National Aeronautics and Space Administration









FY 2023 Volume of Integrated Performance

FY 2021 Annual Performance Report

FY 2022 Agency Performance Plan Update

FY 2023 Agency Performance Plan

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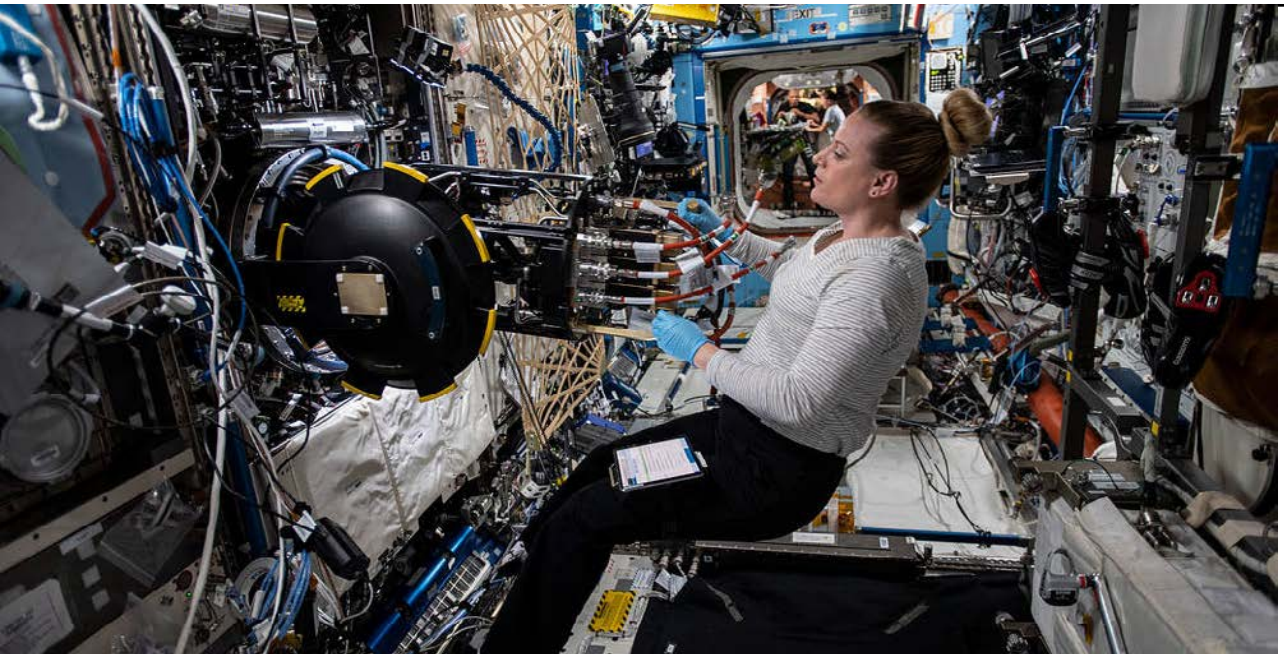
Above: NASA Communications' Jasmine Hopkins moderates a CRS-21 prelaunch news conference at Kennedy Space Center in Florida on December 4, 2020. Participants included Kenny Todd, deputy program manager, International Space Station Program Office; Kirt Costello, chief scientist, International Space Station Program Office; Sarah Walker, director, Dragon Mission Management, SpaceX; and Melody Lovin, launch weather officer, U.S. Air Force 45th Space Wing. SpaceX's Falcon 9 rocket, with the upgraded version of the Cargo Dragon spacecraft atop, launched on December 6, 2020, from Kennedy's Launch Complex. It delivered supplies, equipment, and critical materials needed to support a variety of science and research investigations on the International Space Station. Image credit: NASA/Isaac Watson

Part 1

Performance Management at NASA

Above: After a 5,800-mile move, the James Webb Space Telescope has safely made it inside the cleanroom at its launch site at Guiana Space Center, in French Guiana. After its arrival, Webb was carefully lifted from its packing container and then raised vertical. This is the same configuration Webb was in when it launched on board an Ariane 5 rocket on December 25, 2021. Image credit: NASA/Chris Gunn



NASA Performance Foundations

Vision

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

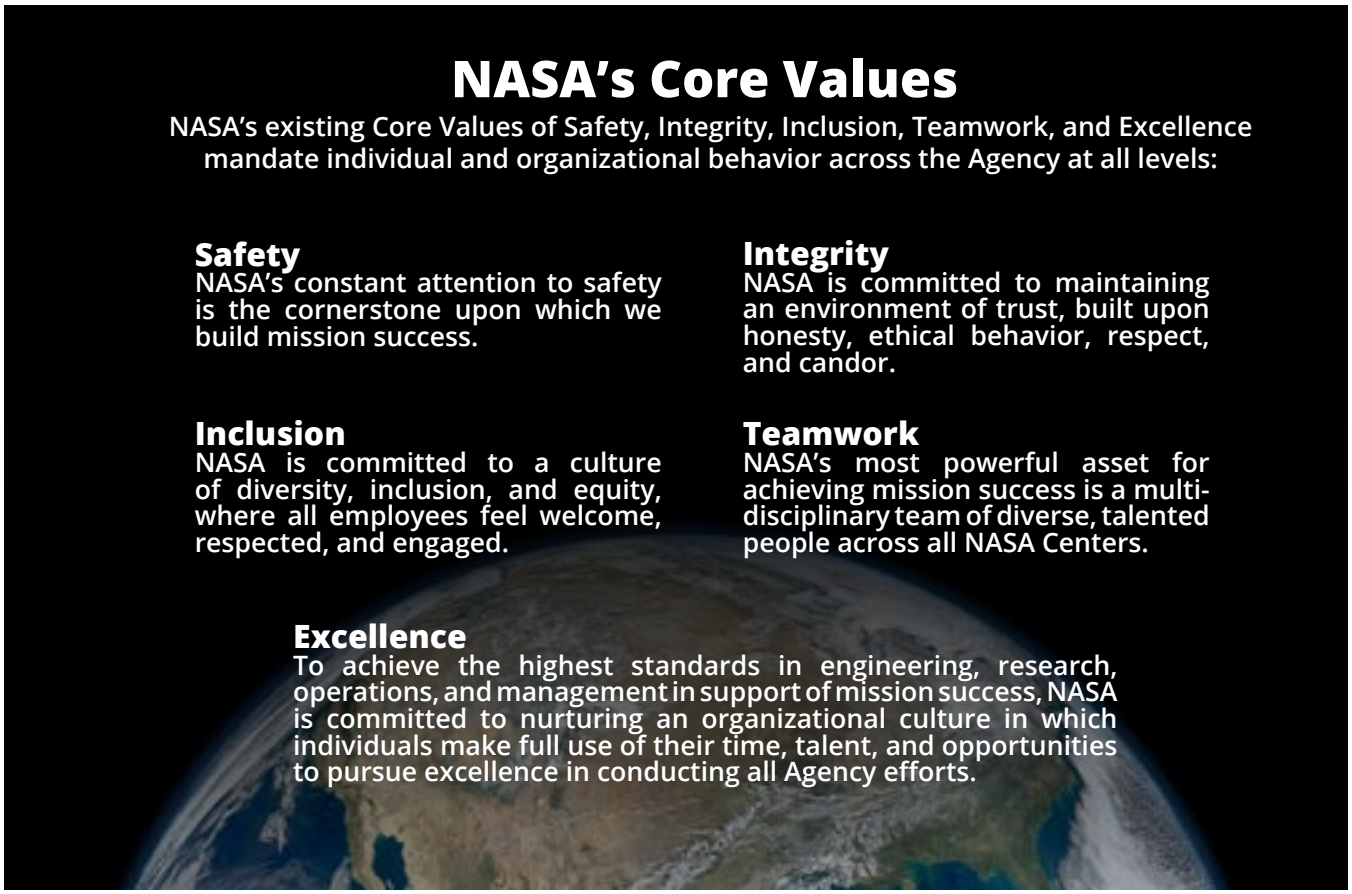
Mission

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

Since 1958, NASA has led the peaceful exploration of space, advancing knowledge of Earth while making discoveries about the furthest reaches of the universe. NASA research has advanced aeronautics, helped develop the commercial space industry, and strengthened the U.S. economy. Our efforts in space help to further the national economy, including through innovative commercial 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. In addition, NASA's partnerships with academic institutions support 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 largely determined by the strategic decisions and investments we make today, as well as constant adherence to our five guiding Core Values.

Above: NASA astronaut and Expedition 64 Flight Engineer Kate Rubins removes research hardware from inside the Combustion Integrated Rack. She was replacing gear to support a suite of fuel efficiency, pollution, and fire safety studies known as the Advanced Combustion in Microgravity Experiments, or ACME. Image Credit: NASA



The Agency's success also is supported by continuously evolving and strengthening our performance management. We use common business and development practices 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, 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 is transparent in these efforts, complying fully with requirements on performance reporting and accountability, in accordance with the Government Performance and Results Act (GPRA) Modernization Act of 2010. NASA's commitment to performance reaches further than compliance. We have an ingrained culture of self-evaluation and continuous improvement, using findings from studies and assessments to improve the Agency in the short term and position NASA for long-term success.

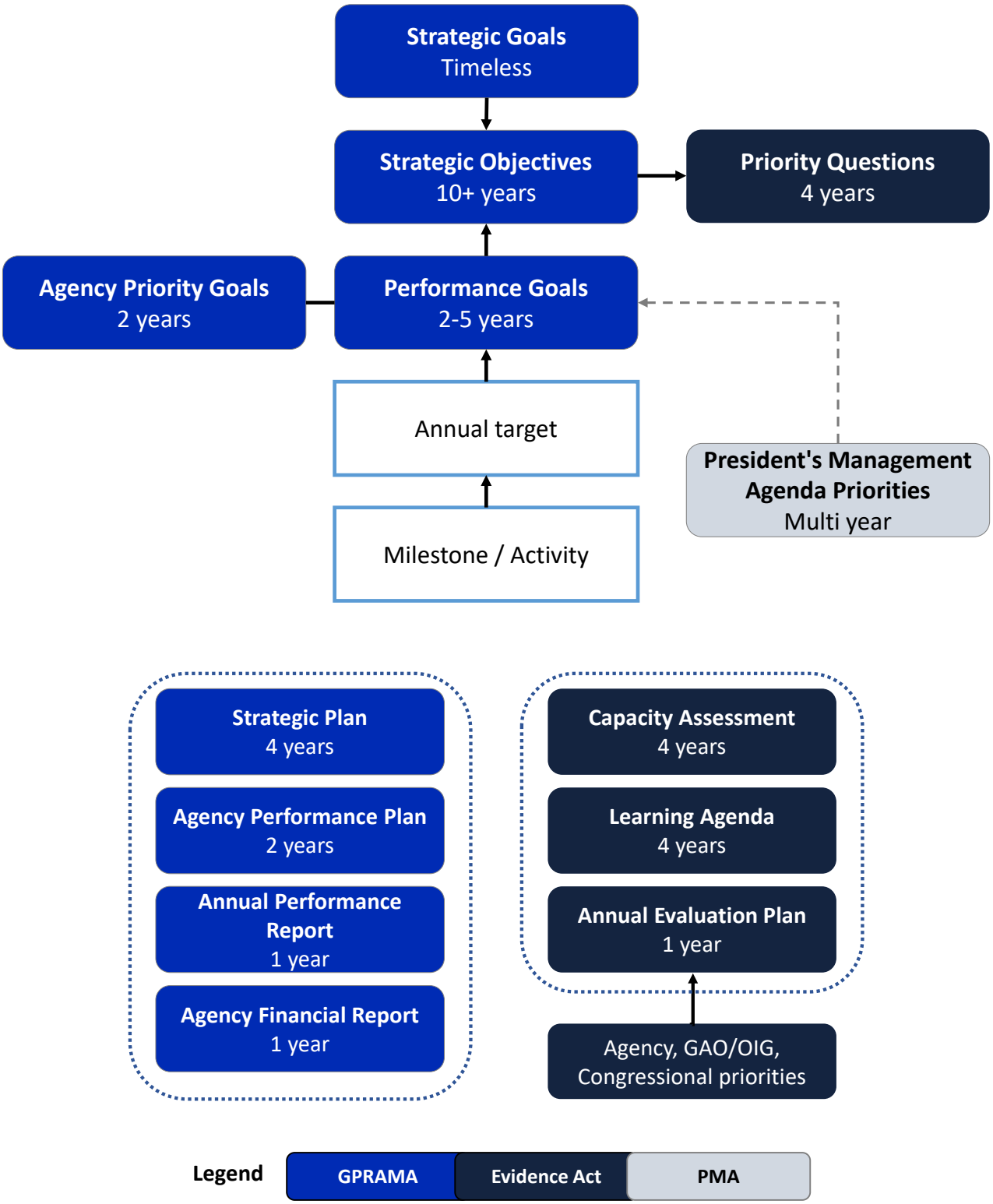
The *NASA 2022 Strategic Plan* outlines our continuing plans for human and robotic space exploration, aeronautics, technology development, and Agency operations and provides a clear and unified direction for our programs and projects. This direction is captured in NASA's Vision and Mission statements—why NASA exists, what we aspire to achieve, and how we expect to achieve societal benefits.

The information reported in this document is aligned with the NASA 2022 Strategic Plan and the FY 2023 Congressional Justification, in accordance with the requirements of the GPRA Modernization Act, as described below.

Strategic-Performance-Evidence Framework

The quadrennial NASA *2022 Strategic Plan* describes a framework that consists of Strategic Goals aligned to our Mission; Strategic Objectives describing our long-term strategies for achieving the Strategic Goals; and multiyear, outcome-oriented Performance Goals. Annual targets and milestones allow NASA to measure and track incremental progress towards achieving the Performance Goals.

NASA's 2022 Strategic-Performance-Evidence Framework



Learning Agenda, Capacity Assessment, and Annual Evaluation Plan

Congress signed the Foundations for Evidence-Based Policymaking Act of 2018 (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. The *NASA 2022 Strategic Plan* includes NASA's first-ever Learning Agenda and Capacity Assessment, which support this new requirement.

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 moving our operations and Mission forward 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 provides an overview of evidence-building activities across the Agency that are appropriate to achieve NASA's Mission. The Capacity Assessment reviews NASA's ability to conduct evidence-building activities and identifies where resources are needed to develop and improve our capacity. 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 (see Appendix A: FY 2023 Annual Evaluation Plan) identifies evaluations the Agency plans to undertake over the next fiscal year. This plan cultivates data sharing and resources between NASA organizations and provides information to help support our evidence-driven culture.

Agency Performance Plan

The Agency Performance Plan includes Performance Goals, which are multiyear, outcome-oriented statements of future achievement supporting each Strategic Objective. The Agency Performance Plan describes annual Performance Goal targets consistent with program and project commitments in the FY 2022 budget appropriation and the FY 2023 President's Budget Request. Every fiscal year, NASA reevaluates and updates the existing Performance Goals and targets to ensure they still accurately reflect NASA's budget, priorities, strategies, and programmatic plans. Agency Priority Goals are a subset of Performance Goals that highlight high-priority, high-profile activities the Agency plans to accomplish within a two-year timeframe. The description and targets remain unchanged during the Agency Priority Goal's two-year lifespan.

Part 2 includes a description and FY 2021 progress update on each of the Performance Goals and Agency Priority Goals.

President's Management Agenda

The President's Management Agenda (PMA) defines Government-wide management priorities for all Federal agencies to improve how Government operates and performs. The Biden Administration PMA focuses on strategies to advance three core priorities: Strengthening and empowering the Federal workforce; Delivering excellent, equitable, and secure Federal services and customer experience; and Managing the business of Government to build back better.

The work of the PMA will comprise sustained, multi-year, Government-wide efforts to advance each of the three PMA priorities and their supporting strategies. Through the PMA, cross-agency teams will further 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 within one or more of the key delivery agencies. While NASA is not leading any of the PMA priorities, we will support the collaborative efforts and this work will support performance management in several mission support areas within NASA.

Performance Assessment Criteria

NASA's Performance Goals consist of an outcome-based statement and measurable targeted level of performance to be achieved each year. We assign a color rating (see below) based on the actual level of performance against the annual target. NASA internal success criteria determine the levels of performance required for a Yellow or Red rating.

Green

Achieved or on track to achieve

Yellow

Slightly below target or behind schedule

Red

Significantly below target or behind schedule

White

Measure canceled or postponed

Agency Priority Goals

NASA assesses progress toward achieving Agency Priority Goals every quarter, per GPRA Modernization Act guidance. In addition to reporting progress to Agency leadership, we report progress to external stakeholders through Performance.gov.

In January 2021, the Office of Management and Budget (OMB) discontinued external reporting for the FY 2020-2021 Agency Priority Goals. NASA transitioned the four Agency Priority Goals to Performance Goals to complete FY 2021 reporting. Below are the Performance Goals and their ratings for FY 2021, as well as the original Agency Priority Goal description through FY 2020. Additional information can be found in Part 2.

FY 2021 Performance Goals* and Original Agency Priority Goal Statements

FY 2021 Performance Goal Statements and Related FY 2020-2021 Agency Priority Goal Statements	Responsible Program	Rating
1.1.11: Complete shipment of the James Webb Space Telescope in preparation for launch in FY 2022. Agency Priority Goal through FY 2020: *By September 30, 2021, NASA will launch the James Webb Space Telescope, complete on-orbit checkout, and initiate observatory commissioning.*	James Webb Space Telescope Program, Science Mission Directorate (SMD)	Yellow
2.1.2: Enable a robust commercial low Earth orbit economy in which transportation, habitation, and on-orbit services are available for purchase by NASA and other customers. Agency Priority Goal through FY 2020: *By September 30, 2021, NASA will support the development of commercial services, including through releasing new business opportunities, supporting demonstration flights, beginning certification activities, and demonstrating commercial capabilities.*	Commercial Spaceflight Development and International Space Station, Human Exploration and Operations Mission Directorate**	Green
2.2.1: Advance America's goal to land the first woman and the next man on the Moon by demonstrating the necessary capabilities that advance lunar exploration. Agency Priority Goal through FY 2020: *By September 30, 2021, NASA will launch Artemis I and make significant progress for Artemis II, and have multiple companies under contract to develop systems to land humans on the Moon.*	Exploration Systems Development and Advanced Exploration Systems, Human Exploration and Operations Mission Directorate**	Green
2.2.2: Commence lunar surface technology demonstrations to enable a sustainable lunar surface exploration strategy. Agency Priority Goal through FY 2020: *By September 30, 2021, deliver NASA science and technology payloads to the awarded Commercial Lunar Payload Services (CLPS) provider(s) for delivery to the surface of the Moon.*	Multiple Programs, Space Technology Mission Directorate (STMD)	Yellow

*Performance Goal numbering is based on the *NASA 2018 Strategic Plan* framework.

