people, content, and facilities

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	2 of 4	2 of 4	3 of 5
Result	3		
Rating	Green		

Critical milestones for FY 2023

1. Meet or exceed 7.6% of student diversity for racially underrepresented students (African Americans, American Indians, Alaska Native, Native Hawaiians and Pacific Islanders).
2. Meet or exceed 15.9% of student diversity for ethnically underrepresented students (Hispanics and Latinos).
3. Meet or exceed 44.1% of student diversity for women.
4. Engage students across all institutional categories and levels (as defined by the U.S. Department of Education).

Critical milestones for FY 2024

Meet or exceed targets for two of the four categories: provide STEM Engagement opportunities to higher education students in four categories of student diversity for both virtual and in-person higher education STEM engagement activities:

1. Racially underrepresented students
2. Ethnically underrepresented students (Hispanics and Latinos, African Americans, American Indians, Alaska Native, Native Hawaiians and Pacific Islanders)
3. Women
4. Students across all institutional categories and levels (as defined by the U.S. Department of Education).

Critical milestones for FY 2025

Meet or exceed targets for three of the five categories: provide STEM Engagement opportunities to higher education students in four categories of student diversity for both virtual and in-person higher education STEM engagement activities:

1. Racially underrepresented students
2. Ethnically underrepresented students (Hispanics and Latinos, African Americans, American Indians, Alaska Native, Native Hawaiians and Pacific Islanders)
3. Women
4. Students across all institutional categories and levels (as defined by the U.S. Department of Education).
5. Baseline the number of higher education students who participate in opportunities designed to develop STEM identity across all institutional categories and levels.

Lead Organization: Office of STEM Engagement (OSTEM)

FY 2023 Performance Progress

NASA met the target for Performance Goal 4.3.2. NASA achieved this performance goal by exceeding national averages in three of four diversity categories in providing significant higher education awards, such as internships and fellowships, for the 2021–2022 academic year resulting in a Green rating.*

NASA provided 10,085 internships, fellowships, research opportunities, educator professional development, challenges, and other college/pre-college STEM engagement opportunities to 9,498 student and educator participants representing K-12 institutions and higher education institutions including 2-year, 4-year institutions and all Minority Serving Institution (MSI) classifications (Asian American and Native American Pacific Islander-Serving Institutions, Alaskan Native-Serving and Native Hawaiian-Serving Institutions, Historically Black Colleges and Universities, Hispanic-Serving Institutions, Native American-Serving Nontribal Institutions, Predominantly Black Institutions, Predominantly White Institutions, and Tribal Colleges and Universities). These significant awards provided a total of over $43.9M in direct financial support to participants and engaged participants in over 2.3M total contact hours. In these opportunities, 15.9% of participants identified as racially underrepresented** and 17.6% of participants identified as ethnically underrepresented***. Also, 41.5% of the Agency's higher education internships and fellowship positions were filled by women. NOTE, two underrepresented statistics (i.e., race, ethnicity) exceeded the national averages for underrepresented students enrolled in STEM degree programs (per the National Center for Educational Statistics - https://nces.ed.gov).

The table below contains a year over year comparison of significant awards and awardees for internships, fellowships, and scholarships, from 2019-2022 and preliminary results for FY 2023.

	FY19	FY20	FY21	FY22	FY23
Significant Awards	6,412	6,410	8,764	10,085	9,002
Significant Awardees	6,066	5,992	8,006	9,498	8,288

Awards includes Internships, Fellowships, Scholarships, and other sustained engagement opportunities (e.g., engineering design challenges, student competitions). Beginning in FY 2022, this description changed slightly to include research opportunities, educator professional development, challenges, and other college/pre-college STEM engagement opportunities.

*NASA rates this performance goal using data reported on the academic calendar. The FY 2023 rating is based on verified and validated data from the 2021–2022 academic calendar.
**Underrepresented racial categories (American Indian or Alaskan Native; Black or African American; and/or Native Hawaiian or Pacific Islander)
*** Underrepresented ethnicity (Hispanic or Latino)

4.3.3: Attract diverse groups of students to STEM through learning opportunities that spark interest and provide connections to NASA's mission and work

Number of critical milestones completed

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	2 of 2	1 of 1	1 of 1
Result	2		
Rating	Green		

Critical milestones for FY 2023

1. Complete assessment of STEM Engagement Educator Community of Practice and establish baseline demographics.
2. Establish a baseline for the percentage of students that increase STEM interest following participation in a NASA K-12 STEM Engagement investments.

Critical milestones for FY 2024

1. Measure the number and diversity of K-12 students exposed to NASA STEM Engagement opportunities designed to spark student interest in STEM.

Critical milestones for FY 2025

1. Measure the number and diversity of K-12 students exposed to NASA STEM Engagement opportunities designed to spark student interest in STEM.

Lead Organization: Office of STEM Engagement (OSTEM)

FY 2023 Performance Progress

NASA met the target for Performance Goal 4.3.3. Results indicate NASA has achieved this performance goal by completing the FY 2023 milestones resulting in a Green rating. An assessment was completed of the NASA OSTEM Next Gen STEM (NGS) project online community of practice (CONNECTS), which facilitates synchronous and asynchronous collaboration among educators and NASA to inspire the next generation of explorers through authentic STEM learning experiences. The online platform provides registered members access to engagement events, networking opportunities, resources (e.g., lesson plans and interactive media), and activities from both the OSTEM's NGS project and NASA Mission Directorates. CONNECTS allows educators to ask questions and share lessons learned to improve access, navigability, and usability of NASA STEM Engagement K-12 products and learning opportunities aimed at attracting diverse groups of students to STEM.

As of September 2023, CONNECTS has reached 2674 formal and informal educators in the community of practice.

The NASA Gateway data file, obtained in February 2023, included demographic data provided by the 1,278 members upon registration for NASA CONNECTS. Removed from analysis were users from outside the United States (182) and U.S.-based members without verifiable institutional addresses (14). Below are the NASA CONNECTS registration data reported demographics and characteristics.

Gender: Female (71%); Male (26%); Did not wish to provide (3%)

Race: American Indian or Alaskan Native (2%); Asian (6%); Black or African American (8%); Native Hawaiian or Pacific Islander (1%); White (75%); Did not wish to provide (11%)

Ethnicity: Hispanic (17%); Not Hispanic (76%); Did not wish to provide (8%)

Geographic Locale: Urban (45%); Rural (17%); Suburban (38%); Educator Type: Formal (63%); Informal (29%); Other (8%)

The K-12 Student Outcome Assessment was also conducted including completion of data collection and analysis and the development of an evaluation report, including findings and recommendations, of targeted STEM Engagement K-12 investments. To establish a baseline for the percentage of students that increase STEM interest following participation in a NASA K-12 STEM Engagement investments, the following two survey questions about student perceptions of STEM Interest following participation in the K-12 activity: 1) I like learning about STEM; and 2) I like to solve STEM problems. Analysis of 1,404 completed participant surveys established the following baseline percentages of STEM interest by students following participation in a NASA K-12 STEM Engagement investment: 1) 85.3% agreed; and 2) 72.5% agreed.

4.3.4: Promote equal opportunity compliance and encourage best practices among NASA grant recipient institutions to ensure that grantees are providing equal opportunity regardless of race, color, national origin, sex (including pregnancy, sexual orientation, gender identity), age, or disability

Percentage of NASA civil rights recommendations or corrective actions that have been implemented within 1 year by the grant recipient institution.

	Execution	Planned	
Fiscal Year	FY 2023	FY 2024	FY 2025
Target	100%	100%	100%
Result	100%		
Rating	Green		

Lead Organization: Office of STEM Engagement (OSTEM)

FY 2023 Performance Progress

To help build a diverse future STEM workforce, NASA conducts compliance reviews under Title IX of the Education Amendments to ensure NASA-funded educational programs are free of discrimination based on sex. NASA also conducts compliance reviews of NASA-funded educational and other programs under Title VI of the Civil Rights Act and under Section 504 of the Rehabilitation Act to ensure NASA-funded programs are free of discrimination based on disability, race, color, or national origin, and to ensure these programs are accessible to individuals with disabilities and to individuals with limited English proficiency.

During FY 2023, NASA completed Title IX compliance reviews of three educational institutions and initiated Title IX compliance reviews of two additional educational institutions. NASA also completed a Title VI compliance review of a museum. NASA provided technical assistance to the institutions to help facilitate the implementation of best practices aimed to ensure civil rights compliance. NASA continues to work cooperatively with these institutions to implement any needed corrective actions.

Throughout 2023, NASA provided outreach relating to civil rights compliance. As part of NASA Day at the Mississippi State Capitol, NASA led an effort to conduct targeted outreach to current and prospective grantee institutions in the surrounding area, including providing technical assistance to a Historically Black University. In March, NASA hosted an “Ask NASA” event for grant recipients, providing them with best practices in award administration and information on compliance pitfalls, including civil rights compliance. At the Office of STEM Engagement’s Better Together 2023 conference (held in November), we provided civil rights best practices to STEM education stakeholders.

PART 3

FY 2025 ANNUAL EVALUATION PLAN

FY 2025 SIGNIFICANT EVALUATIONS

The image showcases a series of bow shocks to the southeast (lower-left) and northwest (upper-right) as well as the narrow bipolar jet that powers them in unprecedented detail. Molecules excited by the turbulent conditions, including molecular hydrogen, carbon monoxide and silicon monoxide, emit infrared light, collected by Webb, that map out the structure of the outflows.
Image Credit: ESA/Webb, NASA, CSA, T. Ray (Dublin)

FY 2025 ANNUAL EVALUATION PLAN

The Foundations for Evidence-Based Policymaking Act of 2018 (Evidence Act) Title I reinforces and supports Federal evidence-building activities, the Open, Public, Electronic, and Necessary Government Data Act, and the Confidential Information Protection and Statistical Efficiency Act. Title I of the Evidence Act requires CFO-Act Agencies to publish an Annual Evaluation Plan (AEP) that conveys significant evaluations across the Agency each fiscal year, developed in coordination with the Annual Performance Plan. The AEP establishes and informs NASA's key stakeholders about planned evaluations. Evaluations will uncover findings that will inform NASA program budgets, the Strategic Plan and Learning Agenda, annual Strategic Review, ongoing program management and development, and integrate evidence into the performance planning process.

Above: In this image, the high gain antenna of NASA's Psyche spacecraft takes center stage in this photo, captured at the Astrotech Space Operations facility near the Agency's Kennedy Space Center in Florida.
Image Credit: NASA/Frank Michaux

Evaluation Standards

NASA relies on a culture of evidence-based, data-driven research designs and methodologies to evaluate its programs, policies, and organizations across the Agency. Evaluation, as defined by the Evidence Act, is an assessment using systematic data collection and analysis of one or more programs, policies, or organizations intended to assess their effectiveness and efficiency. The AEP details only those NASA evaluations that meet the Agency's definition of "significant" evaluations (see Figure 1 below). Led by NASA's Evaluation Officer, in conjunction with the Statistical Officer and Chief Data Officer, five standards guide NASA's evaluation culture: rigor, relevance and utility, independence and objectivity, transparency, and ethics. These standards, in addition to the criteria established for significant evaluations are the foundation that NASA uses to support its array of evaluation activities.

Purpose

The AEP identifies planned significant evaluations from across the Agency. It serves as a means to inform Agency senior officials and the public where the most significant evaluations are conducted, cultivate data sharing and resources between NASA organizations, and provide information to help support the Agency's evidence-driven culture.

Dissemination and Sharing

NASA has long been committed to disseminating and sharing results from its evidence-building activities with the greater scientific community and, when permissible, making this information broadly available to the public. As detailed in NASA Procedural Requirement (NPR) 2200.2E – Requirements for Documentation, Approval and Dissemination of Scientific and Technical Information, the Agency strives for the widest practicable and appropriate dissemination of information concerning its activities and scientific and technical information. NASA will leverage this framework in sharing findings from its significant evaluations.

The Agency's dissemination framework includes an array of symposium presentations, peer-reviewed journal publications, and NASA internal and external council discussions. Agency evaluations that provide promising and effective findings are systematically and broadly disseminated to potential beneficiaries and to Federal Agency partners. Criteria and requirements for the dissemination of symposia lectures and papers, in addition to journal materials beyond the Agency, are detailed in Chapter 4 of NPR 2200.2E to ensure proper review of substantive content, technical accuracy, overall quality, and value to the larger scientific community. The Evaluation Officer, as well as Mission Directorate Associate Administrators and Center Directors, have responsibility for the technical, scientific, and programmatic accuracy of information released externally from the Agency by their respective programs.

While NASA maintains a free exchange of scientific and technological information among scientists and engineers, between NASA staff and the scientific community, and between NASA employees and the public, the AEP is a formal dissemination of significant evaluations. Table 1, below, depicts broad evaluation dissemination methods by stakeholder groups and the formats used to share significant evaluations.

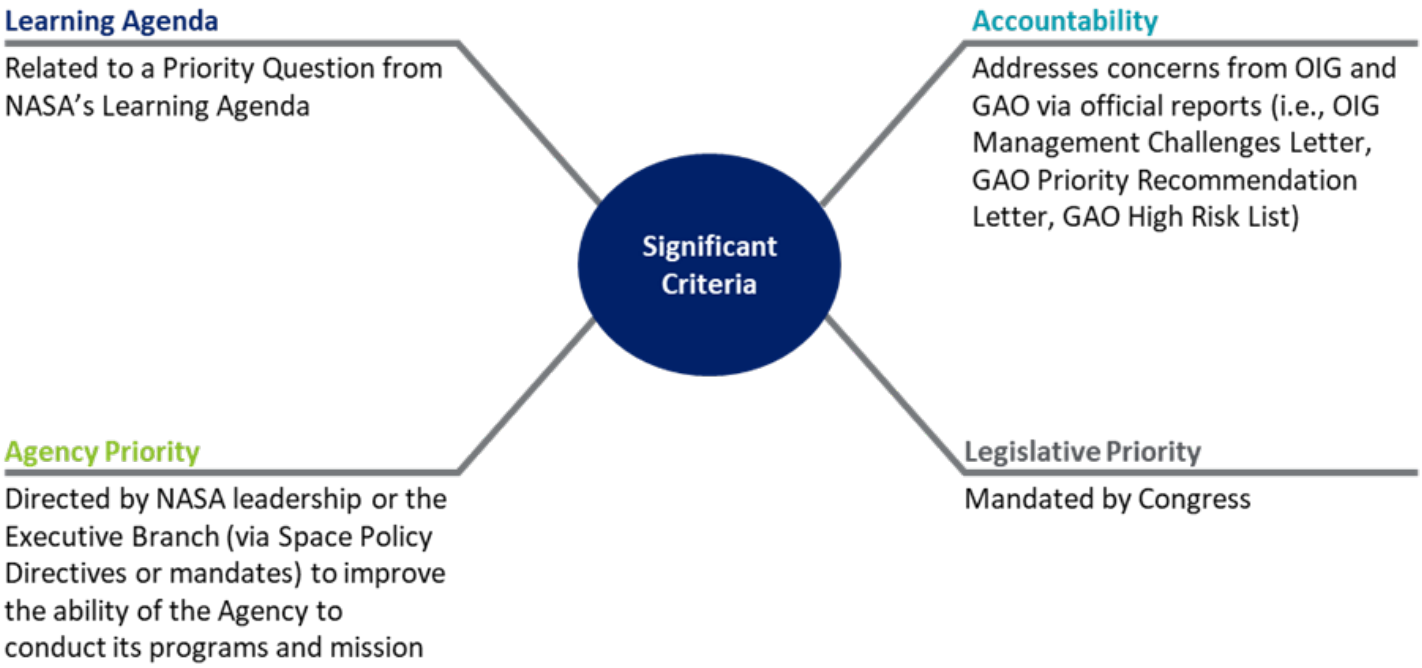
Table 1: Dissemination and Sharing Summary

Stakeholder Group	Dissemination Channel
NASA Senior Officials	Council Meetings, Conferences, Reports
Centers and Mission Directorates Leadership	Conferences, Webinars, Performance Reviews
Internal Councils and Symposia	Reports, Briefings, Conferences
External Councils, NASA Advisory Council (NAC)	Conferences, Webinars
Congress	Committee Hearings, Briefings
Office of Management and Budget (OMB)	Budget Submission and Reviews, Council Meetings
Public, National Academies	Press Releases, Webinars, NAC Meetings, Conferences

NASA's Criteria for Defining "Significant" Evaluations

NASA has an extensive evidence culture that leverages the findings from the numerous evaluations performed across the Agency to make evidence-based decisions that support NASA's mission, foster a culture of evaluation, and promote better value for the public. While the Agency considers every evaluation important, some rise to the level to influence policy and program decisions. To determine these significant evaluations, NASA has formulated criteria in accordance with the Evidence Act. These criteria identify NASA's most significant evaluations and include those that fit one or more of the criteria illustrated in Figure 1.

Figure 1: Criteria for NASA's Significant Evaluations



FY 2025 SIGNIFICANT EVALUATIONS

Composite image of the Tarantula Nebula: Royal blue and purple gas clouds interact with red and orange gas clouds, as specks of light and large gleaming stars peek through. The blue and purple patches represent X-ray data from Chandra. The most striking blue cloud is shaped like an upward pointing triangle at the center. Wispy white clouds outline this blue triangle. Inside this frame is a gleaming star with six long, thin spikes. Beside it is a cluster of smaller bright blue specks showing young stars in the nebula. Darker X-ray clouds can be found near the right and left edges of the image. The red and orange gas clouds, which look like roiling fire, represent infrared data from Webb. Image Credit: X-ray: NASA/CXC/Penn State Univ./L. Townsley et al.; IR: NASA/ESA/CSA/STScI/JWST ERO Production Team

Full Workforce Barrier Analysis

NASA is committed to attracting and retaining a diverse workforce. In order to do this, NASA works to ensure equal opportunity in all aspects of its human capital management, including recruitment, hiring, promotions, awards, et cetera. The Agency monitors its workforce composition data to determine if discrepancies exist in the employment of any demographic group as compared to the National Civilian Labor Force (NCLF) benchmarks. NASA's workforce is highly specialized, as two-thirds of NASA employees are in Science and/or Engineering occupations. As such, NASA also uses the Federal STEM workforce population for employment demographic comparisons.

NASA regularly conducts trigger analyses of its workforce. A "trigger" is defined as "a trend, disparity, or anomaly that suggests the need for further inquiry into a particular policy, practice, procedure, or condition" to determine if there are barriers to equal employment opportunity (EEO). Accordingly, a low participation rate for any group (in relation to a benchmark) is a "trigger." In other words, low participation (or representation) of a group in certain occupations, or among employees receiving promotions, awards, etc., may indicate that there is an Agency policy or practice that limits the full participation of that group. A trigger does not by itself demonstrate a barrier to EEO; it indicates an area to be further analyzed and monitored.

In performing these trigger analyses, NASA discovered a downward trend in the percentage of minorities and women between grades GS-13 and GS-15. In addition, Hispanics, Asian Americans and Pacific Islanders (AAPI), Women, people with disabilities, and people who identify as LGBTQIA+ are underrepresented in SES positions compared to their overall representation in the NASA workforce. Therefore, the Agency is undertaking a barrier analysis in FY 2024-FY 2025 to further explore potential underlying causes of these identified discrepancies to try to determine the root cause(s). NASA will utilize the insights obtained through this barrier analysis to formulate and implement equitable workforce policies.

Strategic Goal

Enhance Capabilities and Operations to Catalyze Current and Future Mission Success.

Strategic Objective

Attract and develop a talented and diverse workforce (SO 4.1).

Theory of Change

If NASA can better understand any recurring barriers facing minorities, women, people with disabilities, and people who identify as LGBTQIA+ when striving for promotions and new hires from GS-13 and above, then NASA may be able to formulate workforce and hiring policies that are more equitable, which will hopefully increase the diversity of individuals in senior civil servant roles.

Evaluation Question(s)

The following evaluation questions will guide the approach and design of this barrier analysis:

1. Do Agency responses from FEVS questions or Employee Engagement, Satisfaction, and Inclusion indices indicate negative responses to questions regarding promotion practices? Does this vary between groups?
2. Do hiring officials include supplementary qualifications for positions, in addition to those recommended by OPM?
3. Are promotion and new hire outcomes aligned with the percentages of qualified applicants?
4. Do outcomes differ for minorities, women, people with disabilities, and people who identify as LGBTQIA+ who are promoted into higher GS grades versus newly hired?
5. How do demographic percentages in the workforce align with Civilian Labor Force and Relevant Civilian Labor Force data?
6. How do demographic percentages in the applicant pool align with Civilian Labor Force and Relevant Civilian Labor Force data?
7. Do promotion rates show gender, race, or ethnicity differences?

Methods to Be Used and Evaluation Design

NASA will use a multiphase barrier analysis process to systematically assess representation in the higher grades. Phase 1 will focus on analyzing personnel data in existing data systems. Phase 2 is aimed at identifying potential

triggers within our systems and/or personnel management approaches around the Agency. The 3rd phase involves analyzing results of the Agency's DEIA climate survey for potential triggers and developing a new survey for Agency-wide distribution that will address gaps in the climate survey that were identified in phases 1-2. Phase 4 is designed for a deeper exploration of identified triggers through interviews and focus groups. Phase 5 is designed to be a compilation phase, where the findings of phases 1-4 are collectively examined, root causes are described and identified, and corrective actions are identified from the root causes. This information will be organized into a final report, shareholder presentations will be developed, and a roll out plan for corrective actions will be generated in Phase 6.

Data and Information

Source	Purpose
NASA Personnel Data Warehouse	Landscape of NASA current employment and applicants, broken down by race, gender identity, age, education, and position type to establish baselines. Data is also available on distribution of the workforce, distribution of grades and positions, length of time people have lingered in positions, hire and loss demographics, training participation data, and job applicant data.
NASA USA Staffing Data	Record of competitive promotions within the Agency, to map outcomes from competitive promotions.
Survey Results	Psychometric survey measures to further investigate, validate, and understand where barriers to equal employment opportunity might exist. Staff will distribute the survey to all NASA civil servants and the data collected will be analyzed using quantitative inferential analytic techniques.
Focus Group Interviews	Qualitative feedback from impacted populations.
Federal Employee Viewpoint Survey (FEVS)	Employee Engagement, Global Satisfaction, DEIA climate.
Publicly Available Information	National Civilian Labor Force (NCLF), Federal STEM Workforce.

Challenges

Anticipated challenges include correlating statistical data regarding outcomes with everyday practices at the Agency, obtaining sufficient sample sizes of minorities and women across various age and ethnic classifications for focus groups, designing questions to solicit honest, actionable feedback from focus group members, and distinguishing the impact of root causes internal to the Agency from outside factors. Additionally, specifically for people who identify as LGBTQIA+, it may be hard to identify these employees because there is not a formal identification mechanism.