**FY 2021 performance was managed by the Human Exploration and Operations Mission Directorate. This Mission Directorate was divided into two organizations (Exploration Systems Development Mission Directorate and Space Operations Mission Directorate) at the beginning of FY 2022.

NASA has identified four new Agency Priority Goals for the FY 2022–2023 reporting cycle (see below). These Agency Priority Goals are included in the *NASA 2022 Strategic Plan*.

FY 2022–2023 Agency Priority Goals*

Agency Priority Goal Statements	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.*	Multiple Programs, Science Mission Directorate
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.*	Cosmic Origins, Science Mission Directorate
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.*	Common Exploration Systems Development and Artemis Campaign Development, Exploration Systems Development Mission Directorate
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.*	Early Stage Innovation and Partnerships, Technology Demonstrations, Technology Maturation, and SBIR and STTR, Space Technology Mission Directorate (STMD)

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

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 that continually improves our performance management systems, increasing accountability, transparency, and oversight. This approach leads to more consistent performance reporting across NASA's missions and ensures the optimal use of our resources.

NASA plans and evaluates performance in a continuous cycle, spanning 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, in return, those performance results inform planning decisions.

The GPRA Modernization Act requires agencies to set long-term Strategic Goals and Objectives, as well as near-term Performance Goals. The GPRA Modernization Act also requires frequent data-driven perfor-

mance reviews and a performance management leadership structure that begins with the Agency Administrator, the Chief Operating Officer, the Performance Improvement Officer/Evaluation Officer, Chief Performance Management Officer, and the goal leaders. The GPRA Modernization Act's performance framework must translate across and cascade down the organization to all Agency managers and team leaders.

Annual Strategic Reviews

The annual Strategic Review process encompasses a comprehensive review of each of our Strategic Objectives. Agency leaders assess progress on executing the near-, mid-, and long-term strategies of each Strategic Objective and how contributing portfolios address opportunities, risks, external factors, and other events that may affect progress. The review also considers current or planned evaluations and evidence-building activities that may support strategy implementation.

Based on a self-assessment of progress by the Strategic Objective leader, NASA determines whether a Strategic Objective demonstrates noteworthy progress, satisfactory performance, or is a focus area for improvement. Our Chief Performance Management Officer and Performance Improvement Officer/Evaluation Officer determine final ratings and next steps for the Agency. The Strategic Review inputs, findings, and results inform our budget process and are inputs to the annual performance planning process.

NASA's 2021 Strategic Review assessed progress towards achieving the Strategic Objectives in the *NASA 2018 Strategic Plan*. The ratings from the review and the Summary of Progress by Strategic Objective are provided in Appendix B: FY 2021 Summary of Progress. The 2022 Strategic Review will provide a baseline for the Strategic Objectives in the *NASA 2022 Strategic Plan* and assess portfolio strategies.

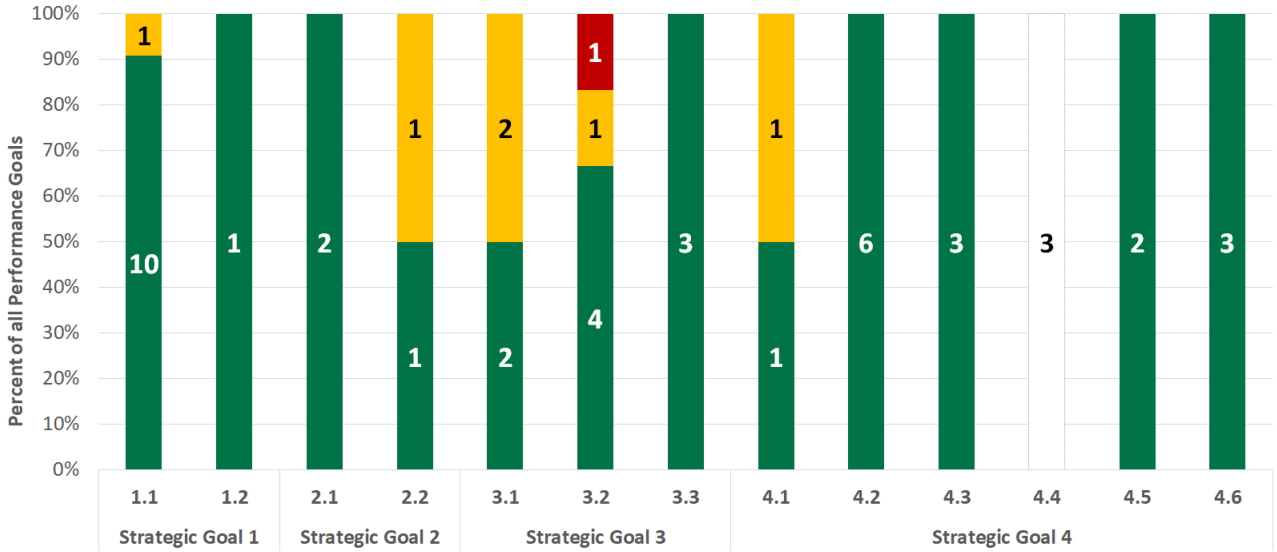
Annual Performance Assessments

During the third and fourth quarters of each fiscal year, program officials assess progress towards achieving the Performance Goals listed in the Annual Performance Plan. They determine whether targets and any supporting milestones were met as anticipated, assign the appropriate color 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.

NASA publishes a summary of preliminary fiscal year performance ratings in the annual Agency Financial Report, in accordance with OMB Circular A-136 guidance. We publish the final fiscal year performance ratings in the Annual Performance Report, which becomes part of the Volume of Integrated Performance.

NASA's FY 2021 ratings for our 48 Performance Goal include 38 Green, 6 Yellow, and 1 Red. Three Performance Goals could not be assessed for FY 2021 because of missing data and, therefore, were rated White. (See the summary chart below.)

Summary FY 2021 Performance Goal Ratings by Strategic Objective (*NASA 2018 Strategic Plan Framework*)



Part 2 presents the individual FY 2021 ratings and supporting performance explanations.

The FY 2021 performance ratings and explanations represent the last reported performance progress in support of the *NASA 2018 Strategic Plan* framework. Beginning in FY 2022, our performance will support the *NASA 2022 Strategic Plan* strategy-performance-evidence framework.

Performance Management Goals and Mandates

Several pieces of legislation have been passed over the years that build on the GPRA Modernization Act's framework for performance management. The key pieces of legislation that have impacted performance reporting are the Evidence Act, 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 this legislation informs all aspects of performance management goals and mandates.

FY 2023 Budget Request

FY 2023 Budget Request by Strategic Objective ($M)

Strategic Objective	Requested
1.1	$1,967.2
1.2	$5,576.8
1.3	$444.3
2.1	$6,153.0
2.2	$4,616.6
2.3	$252.7
2.4	$722.2
3.1	$1,437.9
3.2	$971.5
4.1	$108.4
4.2	$158.9
4.3	$48.4

*FY 2021 reflects funding amounts specified in Public Law 116-260, Consolidated Appropriations Act, 2021, as adjusted by NASA's FY 2021 Operating Plan, December 2021.

The 12 Strategic Objectives are mapped to NASA's FY 2023 President's Budget Request. The table above provides the FY 2023 budget request for each Strategic Objective. Detailed budget tables, provided in Part 2, include the FY 2021 actual, FY 2022 enacted, and outyear budget numbers through FY 2027. The budget numbers for FY 2021 and FY 2022 represent actual budget authority and the budget numbers for FY 2023 through FY 2027 are based on the requested budget. The funding lines combine multiple programs and projects that 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

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 a program management integration function with matrixed support from the Office of the Chief Engineer and Office of the Chief Financial Officer and in partnership with the Mission Directorates and Centers. While we cannot mitigate all risks related to achieving our Strategic Goals and Objectives, the Agency is using these risk-management strategies to identify, measure, and assess challenges related to mission delivery to the greatest extent possible. Enterprise risk management is integrated with the Strategic Review process to provide an analysis of the risks and opportunities NASA faces in achieving the Strategic Objectives.

Using Evidence for Decision-Making

NASA uses evidence to inform investment decisions at all levels, 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. The Evidence Act formalized requirements for agencies to utilize evidence, evaluation, and data as a planning tool for policy and decision making.

Annual Evaluation Plan (see Appendix A) features significant evaluations to support the performance planning process and provide evidence to decision-makers. The Learning Agenda (see Appendix A of the *2022 Strategic Plan*) is a four-year plan to build evidence across several priority areas for NASA to cultivate interagency collaboration, establish pathways for dissemination and data sharing, and identify gaps that exist across the Agency's vibrant performance and planning culture. Both the Annual Evaluation Plan and Learning Agenda will help us determine if we have accomplished what we set out to do and inform future priorities.

Program and Project Management for Executive Agencies

PMIAA formalized requirements to strengthen program and project management within Federal agencies. As a research and development agency, NASA uses the core concept of cost, schedule, and program and project management to assess performance during the development phase. NASA established a Program Management Improvement Officer and a permanent program management working group to address PMIAA requirements and develop implementation plans. NASA is currently carrying out a five-year PMIAA implementation plan that includes performing periodic portfolio assessments to examine and determine focused improvements to our program management practices, guidance, and trainings that strive to improve performance overall.

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 decisions. Independent verification and validation in planning and executing work provides greater confidence in performance during development and execution and improves expected outcomes. In many cases, these assessments include a routine measure of progress against a predetermined set of indicators or other targets that effectively establish an early warning system so that deviations can be more quickly and easily 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 particular work assignments to Centers and updates to Center roles; and evaluates mission needs and Agency workforce capacity through an annual Agency Strategic Implementation Planning meeting.

Technical Authorities

The 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 decision in regard to the Technical Authority technical baseline.

Baseline Performance Reviews

NASA conducts a monthly internal forum where NASA's leadership tracks and assesses performance of the Agency's work against established plans. The baseline performance review is a bottom-up review of mission and select mission support programs and projects with risks in performance areas such as cost and schedule, contract commitments, and technical objectives. It also includes performance progress for Agency Priority Goals and the annual Strategic Review of our Strategic Objectives. Each Mission Directorate provides a performance assessment of the activity it oversees and analysts outside of the performing organization conduct independent assessments. NASA's Technical Authorities provide oversight and an additional level of control.

Program and Project Key Decision Point Reviews

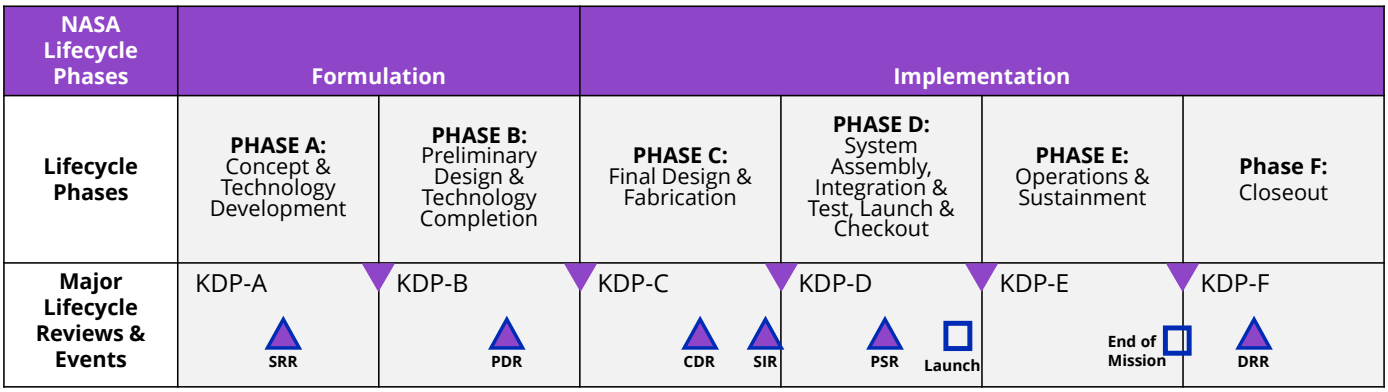
As stated above, NASA requires internal independent assessments on the progress of programs and projects through their life cycles. Senior leaders convene a series of formal gatekeeping key decision point reviews, requiring managers to provide assessments of how the programs and projects are performing in key areas. 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 on page 17.).

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 have the opportunity to 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. Additionally, NASA senior leaders monitor overall performance monthly through the Baseline Performance Review. NASA 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.

NASA Office of Inspector General and the Government Accountability Office

Two independent organizations, the NASA Office of Inspector General and the Government Accountability Office, conduct both broadly and narrowly focused evaluations of how well the Agency is achieving outcomes and performing to expectations. Evaluations cross all types of NASA work, from planning new initiatives, managing major programs, implementing necessary infrastructure modernization, to the potential impact 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. NASA reviews the resulting reports and provides feedback on how the Agency will improve on identified management challenges.

NASA Flight Project Lifecycle Phases, Key Decision Points, and Milestones*



Key Decision Point (KDP) is an event where NASA determines whether a project is ready to move to the next phase of its life cycle and establishes content, cost, and schedule commitments for that phase

System Requirements Review (SRR) evaluates whether the functional and performance requirements for the system meet the needs of the project and represent achievable capabilities

Preliminary Design Review (PDR) evaluates completeness/consistency of the planning, technical, cost, and schedule baselines developed during Formulation

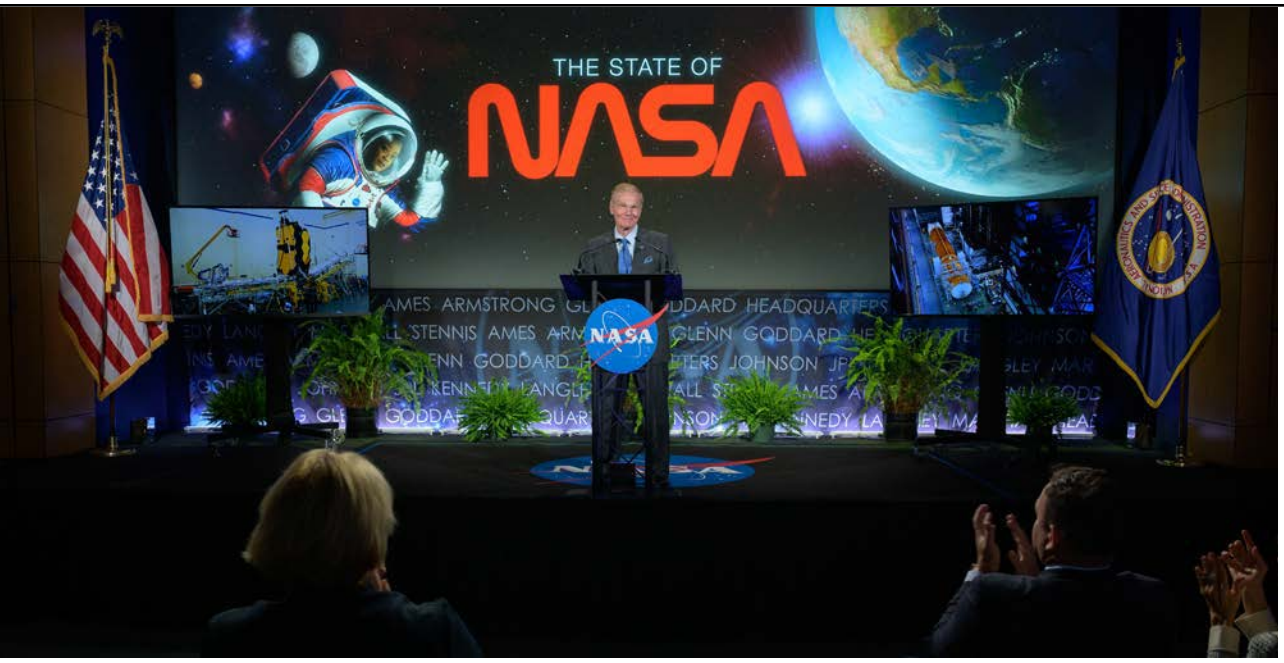
Critical Design Review (CDR) evaluates the project design and its ability to meet mission requirements with appropriate margins and acceptable risk

System Integration Review (SIR) evaluates whether the projects is ready for integration and test, can be completed with available resources, and is ready for Phase D

Pre-Ship Review (PSR) ensures the completeness of any item of hardware or software before it is released to another facility for integration with a larger system or the spacecraft

Disposal Readiness Review (DRR) evaluates the readiness of the project and system for a disposal event, such as deorbiting

*Project lifecycle phases, key decision points, and milestones are established by and defined in NASA Space Flight Program and Project Management Requirements (NASA Procedural Requirements 7120.5E) and NASA Research and Technology Program and Project Management Requirements (NASA Procedural Requirements 7120.8A).



Strategies for Improvement

NASA's commitment to good governance and stewardship of taxpayer funds requires that the Agency routinely conducts internal assessments and evaluations to aid in maintaining, managing, and improving operations. In addition, periodic external assessments focus management attention on areas of high risk or potential difficulty. The Government Accountability Office (GAO) and the NASA Office of Inspector General (OIG) conduct such external assessments, identifying trouble spots and recommending how to address them. Issues raised by the GAO and OIG represent high-priority areas for management attention.