Dissemination Strategies

Once the final report is completed, the final phase will be to roll out corrective actions by meeting with key shareholders that make managerial and personnel process decisions around the Agency. Within 4 weeks after the report is finalized internally by ODEO, briefings will be scheduled to begin implementing the corrective actions.

Timeframe

The timeframe for this evaluation is FY 2024-2025.

Cost and Schedule

NASA is on the cutting edge of scientific discovery and space exploration and develops large projects that span multiple years or decades. A major management challenge for NASA is developing estimates for, and managing cost and schedule commitments given the technical complexity of these development projects. Improving cost and schedule models should help NASA to better predict and deliver on its project commitments.

For NASA spaceflight projects, NASA utilizes the following three general techniques in helping inform Agency management and external stakeholders with predicting project development costs and schedules.

1. Early in formulation, the Agency requires projects to produce probabilistic cost and schedule estimates.
2. As a prerequisite to approval for implementation, the Agency requires projects to produce a probabilistic model of its baseline project plan to help inform Agency cost and schedule commitments.
3. Lastly, within the implementation phase of development, the Agency utilizes earned value management to track projects' performance against that commitment.

Given a project's relative lack of maturity during formulation, the probabilistic cost and schedule estimate incorporates broad uncertainties regarding the project's scope, technical approach, safety objectives, acquisition strategy, implementation schedule, and associated costs. The project team develops its cost and schedule estimates using many different techniques. These include, but are not limited to, bottom-up estimates where specific work items are estimated by the performing organization using historical data or engineering estimates; vendor quotes; analogies; and parametric cost and schedule models.

In addition to the requirement for projects to produce probabilistic cost and schedule analysis in formulation, the Agency also conducts independent assessments on the probabilistic analysis. Independent assessments of cost and schedule in early formulation often utilize Agency parametric models as cross checks. This evaluation, which supports priority question #2 in the Learning Agenda, primarily deals with the Agency's in-house parametric capability to help inform early formulation probabilistic cost and schedule estimates.

Parametric cost and schedule models utilize relationships between historic program costs/schedules and technical parameters to predict future costs/schedules. Cost and Schedule Estimating Relationships (CERs/ SERs) are used to capture these relationships and are developed using statistical techniques – including regression analysis. These models are a solid foundation for probabilistic cost and schedule estimating and will generally do a good job of estimating unless: a project has major cost drivers not modeled by the CERs (probably the source of outliers); the model does not contain analogous data to estimate; or the programmatic content and approach are not defined properly (test hardware, development approach, funding availability, etc.).

As such, the Agency has invested resources in historical data collection, statistical data analysis, and deployment of cost models to be utilized in early formulation to better inform cost and schedule estimates. Though these efforts have been going on in some capacity for over 40 years, there is a need to enhance these efforts to appropriately capture technology, project management, systems engineering, software, and acquisition trends within the cost and schedule estimates produced. This evaluation plan will outline current plans for incorporating these activities. Continued inherently complex and unique projects, as well as continued poor cost and schedule performance, drives the need to perform this analysis.

Strategic Goal(s) and Strategic Objectives

Efforts described do not map directly to a strategic goal nor a strategic objective. However, properly planning and executing projects at the committed cost and schedule enables execution of all of NASA's strategic goals and objectives. Delivering on-time on-budget development projects permits NASA to continue scientific discovery, exploration, and technology innovation.

Theory of Change

If NASA expands its cost and schedule modeling paradigm and suite of tools, improving the capability to estimate cost and schedule needs early in project formulation when NASA is socializing mission costs with external stakeholders such as Congress and OMB, then the Agency will be better positioned to make baseline project commitments that are statistically achievable, delivering projects closer to on-time and on-budget.

Evaluation Question(s)

The following questions are addressed in Agency's annual parametric tool development.

1. What new NASA mission data has become available to collect and add to the Agency's parametric tool set?
    a. Are there any technical input parameters that have not historically been collected that need to be collected?
    b. What new or existing data sources are most appropriate to mine?
2. Are current normalization techniques (e.g. adjusting for inflation) still valid?
    a. Is additional normalization needed given the impacts of COVID and supply chain issues?
    b. Is there additional stratification of data needed?
    c. Which historical data points are no longer analogous to modern technology or assumptions??
3. What technical parameters are statistical drivers that will form CERs?
    a. Are there additional statistical techniques that can be utilized?
4. What is the best way to deploy and communicate CER research, methodology and results to the cost and schedule communities?
    a. Is the community properly trained to use CERs effectively?

Data and Information

Most data will be collected via the One NASA Cost Engineering (ONCE) database, including technical and mission classification data. ONCE is composed of historical NASA Cost Analysis Data Requirements (CADRe) that have programmatic data by milestone. Other NASA systems and personnel will be utilized for data that may be missing from the sources listed above.

Methods to Be Used and Evaluation Design

For each current Cost and Schedule parametric model, evidence-building activities will include:

- Statistical analysis of technical drivers that drive cost and to what extent. Analysis will be updated as additional data is collected from completed NASA projects. Historically, methods for analysis vary but generally consist of principal component analysis, stepwise regression, and cluster analysis.
- Normalizing new data and adding to historical data sets that drive analysis while existing historical data will be examined to determine if it is still relevant. Methods include normalizing mission externalities, inflation, and acquisition approach (e.g. block buys/builds).
- Further stratification of data will be examined for refined CERs/SERs. Analysis will be supported by methods such as principal component analysis, stepwise regression, multivariable regression, and nearest neighbor analysis.

Challenges

Agency data collection efforts are key to sound model development. For firm fixed priced acquisitions it can be difficult to collect cost data at a detail level that is useful for cost modeling purposes.

Dissemination Strategies

Data analysis results for all NASA cost and schedule models are available to all NASA personnel. Analysis of statistical fits and descriptive statistics are available for broad distribution with each model's supporting documentation.

Timeframe

The timeframe for this evaluation is ongoing. Primary models are continuously collecting and conducting analysis. Deployment of model updates are scheduled every 12-18 months for configuration purposes.

Equity in Grants and Cooperative Agreements

NASA awards approximately 2,000 grants and cooperative agreements each year, the majority across a range of science disciplines. However, organizations serving underserved communities[1] and Minority Serving Institutions (MSIs) including Historically Black Colleges and Universities (HBCUs), Predominately Black Institutions (PBIs), Hispanic-Serving Institutions (HSIs), Tribal Colleges or Universities (TCUs), Native American Non Tribal Institutions (NANTIs), Alaskan Native- or Native Hawaiian-Serving Institutions (ANNHIs), Asian American- and Native American Pacific Islander-Serving Institutions (AANAPISIs) are generally underrepresented in awards.

In June 2021, NASA received public feedback regarding barriers to accessing NASA's grant programs, regulations, and policies through the Request for Information (RFI) process. Additionally, NASA analyzed proposal submission data from calendar years (CY) 2020 and 2021 to support the feedback received from the June 2021 RFI. Grants Policy and Compliance (GPC) found that proposals submitted by organizations from underserved communities represented 13% in CY 2020, and 11% in CY 2021 of total proposal submissions.

The Agency is committed to closing the percentage gap, which means identifying barriers that are in place and potential interventions to address those barriers. Therefore, the Agency is undertaking a barrier analysis to further identify obstacles and other determinants preventing underserved organizations from successfully partnering with the Agency. NASA will utilize the insights obtained through this barrier analysis to formulate and implement equitable grant and cooperative agreement policies.

Strategic Goal

Enhance capabilities and operations to catalyze current and future mission success

Strategic Objectives

Transform mission support capabilities for the next era of aerospace (SO 4.2)
Build the next generation of explorers (SO 4.3)

Theory of Change

If NASA can better understand the recurring barriers facing MSIs when applying for grants and cooperative agreements, then NASA may be able to better target outreach and capacity-building efforts to improve the accessibility of the grantmaking process itself, which will position the Agency to increase the diversity of individuals and institutions participating in NASA's grant and cooperative agreement programs.

Evaluation Question(s)

The following evaluation questions may guide the approach and design of this barrier analysis:

1. Which HBCUs and MSIs are currently eligible to compete for awards?
2. Of those HBCUs and MSIs that are eligible to compete for awards, which institutions are not submitting proposals?
3. What are the underlying factors that prevent or make it difficult for these institutions to apply for grants and cooperative agreements?
4. Of those HBCUs and MSIs that are not eligible to compete for awards, what barriers are impacting their ability to apply?
5. Can identified factors be addressed by NASA in order to create a larger pool of HBCUs and MSIs from which grants can be awarded?

Data and Information

Source	Purpose
Survey Responses	Responses from the institutions regarding which outreach events and forums are most effective, which barriers present the most obstacles, and which policies and procedures need to be explained in further detail to alleviate confusion.
NASA Internal Metrics	Continuously review applicant pool, particularly MSIs and HBCUs, to determine which institutions are applying, which institutions are choosing not to apply, and which institutions applied but did not receive awards.

Methods to Be Used and Evaluation Design

GPC issued a Request for Information (RFI) for feedback on barriers for entities that engaged and/or applied but have not been selected for NASA awards. The results of this RFI will serve as the basis for this formative evaluation, where results will be analyzed to determine where and how the Agency's grant-issuing mission directorates should expand their reach and enhance relationships.

Challenges

Anticipated challenges include the willingness of survey respondents to provide detailed explanations of why they did not submit proposals and determining why proposals were not successful. Additional challenges include the ability for NASA to locate and contact the appropriate points of contact across a sufficient number of institutions to obtain statistically meaningful results.

Dissemination Strategies

NASA will engage with potential proposers through events targeting large multidisciplinary and multicultural STEM diversity events and professional conferences in the U.S. For example, a large cross-functional NASA presence participated in the October 2023 Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) annual conference. NASA will leverage existing Agency programs that have ongoing relationships with MSIs, such as the Office of STEM Engagement's Minority University Research & Education Project (MUREP) program which includes the MSI Exchange, a database providing MSI data that can be utilized for a range of opportunities. The SMD Bridge Program increases engagement with MSIs communication, professional development, and solicitation activities. SMD is also piloting the Research Initiation Award program to provide faculty at emerging research institutions that have not received Agency funding over the previous five years with resources to build a competitive, NASA-relevant research program.

Additionally, NASA plans to continue its "Ask NASA" event series which provides a forum for applicants and recipients looking to partner with NASA on applying for NASA grant and cooperative agreement awards and proper grant and cooperative agreement award administration. GPC also established a NASA Grants and Cooperative Agreements Playlist on the NASA YouTube channel to broaden its reach. This channel features training sessions and informative talks related to grants and cooperative agreements.

Timeframe

The timeframe for this evaluation is FY 2024-2025.

[1] *Underserved organizations* are defined as organizations that are American Indian Owned, Asian Indian Owned, Asian-Indian American Owned, Asian-Pacific American Owned, Black American Owned, Economically Disadvantaged Women Small Owned Business, Self-Certified Small Disadvantaged Business, Small Business, Veteran Owned Business, Women Owned Small Business

Equity in Procurement and Contracts

As NASA continues its Mission Equity journey, the Agency realizes the impact it has on the U.S. economy. Specifically, the 2021 Economic Impact Report, which is published on a bi-annual basis, outlined that NASA's total contracting activity amounted to $21.2 billion. This number underscores the Agency's ability to affect the business landscape throughout the country, especially in underserved communities. Furthermore, the Biden-Harris administration has made it a priority to promote and enhance equity with the issuance of Executive Orders 14091 and 13985.

Therefore, NASA is partnering with the U.S. Small Business Administration (SBA) to assess the best practices and strategies to increase awards to Small Disadvantaged Businesses (SDBs) and other underserved communities. This evaluation is focused on identifying barriers in Agency procurements and contracting opportunities in order to establish more equitable policies and procedures. The ultimate goal is to increase opportunities for contractors and businesses from underserved communities to successfully navigate and participate in NASA's procurement process.

Strategic Goal

Enhance capabilities and operations to catalyze current and future mission success

Strategic Objective

Transform mission support capabilities for the next era of aerospace (SO 4.2)

Theory of Change

If NASA can understand which favorable procurement practices provide more equitable opportunities to underserved communities, then NASA can transform existing practices and policies to break down barriers that underserved communities may face when seeking for procurement/contracting opportunities.

Evaluation Question(s)

The following evaluation questions may guide the approach and design of this barrier analysis:

1. Which businesses from underserved communities are eligible to compete for awards?
2. Based on procurement award data, which underserved community areas are underrepresented in NASA awards?
3. Based on feedback provided from businesses within underserved communities, what factors prevent or make it difficult for these businesses to submit a proposal for upcoming procurement contracts?
4. Are there consistent factors identified by the members of the underserved communities?
5. Can those factors be addressed to expand the pool of businesses from underserved communities to which contracts can be awarded?

Data and Information

Source	Purpose
Survey and Request for Information (RFI) Responses	Authentic responses from the public regarding which outreach events and forums are most effective, which barriers present the most obstacles, and which policies and procedures need to be explained in further detail to alleviate confusion.
NASA Internal Metrics	Continuously review proposal and award data, particularly from businesses within underserved communities, to understand which businesses are submitting proposals, why businesses may choose not to propose in a response to a requirement, and if there is a consistent pattern for businesses submitting a proposal but not receiving awards for which we can evaluate potential changes to our acquisition policies or procedures.

Methods to Be Used and Evaluation Design

The NASA Deputy Administrator formed a Small Disadvantaged Business (SDB) Tiger Team in February 2023 to develop a plan to promote equity in procurement awards to SDBs. That Tiger Team has developed a plan to continue the solicitation of feedback from businesses through a combination of RFIs and Vendor Engagement Surveys. Three RFIs have been issued (June 2021, April 2023, June 2023). The Tiger Team will complete a formative evaluation based on the results of the feedback to determine the most pressing barriers facing SDBs and conclude the best course of action to address these barriers. Additionally, the SDB Tiger Team developed an internal training program to promote and encourage the utilization, growth and engagement of small, disadvantaged businesses within the Agency. The training is primarily for Agency leadership and acquisition professionals

Challenges

Anticipated challenges include the willingness of survey respondents to provide detailed explanations of why they did not submit proposals and determining why proposals were not successful. The SDB Tiger Team is anticipating that respondents will provide a breadth of difficulties they encounter when constructing and submitting NASA proposals. Given limited time and resources, downselecting the most pressing issues and choosing how to address them will be a challenge of this evaluation.

Dissemination Strategies

OSBP and OP utilize a robust outreach and community engagement strategy and a Vendor Communication Plan, ensuring that new connections are made and existing connections are maintained. This will help facilitate intentional interactions between underserved communities and Agency acquisition personnel and decision makers. This strategy also includes periodic learning series webinars and small business listening sessions. OSBP has quarterly outreach events, enhanced digital engagement efforts, and attends regional conferences and industry days hosted by other organizations. Presenters will be made available to small/minority-owned businesses to answer questions and foster relationships.

Timeframe

This barrier analysis is scheduled to take place in FY 2024-2025.

Technology Investment

NASA invests in revolutionary, high-payoff early-stage space technologies and concepts from a community of innovators to enable NASA's Mission and invigorate our economic future. As a priority question in its Learning Agenda, NASA is evaluating its strategy for investing in early-stage innovation that enables the breakthroughs of tomorrow and ensures American global leadership in space technology. Diversity is a key aspect of an early-stage investment and partnership strategy and was the focus of NASA's FY 2022 and FY 2023 Annual Evaluation Plans for this priority question. Those evaluation plans were designed to complement NASA's wider strategy of increasing engagement with underserved and underrepresented communities to bring diverse ideas to NASA's missions and expand NASA's economic impact in these communities. NASA successfully used those results to facilitate and increase early-stage awards to Historically Black Colleges and Universities and Minority Serving Institutions. As a next logical step, NASA's FY 2024 Annual Evaluation Plan focused on our strategy of transitioning promising early-stage investments to the technology maturation stage. We plan to continue this focus in FY 2025.

Early-stage innovation is inherently characterized by a high-risk, high-reward nature, with a small percentage of technologies showcasing the necessary feasibility and potential to advance. Technology development organizations, especially government, often struggle with pushing technologies between early-stage innovation and technology maturation, facing challenges in securing prioritized funding over incremental but lower-risk investments. Once promising and viable early-stage concepts have been identified, NASA will be able to actively support the progression of the technology to further stages of maturity. Pushing promising innovations forward in the development cycle is essential to guarantee the realization of technological advancements.

Building off FY 2024, this FY 2025 evaluation's primary purpose is to address critical evaluation questions centered on the dynamics, challenges, and successes of transitioning early-stage innovation to technology maturation stages. Due to challenges in FY 2023, some of the FY 2024 evaluation's planned milestones have been delayed and are therefore reflected in the FY 2025 evaluation. The FY 2025 evaluation's design will continue to develop throughout FY 2024. The scope will be shaped by a deeper examination of barriers to transition, transition potential metrics, possible intervention methods, and available resources. The resulting recommendations would seek to enhance the success rate of early-stage technology transitions. This challenge is not exclusive to NASA; a deliberate approach to continuing technology development, is essential to optimize Research & Development (R&D) funding across the Federal government to meet tomorrow's needs.

The Space Technology Mission Directorate (STMD) tracks transitions (i.e., conclusion of) an investment where the technology is passed along for further development and since 2015, has identified hundreds of early-stage transitions, including those which were eventually infused into space missions or industry. STMD aims to deepen its understanding of past efforts and strategies to promote increased transitions that promise to yield transformative capabilities. The Early Stage Innovation and Commerce (ESIC) structure was created in FY 2021 to help drive impact, innovation, and transitions in STMD's early stage and commercialization work. ESIC is a cross-cutting support structure for the Early Stage Innovation and Partnerships (ESIP) portfolio of programs and seeks to increase impact through strategic coordination between the Early Stage Innovation, Technology Transfer and Small Business Innovation Research/Small Business Technology Transfer budget accounts/programs, as well as collaboration with higher maturity R&D programs in STMD and across NASA. Meanwhile, to better facilitate technology transition, STMD continues to assess current and potential mechanisms for technology transition at the project, program, portfolio, and Mission Directorate levels. STMD plans to leverage these efforts in the FY 2025 Annual Evaluation Plan focused on early-stage investment. STMD also considers technology transition strategies for the technology maturation and demonstration portfolios, looking to create synergies with the early-stage investments portfolio.

STMD made some noteworthy progress toward this evaluation question in FY 2023. As part of the STMD Strategic Framework, STMD published a set of "Lead" outcomes that focuses on how the Mission Directorate should invest its resources to maximize impact. One of those outcomes centers on increasing the commercialization of NASA-supported technologies, emphasizing technology transition as a vital measure in STMD's broader strategic objectives, while ensuring continued American global leadership in space technology. STMD also reviewed internal and external studies and interviewed a small set of Principal Investigators (PIs) of STMD-funded early-stage technologies to better understand barriers to transition.

Throughout FY 2024, STMD will continue efforts to characterize barriers to transition, identify potential transition mechanisms, assess policy/process, and improve transition tracking. For example, in the summer of 2023, STMD

reached out to hundreds of PIs of completed early-stage projects from the past decade and inquired about barriers to transition and project updates, including technology transitions, investment outcomes, and knowledge transitions. In FY 2024, certain STMD programs will start tracking knowledge transitions, the transfer of information through written form or talent acquisition. STMD will utilize the results from FY 2023 and FY 2024 transition initiatives and analyses to shape the design of the FY 2025 evaluation. STMD plans to pursue a multi-year pilot effort within the STMD ESIP portfolio through which ESIP program offices may nominate their most promising projects to receive deliberate transition facilitation.

These projects may include, for example, promising activities that met their study objectives but have now exhausted sponsor program pathways, or projects that narrowly missed competitive continuation opportunities, but warrant additional study. Prior to final evaluation design, the Directorate will further assess transition barriers to inform the evaluation design, based on experience within STMD, NASA, and other organizations. STMD will assess and identify specific criteria for project inclusion in this evaluation. NASA will include technology maturation and demonstration program offices, as well as Principal Technologists and Systems Capability Leaders – NASA personnel cognizant of strategic technology gaps for which early-stage innovation solutions may play a significant role – in the development of the evaluation design.

STMD will assess and select one or more options for proactive transition intervention in the FY 2025 evaluation. Possible interventions include, but are not limited to:

- Revised budget model(s) to designate funds towards technology maturation efforts and projects beyond the sponsoring program.
- Proposed funding extensions within the sponsoring program, with a focus on identifying transition partners.
- Fostered partnerships between PIs and relevant communities within STMD, across NASA, or beyond the Agency.
- Increased exposure of the concept, potentially through communication and knowledge sharing efforts.

Once STMD has established the interventions to explore in the evaluation, the Mission Directorate will also establish measures of success to enable leadership decision to continue, expand, or modify intervention strategies beyond this evaluation plan. Success measurement of this evaluation plan may include but is not limited to project-specific milestones, recipient surveys, and/or transition partner surveys.

Strategic Goal

Catalyze economic growth and drive innovation to address national challenges

Strategic Objective

Innovate and advance transformational space technologies (SO 3.1)

Theory of Change

If NASA can better understand the challenges associated with the future bridges that span its technology gaps, identify promising early stage innovation concepts most in need of transition facilitation, and proactively implement effective transition interventions, then NASA will increase the probability of progressing breakthrough innovations through technology maturation, demonstration, and adoption, profoundly impacting U.S. aerospace capabilities and global leadership in space technology.

Evaluation Question(s)

The evaluation will inform answers to the following question:

- What investment strategies and interventions will best facilitate early-stage technology transitions required to meet strategic goals and objectives?

Data and Information

This evaluation will leverage existing data and information collection across STMD, and where applicable, across NASA and beyond.

Source	Purpose
NASA TechPort and STMD Performance Analysis Resource (SPAR) System	Provide programmatic technical information on current and previous NASA space technology investments to better understand the STMD portfolio, existing technology transitions, investment outcomes, and other relevant metrics.
NASA Strategic Framework/ Envisioned Futures	Serve as a reference for NASA space technology strategic outcomes, including potential early-stage pathways for meeting future aerospace mission needs and providing desired socioeconomic benefits.
NASA STARPort	Provide the connection between existing investments and strategic technology capability needs, enabling gap analysis that can inform effective transition strategies.
Directorate Program Data and Information	Provide coordination with transition efforts complementary to those in the ESIP portfolio. Ensure any findings or recommendations regarding the pull of early-stage concepts into technology maturation and/or demonstration are considered on the evaluation design and implementation.
2022 ESIP Performance and Accountability Report (PAR) Findings	Inform potential NASA transition strategies, leveraging the findings and recommendations from a recent independent assessment of STMD's ESIP portfolio.
Internal Studies, Assessments, and Findings	Leverage existing transition-relevant studies within STMD. Including a recent literature review of existing or proposed transition mechanisms or methodologies. Also including a recent internal study on barriers to commercialization and transition.
Other Studies	Leverage information and lessons learned from relevant studies by other Federal agencies and other organizations.