High Risk Areas Identified by the GAO

The GAO assesses management activities across the Federal Government and identifies practices and vulnerabilities that put agencies at risk of fraud, waste, abuse, and mismanagement. The GAO's High Risk List, updated every two years, has included NASA's acquisition management since the list was established in 1990. To assist in corrective action planning, the GAO established five criteria that, if addressed, would substantively improve operations and clear the GAO's concern about high-risk activity:

- **Leadership Commitment:** Demonstrated strong commitment and top leadership support.
- **Capacity:** Agency has the capacity (i.e., people and resources) to resolve the risk(s).
- **Action Plan:** A corrective action plan exists that defines the root cause, solutions, and provides for substantially completing corrective measures, including steps necessary to implement recommended solutions.
- **Monitoring:** A program has been instituted to monitor and independently validate the effectiveness and sustainability of corrective measures.
- **Demonstrated Progress:** Ability to demonstrate progress in implementing corrective measures and resolving high-risk areas.

Above: NASA Administrator Bill Nelson talks to the Agency's workforce during his first State of NASA event on June 2, 2021, at NASA Headquarters Mary W. Jackson Building in Washington, DC. Nelson remarked on his long history with NASA, and among other topics, discussed our plans for future Earth-focused missions to address climate change and a robotic and human return to the Moon through the Artemis program, as well as announcing two new planetary science missions to Venus, VERITAS and DAVINCI+. Image Credit: NASA/Bill Ingalls

As part of the 2019 update for NASA, High-Risk Series: Dedicated Leadership Needed to Address Limited Progress in Most High-Risk Areas (GAO-21-119SP), the GAO included a scorecard detailing which of these criteria for improving acquisition management have been met, partially met, or have not been met. NASA has fully met the criteria for leadership commitment, a corrective action plan. NASA has partially met the criteria for capacity and demonstrated progress. The 2021 report reflects an improvement in the leadership commitment and monitoring areas over the previous 2019 report.

NASA's responses to these challenges have yielded more credible cost and schedule baselines, and both the GAO and OIG have observed that NASA's management of its small- and medium-class major flight projects has improved. The effectiveness of these tools is particularly evident for the smaller (under $1 billion lifecycle cost) projects. However, NASA needs to improve management of its larger, more complex projects, which typically involve the development of a significant number of new technologies, greater integration risk, and early cost and schedule estimation challenges. The GAO observed that risks remain for NASA's largest flagship-type projects, such as the James Webb Space Telescope (Webb) (see 1.2.10: Complete commissioning 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)), the Space Launch System (SLS), and Orion (see the Artemis Performance Goal 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)).

A Corrective Action Plan for Acquisition Management Improvements

NASA released an updated high-risk corrective action plan in August 2020 in response to the continued inclusion of NASA's acquisition practices in GAO's 2019 high-risk report, as well as recent challenges in cost schedule growth experienced by several of NASA's highest profile missions. The overall goal of the plan is to strengthen the Agency's cutting-edge program and project management efforts across the board and improve transparency to stakeholders.

In September 2018, NASA senior leadership determined that a new corrective action plan was necessary to continue driving improvements in the Agency's program and project management policies and processes. The plan was comprised of seven initiatives to implement, one initiative to pilot, and one initiative to research.

Between the start of the 2018 plan in December 2018 and approval of the 2020 plan in July 2020, six initiatives were completed, one (Improve Human Exploration and Operations Mission Directorate (HEOMD) Portfolio Insight and Status) was closed and rewritten to better align to GAO's open priority recommendations and to clarify tracking and closure requirements, and two longer-term initiatives remained in process. The two ongoing initiatives—Enhanced Earned Value Management (EVM) Implementation and Program Planning and Control (PP&C) Training Curriculum—are intended to be longer-term initiatives. The initiative to pilot an Agency schedule repository was deemed a success and a new initiative to fully implement the schedule repository was put into place.

The August 2020 Corrective Action Plan update also included two new initiatives. One initiative will be to implement enhancements to NASA's Cost Analysis and Data Requirements (CADRe) data collection process to better capture critical data from Category III/Class D missions. The other will see that major acquisitions (contracts greater than $500 million) include an evaluation of the financial health, stability, and outlook of organizations under consideration prior to contract award in order to enhance competitive and sole-selection procurement processes.

As described in the August 2020 Corrective Action Plan, the next iteration of the Corrective Action Plan will be considered, evaluated, and pursued in the first half of calendar year 2022. The progress of current initiatives will be assessed and/or closed, and new initiatives will be considered for inclusion that address current and emergent issues. NASA's Associate Administrator will decide on the 2022 corrective action plan in the summer of CY 2022 via the Agency Program Management Council. A summer implementation of a Corrective Action Plan update will serve to inform the GAO as they begin work on the upcoming 2023 high risk-report.

NASA will release the next update to the Corrective Action Plan in 2022.

Management Challenges Identified by the OIG

Each fiscal year, NASA's OIG issues a letter 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 OIG audits to improve the overall efficiency and effectiveness of its programs, projects, and functional activities. NASA also is committed to ensuring timely and responsive final management decisions, along with timely and complete final management action, on all audit recommendations issued the NASA OIG.

To this end, NASA has implemented a comprehensive program of audit follow-up intended to ensure that audit recommendations issued by the OIG are resolved and implemented in a timely, responsive, and effective manner. NASA's audit follow-up program is a key element in improving the overall efficiency and effectiveness of NASA's programs, projects, and operations. The requirements for managing the OIG's recommendations are detailed in NASA's FY 2020 Agency Financial Report.

The OIG's 2021 Report on NASA's Top Management and Performance Challenges continues the seven challenges identified in 2020 and adds a new challenge focused on the impacts of COVID-19. Below is a summary of the report.

Returning Humans to the Moon

The Artemis program—currently NASA's most ambitious and costly ongoing activity—is projected to cost the Agency $93 billion by FY 2025 and will require decades-long engagement from NASA and its commercial and international partners to build and support multiple exploration systems, conduct research and technology demonstrations to return humans to the Moon, and prepare for an eventual crewed mission to Mars. The date of the long-awaited return, however, remains a question since development delays, compounded by the COVID-19 pandemic, will preclude NASA from meeting its goal of landing astronauts on the Moon by late 2024.

Artemis is a multi-mission program that allows NASA to extend the length and complexity of lunar missions over time. The first three missions—Artemis I, II, and III—culminate with astronauts landing on the Moon with Artemis III. NASA will use the Space Launch System (SLS) heavy-lift rocket and Orion Multi-Purpose Crew Vehicle (Orion) capsule in all three missions. For Artemis III, the Orion capsule—with four astronauts on board—will dock in lunar orbit with a Human Landing System (HLS) to transport astronauts to the lunar surface, and the astronauts will require next-generation spacesuits, known as Exploration Extravehicular Mobility Units, to explore the lunar surface. Subsequent Artemis missions are expected to include a longer-term presence on the Moon that incorporates additional systems, including a lunar orbiting outpost called the Gateway and Lunar Terrain Vehicles to transport crew on the Moon's surface.

As the OIG has reported in previous reports, NASA's greatest challenge with its human exploration ambitions is development of the systems required to get humans to the Moon and Mars safely with the funding Congress has allocated and within the timeframe the Administration has imposed. For example, for FY 2021, Congress appropriated only $850 million out of an estimated need of $3.4 billion for the HLS. As a result, the NASA selected a single company, thereby affecting its acquisition strategy to promote competition and redundancy. To mitigate the risk of having only one provider, NASA decided to accelerate its Lunar Exploration Transportation Services procurement to allow other companies to develop technologies and potentially receive a contract to deliver astronauts to the Moon. The OIG also found that delays in development of the Agency's next-generation spacesuits—attributed to technical challenges, funding issues, and COVID-19 impacts—will preclude the new suits from being ready for flight no earlier than April 2025 and will cost more than a billion dollars for development and assembly. These are only two recent examples in a series of long-standing challenges to build the systems required for the Agency's Artemis missions and follow-on Mars exploration plans.

Overall, NASA has made progress towards executing the first three Artemis missions, culminating with the planned return of astronauts to the surface of the Moon. The OIG estimates that the SLS, Orion, and Exploration Ground Systems programs will be ready to launch Artemis I by summer 2022. In addition, NASA completed all the contract awards necessary for the initial Gateway capability when it awarded Northrop Grumman a fixed-price contract in July 2021 for the final design and build phase of the Habitation and Logistics Outpost. Development continues for the electrical power system for the Gateway's Power and Propulsion Element. For Artemis III, NASA allowed flexibility for

HLS proposers to either dock with the Gateway or directly with Orion. NASA's award to SpaceX for the Artemis III demonstration includes its HLS Starship linking up directly with the crewed Orion in lunar orbit to ferry astronauts to and from the Moon's surface. NASA aims to have the Gateway operational in time for Artemis IV. Lastly, the Agency continues to develop its next-generation spacesuit capabilities, including a testing suit, two qualification suits, an International Space Station (ISS) demonstration suit, and two lunar flight suits.

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

The OIG also is concerned that relying on such an expensive heavy-lift rocket system will inhibit if not derail NASA's ability to sustain its long-term human exploration goals. NASA's Commercial Crew Program shows how competitively awarded fixed-price contracts can control costs if requirements are properly defined. NASA has applied this acquisition model to the Gateway's Power and Propulsion Element and HLS procurements and intends to use a commercial services approach for next-generation spacesuits. NASA needs to develop a realistic, risk-informed schedule that includes sufficient margin to better align Agency expectations with the development schedule.

See Strategic Objective 2.1: Explore the surface of the Moon and deep space. and in Appendix B, Strategic Objective 2.2: Conduct human exploration in deep space, including to the surface of the Moon.

Improving Management of Major Projects

Historically, NASA's major projects have cost significantly more and taken much longer to complete than initially planned. Although most of the cost growth comes from two of NASA's major projects—James Webb Space Telescope (Webb) and SLS—other major projects have experienced both cost and schedule growth. Some of this can be attributed to the impacts of COVID-19. Additionally, NASA has struggled to provide reliable lifecycle cost estimates for complex projects involving multiple, first-of-their-kind components (such as Webb) and missions that involve multiple iterations of major projects without a definitive lifecycle end date (like the SLS rocket and Orion capsule for Artemis).

The OIG states that, overall, NASA remains challenged to complete its major projects within their planned costs and schedules due to a culture of optimism, underestimating technical complexity, and funding instability—all long-standing issues. However, the OIG notes that NASA's recent efforts to improve management of its major projects have shown indications of improved performance and reduced costs for several projects, including Landsat 9 and Psyche. Progress toward improving NASA's acquisition management is demonstrated by the Agency's commitment to implement its 2018 Corrective Action Plan, which addressed the causes of cost and schedule concerns highlighted in GAO's High-Risk List. As a result of the Corrective Action Plan's initiatives, NASA has developed best practices, added additional requirements, and implemented external monitoring related to cost and schedule of major projects. GAO's 2021 High-Risk Series report listed NASA's acquisition management as one of only seven high-risk areas throughout the entire Federal government that showed progress toward meeting criteria for removal from the High-Risk List over the past two years.

The OIG urges NASA to redouble its efforts to ensure that its science and space exploration projects are grounded in accurate estimates and meet cost, schedule, and performance goals. Given a limited budget to fund multiple ambitious projects, it is critical that NASA implement planned changes to its Joint Cost and Schedule Confidence Level policy, as well as demonstrate sustained progress completing initiatives in its 2020 Corrective Action Plan. Furthermore, when taking on a mission, requirements should be clearly defined, affordable, captured, and communicated early in the development effort to reduce the risk of costly design changes. For example, NASA has begun to acquire major Artemis systems such as the Gateway and the HLS through public-private partnerships, but it has still not fully defined the lunar system architecture or established requirements for its lunar missions.

Consequently, NASA will need to address potential requirements and technology development knowledge gaps in Artemis projects due to a lack of firm requirements before entering implementation.

For more information, see 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., and in Appendix B, Strategic Objective 1.1: Understand the Sun, Earth, solar system, and universe. and Strategic Objective 2.2: Conduct human exploration in deep space, including to the surface of the Moon.

Sustaining a Human Presence in Low Earth Orbit

The continuous operation of research and technology demonstrations in low Earth orbit is critical to achieving NASA's goals in science, technology, and human space flight. Without the availability of a low Earth orbit platform to conduct critical health research and demonstrate key technologies, NASA would be faced with the difficult decision of accepting a higher level of risk or delaying human missions to the Moon and Mars. The U.S. segment of the International Space Station (ISS) is structurally certified to operate until 2028. Recent events highlight risks to the ISS's operational performance, and while NASA determined that these events do not pose an immediate threat to the ISS's operational longevity, NASA and its partners will eventually have to come to a decision to initiate its decommissioning and deorbit.

Looking forward, NASA plans to maintain a human presence in low Earth orbit after the ISS is retired by becoming a customer of commercially owned and operated space destinations. This will require a sustained but largely undetermined financial investment by the Federal government and private companies. NASA's initial efforts to develop a commercial market—relying on the Center for the Advancement of Science in Space, Inc. (CASIS) to advance research endeavors for the commercial sector—were unsuccessful. In 2019, NASA released a plan to expand commercial opportunities in space beyond what was initially allowed under CASIS, including private astronaut missions to the ISS. However, Congress authorized NASA to spend only $17 million to support commercial low Earth orbit development in FY 2021—just over 10 percent of the Agency's requested $150 million.

The OIG notes that the first certified commercial flight of astronauts was launched into space in November 2020 from Crew Dragon, SpaceX's commercial crew transportation vehicle, during the pandemic had closed NASA's facilities and at least 90 percent of its workforce was teleworking. This was the first time since the end of the Space Shuttle Program that American astronauts were able to launch on a U.S. vehicle. However, the Commercial Crew Program continues to be challenged by Boeing's CST-100 Starliner vehicle, which encountered numerous delays and technical issues, and it is not clear when the Starliner will conduct its first crewed flight. Until that time, NASA will be required to rely on SpaceX for commercial transportation to the ISS.

The new Roll-Out Solar Array increased the ISS's power production, ensuring that future power needs can be met, and the aging batteries were replaced with more efficient lithium-ion batteries. In addition, NASA installed the first privately funded commercial airlock (the NanoRacks Bishop Airlock) on the ISS, increasing the capability for transferring equipment, payloads, and deployable satellites to meet growing customer demands.

In FY 2021, NASA invested more than $13 million in seed money for seven companies to develop in-space production applications in what industry studies indicate are the most promising areas for profitable manufacturing in space. Most of these in-space production applications are sponsored by CASIS, which is working with NASA to implement a six-point plan to ensure they maximize the benefit of the ISS National Laboratory for the remainder of its time in orbit. There also is a high level of demand for private astronaut missions to the ISS. In June 2021, NASA moved to an annual competitive process for selecting up to two private astronaut missions per year based on availability. In addition, NASA awarded Axiom Space a firm-fixed-price contract of $140 million to provide at least one habitable commercial module attached to the ISS, which will detach and become a free-flying destination prior to the ISS be deorbited. In July 2021, NASA announced its Commercial Low Earth Orbit Destinations initiative to encourage development of a commercial successor to the ISS through public-private partnerships.

See Strategic Objective 2.2: Develop a human spaceflight economy enabled by a commercial market. and Appendix B, Strategic Objective 2.1: Lay the foundation for America to maintain a constant

human presence in low Earth orbit enabled by a commercial market. for more information.

Managing and Mitigating Cybersecurity Risk

Over the past 20 years, the OIG has identified securing NASA's information technology (IT) systems and data as a top management challenge due, in large part, to the Agency's deficient IT management practices. For 2021, the OIG focused on three specific cybersecurity challenges the Agency is facing with an emphasis on practical issues where meaningful improvement and near-term progress is achievable: (1) improper use incidents, (2) mobile device security, and (3) assessment and authorization (A&A) process.

Improper Use Incidents – In a May 2021 audit, the OIG found that improper use incidents increased from 249 in 2017 to 1,103 in 2020—a 343 percent growth—with failing to protect Sensitive But Unclassified information the most prevalent abuse. For instance, unencrypted email containing Sensitive But Unclassified data, Personally Identifiable Information, and International Traffic in Arms Regulations data continues to expose the Agency to unnecessary cyber risk that can affect national security, loss of intellectual property, and compromise of employee and contractor data.

Mobile Device Security – In an August 2020 audit, the OIG found that the OCIO is not adequately monitoring and enforcing the business rules established for NASA's more than 15,000 mobile devices, potentially exposing the email system and data to viruses, malware, or hacking through connected mobile devices. Since the outbreak of COVID-19, exposure to cyber threats has increased because NASA's workforce has shifted to telework, increasing the usage of mobile devices.

A&A Process – In May 2021, the OIG reported that NASA is inconsistent and ineffective with its A&A process because of its decades-long decentralized approach to cybersecurity. Over the past 6 years, the OIG has reported that certain types of assessment data have been ignored or discarded as irrelevant during the A&A process, leaving systems incorrectly categorized at lower risk impact levels than their criticality requires, resulting in increased vulnerability to cyber risks.

The OIG notes that having a tenured Senior Agency Information Security Officer in place for more than 4 years has been critical to advancing cybersecurity readiness NASA's cybersecurity posture, and NASA senior management has made a combination of strategic, risk management, and collaboration decisions that have begun to strengthen the Agency's cybersecurity posture. In January 2022, under the Mission Support Future Architecture Program, Center Chief Information Security Officers and cybersecurity staff will be realigned from the Center OCIO to the Senior Agency Information Security Officer, moving the Agency towards an enterprise computing model that would centralize and consolidate IT capabilities, such as software management and cybersecurity. Additionally, in February 2022 the OCIO anticipates it will award the Cybersecurity and Privacy Enterprise Solutions and Services contract that expects to eliminate duplicative cyber services and the need for Center-based IT security contracts.

For more information, see Strategic Objective 4.2: Transform mission support capabilities for the next era of aerospace. and Appendix B, Strategic Objective 4.5: Ensure enterprise protection.

Improving Oversight of Contracts, Grants, and Cooperative Agreements

NASA's acquisition management has been a GAO high-risk area for three decades. Similarly, the OIG has highlighted acquisition as an Agency management challenge for the past 15 years, with identified weaknesses in both oversight of the acquisition process and the readiness of its acquisition workforce. Over the past decade, OIG financial statement audits have identified challenges in timely closing out of contracts to ensure the government received what it contracted for, detected and recovered erroneous payments, made final payments to the contractors, and deobligated excess funds.