Methods to be used and Evaluation Design

NASA will undertake a mixed-methods evaluation using quantitative and qualitative methods to better understand strategies that facilitate technology transition. The evaluation formulation, methodology, and metrics will be developed further in FY 2024. Currently, NASA is leveraging external evaluation expertise where needed, (e.g., contracted vendors with evaluation capability) to help ensure a robust and credible evaluation design.

Challenges

Early-stage technology investment impacts are often difficult to measure due to long development times, complicated development pathways, and insufficient transitions tracking data. It can take years before realizing the effectiveness of specific strategies and approaches to the early-stage investments. Learning from previously successful investment and transition strategies can be useful, but the recommendations are often outdated. The often-complicated development path to ultimate implementation also makes it difficult to trace breakthroughs to originating research. With non-continuous and non-linear development pathways, transitions data tracking the development from one milestone to the next is often lost or kept in separate databases, thus unable to provide an overview of the timeline. In absence of hard metrics, STMD plans to focus on proxy measures of effectiveness that are clearly traceable to the results of this evaluation.

Dissemination Strategies

The results will be shared within NASA and other stakeholders, subject to sensitivity and applicability. Other technology programs can use the results to make valuable transition-related programmatic and policy decisions, potentially even beyond early-stage investments.

Timeframe

The evaluation design will be finalized in FY 2024, implementation and evaluation will begin in FY 2025.

Internship Program Evaluation

The focus of this Internship Program Evaluation is to continue the series of investigations that is providing evidence of the effects of a NASA OSTEM Internship on interns. The purpose of the study is to use existing background materials (e.g., internship program-level data), NASA STEM Gateway data for FY 2022 and FY 2023 OSTEM interns, primary data collection (e.g., intern surveys and focus groups), and external data (e.g., National Student Clearinghouse) to understand the experience of NASA OSTEM interns, as well as alumni of the NASA OSTEM Internship Program, a year after internship completion. This Learning Activity, Internship Program Evaluation, and its anticipated evidence will add to robustness of the evidence base related to NASA OSTEM Internships. This comprehensive body of evidence can inform future budgetary, programmatic, and operational deliberations and decisions for NASA, NASA OSTEM, and the OSTEM Internship Program. As such, the intended audience include leaders and community members across the Agency and the NASA OSTEM enterprise.

Previous studies examined information available to support longitudinal evaluation efforts (FY 2020, FY 2021, FY 2022 studies), validated the registrant, applicant, and intern pool (FY 2023); offered insights about the demographic characteristics of the application and intern pools (FY 2023); and created an instrument to collect data from interns about the impact of the OSTEM internship one year after the experience (FY 2023). This Internship Program Evaluation aims to examine the intern experience from before (i.e., recruitment), during, and a year following their NASA OSTEM Internship experience (e.g., Academic and Career Achievements) and the associated outcomes from the internship experience. Findings from the Internship Program Evaluation will enhance the existing base of evidence that will help NASA, NASA OSTEM, and the Internship Program to understand the outcomes of their investment.

NASA OSTEM Internships address both components of Federal guidance: 1) to increase the number of internships in general, and 2) to broaden the numbers of interns from underrepresented and underserved groups (Ahuja & Miller, 2023). NASA OSTEM Internships are competitive awards to support educational opportunities that provide unique NASA-related research and operational experiences for high school and college students. These opportunities serve students by integrating interns with career professionals to perform mentor-directed tasks and contribute to the operation of a NASA facility or advance NASA's missions. NASA OSTEM Internships are short-term, full-time, or part-time work experiences of 10 to 16 weeks in duration. Internships are conducted at sites with ongoing NASA mission activity, such as at a NASA facility or contractor facility. Mentors can be civil servants, contractors, or academics conducting activities directly related to NASA's ongoing missions. Internships are distinguished from other experiential learning opportunities by their focus on mentor-directed, degree-related, work-place task completion.

Strategic Goal

Enhance capabilities and operations to catalyze current and future mission success.

Strategic Objective

Build the next generation of explorers (Engage students to build a diverse future STEM workforce) (SO 4.3)

Theory of Change

If NASA increases the number of interns from underrepresented and underserved communities who apply to and are accepted for a NASA internship, there will be an increase in contributions to NASA's work from diverse viewpoints and lead to full time employment that will strengthen the potential for a more diverse future workforce.

Data and Information

Table 1 below lists the data sources (NASA STEM Gateway, National Student Clearinghouse (NSC), intern surveys, background materials, focus groups, and listening sessions) that will be used to answer the evaluation questions (EQs).

Table 1. Data Sources and Descriptions

Data Type	Data Sources	Description	FY22 Interns	FY23 Interns	FY24 Interns
Quantitative	NASA STEM Gateway	Characteristics of registrants, applicants, and the intern pool	Already have	To be collected	N/A
Quantitative	Internship Experience Survey	STEM identity and Sense of belonging in STEM	N/A	N/A	To be collected
Quantitative	National Student Clearinghouse (NSC)	Persistence, retention, and graduation in STEM majors	To be collected	To be collected	To be collected
Quantitative and Qualitative	Retrospective Internship Survey	Rating scale and qualitative items (open-ended questions)	To be collected	To be collected	N/A
Qualitative	Background Materials	Existing data from Internship Program-level data collection	N/A	To be collected	To be collected
Qualitative	Listening Sessions	Internship Program key personnel discussions on recruitment strategies	N/A	To be collected	To be collected
Qualitative	Focus Groups	Intern feedback about short-term outcomes and recruitment	N/A	To be collected	N/A

Methods to Be Used, Evaluation Design, and Evaluation Questions

The Internship Program Evaluation will apply a complementarity mixed-methods approach to collect quantitative and qualitative data to understand intern experiences and outcomes (Greene et al., 1989; Palinkas et al., 2019). This mixed-methods design will utilize both quantitative and qualitative data sources to confirm, cross-validate, and corroborate findings (Creswell et al., 2003; Teddlie & Tashakkori, 2009) to better understand recruitment strategies used in the NASA OSTEM Internship Program and interns' experience during the NASA OSTEM Internship Program based on internship categories, types, and locations.

This evaluation study will use multiple modes of data collection under the guidelines of the Paperwork Reduction Act (PRA): 1) NASA STEM Gateway, 2) National Student Clearinghouse (NSC), 3) intern surveys, 4) background materials, 5) focus groups, and 6) listening sessions.

- Quantitative data will be collected through the NASA STEM Gateway using data collected during FY 2023 and compared to FY 2022, including demographic information, NASA site affiliation, and application status. Additionally, data from the NSC will be used to better understand persistence, retention, and graduation rates in STEM majors.
- The NSC is an educational nonprofit organization that provides enrollment and degree verifications as well as educational outcome research services to education and workforce communities.
- The Internship Experience Survey will be piloted with the FY 2024 spring cohort of interns to better understand the short-term impact of the NASA OSTEM internship, specifically focused on STEM Identity and STEM belonging.
- The Retrospective Internship Survey asks interns to provide information about the effects of their internship experience on career, education, and future planning one year after completing the NASA OSTEM internship. The survey includes multiple choice, Likert scale, and free-response type questions.
- Existing background materials (e.g., existing data from Internship program-level data collection efforts) will be included in this study to better understand the experiences of NASA OSTEM interns during their internship experience. This data will be included to the extent possible in collaboration with OSTEM Internship Program key personnel.
- Focus groups will be conducted with a sample of FY 2023 NASA OSTEM interns. The intent of the focus groups is to understand intern experiences (e.g., social experiences, onboarding, etc.), short-term outcomes

(e.g., sense of belonging and STEM identity), and the recruitment strategies employed with interns and how these strategies impacted their decision to apply to the NASA OSTEM Internship, specifically those individuals from underserved and underrepresented groups.
- Listening sessions with NASA OSTEM Internship Program key personnel will be conducted to understand the recruitment activities that the internship team implements for the NASA OSTEM Internship Program and the data the internship team collects from interns during the intern experience.

This study's evaluation questions and their associated data sources and corresponding data analysis procedures are described below in Table 2.

Table 2. Evaluation Questions, Data Sources, and Analysis Procedures

Evaluation Questions	Data Sources	Analysis Procedures
Internship Recruitment and Application		
1. How are prospective interns recruited to NASA OSTEM Internship opportunities? How did the recruitment strategies impact prospective interns' decision to apply?	• Intern Focus Groups • Listening Sessions with NASA OSTEM Internship Key Personnel	• Thematic Analysis
2. What are the characteristics of the registrant, applicant, and intern pool in the NASA OSTEM Internship Program and how do they compare year over year?	• NASA STEM Gateway	• Descriptive Statistics
Internship Experience		
3. What short-term outcomes are experienced by interns during the internship experience and how does it vary across different internship categories, types, and locations (full-time/part-time, undergraduate/graduate, length of internship, NASA Centers/Facilities, virtual/in-person)?	• NASA OSTEM Internship Background Materials • NASA STEM Gateway • Internship Experience • Survey • Intern Focus Groups	• Document Analysis • Descriptive Statistics
Internship Outcomes		
4. How did participation in the NASA OSTEM Internship program affect interns' education, careers, and future planning one year after internship completion?	• Retrospective Internship Survey • NSC Data	• Descriptive Statistics • Hierarchical Linear Modeling • Regression Analysis

Challenges

Utilization-focused evaluations employ pragmatic design principles to manage practical trade-offs that occur in real world contexts. Table 3 identifies three common evaluation challenges and corresponding pragmatic principles relevant to this investigation.

Table 3. Challenges of Utilization-Focused Evaluation

Evaluation Challenge	Pragmatic Principle
Providing the best possible data in time to affect decisions.	Providing less than perfect data that is available on time to affect decision is better than using more perfect data that is available after decisions have been taken.
Using rigorous methods and data collection processes to enable either credible results or high-quality, accurate data.	Per Office of Management and Budget (OMB) Memorandum M-20-12, in order to be considered rigorous an evaluation must have the most appropriate design and methods to answer key questions, while balancing its goals, scale, timeline, feasibility, and available resources.
Providing comprehensive findings.	Timeliness trumps comprehensiveness. Less is more when the evaluation can cut to the chase and focus on what is most useful.

All research and evaluation studies have issues and risks that can pose threats to their success. Table 4 lists the primary risks associated with this study and the management strategies that will be used to minimize these risks.

Table 4. Risk Mitigation Strategy

Potential Issues and Risks	Management Strategies
Schedule Slippage	A schedule of tasks and milestones will be established for the study. The schedule will be closely monitored by the evaluator and NASA. Any potential schedule slippage will be addressed and adjustments to project timeline will be collaboratively decided.
Conflicts of Interest	Potential conflicts of interest will be openly discussed with NASA. Any perceived or real conflicts of interest will be minimized by the independence of the individuals conducting the evaluation from the policies, decision-making, operations, and/or implementation of the activities which are the subject of this investigation.

Dissemination Strategies

The findings of this study will be summarized in an evaluation report. The report will be shared broadly among the NASA STEM Engagement community. The findings will also be presented at the OSTEM Performance and Evaluation Community of Practice, STEM Engagement Council meetings, and to the NASA stakeholders. A summary report brief of the findings will be posted online in the NASA OSTEM, STEM Impacts website.

Timeframe

This study will take place in FY 2024 – 2025.