NASA continues to be challenged with oversight of its acquisition process. Most recently, in a July 2021 audit of NASA's cooperative agreements with the Universities Space Research Association, the OIG reported that the Agency needed to take additional steps to improve its management and financial oversight of cooperative agreements, especially with regard to significant extensions and augmentations to those agreements. The OIG FY 2020 financial statement audit also revealed oversight issues with the Agency's internal controls related to the grant management process that the OIG found were not designed to effectively monitor grantees and the Federal awards they received.

More broadly, NASA is challenged with Agency-wide oversight of its acquisition workforce. The OIG expresses concern that NASA does not collect Agency-wide acquisition workforce workload or performance data, which limits its ability to have an accurate picture of who comprises the acquisition workforce, determine whether they are certified as required, and measure workforce performance consistently across the entire Agency.

NASA has taken numerous steps to address its contract management challenges. The ongoing Mission Support Future Architecture Program, NASA's transition to an enterprise-wide workforce, allows the Office of Procurement to leverage employees' skills for use across the Agency. The Office of Procurement has developed a Strategic Workforce Plan to maintain a workforce capable of responding to current and future contracting needs. They also have developed an Acquisition Portfolio Assessment Team to assess all Agency contracts and identify redundant contracts managed at the Center level. NASA has consolidated the award and administration of grants and cooperative agreements through the NASA Shared Services Center. This consolidation is designed to improve service and data quality, standardize processes, leverage skills and investments, and provide economies of scale. In addition, NASA has made efforts to increase its efficiency in closing expired grants by incentivizing closeout contractors to complete timely and proper grant closeout.

Attracting and Retaining a Highly Skilled and Diverse Workforce

Previous OIG audits have shown that NASA faces interrelated workforce challenges, including not having enough employees with the right skills in technical areas; implementation shortfalls; an aging workforce; and science, technology, engineering, and mathematics (STEM) pipeline risks. NASA OIG and GAO have reported on multiple NASA projects—Low-Boom Flight Demonstrator, Europa Clipper, and Mars 2020 to name a few—that have experienced workforce challenges, including not having enough staff at the right times or staff with the right skills. In 2020, the OIG reported that NASA's engineering technical disciplines faced significant risks to their specialized workforces, with particular concern to the loss of unique skillsets from retiring employees before their knowledge could be passed on to others within the Agency. More recently, the OIG reported on NASA's challenges to develop an agile and mission-driven acquisition workforce as the Agency continues to implement an enterprise-wide approach to procurement under the Mission Support Future Architecture Program. The OIG states that despite establishing strategic frameworks for change, NASA has had limited success implementing these efforts to reorganize Agency-wide operations. Furthermore, the Aerospace Safety Advisory Panel noted in its 2020 Annual Report that NASA was not addressing certain workforce issues at the strategic level, risking an erosion of expertise and experience in the NASA workforce, thereby undermining NASA's ability to effectively manage the highly complex risk problems of future exploration programs, including those envisioned for the Artemis campaign.

The OIG notes that of the nearly 12,000 civil servant science and engineering employees (representing nearly 65 percent of the civil servant workforce), 6,000 are over 50 years old, and of those employees, approximately 3,000 were eligible to retire in 2021. These potential impending retirements could result in a significant loss of institutional knowledge and skills. As an agency highly dependent on skilled STEM workers to accomplish its mission, NASA remains at risk from a shortage of such staff. The U.S. Bureau of Labor Statistics reported the STEM labor market is highly segmented into different disciplines, sectors, and skill levels with varying degrees of supply and demand. In 2018, the Executive Director of the American Institute of Aeronautics and Astronautics testified before Congress about a STEM worker shortage in the aerospace community. The Institute also highlighted in its work the need to increase diversity and foster inclusion by encouraging women and underrepresented minorities to pursue careers in the aerospace industry and emphasized that STEM school curriculums should be aligned to current workforce needs.

NASA is implementing a flexible and agile workforce approach through the Strategic Workforce Plan and replacing its aging talent acquisition system with one that will enable the Agency to more strategically hire, develop, and manage its workforce. NASA has also made efforts to reduce the hiring cycle time, leverage special hiring authorities, clear the hiring backlog from prior years, and work with Centers and Mission Directorates to develop plans to lessen the impact of a future retirement wave.

For the past 9 years, NASA has been voted the best large agency to work for in the Federal government

and again held the top rank in 2020 according to the Partnership for Public Service. NASA is attempting to cultivate a diverse and innovative workforce with the right balance of skills and experience to provide an inclusive work environment. NASA is rolling out at least two initiatives—Agency Unity Campaign for employees emphasizing mission success through increased collaboration, connection, and communication, and Mission Equity, a comprehensive effort to assess expansion and modification of NASA programs, procurements, grants, and policies, and examine potential barriers and challenges for communities that are historically underrepresented and underserved. NASA also is making efforts to attract and retain underserved and underrepresented students in engineering and other STEM fields in partnership with minority serving and other higher education institutions

See Strategic Objective 4.1: Attract and develop a talented and diverse workforce. and Appendix B, Strategic Objective 4.4: Manage human capital.

Managing NASA's Outdated Infrastructure and Facilities

NASA is one of the largest property holders in the Federal government, with $40 billion in physical assets and an inventory of more than 5,000 buildings and structures. Of these, over 75 percent are beyond their original design life. In addition, NASA has 166 abandoned properties worth $291 million that present a safety and maintenance liability due to their structural or interior deficiencies.

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

The OIG also found in a December 2020 audit that hazardous materials pose a safety risk to NASA installations. Hazardous materials are used daily, including acids, bases, and oxidizers in research laboratories; propellants and fuels in engine testing; ethanol-based solvents in engineering laboratories; ammonia, acetone, and glycols in flight equipment operations; and chemicals in simulated planetary environmental testing. These materials can be toxic, reactive, flammable, or explosive and, if poorly managed, can result in costly cleanup efforts, damage to facilities and equipment, personal injury, and loss of mission capabilities. The OIG's review found that hazardous materials are not managed uniformly across NASA and the Agency lacks adequate internal controls for managing its hazardous materials inventory.

One key goal of NASA's Construction of Facilities (CoF) program is to modernize the Agency's infrastructure into fewer, more sustainable facilities and repair failing infrastructure to reduce overall maintenance costs. Between FYs 2016 and 2020, NASA received nearly $1.8 billion in CoF funding that has resulted in an increasing number of projects to construct and facilities to upgrade. In relation to hazardous materials, NASA is updating policies and procedures to designate appropriate officials to approve hazardous materials purchases, track and report hazardous material inventories, and inspect and evaluate storage sites.

For more information, see Strategic Objective 4.2: Transform mission support capabilities for the next era of aerospace. and Appendix B, Strategic Objective 4.6: Sustain infrastructure capabilities and operations.

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

During the first 6 months of the pandemic, the OIG found that 56 of NASA's programs and projects were impacted and could potentially incur a total lifetime cost growth of $3 billion. In addition, the pandemic would continue to affect 35 programs and projects into FY 2022 and beyond. The OIG cites inability to conduct onsite activities, workforce startup inefficiencies, and delivery delays of government furnished equipment.

This dramatic shift in NASA's operations, which has required 90 percent of its workforce to work from home for an extended period of time, has raised fundamental questions about how the workforce will return to on-site work after it is deemed safe

to do so. Additionally, the Biden Administration released a pair of Executive Orders in September 2021 requiring COVID-19 vaccinations for Federal employees and contractors.

Despite the ongoing challenges NASA continues to face due to COVID-19, the Agency has demonstrated flexibility and adaptability in its operations. NASA began categorizing and tracking COVID-19's impact on its programs and projects beginning in April 2020. To accommodate new work-life dynamics resulting from COVID-19, NASA successfully expanded its telework capabilities and continued software development remotely. In addition, NASA used about 35 percent of its $60 million CARES Act appropriation to pay for contractor leave authorized under Section 3610.

While NASA will be unable to quantify the complete impact of the pandemic until after the COVID-19 emergency has subsided, the Agency has established a long-term baseline for normal operations. Looking forward, OIG notes that the Agency will face new challenges in implementing a far-reaching return-to onsite-work plan for large swaths of its workforce, which likely will embrace significantly expanded telework and remote work flexibilities.

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.

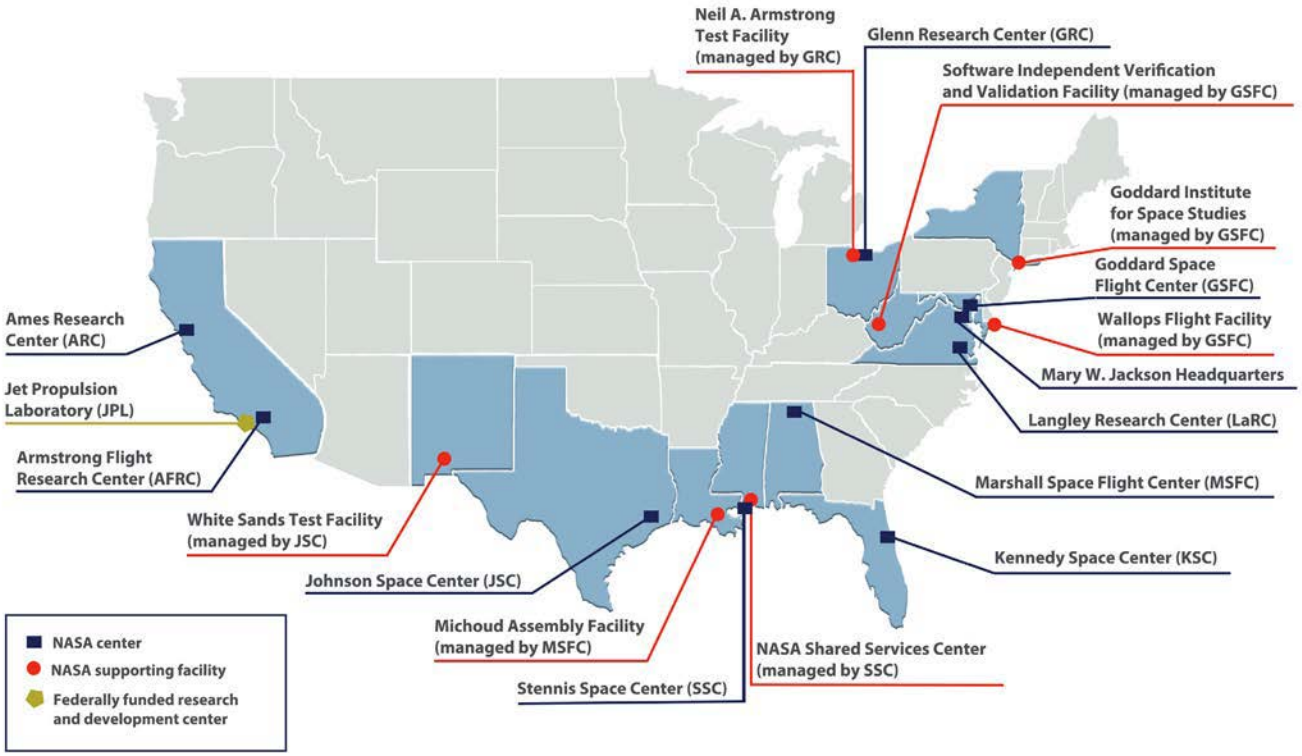
The innovative, responsive, and dynamic nature of our work benefits from the relationships within and between Mission Directorates, Mission Support Offices, and Centers. This organizational model ensures our leaders can take both a holistic and more narrowly focused approach to programmatic, operational, business, and safety management.

Centers and Facilities Nationwide

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.

Artist Tenbeete Solomon, also known as Trap Bob, right, presents her artwork honoring Mary W. Jackson to Wanda Jackson, granddaughter of Mary W. Jackson, left, during a ceremony officially naming the NASA Headquarters building in honor of Mary W. Jackson, February 26, 2021, at NASA Headquarters in Washington, DC. Mary W. Jackson, the first African American female engineer at NASA, began her career with the Agency in the segregated West Area Computing Unit of NASA's Langley Research Center in Hampton, Virginia. The mathematician and aerospace engineer went on to lead programs influencing the hiring and promotion of women in NASA's science, technology, engineering, and mathematics careers. In 2019, she posthumously received the Congressional Gold Medal. Image Credit: NASA/Joel Kowsky

NASA's Centers and Facilities



The NASA workforce of 17,814[1] civil servants is distributed at its Centers, facilities, and Headquarters (see the figure below). A contractor workforce supports each location by providing technical and business operations services.

NASA's Organizational Structure

The innovative, responsive, and dynamic nature of NASA's work benefits from our highly leveraged relationships with and between Mission Directorates, Mission Support Offices, and Centers. This organizational model ensures that our leaders can take both a holistic and more narrowly focused approach to programmatic, operational, business, and safety management. 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 organization-wide performance management activities.

Mission Directorates and Mission Support Offices at Headquarters manage decisions on programmatic investments and guide operations of the Centers (see organizational structure below). 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.

1 NASA Workforce Profile, Workforce Information Cubes for NASA (WICN). Last updated February 12, 2022.

The Exploration Systems Development Mission Directorate (ESDMD)[2] 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.

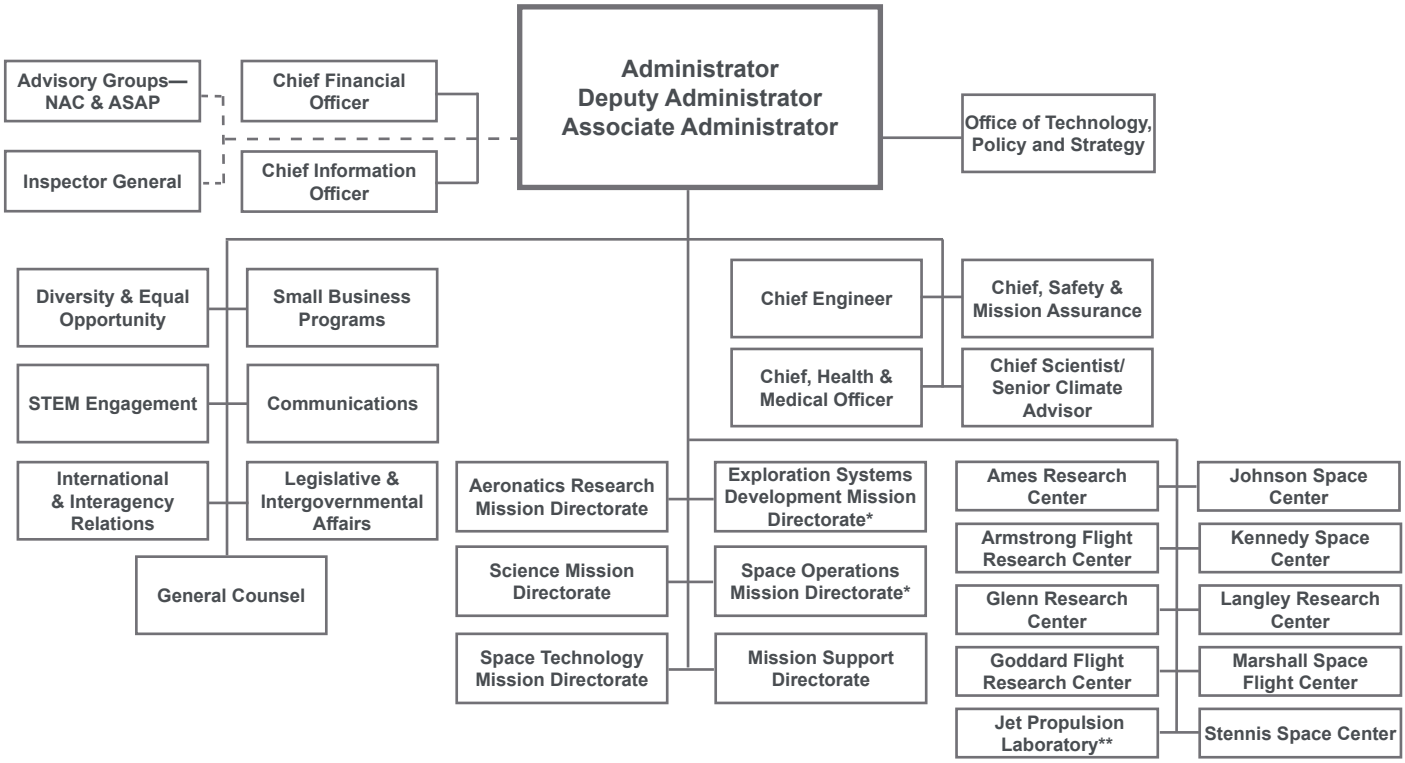
The Space Operations Mission Directorate (SOMD) focuses on launch and space operations, including launch services, space communications and navigation, and eventually, sustaining operations on and around the Moon. SOMD also manages the International Space Station (ISS) and commercial space capability 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.

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.

2 At the beginning of FY 2022, the Human Exploration and Operations Mission Directorate was divided into the Exploration Systems Development Mission Directorate and the Space Operations Mission Directorate.

NASA Organization



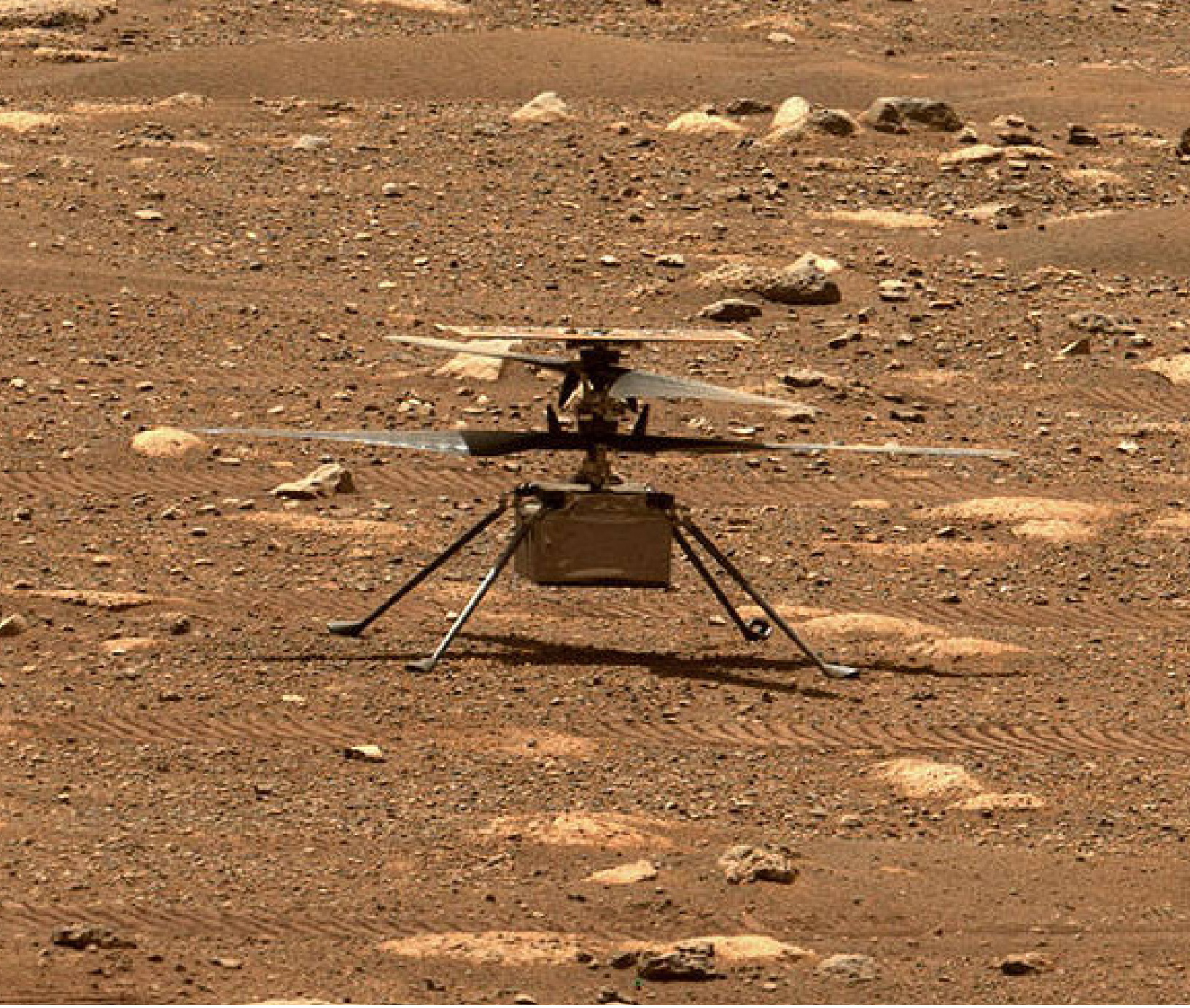
*The Human Exploration and Operations Mission Directorate reorganized into two Mission Directorates at the beginning of FY 2022

**JPL is a Federally Funded Research and Development Center (FFRDC) managed by the NASA Office of JPL Management and Oversight

Dotted lines indicate independent advisory or oversight organizations

NASA Advisory Council (NAC)

Aerospace Safety Advisory Panel (ASAP)



Part 2

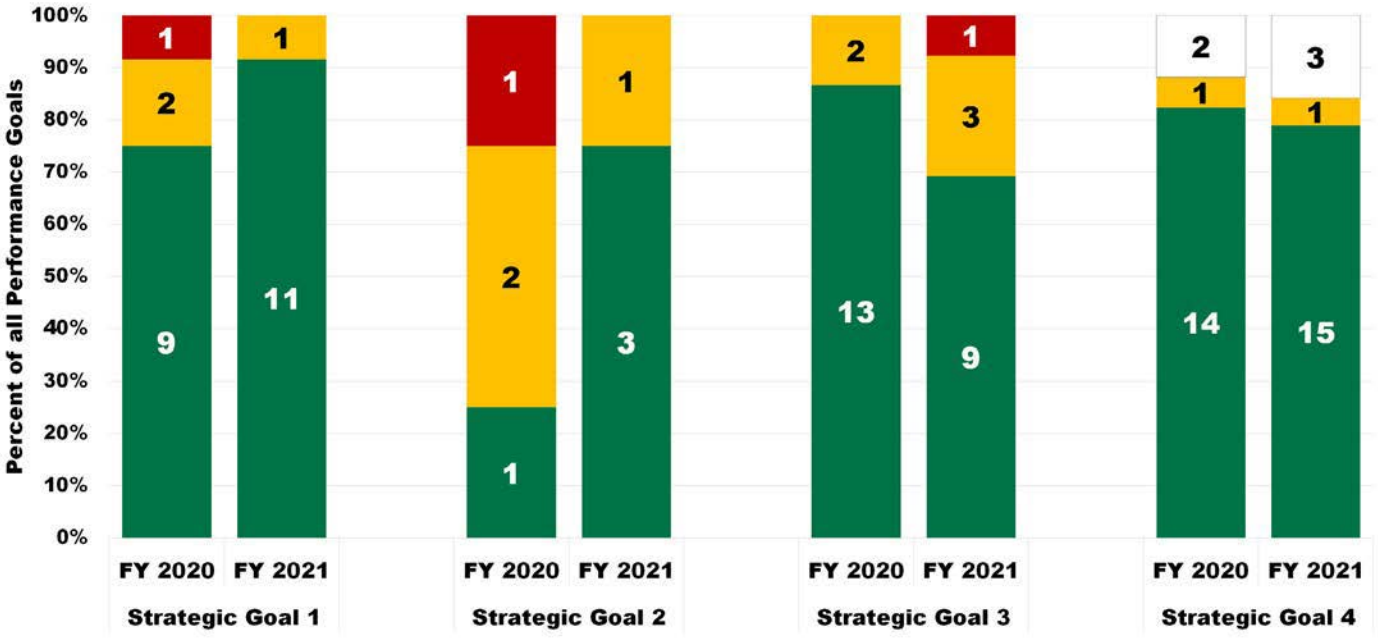
Performance Planning and Reporting

NASA's Ingenuity helicopter unlocked its rotor blades, allowing them to spin freely, on April 7, 2021, the 47th Martian day, or sol, of the Mars Perseverance mission. They had been held in place since before launch, and the unlocking is one of several milestones that needed to be met before the helicopter attempted the first powered, controlled flight on another planet. This image was captured by the Mastcam-Z imager on NASA's Perseverance Mars rover on the following sol, April 8. Image Credit: NASA/JPL-Caltech

NASA's assessment of performance progress against the *NASA 2018 Strategic Plan* concluded at the end of FY 2021. Below is a summary of Performance Goal ratings for FY 2020-2021.

Beginning in FY 2022 and for the following three fiscal years, NASA's performance will support the strategy-performance-evidence framework in the *NASA 2022 Strategic Plan*.

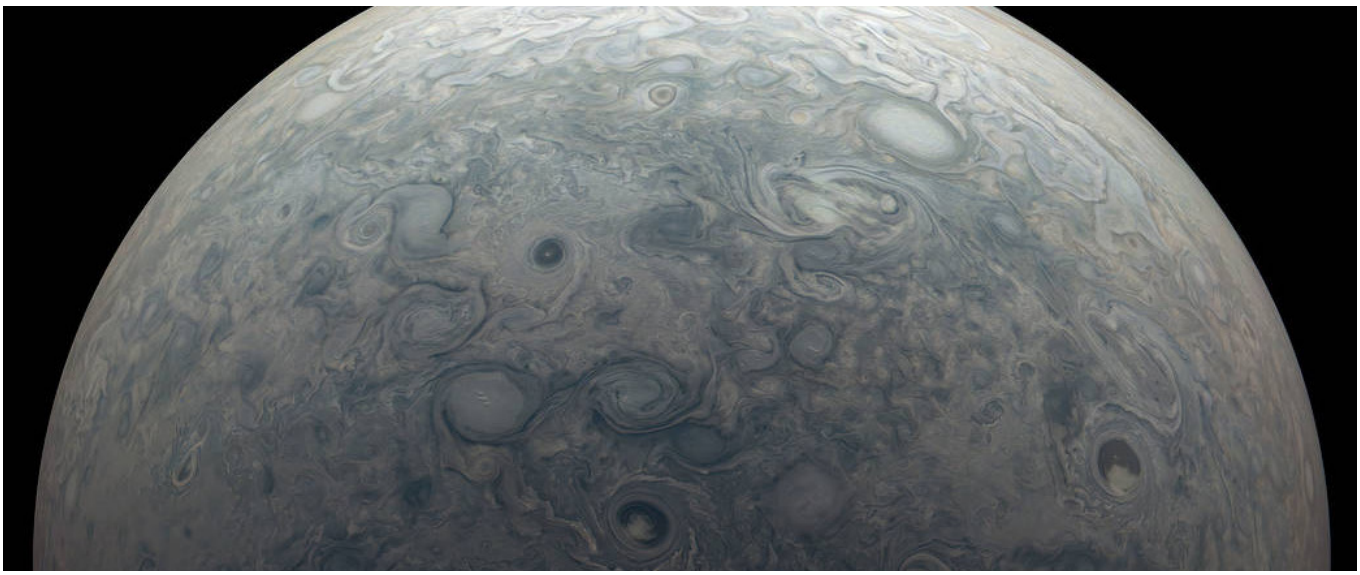
Summary of Performance Goal Ratings by Strategic Goal, FY 2020 and FY 2021
(NASA *2018 Strategic Plan* Framework)



Above: Members of NASA's Ingenuity helicopter team in the Space Flight Operations Facility at NASA's Jet Propulsion Laboratory prepare to receive the data downlink showing whether the helicopter completed its first flight on April 19, 2021. Image Credit: NASA/JPL-Caltech

Strategic Goal 1

Expand human knowledge through new scientific discoveries.



Top: This view of Jupiter's turbulent atmosphere from NASA's Juno spacecraft includes several of the planet's southern jet streams. Using data from Juno's instruments, scientists discovered that Jupiter's powerful atmospheric jet streams extend far deeper than previously imagined. Evidence from Juno shows the jet streams and belts penetrate about 1,800 miles (3,000 kilometers) down into the planet. Image Credit: NASA/JPL-Caltech/SwRI/MSSS

Bottom: This image from NASA's Juno mission captures the northern hemisphere of Jupiter around the region known as Jet N7. The planet's strong winds create the many swirling storms visible near the top of its atmosphere. Data from Juno helped scientists discover another, less visible effect of those winds: Jupiter's powerful magnetic field changes over time. The winds extend more than 1800 miles (3000 kilometers) deep, where the material lower in Jupiter's atmosphere is highly conductive, electrically. Scientists determined that the wind shears this conductive material apart and carries it around the planet, which changes the shape of the magnetic field. Image Credit: NASA/JPL-Caltech/SwRI/MSSS

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	2021	$1,627.9
Requested	2022	$1,832.1
Requested	2023	$1,967.2
Outyear	2024	$1,971.8
	2025	$2,102.4
	2026	$2,216.4
	2027	$2,257.2

Earth's changing environment impacts every aspect of life on our planet and has profound implications on society and our Nation's well-being. Climate adaptation and mitigation efforts cannot succeed without robust climate observations and research. As the impacts of global climate change become more numerous and acute, the demand for accurate, timely, and actionable knowledge about the Earth system is more pressing than ever. NASA is a world leader in the production of data necessary to understand, model, monitor, and ultimately predict climate and environmental change. NASA is the only organization in the world with an integrated end-to-end program in Earth-observing mission development, launch, operations, technology, research, data systems, and applications.

NASA's measurements and predictive models provide information for decision makers and organizations that work with communities affected by the impacts of changing climate, including information regarding the efficacy of policies and decisions that help the United States and others adapt and thrive on our changing planet. NASA also works with international partner satellites; data from airborne, ship-based, and ground network instrumentation; and outputs from operational weather models from National Oceanic and Atmospheric Administration (NOAA) and other meteorological agencies. NASA integrates and harnesses these disparate data sources, enabling scientists to investigate and solve large questions that cannot be addressed using data from only a single mission or spaceborne instrument.

Below: Vice President Kamala Harris gives remarks in front of the Space Environment Simulator (SES). Harris underscored how the United States is harnessing one of the Nations' most powerful tools – our space program — to combat the climate crisis and protect vulnerable communities. Image Credit: NASA/Taylor Mickal

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.

NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	Significant progress demonstrated		1	1		
Achieved	Demonstrated as planned in 2 areas					
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

Areas contributing to performance goal in FY 2021

1. Annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.8.
2. Complete Gravity Recovery and Climate Experiment Follow-On (GRACE-FO) mission success criteria.

Areas for FY 2022

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.

Areas 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.

This Performance Goal aligns to 1.1.8 under the NASA 2018 Strategic Plan.

NASA's Science Mission Directorate uses the vantage point of space to achieve a deep scientific understanding of our planet, other planets and solar system bodies, the interplanetary environment, the Sun and its effects on the solar system, and the universe beyond.

FY 2021 Performance Progress

The Earth Science Advisory Committee determined on November 4, 2021, that NASA achieved the FY 2021 target for this multiyear Performance Goal. Below are examples of scientific progress reported in FY 2021.

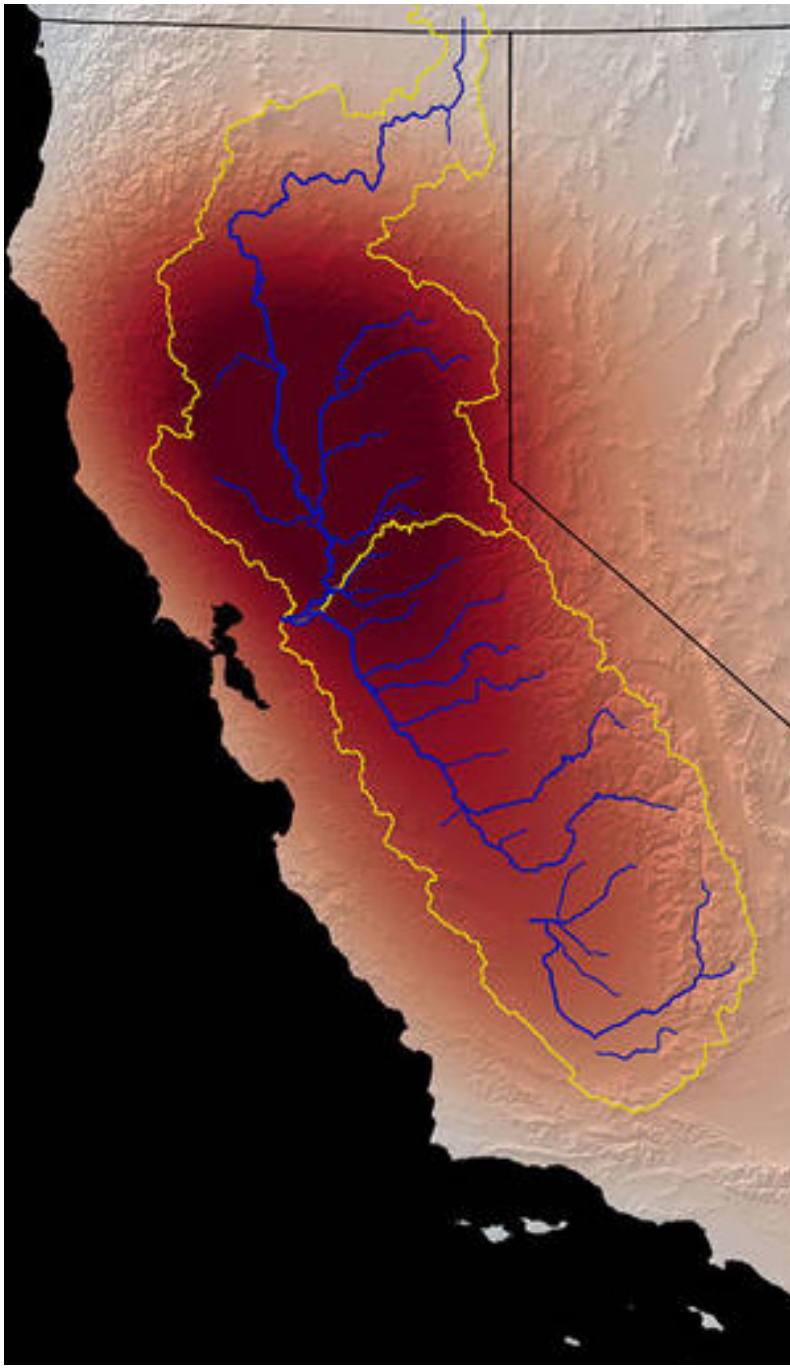
The Ice, Cloud and land Elevation Satellite (ICESat)-2 carries a single instrument, the Advanced Topographic Laser Altimeter System (ATLAS), that measures sea ice thickness and ice sheet elevation by timing the travel of laser pulses from the satellite to Earth's surface. A research team demonstrated for the first time that a spaceborne altimeter system can measure summer melt features on sea ice from. They showed that ICESat-2 can provide highly precise measurements, resolving features as narrow as 7 meters and achieving a vertical height precision of 0.01 meter, of sea ice surface roughness; the height of ridges created by buckling or lateral pressure; and sea ice floe size distribution. Another study used ICESat-2 data and coincident high-resolution satellite imagery from the European Space Agency's (ESA's) WorldView-2 and Sentinel-2 over different sea ice topographies to locate individual melt ponds on Arctic sea ice during the summer months. Sea ice melt ponds reduce both the reflective and insulative properties of sea ice, so determining their locations on sea ice is a critical observation for accurately calculating sea ice height and sea ice freeboard (i.e., the thickness of sea ice protruding above the water level).