APPENDIX

NASA astronauts Kjell Lindgren, left, Jessica Watkins, center, and Robert Hines, right, are seen in the in the One World Connected gallery looking at an interactive recreation of the International Space Station's Cupola, Tuesday, March 28, 2023 at the Smithsonian's National Air and Space Museum in Washington. Lindgren, Watkins, and Hines spent 170 days in space as part of Expeditions 67 and 68 aboard the International Space Station. Image Credit: NASA/Joel Kowsky

Acronym List

AAM	Advanced Air Mobility
AAPI	Asian American Pacific Islander
ACR	Architecture Concept Review
AEP	Annual Evaluation Plan
AFRC	Armstrong Flight Research Center, Edwards, CA
AI	Artificial Intelligence
AIAA	American Institute of Aeronautics and Astronautics
AIM	Aeronomy of Ice in the Mesosphere
AOS	Atmospheric Observing System
APG	Agency Priority Goal
ARC	Ames Research Center, Moffett Field, CA
ARF	Agency Resiliency Framework
ARL	Applications Readiness Level
ARMD	Aeronautics Research Mission Directorate
ARTEMIS	Acceleration, Reconnection, Turbulence and Electrodynamics of the Moon's Interaction with the Sun
ASL	Autonomous Systems Lab
BOAT	Brightest of All Time
BPR	Baseline Performance Review
BPS	Biological and Physical Sciences
CADRE	Cooperative Autonomous Distributed Robotic Explorers
CADre	Cost Analysis Data Requirements
CAP	Corrective Action Plan
CAPSTONE	Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment
CCM	Cooperative Conflict Management
CCP	Commercial Crew Program
CDFF	Commercial Destination Free Flyers
CDISS	Commercial Destinations on the ISS
CDR	Critical Design Review
CFM	Cryogenic Fluid Management
CFO	Chief Financial Officer
CIF	Center Innovation Fund
CLPS	Commercial Lunar Payload Services
CME	Coronal Mass Ejections
CONNECTS	NASA OSTEM Next Gen STEM Project Online Community of Practice
COO	Chief Operating Officer
CPMO	Chief Program Management Officer
CSA	Canadian Space Agency
CSM	Crew and Service Module
CY	Calendar Year

DARPA	Defense Advanced Research Projects Agency
DART	Days Away from Work or Restricted Duty
DEIA	Diversity, Equity, Inclusion, and Accessibility
DHA	Direct Hire Authority
DIP	Digital Information Platform
DRACO	Demonstration Rocket for Agile Cislunar Operations
DSA	Distributed Spacecraft Autonomy
DSN	Deep Space Network
DSOC	Deep Space Optical Communications
DTE	Direct-to-Earth
EAP	Electrified Aircraft Propulsion
EC	Executive Council
EDL	Entry, Descent, and Landing
EEO	Equal employment opportunity
EGS	Exploration Ground Systems
EO	Executive Order
EPFD	Electrified Powertrain Flight Demonstration
ESA	European Space Agency
ESDMD	Exploration Systems Development Mission Directorate
ESIC	Early Stage Innovation and Commerce
ESIP	Early-Stage Innovation and Partnerships
EVA	Extravehicular Activities
EVM	Earned Value Management
FAA	Federal Aviation Administration
FEVS	Federal Employee Viewpoint Survey
FFRDC	Federally Funded Research and Development Center
FO	Flight Opportunities
FSAA	Funded Space Act Agreement
FSP	Fission Surface Power
FY	Fiscal Year
GAO	Government Accountability Office
GCD	Game Changing Development
GEDI	Global Ecosystem Dynamics Investigation
GISS	Goddard Institute of Space Studies
GPC	Grants Policy and Compliance
GPRAMA	Government Performance and Results Act Modernization Act of 2010
GRB	Gamma-ray burst
GRC	Glenn Research Center, Cleveland, OH
GS	General Schedule
GSA	General Services Administration
GSFC	Goddard Space Flight Center, Greenbelt, MD
HALO	Habitation and Logistics Outpost
HBCU	Historically Black Colleges and Universities
HLS	Human Landing System
HMTA	Health and Medical Technical Authority

IBEX	Interstellar Boundary Explorer
ICPS	Interim Cryogenic Propulsion Stage
IMAP	Interstellar Mapping and Acceleration Probe
ISAAC	Integrated System for Autonomous and Adaptive Caretaking
ISRO	Indian Space Research Organisation
ISS	International Space Station
IT	Information Technology
IXPE	Imaging X-ray Polarimetry Explorer
JAXA	Japan Aerospace Exploration Agency
JPL	Jet Propulsion Lab, La Cañada Flintridge, CA
JPSS	Joint Polar Satellite System
JSC	Johnson Space Center, Houston, TX
KDP	Key Decision Point
KPP	Key performance parameter
KSC	Kennedy Space Center, Titusville, FL
LBFD	Low Boom Flight Demonstrator
LCR	Lifecycle Review
LEO	Low Earth Orbit
LGBTQIA	Lesbian, Gay, Bisexual, Transgender, Queer, Intersex, and Asexual
LOFTID	Low-Earth Orbit Flight Test of an Inflatable Decelerator
LSP	Launch Services Program
LTV	Lunar Terrain Vehicle
MD	Mission Directorate
ML	Machine Learning
MOXIE	Mars Oxygen In-Situ Resource Utilization Experiment
MSD	Mission Support Directorate
MSFC	Marshall Space Flight Center, Huntsville, AL
MSI	Minority Serving Institutions
MUREP	Minority University Research and Education Project
NAC	NASA Advisory Council
NARI	NASA Aeronautics Research Institute
NASA	National Aeronautics and Space Administration
NCLF	National Civilian Labor Force
NEO	Near Earth Objects
NISAR	NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar
NOAA	National Oceanic and Atmospheric Administration
NPR	NASA Procedural Requirement
NSN	Near Space Network
NTRE	Nuclear Thermal Rocket Engine
OCE	Office of the Chief Engineer
OCFO	Office of the Chief Financial Officer
OCHCO	Office of the Chief Human Capital Officer
OCIO	Office of the Chief Information Officer
ODEO	Office of Diversity and Equal Opportunity
OIG	Office of the Inspector General

OMB	Office of Management and Budget
ONCE	One NASA Cost Engineering Database
OP	Office of Procurement
OPM	Office of Personnel Management
OSAM-1	On-Orbit Servicing and Manufacturing 1
OSBP	Office of Small Business Programs
OSHA	Occupational Safety and Health Administration
OSI	Office of Strategic Infrastructure
OSTEM	Office of STEM Engagement
PA	Protected areas
PACE	Plankton, Aerosol, Cloud, ocean Ecosystem
PDR	Preliminary Design Review
PG	Performance Goal
PP&C	Program, Planning, and Control
PPBE	Planning, Programming, Budgeting, and Execution
PPE	Power and Propulsion Element
PSP	Parker Solar Probe
RFI	Request for Information
RVLT	Revolutionary Vertical Lift Technology
SBA	Small Business Administration
SBIR	Small Business Innovation Research
SCM	Strategic Conflict Management
SDB	Small Disadvantaged Businesses
SDE	Science Discovery Engine
SEP	Solar Electric Propulsion
SES	Senior Executive Service
SFD	Sustainable Flight Demonstration
SIB	Strategic Insights and Budget Division
SLS	Space Launch System
SMART-VG	Shape Memory Alloy Reconfigurable Technology-Vortex Generator
SMD	Science Mission Directorate
SNP	Space Nuclear Propulsion
SO	Strategic Objective
SOMD	Space Operations Mission Directorate
SOP	Statement of Progress
SRR	System Requirements Review
SSC	Stennis Space Center, Kiln, MS
SST	Small Spacecraft Technology
STEM	Science, Technology, Engineering, and Mathematics
STMD	Space Technology Mission Directorate
STPI	Science and Technology Policy Institute
STRG	Space Technology Research Grants
STTR	Small Business Technology Transfer
SWOT	Surface Water and Ocean Topography
SWS	System Wide Safety

TCIR	Total Case Incident Rate
TCM	Tactical Conflict Management
TDM	Technology Demonstration Missions
TEMPO	Tropospheric Emissions: Monitoring Pollution instrument
TESS	Transiting Exoplanet Survey Satellite
TN	Tail Number
TRL	Technology Readiness Level
U.S.	United States
UAM	Urban Air Mobility
ULA	United Launch Alliance
VIPER	Volatiles Investigating Polar Exploration Rover
VIPer	Volume of Integrated Performance
VTOL	Vertical take-off and landing
ZEV	Zero Emissions Vehicles

Agency Response to Office of the Inspector General 2023 Report on Top Management and Performance Challenges

This image taken by the Mars Reconnaissance Orbiter (MRO) spacecraft's HIRISE instrument on October 23, 2022, of the northern plains of Arabia Terra shows craters that contain curious deposits with mysterious shapes and distribution.
Image Credit: NASA

National Aeronautics and Space Administration

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

October 13, 2023

TO: Inspector General

FROM: Administrator

SUBJECT: Agency Response to Office of Inspector General Report, "2023 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, "2023 Report on NASA's Top Management and Performance Challenges" (Q-23-04-00-AOQA), issued September 11, 2023.

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, we continue to aggressively pursue the mitigation and remediation of findings related to the audit recommendations issued by your office, including those which form the underpinnings of your observations as cited in your 2023 Report on NASA's Top Management and Performance Challenges.

While we fundamentally agree that the seven areas outlined in your 2023 report constitute significant challenges for the Agency, we would like to highlight the following mitigation and remediation efforts relative to each challenge outlined in your report that have either been taken or are currently underway. We believe 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

NASA continues to make significant progress towards returning humans to the Moon through the Artemis campaign. NASA's uncrewed 25.5-day Artemis I flight test proved the Space Launch System (SLS) rocket, Orion spacecraft, and the Exploration Ground Systems (EGS) needed for launch and recovery are ready to fly astronauts on missions to the Moon. Engineers conducted analysis of flight data during the mission from November 16 – December 11, 2022, and, afterwards, have continued to assess data and hardware to validate system performance ahead of Artemis II. On the debut flight of SLS, the rocket flew as designed and with precision, with all systems meeting, and in many cases exceeding, performance expectations. Following a near-perfect trans-lunar injection burn, the rocket's

interim cryogenic propulsion stage and Orion successfully separated, delivering Orion to its initial target orbit and then on a trajectory toward the Moon. Meanwhile, engineers with the EGS program completed detailed assessments of Mobile Launcher (ML-1) shortly after launch and determined ML-1 sustained more damage than initially expected from the 8.8 million pounds of thrust generated at liftoff by SLS on Artemis. NASA repaired damaged components and completed modifications for the first crewed mission on Artemis II, including verification and validation of the Crew Access Arm and fabrication, installation, and commissioning of the emergency egress system. Teams also are extensively reviewing more than 155 gigabytes of Orion data to confirm the spacecraft's successful performance during its journey nearly 270,000 miles beyond the Moon. Orion accomplished 161 test objectives to fully demonstrate every aspect of the spacecraft, including 20 objectives added mid-flight. Data shows the European-built service module generated 20 percent more power than initial expectations and consumed about 25 percent less power than predicted. All the spacecraft's dynamic separation events were completed without issue and splashdown occurred 2.4 miles from the target landing spot, well within requirements. Upon return to Kennedy Space Center (KSC) in Florida, avionics components earmarked for reuse on Artemis II have been removed, refurbished, and integrated into the Artemis II crew module. NASA also continues to review data from reentry and post-flight inspections to understand differences between the demonstrated performance of Orion's Avcoat heatshield on this test flight compared to predictions made before the flight.