While the Orbiting Carbon Observatory (OCO)-2 spacecraft retrieves data in regularly repeating, narrow swaths, the OCO-3 instrument aboard the International Space Station (ISS) can do multiple swaths over selected regions. A team of investigators are the first to describe results of the OCO-3 special sampling, snapshot-area maps, which collect detailed spatial information on carbon dioxide over regions on the scale of about 50 miles by 50 miles. For example, the snapshot-area maps highlighted the carbon dioxide enhancements—typically about 2 parts per million—over Los Angeles relative to desert regions to the northeast. Variations in the wind speed and direction largely explain variations in the magnitude and location of enhancements. The work also highlighted that OCO-3 snapshot-area maps observe about three times the emissions from the city as compared to the OCO-2 validation sampling over the region.

Less than half of Earth's 1,400 subaerial (existing in open air) volcanoes have ground monitoring because of practical limitations, especially at remote or heavily vegetated volcanoes. Researchers developed the first archive of both satellite and ground-based seismic, deformation, degassing, and thermal data to quantify the amount of detectable volcanic activity in the United States and its territories. The researchers found that 96 volcanoes in the United States showed some type of volcanic activity, including thermal activity at 30 volcanoes newly identified from analysis by the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) sensor. Researchers also used the Multi-angle Imaging SpectroRadiometer (MISR), the Moderate Resolution Imaging Spectroradiometer (MODIS), and the Ozone Measuring Instrument (OMI) to classify and track volcanic emissions from Icelandic volcanoes based on content and ash particle size. They used these data to illustrate the potential to distinguish qualitative differences in eruptive magma composition based on particle light absorption and plume profile from remote sensing.

Human activities releasing greenhouse gases and aerosols into the atmosphere disrupt Earth's energy balance between absorbed sunlight and emitted thermal radiative energy, with a net effect of causing Earth's surface and atmosphere to warm. The additional energy being added to the system by humans, previously estimated by models, has now been inferred by researchers using 16 years of measurements from the Clouds and the Earth's Radiant Energy System (CERES) and Atmospheric Infrared Sounder (AIRS) instruments aboard the Aqua satellite. They used a new technique to parse out how much of the total energy change is caused by humans, finding that 0.5 Watts per square meter of energy were added between 2003 and 2018, primarily because of anthropogenic greenhouse gas emissions from such processes as power generation, transport, and industrial manufacturing, and secondarily because of reduction in reflective aerosols.

During FY 2021, NASA completed the mission success criteria for the Gravity Recovery and Climate Experiment Follow On (GRACE-FO), which measures variations in gravity over Earth's surface caused by the constant redistribution of mass.



Above: A research team studied California's Tulare Basin, part of the Central Valley, and found that the key to distinguishing between underground sources of water relates to patterns of sinking and rising ground levels in this heavily irrigated agricultural region. They attacked the problem by combining data on water loss from U.S.-European Gravity Recovery and Climate Experiment (GRACE) and GRACE Follow-On satellites with data on ground-level changes from an ESA Sentinel-1 satellite. This map shows changes in the mass of water, both above ground and underground, in California from 2003 to 2013, as measured by NASA's GRACE satellite. The darkest red indicates the greatest water loss. The Central Valley is outlined in yellow; the Tulare Basin covers about the southern third. Extreme groundwater depletion has continued to the present. Image Credit: NASA/GSFC/SVS

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

NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	Significant progress demonstrated		1	1		
Achieved	Significant progress demonstrated in 3 areas					
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

List of areas for external review panel determination in FY 2021

1. Annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.9.
2. 40% of Earth science applications projects advancing one Applications Readiness Level (ARL) with 3 projects advance to ARL 8 or 9.
3. Customer satisfaction rating for the Earth Observing System Data and Information System (EOSDIS) exceeds the most recently available Federal Government average rating of the American Customer Satisfaction Index.

Areas for FY 2022

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.

Areas 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.

This Performance Goal aligns to 1.1.9 under the 2018 Strategic Plan.

FY 2021 Performance Progress

The Earth Science Advisory Committee determined on November 4, 2021, that NASA achieved the FY 2021 target for this multiyear Performance Goal. Below are examples of scientific progress reported in FY 2021.

NASA's Science Mission Directorate uses the vantage point of space to achieve a deep scientific understanding of our planet, other planets and solar system bodies, the interplanetary environment, the Sun and its effects on the solar system, and the universe beyond.

Researchers studied how to improve forecasts of flooding in the Northern Great Plains of North America. This region is flat and has soil that does not readily drain away water. It also receives a lot of snow, and in the spring, a sharp rise in temperature can quickly melt the snow and cause flooding for communities that lie near rivers. To better forecast floods like this, researchers used 2002-2011 data from the Advanced Microwave Scanning Radiometer for EOS (AMSR-E) aboard the Aqua satellite to better estimate the amount of snowfall that often occur at weather stations in windy areas. By linking snow water equivalent to the streamfall in rivers, these adjustments improved the model estimates of streamflow.

Human activities have large impacts on ecosystems and associated biogeochemical cycles, especially when coupled with natural processes. A recent study estimated that although woody plants in forested savannahs globally are responsible for 80 percent of the land carbon sink, human-induced deforestation releases back into the atmosphere an amount of carbon equal to about half of that emitted by burning of fossil fuels each year. However, replanting trees and reestablishing forests can offset a portion of these emissions. Another study leveraged a time series of MODIS data in conjunction with a carbon bookkeeping model to assess the impacts of land use/land cover change on carbon emissions in the Mekong River Basin from 2001 to 2019. They found that the largest components of land use/land cover change in the region are the establishment of plantations and agricultural expansion in previously forested areas. Although this land use conversion released carbon, carbon uptake from the establishment of new plantations offset almost half of those emissions, indicating that the assessment of post-deforestation land use is crucial for quantifying the short-

and longer-term carbon consequences of land use/land cover change.

Satellite multi-sensor precipitation products (SMPPs) fill in precipitation data for various applications where surface rain gauge data are not sufficient. However, uncertainty in the accuracy of SMPPs has hampered such use. Researchers demonstrated how considering the uncertainty in SMPPs can improve predictions from a landslide hazard model over the mountainous southeastern United States. They developed an error formulation using coincident data from the Integrated Multi-satellite Retrievals for GPM (IMERG) mission and ground-based gauge precipitation data and input to a probabilistic version of NASA's Landslide Hazard Assessment for Situational Awareness (LHASA) model. The additional uncertainty information allowed the probabilistic LHASA model to forecast more landslides than the existing deterministic version, particularly in high hazard nowcast categories.

During FY 2021, 64 of 90 Applied Sciences projects (71 percent) advanced at least one ARL, with nine achieving ARL 8 or 9. NASA uses ARL to track and manage the development, testing, validation, and integration of applications. ARL-1 is the level at which basic scientific concepts provide the basis for application ideas, and ARL-9 indicates that an application is approved for operational deployment and integration into a partner's system.

To support disaster preparedness and resiliency, the Applied Sciences Disasters program targeted over 300 partner organizations to strengthen relationships, with Disaster Assistance Response and Resilience Teams supporting four exercises and 46 activations (10 domestic, 36 international) to help exposed and vulnerable communities. In FY 2021, the program posted more than 2,500 data products on the NASA Disasters Mapping Portal. For a combination of perils including tropical cyclones, volcanoes, flooding, and wildfires, this provided increased situational awareness for key partners including the Federal Emergency Management Agency (FEMA), the U.S. Agency for International Development's (USAID's) Bureau of Humanitarian Affairs, The World Food Programme, and The International Federation of Red Cross and Red Crescent Societies. An example of these efforts is NASA's contribution to the Hurricane Ida response, for which data products fully integrated and available on both NASA's Portal and the FEMA National Response Coordination Center website were used in real-time by FEMA's Region IV and their interagency and state partners. Lessons learned also prompted four rapid response projects to improve future hurricane/flood activations and decision support.

Users indicated continued satisfaction with NASA's Earth Observing System Data and Information System (EOSDIS), as determined by the American Customer Satisfaction Index (ASCI) survey. The 2021 score improved slightly from already high levels as the data system continues to improve and evolve. The ACSI is a leading national indicator of customer satisfaction for more than 300 companies in 43 industries and 10 economic sectors, including the U.S. Federal Government.

Above: The BurnEx drill is an opportunity for first responders to practice their craft and try out new techniques, and for the first time in one of these exercises, NASA was in the room too. BurnEx, which took place on June 8-10, 2021, included prominent wildfire response organizations including the California National Guard, CAL FIRE and the California State Guard. The prescribed burn happened at Camp Pendleton, California. In the photo Brady Helms (center), disaster management coordinator with NASA Applied Sciences Disasters program, shows California National Guard Incident Awareness and Assessment Chief Warrant Officer, Mark Johnson (left), and Private First Class, Pio Tuban (right), the model output created for the exercise from NASA research activity. Image credits: California Guard Joint Forces Headquarters Public Affairs/SSG Kimberly Hill

1.1.3: Achieve critical milestones for the Science Mission Directorate's Earth system major projects.

Number of critical milestones completed.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	10	12	At least 3 of 4			
Achieved	8	15				
Rating	Yellow	Green				

2015	2016	2017	2018	2019
Green	Green	Yellow	Green	Green

List of critical milestones for FY 2022

1. Complete Sentinel-6B mission Pre-Storage Review.
2. Complete the Surface Water and Ocean Topography (SWOT) mission Operational Readiness Review (ORR).
3. Deliver the NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR) Radar Antenna Boom integration and alignment onto the Radar Structure.
4. Initiate the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) Observatory Integration and Test (I&T).

List of critical milestones for FY 2023

1. Complete the NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR) mission TBD.
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.
4. Deliver the Geostationary Carbon Observatory (GeoCarb) mission instrument.

This Performance Goal aligns to 1.1.10 under the 2018 Strategic Plan.

1.1.10: Achieve critical milestones of Science Mission Directorate major projects

List of major projects critical milestones FY 2021

1. Launch Sentinel-6A.
2. Complete the Landsat 9 Pre-Ship Review (PSR).
3. Initiate Surface Water and Ocean Topography (SWOT) mission Observatory Integration and Testing (I&T).
4. Initiate the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission spacecraft element Integration and Testing (I&T).
5. Land the Mars 2020 rover in the Jezero Crater, complete checkout, and begin surface operations.

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6. Complete the Mars Sample Return mission Key Decision Point (KDP)-A review.
7. Complete the Double Asteroid Redirection Test (DART) mission Pre-Ship Review (PSR).
8. Complete the Europa Clipper mission Critical Design Review (CDR).
9. Complete the Psyche mission System Integration Review (SIR).
10. Complete the Lucy mission Pre-Environmental Review (PER).
11. Complete one Dragonfly Mobility radar and lidar performance characterization tests.
12. Complete the Interstellar Mapping and Acceleration Probe (IMAP) Preliminary Design Review (PDR).
13. Complete the Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer (SPHEREx) Key Decision Point (KDP)-C review.
14. Complete the two Nancy Grace Roman Space Telescope instrument Critical Design Reviews (CDRs).
15. Complete the Volatiles Investigating Polar Exploration Rover (VIPER) mission Key Decision Point (KDP)-C review.

FY 2021 Performance Progress

NASA achieved 8 of the 12 milestones planned for FY 2021. Beginning in April 2020, NASA and its partners limited hands-on work to prioritized projects, following health guidance from the Centers for Disease Control and Prevention, to help protect the workforce from COVID-19 impacts. As a result of the change of operations, some projects did not achieve their milestones. NASA delayed the SPHEREx KDP-C review to the first quarter of FY 2021 due to COVID-19 impacts and the loss of the originally selected telescope vendor. The SIRs for SWOT and NISAR also were delayed until FY 2021 due to COVID-19 impacts. In addition, the Europa Clipper CDR was postponed to December 2020 due to delays in finalization of the launch vehicle selection for the mission and the associated uncertainties in the design of launch vehicle-specific mission elements.

The Lucy CDR was completed in October 2019 and the KDP-B review for IMAP was completed in January 2020. NASA awarded the second CLPS mission task order in April. The Psyche CDR and Landsat-9 KDP-D review were completed in May, and the KDP-D review for the DART mission and the Flight Acceptance Review, now referred to as the Qualification and Acceptance Review, for Sentinal-6 Michael Freilich were in July. Mars 2020 Perseverance launched on July 2020 on its way to the Red Planet. (Watch the launch on YouTube.)

Below: Technicians attach the Landsat 9 spacecraft to the evolved expendable vehicle secondary payload adapter (ESPA) inside the Vertical Integration Facility at Vandenberg Space Force Base in California on August 11, 2021. The ESPA connects Landsat 9 and the payload adapter (PMA). The PMA then will attach to the second stage of a United Launch Alliance Atlas V rocket. Landsat 9 launched on September 27, 2021. Photo credit: NASA/Randy Beaudoin

1.1.4: Use the vantage point of space, airborne, and surface observations to advance our understanding of the Earth system, its processes, and changing climate. (Agency Priority Goal)

Number of critical milestones completed.

Fiscal Year	2020	2021	2022 (APG)	2023 (APG)	2024	2025
Target	N/A	N/A	5	4		
Achieved	N/A	N/A				
Rating	N/A	N/A				

List of critical milestones for FY 2022

1. Release Landsat first light images.
2. Competitively select Earth Venture Mission (EVM)-3.
3. Release Equity and Environmental Justice research opportunity solicitation.
4. Deliver Earth Surface Mineral Dust Source Investigation (EMIT) for launch on the International Space Station (ISS).
5. Initiate Phase A for at least two of Earth System Observatory missions addressing four designated observables from the 2017 Decadal (Atmosphere; Clouds, Convection, and Precipitation; Surface Biology and Geology; and Mass Change).

List of critical milestones for FY 2023

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

NASA's Science Mission Directorate uses the vantage point of space to achieve a deep scientific understanding of our planet, other planets and solar system bodies, the interplanetary environment, the Sun and its effects on the solar system, and the universe beyond.

Strategic Objective 1.2

Understand the Sun, solar system, and universe.

LEAD OFFICE
Science Mission Directorate (SMD)

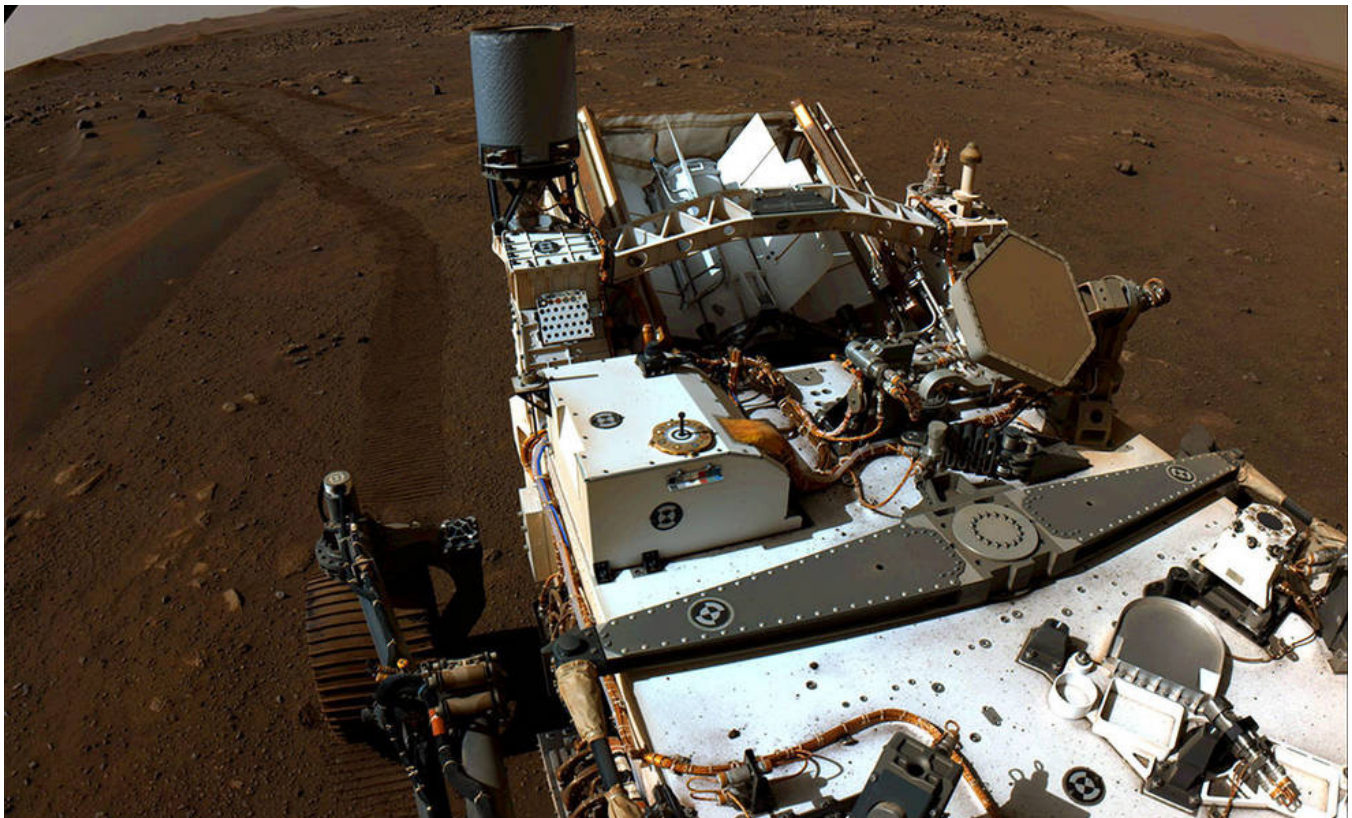
GOAL LEADER
Karen Flynn, Deputy Associate Administrator for Management, SMD

	Budget	
	FY	$M
Op Plan	2021	$5,294.2
Requested	2022	$5,681.4
Requested	2023	$5,576.8
Outyear	2024	$5,687.8
	2025	$5,722.1
	2026	$5,755.1
	2027	$5,864.8

Astrophysics is humanity's scientific quest to discover the origin of the universe and of life itself. How does the universe work? How did we get here? Are we alone? Progress is advanced through the combination of basic research and flight missions. Astrophysics is guided by the *Pathways to Discovery in Astronomy and Astrophysics for the 2020s* (Astro2020) decadal survey, which identifies science goals and recommendations for astrophysics planning and investment for the next decade. Basic research uses the data from our missions to create new knowledge and advance our understanding of the universe.

Through the observation and discovery of complex planetary worlds and objects, we seek to understand our solar system and the distribution of life within it. The focus of planetary science is to advance scientific knowledge of the origin and history of the solar system, the potential for life elsewhere, and the hazards and resources present as

Below: Perseverance looks back with one of its navigation cameras toward its tracks on July 1, 2021 (the 130th sol, or Martian day, of its mission), after driving autonomously 358 feet (109 meters) – its longest autonomous drive to date. The image has been processed to enhance the contrast. Image Credit: NASA/JPL-Caltech



humans explore space. The scientific foundation of this endeavor is the *Origins, Worlds, and Life: A Decadal Survey for Planetary Science and Astrobiology 2023-2032*. NASA manages a diverse portfolio of research and technology development and unique mission investigations.

Advances in planetary science, coupled with leading efforts to detect, track, and characterize near-Earth objects, will continue to improve planetary defense. Biological and physical sciences pioneers scientific discovery and enables space exploration by using the spaceflight environment, in and beyond low Earth orbit, to conduct experiments that cannot be done on Earth. This work focuses on transformative science to contribute to advances in science, technology, and space exploration. NASA strives for broad involvement of the research and technology development communities in the formulation and dissemination of its work.

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.

NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	Significant progress demonstrated		2	1		
Achieved	Demonstrated as planned					
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

Areas contributing to performance goal in FY 2022

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.
2. Complete the Parker Solar Probe (PSP) mission success criteria.

Areas contributing to performance goal in 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.

This Performance Goal aligns to 1.1.1 under the 2018 Strategic Plan.

FY 2021 Performance Progress

NASA achieved the FY 2021 target for this multiyear Performance Goal, as determined by the assessment of progress led by the Heliophysics Advisory Committee in October 2021. Below are examples of scientific progress reported in FY 2021. 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.

A full solar cycle of energetic neutral atom flux observations (a way to image otherwise invisible neutral atoms) from the outer heliosphere by the Interstellar Boundary Explorer (IBEX) have made possible the construction of a 3D map of the heliosphere, the bubble that describes the extent of our Sun's influence.

NASA's Science Mission Directorate uses the vantage point of space to achieve a deep scientific understanding of our planet, other planets and solar system bodies, the interplanetary environment, the Sun and its effects on the solar system, and the universe beyond.

New studies from the Magnetospheric Multiscale (MMS) mission of charged particle acceleration by magnetic reconnection and by the Interface Region Imaging Spectrograph (IRIS) and the Solar Dynamics Observatory (SDO) of nanoflares embedded within flaring regions are important for understanding charged particle acceleration in solar flares and planetary magnetospheres throughout the solar system and the universe.

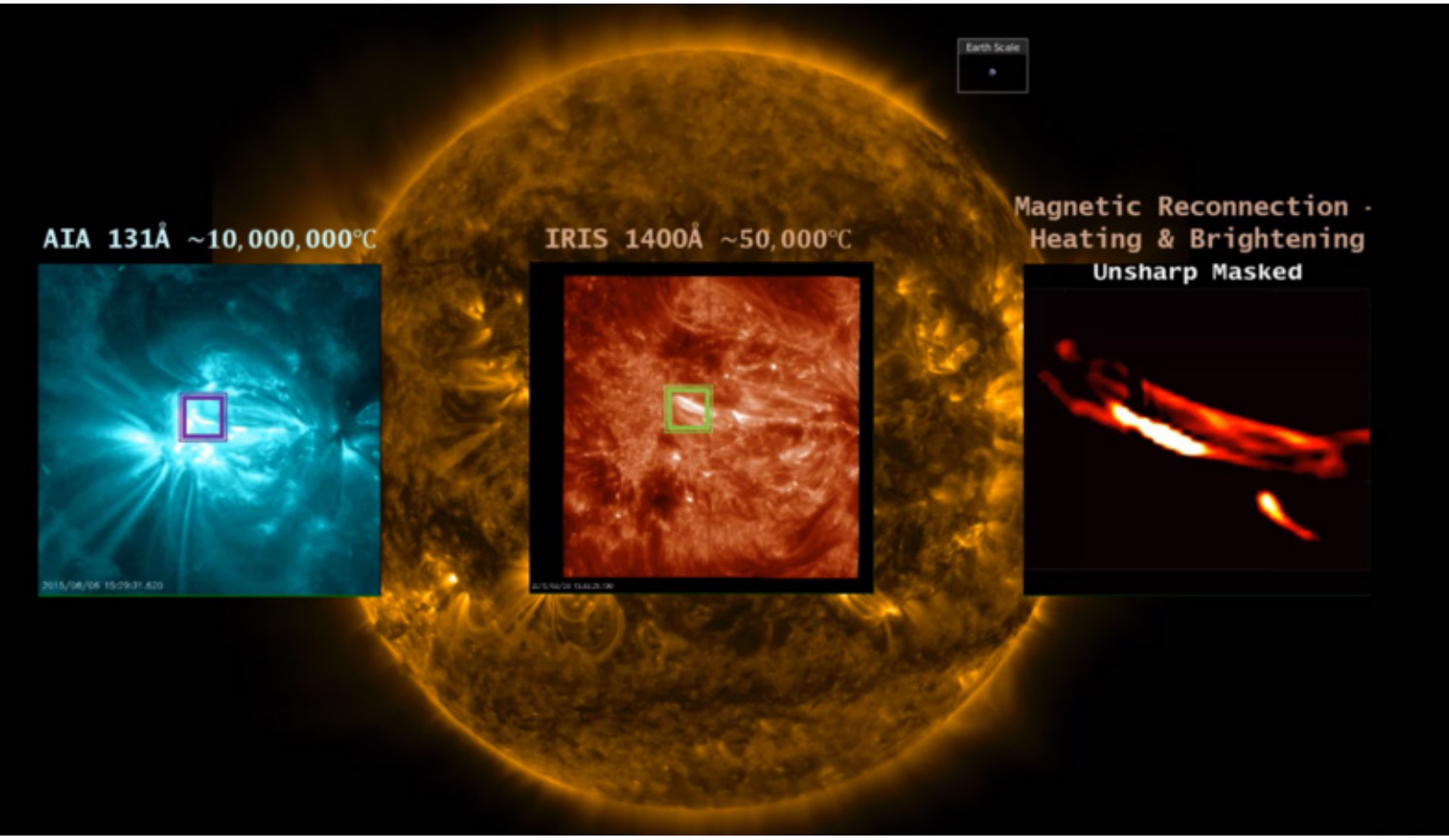
NASA's Ionospheric Connection Explorer (ICON) mission is providing new insights into how neutral winds drive the currents that form the equatorial electrojet, crucial to improving understanding and modeling of thermosphere-ionosphere coupling and equatorial space weather.

The Mars Reconnaissance Orbiter (MRO) observed spatial/temporal variability in the Martian thermosphere density due to solar tides that also have important implications for variability in the thermosphere at Earth. Seeing the effects of the same physical process in two very different planetary atmospheres provides deeper understanding of how one physical process couples to others and leads to better atmospheric models at both Earth and Mars.

The signatures of extrasolar planets can be masked by stellar irradiance variability associated with magnetic activity cycles. Earth Science missions are contributing to the interpretation of measurements conducted in the search for extrasolar planets. Using the Sun as a viable template, daily full-disk solar observations from NASA's Aura Ozone Monitoring Instrument (OMI) and the Dutch Tropospheric Monitoring Instrument (TROPOMI) resulted in both new information about the sources of variability in selected solar lines and a valuable data set for future progress.

Citizen science recently identified a new form of aurora called the "dunes," contributing to lead-

ing-edge discoveries in heliophysics. Observations from NASA's Thermosphere-Ionosphere-Mesosphere Energetics and Dynamics (TIMED) mission were critical to developing a theory to explain the dune-like structure as the result of an atmospheric wave known as a mesospheric bore.



Above: Solar flares range in size from nanoflares to giant eruptive flares. Each inset frame zooms in to the selected region in the frame to its left. The frame on the far right is the most zoomed in, showing the putative nanoflare. Image Credit: NASA/SDO/IRIS/Shah Bahauddin

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.

NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	Significant progress demonstrated		1	1		
Achieved	Significant progress demonstrated					
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

Areas for FY 2022

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.

Areas 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.

This Performance Goal aligns to 1.1.2 under the 2018 Strategic Plan.

FY 2021 Performance Progress

NASA achieved the FY 2021 target for this multi-year Performance Goal as determined by the assessment of progress led by the Astrophysics Advisory Committee in October 2021. Below are examples of scientific progress reported in FY 2021.

The Nuclear Spectroscopic Telescope Array (NuSTAR) and X-ray Multi-mirror Mission (XMM)-Newton observations of X-ray emissions produced by gas falling into a black hole, which is then gravitationally bent by the black hole, enable for the first time the study of processes on the far side of the black hole and allow a three-dimensional view. Observing photons bent around the black hole confirms a key prediction of general relativity. NuSTAR is a NASA mission developed in partnership with the Danish Technical University (DTU) and the Italian Space Agency (ASI). XMM-Newton was built and launched by the European Space Agency (ESA). NASA contributed resources for two of XMM-Newton key instruments and funds the Guest Observer Facility at our Goddard Space Flight Center in Maryland. The Juno spacecraft, heading to Jupiter, provided the first radial profile of interplanetary dust (as small as a few microns) and determined it came from Mars. Astronomers have long thought that dust is brought into the inner solar system by asteroids and comets, but Juno data shows the dust in the Martian orbit plane could contribute, too. This dust distribution solves the mystery of Zodiacal Light. This work will impact our understanding and interpretation of zodiacal emission and solar system dust, to be studied by future NASA exoplanet missions that explore the process of planet building.

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A new type of supernova, 2018zd, discovered using Hubble Space Telescope and Spitzer Space Telescope data, has shown strong evidence of being triggered by "electron capture," which is suspected to occur for stars between 8 and 10 times the mass of the Sun. These stars are too massive to expire as white dwarf stars, but too small to undergo standard core-collapse supernova explosions. This discovery will provide scientists with a deeper understanding of the diversity of stellar death.

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.

NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	Significant progress demonstrated		1	2		
Achieved	Significant progress demonstrated					
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

Areas for FY 2022

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.

Areas 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.
2. Complete the Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS-REx) mission success criteria.

This Performance Goal aligns to 1.1.3 under the 2018 Strategic Plan.

FY 2021 Performance Progress

NASA achieved the FY 2021 target for this multiyear Performance Goal as determined by an assessment of progress led by the Planetary Advisory Committee in October 2021. Below are examples of scientific progress reported in FY 2021. The selected results represent a breadth of accomplishment in exploring, observing, and understanding objects in the solar system and how they formed, as well as how they continue to operate, interact, and evolve. These selected results also demonstrate that high-impact science comes not just from newly collected observations, but also from continued assessment of data collected decades ago.

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For two years, the Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) lander has been recording seismic activity on Mars to better understand the planet's structure, thermochemical state, and geologic history. Results from InSight demonstrate that Mars is seismically active with plentiful marsquakes that are generally small in magnitude. Initial data analysis reveals that Mars possesses a 24- to 72-kilometer-thick layered crust, with a 500 kilometer-deep lithosphere, the rocky outermost part of Mars made up of the crust and mantle. Mars is surfaced by a crust enriched in radioactive elements and contains a large, approximately 1,830 kilometer-wide core composed of iron-nickel that is enriched in light elements and is at least partially in a liquid state. These results point to a planetary interior with general similarities to those of Earth, but one that followed a very different evolutionary path.

At the outer planets, scientists took a fresh look at images acquired by the Voyager 2 spacecraft in light of other more recent discoveries. The data revealed that the surfaces of the mid-sized Uranian moons exhibit geologic features that could have been formed by cryovolcanism (where volcanoes erupt liquids and vapor that freeze at the planetary surface), hinting at ocean world activity, now or in the past. Ammonia is an efficient anti-freeze agent that is associated with cryovolcanic deposits and processes on confirmed ocean worlds like Enceladus and Ceres. Using NASA's Infrared Telescope Facility, a team detected a 2.2-μm band on Ariel and the other Uranian moons that is consistent with the presence of ammonia-bearing species, supporting the photogeologic evidence for cryovolcanism on the Uranian moons.

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

NASA portfolio areas assessed, guided by an annual external expert review of progress made by contributing programs, missions, and research.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	Significant progress demonstrated		1	1		
Achieved	Significant progress demonstrated in 1 area					
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

Areas for external review panel determination in FY 2021

1. Annual external expert review determination of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.4.
2. Complete Transiting Exoplanet Survey Satellite (TESS) mission success criteria.

Areas for FY 2022

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.

Areas 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.

This Performance Goal aligns to 1.1.4 under the 2018 Strategic Plan.

FY 2021 Performance Progress

NASA achieved the FY 2021 target for this multi-year Performance Goal as determined by the assessment of progress led by the Astrophysics Advisory Committee in October 2021. Below are examples of scientific progress reported in FY 2021.

Discoveries made with the Transiting Exoplanet Survey Satellite (TESS) include an Earth-like planet found in the liquid water zone of its host star, several multi-planet systems (like our solar system), planets orbiting binary stars, super-hot planets extremely close to their host star, planets around white dwarfs (the Sun will evolve into such an object after it exhausts its nuclear fuel in about 5 billion years), the remnant core of a gas giant whose atmosphere has been stripped away, and many more.

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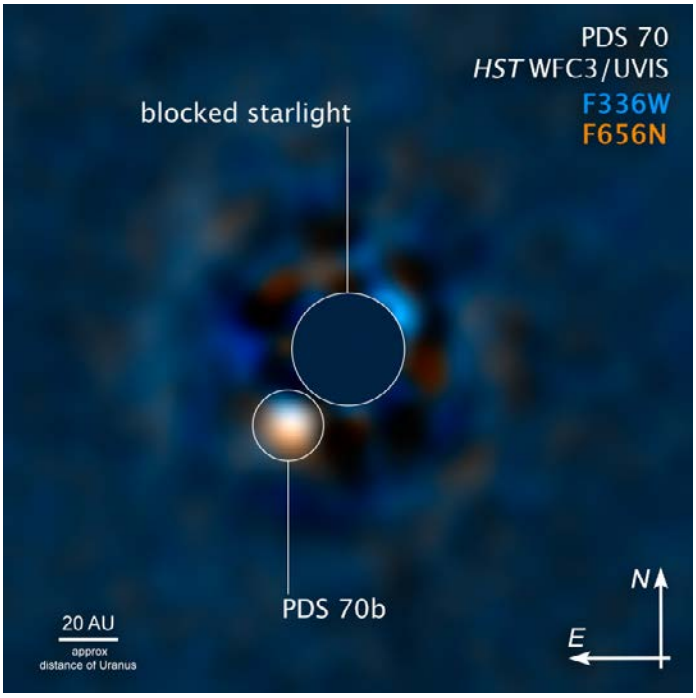
A newly published catalogue of TESS exoplanets will enable astronomers to study exoplanet demographics. This TESS catalog builds on the remarkable results from the earlier Kepler mission, which detected the first large population of exoplanets. TESS has discovered planets across the whole sky, and around stars nearby to the Sun, providing target lists for future follow-up with the James Webb Space Telescope and other facilities.

The Hubble Space Telescope directly measured the mass growth rate of exoplanet PDS 70b by observing radiation from extremely hot gas falling onto the planet. The massive, Jupiter-sized world orbiting at approximately the same distance as Uranus does from the Sun, began forming approximately 5 million years ago, and may be in the tail end of its formation process. This technique for using Hubble to directly image this planet paves a new route for further exoplanet research, especially during a planet's formative years.



Left: NASA's Hubble Space Telescope is giving astronomers a rare look at a Jupiter-sized, still-forming planet that is feeding off material surrounding a young star. This huge exoplanet, designated PDS 70b, orbits the orange dwarf star PDS 70, which is already known to have two actively forming planets inside a huge disk of dust and gas encircling the star. Image Credit: NASA, ESA, McDonald Observatory–University of Texas, Yifan Zhou (UT), Joseph DePasquale (STScI). Image Credit: NASA

Above: In this artist's interpretation, researchers working with data from NASA's Transiting Exoplanet Survey Satellite (TESS) have discovered the mission's first circumbinary planet, a world orbiting two stars. The planet, called TOI 1338 b, is around 6.9 times larger than Earth, or between the sizes of Neptune and Saturn. It lies in a system 1,300 light-years away in the constellation Pictor. Watch a video about this discovery [https://www.nasa.gov/tess-transiting-exoplanet-survey-satellite]. Image credit: NASA Goddard Space Flight Center

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.

NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	Significant progress demonstrated		1	1		
Achieved	Significant progress demonstrated					
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

Areas for FY 2022

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.

Areas 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.

This Performance Goal aligns to 1.1.5 under the 2018 Strategic Plan.

FY 2021 Performance Progress

NASA achieved the FY 2021 target for this multiyear Performance Goal as determined by an assessment of progress led by the Planetary Science Advisory Committee in October 2021. Below are examples of scientific progress reported in FY 2021.

Earth's status as the only life-sustaining planet is a result of the timing and delivery mechanism of carbon, nitrogen, sulfur, and hydrogen. Determining the characteristics of the body or bodies that delivered this material to early Earth is crucial. Based on their isotopic signatures, terrestrial volatiles (small molecules) are thought to have derived from carbonaceous meteorites, while the isotopic compositions of nonvolatile major and trace elements suggest that a different type of meteorite material is the primary building blocks of Earth. Using experiments at high pressure and temperature, as well as modeling simulations, researchers have demonstrated that an impact of a Mars-sized planet of particular composition around the time of the Moon-forming event (5 to 10 million years after the formation of the solar system) could be the source of major volatiles on Earth.