NASA has also made steady progress towards Artemis II. In April 2023, NASA named the Artemis II crew of Americans Christina Hammock Koch, Reid Wiseman, and Victor Glover, and Canadian Space Agency astronaut Jeremy Hansen. The five SLS core stage elements for Artemis II are mated, and the stage is going through final integration and testing at the Michoud Assembly Facility in Louisiana. The SLS solid boosters and interim cryogenic propulsion stage have been delivered to the KSC in preparation for vehicle stacking. ML-1 repairs are ongoing, Crew Access Arm functional testing completed, and launch pad 39B upgrades (including a new 1.4 million gallon liquid hydrogen sphere that will increase launch availability and support the tanking needs of SLS Block 1B) at KSC are progressing. Orion Crew Module (CM) and Service Module (SM) are preparing for mate.

NASA will follow the Artemis II crewed test flight with the first human lunar return mission on Artemis III. NASA convened a lunar surface science workshop in April 2022 to gather data and points of interest within thirteen potential landing sights at the Moon's south pole. Manufacturing is underway on all SLS Artemis II hardware with a new core stage production flow planned to balance integration tasks between the Michoud Assembly Facility and the KSC. Orion Artemis III hardware is also in production, the first crew module being built under the Orion Production and Operations Contract (OPOC) and European service module integration in progress in Bremen, Germany. SpaceX, on contract with NASA to provide the Human Landing System for Artemis III, attempted a flight test of the integrated Starship/Super Heavy in April 2023 that ended prematurely approximately four minutes into the flight; a SpaceX-led investigation has completed with Federal Aviation Administration (FAA) oversight and NASA participation ahead of a second planned test.
NASA is organized to ensure the success of the lunar return mission, a sustainable program of lunar exploration, and preparations for human missions to Mars. On March 23, 2023, NASA announced the establishment of the Moon to Mars Program Office within the

Exploration Systems Development Mission Directorate (ESDMD). As directed by the NASA Authorization Act of 2022, the Moon to Mars Program Office focuses on hardware development, mission integration, and risk management functions for programs critical to the Agency's exploration approach. The Moon to Mars Program Office consolidates the management of programs (including the Space Launch System rocket; the Orion spacecraft; exploration ground systems; the lunar Human Landing System; spacesuits, rovers, and lunar surface habitats; and the lunar orbiting Gateway platform) and cross-program integration functions (including systems engineering, program planning and control, safety, and exploration operations) into a single organization with clear responsibility and authority for conducting Artemis missions. The office also leads planning and analysis for long-lead developments to support human Mars missions.

The Moon to Mars Program Office has streamlined governance through such measures as consolidating decision-making through a single Moon to Mars control board. NASA manages the Artemis manifest and the associated integrated mission schedules at the enterprise level ensuring a single effort towards schedule management. This integrated mission schedule approach increases program and contractor accountability and risk mitigation for elements along and near the critical path. Top technical concerns and issues, tracked by mission, are continuously monitored and progress is reported through a series of Moon to Mars, ESDMD, and Agency quarterly reviews, management councils, and baseline performance reviews.

NASA is working closely with the Artemis contractors to ensure their performance and mission success. NASA is increasing prime contractor participation in Quarterly Program Status Reviews, control boards, and other integrated forums with the Moon to Mars programs. This also includes contractors actively participating in flight readiness assessments, sharing of integration tasks where applicable, and exchanging lessons learned. With an acquisition approach aligned to risk management, NASA utilizes a wide variety of contract mechanisms tailored to the specific technical and programmatic conditions for each program. NASA's exploration program, for example, leverages a mix of cost-plus contracts as well as utilization of firm-fixed price contracts that reflect the growing maturity, innovation, and diversity of the United States (U.S.) space industry.

Challenge 2: Improving Management of Major Programs and Projects

NASA recognizes the inherent challenges of managing large, complex, often first-of-their-kind space flight and aeronautics programs and has worked over many years to improve policies and processes that control cost and schedule while ensuring mission success. These efforts coincide with NASA's continued observance of sound financial practices and programmatic rigor as good stewards of taxpayer dollars.

The Agency has pursued improvements in acquisition and project management to further strengthen program formulation, approval, implementation, and ongoing evaluation. We appreciate that this report highlighted the Government Accountability Office's (GAO) recognition of NASA's continued improvement in acquisition management and its assessment that NASA has fully met four out of five criteria to be removed from GAO's Acquisition High Risk List and is partially met on the final criterion. Further, in August 2021, the NASA Deputy Administrator initiated a Tiger Team whose recommendations

created a more robust structure for acquisition planning. A key initiative was the elevation of the Chief Acquisition Officer (CAO) role to the NASA Deputy Administrator, raising acquisition planning to the attention of the Agency's most senior officials. In December 2022, the CAO released a memorandum of intent to Agency leaders detailing acquisition priorities to enhance Agency insight, oversight, and project performance. The CAO later hosted a series of town hall meetings across NASA Headquarters and its nine Centers to communicate the Agency's commitment to improved acquisition outcomes. These CAO actions emphasized the importance of ensuring rigorous acquisition approaches are aligned with best practices and the value of an acquisition workforce to advancing these objectives.

NASA leadership also leveraged the Tiger Team findings by establishing a Chief Program Management Officer (CPMO) to enact measurable, enduring improvement in program and project performance through cross-enterprise coordination. Among the CPMO's responsibilities is providing executive guidance as NASA works to mitigate high-risk areas identified through its Corrective Action Plan (CAP). As OIG recognizes in the report, the Agency has made substantial progress in the implementation of its CAP, including the improvements highlighted in the most recent update approved by NASA leadership in summer 2022. Additional initiatives from the Tiger Team included the promotion of early discussions on acquisition strategies and plans; requiring an Analysis of Alternatives for Acquisition Strategy Meetings to address acquisition options measured against an established set of key drivers such as performance, cost, schedule, ownership, policy, and workforce; and initiating in-depth reviews of major programs at a monthly assessment to ensure senior leadership maintains situational awareness of program performance.

These efforts are reinforced by NASA's sustained commitment to providing transparent and accountable communication in accordance with our statutory obligations. NASA is fully compliant with Title 51 by having all major development activities subject to congressional reporting and performance thresholds. For programs and projects with an unspecified Phase E scope and duration, the initial capability cost estimate and other parameters become the Agency Baseline Commitment (ABC). In addition, NASA establishes ABCs for all future major upgrade development activities and communicates an annually updated five-year operations cost estimate starting prior to Phase E. This approach complies with Title 51 and ensures the Agency consistently and effectively communicates estimates of Phase E operations as the mission cadence matures.

Regarding the report's comments about the Agency's application of the Joint Cost and Schedule Confidence Level (JCL) and consideration of external risks as part of the analysis, it is important to note that NASA appropriately applies the JCL in alignment with the established Agency commitments pursuant to Title 51. Commitments at the mission level are not required by Title 51 since missions consist of multiple elements, and these costs are captured in their individual element Phase E costs, which may be five-year estimates for systems with unspecified operational scope and duration, as mentioned above. Therefore, even though the Agency actively manages technical and operational requirements and risks across Artemis missions, NASA does not plan to make formal commitments at the mission level—as such, confidence-level analysis is not provided by mission. While the Agency does not have a formalized requirement to perform risk analysis by mission specifically, it does

have formal processes to inform management of global and interdependency risks across major programs and projects as it relates to their commitments.

Major programs are already required to address potential externality risks by identifying and estimating the cost and schedule impacts. For projects and single-project programs, a JCL analysis is required to support the ABC in accordance with NASA Procedural Requirements (NPR) 7120.5F. The JCL calculation includes consideration of the risk associated with all elements. JCL analysis derived from a probabilistic cost and loaded probabilistic schedule approach typically includes content only through the completion of Phase D, which, by definition, is not representational of the total life-cycle cost or operational life of a project. While NPR 7120.5F does not require tightly coupled, loosely coupled, and uncoupled programs to develop program cost and schedule confidence levels, they must provide analysis of the program's risk posture as each new project reaches KDP-B and C, or when a project is re-baselined. NASA continues to promote consistency as well as identify opportunities to improve how management policies are applied across mission areas while also implementing performance metrics informed by proven analytical techniques.

Specific to the report's encouragement for enhanced visibility into the investments of the Artemis campaign, costs of newly developed capabilities will be provided in addition to production and operation cost estimates for any hardware in the mission that has been previously produced and operated.

NASA is at a historic inflection point, poised to advance the most significant series of science and human exploration missions in over a generation. The Agency continues to optimize the use of available resources in the pursuit of effective and efficient solutions that improve project management and support the advancement of ingenuity and innovation in space science, human exploration, and aerospace technology.

Challenge 3: Sustaining a Human Presence in Low Earth Orbit

NASA recognizes that forward work remains to avoid a gap between the initial operations of commercial LEO destinations (CLDs) and the retirement of the International Space Station (ISS) by 2030. NASA's Commercial LEO Development Program (CLDP), Commercial Crew Program (CCP), and International Space Station (ISS) Program work together as parts of a LEO ecosystem. NASA has aligned the activities of these programs to ensure that the U.S. continues to provide leadership in developing the LEO economy while continuing the uninterrupted human presence in LEO. NASA also agrees that the Agency will need to continue balancing multiple priorities including maintaining ISS operations, stimulating a commercial LEO economy, ensuring sufficient crew and cargo capabilities, managing orbital debris, and planning for ISS deorbit.

Stimulating a LEO economy

NASA is continuing to safely maintain operations aboard the ISS while also enabling the development of the LEO economy. During FY23, NASA successfully executed Expeditions 68 and 69 which supported over 17 US Orbital Segment (USOS) crewmembers, conducted over 265 investigations, of which over 180 were NASA-led. In May 2023, the ISS also hosted the second private astronaut mission, Axiom Space's Ax-2. These private astronaut missions represent both a culmination of NASA's efforts to foster a commercial market in

LEO and the beginning of a new era of space exploration. NASA also announced the selection of Axiom Space for private astronaut missions, Ax-3 and Ax-4, respectively. Ax-3 is set to launch no earlier than January 2024 and Ax-4 no earlier than August 2024 from KSC. These additional missions are opening access to LEO and the ISS to more international partners, people, science, and commercial opportunities.

In October 2023, Nanoracks, part of Voyager Space's Exploration Segment, and Northrop Grumman announced that they are teaming up to support Nanoracks' development of the Starlab commercial space station. Rather than developing its own destination as planned under a separate Space Act Agreement (SAA) with NASA, the Agency and Northrop Grumman agreed to withdraw from its agreement so the company can join Voyager Space and Nanoracks in providing cargo logistics services and engineering services to support the Starlab station. This was a positive development for the commercial low Earth orbit destinations effort. Refining strategies and evolving partnerships are part of the process as NASA enables the development of a robust low Earth orbit economy where NASA is one of many customers. NASA plans to take the remaining funding associated with Northrop Grumman's withdrawal and other program funding to add milestones to the Agency's existing agreements with the other funded destination partners including Voyager Space/Nanoracks, Blue Origin, and Axiom Space, assuming NASA and the companies can agree on the additional milestones and value. This opportunity will provide NASA the ability to reduce risk and have additional insight into the partners' technical designs. NASA has quarterly meetings with industry partners to assess their progress and gain insight into their development schedule. The CLD partners are strongly incentivized to be first-to-market, particularly for their commercial customers. NASA continues to refine its acquisition strategy for the eventual certification and services purchases for CLDs.

In June 2023, NASA partnered with seven U.S. companies to meet future commercial and Government needs through the second Collaborations for Commercial Space Capabilities-2 (CCSC-2) initiative. Using unfunded Space Act Agreements (SAAs), CCSC-2 is designed to advance commercial space-related efforts through NASA contributions of technical expertise, assessments, lessons learned, technologies, and data. Sharing of NASA expertise utilizes minimal Government resources but fosters development of capabilities that can be crucial to development of a robust LEO economy.

Ensuring crew/cargo transportation

CCP is continuing to provide crew transportation services to the ISS from U.S. Commercial Space Transportation service providers. SpaceX successfully launched Crew-6 and Crew-7 to the ISS and is targeting to launch Crew-8 in February 2024. Boeing's latest crewed flight, Crewed Flight Test (CFT), was scheduled for July 2023 but was deferred due to emerging parachute issues. Boeing has made significant progress on CFT hardware processing and product closure and is continuing to work through spacecraft issues. Ninety-eight percent of the certification products required for the CFT are complete. The CFT launch date is currently under review with a spacecraft readiness date of no earlier than March 2024.

NASA issued a sole source modification to SpaceX to acquire up to three additional crew flights to the ISS, as part of its Commercial Crew Transportation Capabilities (CCtCap) contract, which will allow NASA to maintain an uninterrupted U.S. capability for human access to space. Currently, the SpaceX crew transportation system is the only one certified to

meet NASA's safety requirements to transport crew to the space station, and the additional award maintains the Agency's obligation to its international partners.

NASA also ordered 12 additional missions under the Commercial Resupply Services-2 (CRS-2) contracts. The 12 additional missions ordered – six each to Northrop Grumman and SpaceX – will provide resupply services to the station through 2026. NASA continues to work with Sierra Space on their Dream Chaser spacecraft which could be certified as another cargo resupply vehicle.

Orbital debris mitigation

NASA is highly aware that orbital debris created by objects, such as abandoned vehicle stages, non-functional satellites, and fragments of launched materials, impedes our ability to use space by increasing the cost of space operations (maneuvering around debris), threatening the safety of astronauts and satellites, limiting the ability to launch spacecraft, and potentially rendering entire orbits unusable for a generation or more. Small debris are the most likely source of collisions with spacecraft due to the overall amount and current inability to track and avoid them.

Currently, NASA's Space Technology Mission Directorate (STMD) has multiple investments in low technology readiness level (TRL) orbital debris mitigation, detection, and remediation technologies across several programs, including the Small Spacecraft Technology (SST) and the Early-Stage Innovations and Partnerships (ESIP) portfolio through various mechanisms such as: Space Technology Research Grants (STRGs); Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR); and Prizes, Challenges, and Crowdsourcing (PCC).

In August 2023, as a part of STMD's SBIR Ignite initiative, a pilot solicitation which aims to increase participation from product-driven small business, startup, and entrepreneur companies that are *not* looking at NASA as their primary customer, NASA awarded 2 Phase II awards to companies for concepts dealing with orbital debris. These are:

- *Trans Astronautica Corporation, Los Angeles: Mini Bee Capture Bag for Active Debris Remediation.*
- *Turion Space Corp., Irvine, California: Low-Cost CubeSat for Active Removal of Sizable Space Debris Utilizing a Mothership Architecture.*

In FY23, NASA developed and initiated a small orbital debris challenge through its ESIP with the objective of identifying, tracking, and remediating small debris by honing concepts already proposed and generating additional ideas. The challenge will also provide NASA with insight into how such technologies could be deployed, the scalability and costs of various remediation approaches, the pool of innovators from known and adjacent areas of expertise who are capable and/or willing to work on small debris mitigation, and technology gaps that could be addressed by other funded efforts.

Deorbit planning

During FY23, NASA developed requirements for a commercial U.S. Deorbit Vehicle (USDV) based on industry responses and released a request for U.S. industry proposals for a

USDV that safely deorbits the ISS as part of its planned retirement after 2030. Proposals are due in November 2023, with a subsequent award expected in 2024.

Challenge 4: Managing and Mitigating Cybersecurity Risk

In 2023, the Office of the Chief Information Officer (OCIO) participated in a months-long National Security Council (NSC) directed effort to improve Agency use of multi-factor authentication (MFA) and encryption of data-in-transit (DIT) and data-at-rest (DAR). Although NASA has not reached the numeric goals set by the NSC, OCIO is working on a detailed plan of action to improve these results. To achieve Executive Order (EO) 14028 goals, NASA assembled a Cybersecurity Improvement Portfolio (CIP) with a near-term focus of achieving Zero Trust Architecture within three years on the corporate network.

The OCIO Software Licensing and Asset Management (SLAM) team is working the seven recommendations from the recent audit, including implementation of enhanced policy, training, and software management tools.

NASA's responsible Artificial Intelligence (AI) officials have approved NASA adoption of the definition of AI from the 2019 National Defense Authorization Act. The responsible AI team has begun promulgation of the use of this definition, and it will be used in future AI inventories and responsible AI governance work.

As noted in the closure of the NASA OIG audit, "NASA's Cybersecurity Readiness," OCIO has established an Agency-level office led by the NASA Chief Enterprise Architect with direct oversight of the Enterprise Cybersecurity Architect, with all requisite organizational structure, roles and responsibilities, supporting governance, Agency-level strategic direction, and metrics that evaluate the effectiveness and success of the overall Environmental Assessment program.

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

NASA continues to make meaningful progress in addressing contracts, grants, and cooperative agreement oversight challenges and continues to strengthen its overall procurement processes and policy.

NASA Office of Procurement (OP) collaborated closely via regular weekly engagements with technical, program, legal, and financial stakeholders to enhance transparency, accountability, and oversight of Category 1 contracts to ensure quality, timeliness of delivery, and cost control.

NASA OP procurement analysts advised and assisted Centers through Procurement Strategy Meetings (PSMs) to conduct risk analyses to best determine appropriate contract type. NASA OP advised and assisted on six major programs/activities (SEWP VI Governmentwide Acquisition Contract (GWAC) for Commercial IT Products and Services; Lunar Terrain Vehicle Services; GeoXO Spacecraft; SLS, Pre-SLS Exploration Production and Operations Contract (Pre-EPOC); LaRC Center Maintenance Operations and Engineering (CMOE III) Contract; and U.S. ISS Deorbit Vehicle (USDV)) to ensure the

contract type determination was justified and supported by historic data, market research, and appropriately considered performance risk.

Additionally, NASA OP added increased rigor to its review of contractor performance to ensure assigned ratings accurately reflected past performance and were well documented. Similar enhanced reviews were conducted for award-term and award-fee determinations to more appropriately incentivize contractor performance. OP procurement analysts and leadership were included in meaningful deliberations with Centers to finalize ratings and fee determinations to ensure consistent standards across the NASA enterprise with particular attention given to cost and schedule concerns.

With respect to grants and cooperative agreements, this monitoring plan includes:

- Pre-award risk assessment: Determines the level of risk associated with the recipient managing an award, as well as the award type. Assessment results determine the level of required monitoring to mitigate areas of high risks.
- Routine monitoring: An observation of award compliance through the review of recipient drawdowns and costs charged to an award. Recipient drawdowns are monitored quarterly through an analysis of the Federal Cash Transaction Report in accordance with 2 CFR § 200.328, Financial Reporting. In addition to Federal Cash Transaction Report, Grant Officers are charged with performing a systematic test of grantee expenditures from a selected quarter to identify potential unallowable, or unreasonable costs to assess the likelihood that recipients' errors would result in a material effect on Federal awards.
- Advanced monitoring: Focuses on an inclusion of award-specific terms and conditions, including more frequent reporting, to provide reasonable assurance that recipient entities managing the higher-risk awards have increased awareness of project goals and potential shortfalls.

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

The Agency remains committed to tackling workforce issues and to building an even stronger talent pipeline to accomplish NASA missions. NASA's Office of the Chief Human Capital Officer modernized the recruiting process and developed a coordinated recruitment strategy using a standardized approach and leveraging digital platforms to engage with prospective candidates. A critical piece of the recruitment strategy focuses on increasing workforce diversity by reaching new talent communities and establishing NASA as an employer that celebrates diversity and inclusion as keys to success. NASA has received multiple awards in 2022 and 2023 in recognition for our outreach and employment of under-represented groups: Ranked #1 Most Prestigious Internships (Vault/Firsthand, 2023), Top 20 Government Employers (Woman Engineer Magazine, 2023), Top 20 Government Employers (STEM Workforce Diversity Magazine, 2023), America's Best Employer for Veterans (Forbes, 2022), and America's Best Employers For Women (Forbes, 2022, 2023). NASA continually measures efforts and iterates on its recruitment strategy to ensure success. Multiple hiring authorities are utilized to quickly fill positions as well as pay incentives to recruit the right skills into the Agency.

NASA's workforce planning includes all NASA Mission Directorates, NASA Centers, and Mission Support Enterprise Organizations (MSEOs). NASA Mission Directorates develop guidance that provides clarity on future work content engaging with Centers and MSEO in demand-driven workforce planning activities to ensure the workforce is sufficiently agile in size and mix. This process positions NASA to continue global leadership in space science, human exploration, aerospace innovation, and technology development and effectively respond to both known and uncertain mission demands. Annual workforce plans for both Centers and MSEOs include projections of workforce size over a five-year time horizon, future composition of the workforce and expected hiring patterns, strategies for shaping and managing the workforce, and risk assessment. This strategic planning process helps NASA to shape the future by defining clear and challenging workforce roles needed to enable long-term goals in science, exploration, aerospace, technology, and innovation.

NASA 2040 was launched in June 2023 to bring a new focus to aligning our institutional operations to our priority mission needs. This initiative aims to drive meaningful changes that ensure NASA in the year 2040 remains the global leader in aerospace and science. A specific area of focus includes shaping an Agency workforce strategy.

Challenge 7: Managing NASA's Outdated Infrastructure and Facilities

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

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

In 2019, OSI began to conduct an analysis on the Agency's leasing policies, procedures, and practices. As a result of this analysis, in 2020, NASA decided to centralize real estate functions across all Centers to OSI-FRED (OSI-Facilities and Real Estate Division). Additionally, OSI-FRED is in the process of updating the NPR 8800.15, "Real Estate Management Program" and is conducting a complete analysis of the Agency's Enhanced Use Lease Program to ensure that internal controls are established, real estate agreements are properly coordinated with all stakeholders, and are compliant with all rules, regulations, and laws. NASA has also identified investment strategies using Reliability Centered Maintenance (RCM) principles to stave off the increasing deferred maintenance liability

within the Agency. OSI-FRED is implementing a Tiered Maintenance approach with foundations of Condition-Based Maintenance principles for relevant and critical assets. These efforts will lead to optimized maintenance programs and prioritization of available operations and maintenance resources.

OSI leadership continues to inform and carry forward advocacy for additional investments necessary to improve the condition of important building systems and facilities across the Agency. Ultimately, this will increase the availability and reliability of these critical assets to meet current, emerging, and future mission needs. Implementation of these RCM principles ensures that the right type of maintenance is performed on the most critical assets, at the right time, and for the right reasons. RCM, paired with immediate investments in the replacement of obsolete items associated with the Agency's higher-criticality assets, can provide near-term corrective mitigation for known risks and avoid mission/schedule impacts. These maintenance strategies focus on increasing equipment availability and avoiding disruptive failures and unplanned repair costs. These initiatives will mitigate the Agency's ongoing challenge of aging and outdated infrastructure and facilities.

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

If you have any questions regarding NASA's response to the 2023 Top Management and Performance Challenges, please contact Anthony Mitchell, Audit Liaison Project Manager, at (202) 358-1758.

cc:
Chief Financial Officer/Ms. Vo Shaus
Chief Information Officer/Mr. Seaton
Associate Administrator Space Operations Mission Directorate/Mr. Bowersox
Assistant Administrator for Procurement/Ms. Smith Jackson
Assistant Administrator for Strategic Infrastructure/Mr. Carney
Chief Human Capital Officer/Ms. Elliott (Acting)