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The study of an extreme outburst, or flare, from the Sun's nearest stellar neighbor, Proxima Centauri, could help guide the search for life beyond our solar system. The flare was discovered by a team of astronomers using the Hubble, TESS, and ground-based telescopes that included the Australian Square Kilometre Array Pathfinder (ASKAP), Atacama Large Millimeter/submillimeter Array (ALMA), and the du Pont Telescope. Proxima Centauri is a "red dwarf" with about one-eighth the mass of our Sun. It sits just four light-years, or almost 25 trillion miles, from the center of our solar system and hosts at least two planets, one of which may look something like Earth. As the closest exoplanet to Earth, and located in the star's Habitable Zone, Proxima b is the most likely candidate for follow-up observations and astrobiological surveys. But according to this latest study, the flares its star emits would have likely rendered the planet sterile a long time ago. The team's findings constitute one of the most in-depth anatomies of a flare from any star in our galaxy. In the future, these signals could help researchers gather more information about how stars generate flares, which could have immense implications for exoplanet and habitability studies.

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.

NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	Significant progress demonstrated		2	2		
Achieved	Demonstrated as planned in 2 areas					
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

Areas for external review panel determination in FY 2021

1. Annual external expert review determination of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.6.
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.

Areas for FY 2022

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.

Areas 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.

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This Performance Goal aligns to 1.1.6 under the 2018 Strategic Plan.

FY 2021 Performance Progress

NASA achieved the FY 2021 target for this multiyear Performance Goal as determined by the assessment of progress performed by the Heliophysics Advisory Committee in October 2021. Below are examples of scientific progress reported in FY 2021. 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.

Geomagnetically induced currents (GICs) result from geoelectric fields produced by space weather. GICs, which manifest at ground level, are a considerable risk to technological systems, like powerlines. A recent study using coordinated observations from the Time History of Events and Macroscale Interactions during Substorms (THEMIS) mission, ground-based magnetometers, radars, and the Earthscope facility revealed the direct coupling of conditions in the magnetotail-to-ground-level electromagnetic conditions. Findings from the study are expected to lead to better characterization and prediction of geoelectric signals from ultra-low-frequency waves that can reach amplitudes that may cause intense geoelectric fields and GICs.

Solar energetic particles are the most hazardous outputs from solar activity. Recent studies utilizing the Heliophysics System Observatory show the plasma composition of the most damaging solar energetic particles can be traced back to the confined magnetic field environment in the Sun's

lower atmosphere. The studies also confirm shock acceleration as a major acceleration mechanism.

Changes in thermospheric mass density impact the aerodynamic drag on space vehicles and debris in the near-Earth space environments. Cooling of the mesosphere and lower thermosphere (MLT) results in a decrease in its temperature and density, which results in less aerodynamic drag and leads to longer lifetimes for debris on orbit. A recent study by the TIMED mission reveals that the MLT has cooled dramatically since 2002 and suggests that the MLT in 2020 was colder than at any other time since the late 1700s. The long-term cooling effects are attributed to increasing carbon dioxide due to climate changes and weakening solar cycles.

Researchers have developed new methodologies to understand coronal mass ejection propagation using heliospheric images from the Solar Terrestrial Relations Observatory (STEREO) mission, improving the capability to predict arrival time at Earth. Furthermore, there has been significant progress made in global integrated models of the solar corona and heliosphere, in particular to understand the build-up of magnetic energy that leads to solar eruptive events.

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.

NASA portfolio assessment guided by an annual external expert review determination of contributing programs, missions, and research.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	Significant progress demonstrated		2	3		
Achieved	Demonstrated as planned in 2 areas					
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

Areas contributing to performance goal in FY 2021

1. Annual external expert review of programs, missions, and published, peer-reviewed research contributing to Performance Goal 1.1.7.
2. Identify and catalogue 9,750 near-Earth asteroids that are 140 meters in diameter or larger.

Areas contributing to performance goal in FY 2022

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 10,300 near-Earth asteroids that are 140 meters in diameter or larger.

Areas contributing to performance goal in 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 10,800 near-Earth asteroids that are 140 meters in diameter or larger.
3. Complete the Double Asteroid Redirection Test (DART) mission success criteria.

This Performance Goal aligns to 1.1.7 under the 2018 Strategic Plan.

FY 2021 Performance Progress

NASA achieved the FY 2021 target for this multiyear Performance Goal as determined by an assessment of progress led by the Planetary Science Advisory Committee in October 2021. Below are examples of scientific progress reported in FY 2021.

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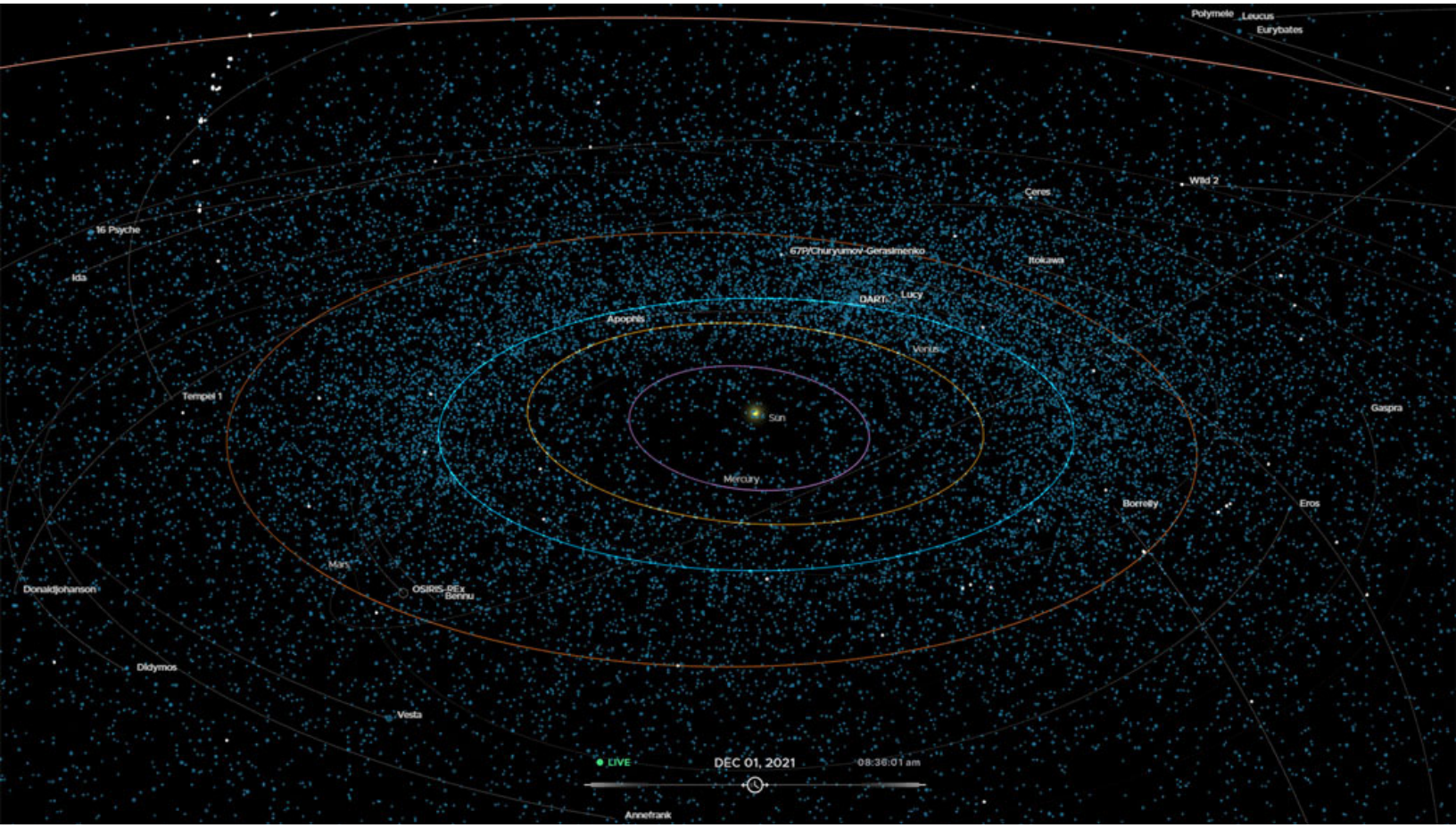
In this fiscal year, asteroid search teams funded by NASA's Near-Earth Object Observations (NEOO) Program found another 5 asteroids larger than one kilometer in size with orbits that can come within Earth's vicinity. Asteroid search teams also found 3,039 smaller asteroids less than one kilometer in size. This brings the total known population of near-Earth asteroids to 26,907 as of September 30, 2021. 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 Earth in the next century. However, 2,215 small bodies (of which 162 are larger than one kilometer in diameter), with 117 near-Earth comets, are in orbits that could become a hazard in the more distant future and warrant continued monitoring. The NASA Authorization Act of 2005 directed NASA to find 90 percent of the near-Earth objects down to 140 meters in size. As of September 30, 2021, 9,837 near-Earth asteroids with sizes greater than 140 meters have been discovered and catalogued, exceeding the target of 9,750 .

Asteroid 99942 Apophis, discovered in 2004, was identified as one of the most hazardous asteroids that could impact Earth. Estimated to be about 1,100 feet (340 meters) across, astronomers predicted that it would come uncomfortably close in 2029. Thanks to additional observations, the risk of an impact in 2029 was later ruled out, as was the potential impact risk posed by another close approach in 2036. However, the astronomers could not rule out a small chance of impact in 2068. During Apophis' distant flyby of Earth in March 2021, astronomers took the opportunity to precisely track its motion and to refine the estimate of its orbit around the Sun with extreme precision, enabling scientists to confidently rule out any impact risk in 2068 and long after. With the support of recent optical observations and additional radar observations, NASA scientists found that the

uncertainty in Apophis' orbit has collapsed from hundreds of kilometers to just a handful of kilometers when projected to 2029. This greatly improved knowledge of its position in 2029 provided more certainty of its future motion, so Apophis could be removed from the risk list. On April 13, 2029, the asteroid Apophis will pass less than 20,000 miles (32,000 kilometers) from our planet's surface—closer than the distance of geosynchronous satellites.



With NASA's Eyes on Asteroids, you can watch all the known near-Earth asteroids and comets as they orbit the Sun. Updated twice daily with the latest tracking data, the web-based application will automatically add new near-Earth object discoveries for you to explore. Image credits: NASA/JPL-Caltech

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.

NASA portfolio areas assessed, guided by an annual external expert review of progress made by contributing programs, missions, and research.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	N/A	N/A	1	1		
Achieved	N/A	N/A				
Rating	N/A	N/A				

Areas for FY 2022

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.

Areas 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.

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Right: The eXposed Root On-Orbit Test System (XROOTS) investigation team review Astro Garden plant growth testing in a laboratory facility at Sierra Space in Madison, Wisconsin (left to right: John Wetzel, Dan Wyman, Bob Morrow, Gil Tellez). The XROOTS investigation, sponsored by NASA's Biological and Physical Sciences Division, is designed to test critical aspects of the Astro Garden system by using hydroponic and aeroponic techniques to grow crop plants without soil, making large scale plant production in space feasible. Image credit: Sierra Space

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

Number of critical milestones completed.

Fiscal Year	2020	2021	2022 (APG)	2023 (APG)	2024	2025
Target	10	12	At least 10 of 12	At least 6 of 8		
Achieved	8	15				
Rating	Yellow	Green				

2015	2016	2017	2018	2019
Green	Green	Yellow	Green	Green

List of major projects critical milestones FY 2021

1. Launch Sentinel-6A.
2. Complete the Landsat 9 Pre-Ship Review (PSR).
3. Initiate Surface Water and Ocean Topography (SWOT) mission Observatory Integration and Testing (I&T).
4. Initiate the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission spacecraft element Integration and Testing (I&T).
5. Land the Mars 2020 rover in the Jezero Crater, complete checkout, and begin surface operations.
6. Complete the Mars Sample Return mission Key Decision Point (KDP)-A review.
7. Complete the Double Asteroid Redirection Test (DART) mission Pre-Ship Review (PSR).
8. Complete the Europa Clipper mission Critical Design Review (CDR).
9. Complete the Psyche mission System Integration Review (SIR).
10. Complete the Lucy mission Pre-Environmental Review (PER).
11. Complete one Dragonfly Mobility radar and lidar performance characterization tests.
12. Complete the Interstellar Mapping and Acceleration Probe (IMAP) Preliminary Design Review (PDR).
13. Complete the Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer (SPHEREx) Key Decision Point (KDP)-C review.
14. Complete the two Nancy Grace Roman Space Telescope instrument Critical Design Reviews (CDRs).
15. Complete the Volatiles Investigating Polar Exploration Rover (VIPER) mission Key Decision Point (KDP)-C review.

List of major projects critical milestones FY 2022

1. Launch the Lucy mission.
2. Complete the Volatiles Investigating Polar Exploration Rover (VIPER) Critical Design Review (CDR).

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3. Complete the Europa Clipper System Integration Review (SIR).
4. Launch the Double Asteroid Redirection Test (DART) mission.
5. Complete the Psyche mission Pre-Ship Review (PSR).
6. Complete one Dragonfly mission instrument Preliminary Design Review (PDR).
7. Complete the Mars Sample Return (MSR) program Key Decision Point (KDP)-B review.
8. Complete one Geospace Dynamics Constellation (GDC) mission instrument selections.
9. Complete the Interstellar Mapping and Acceleration Probe (IMAP) CDR.
10. Complete the Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer (SPHEREx) CDR.
11. Complete the telescope for the Nancy Grace Roman Space Telescope.
12. Award two Commercial Lunar Payload Services (CLPS) delivery task orders.

List of major projects critical milestones FY 2023

1. Complete the Volatiles Investigating Polar Exploration Rover (VIPER) Key Decision Point (KDP)-E 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)-1 Preliminary Design Review (PDR).
5. Complete the Interstellar Mapping and Acceleration Probe (IMAP) mission System Integration Review (SIR).
6. Complete the Nancy Grace Roman Space Telescope instrument carrier.
7. Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer (SPHEREx) TBD
8. Award two Commercial Lunar Payload Services (CLPS) delivery task orders.

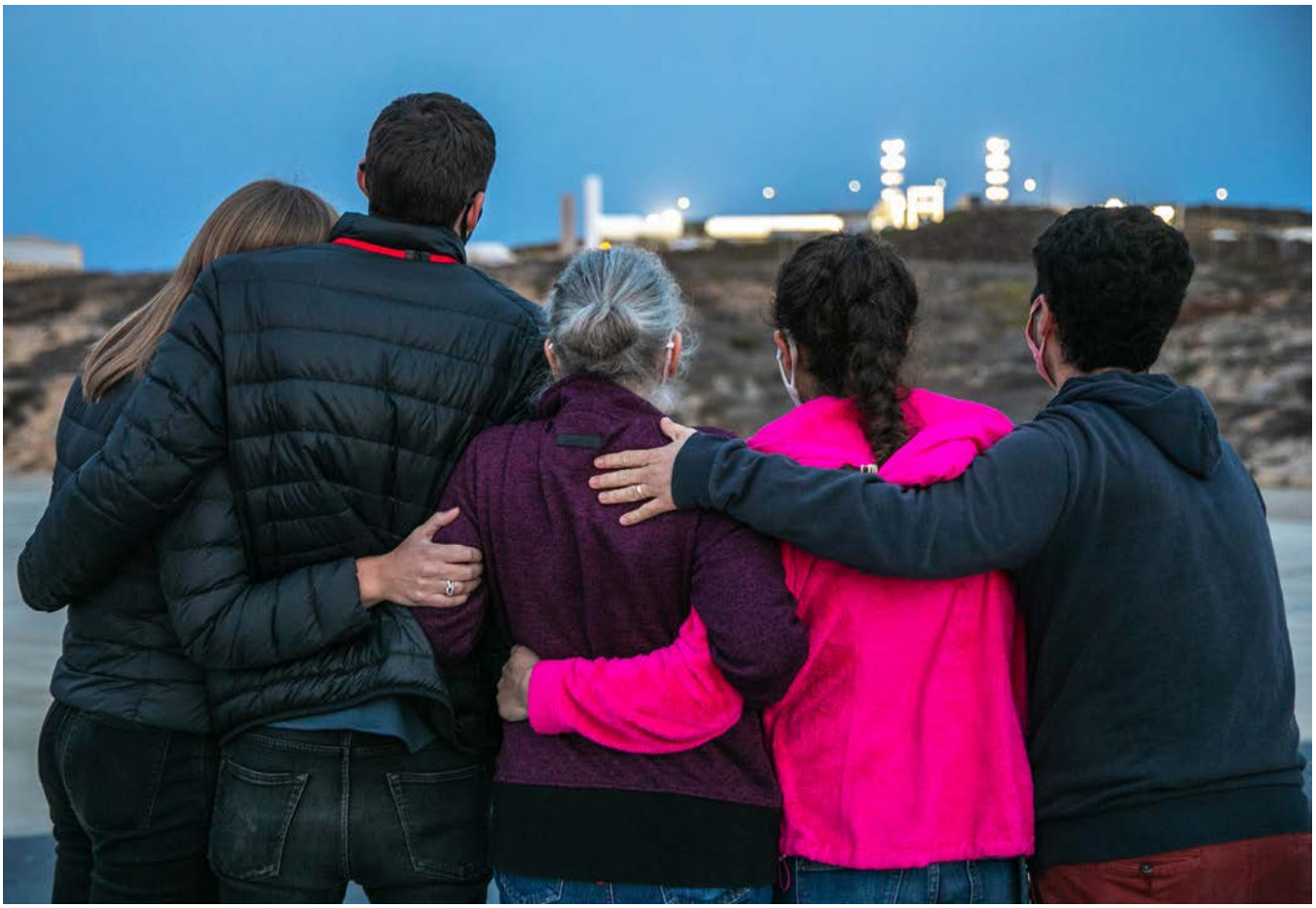
This Performance Goal aligns to 1.1.10 under the 2018 Strategic Plan.

FY 2021 Performance Progress

NASA achieved 8 of the 12 milestones planned for FY 2021. Beginning in April 2020, NASA and its partners limited hands-on work to prioritized projects, following health guidance from the Centers for Disease Control and Prevention, to help protect the workforce from COVID-19 impacts. As a result of the change of operations, some projects did not achieve their milestones. NASA delayed the SPHEREx KDP-C review to the first quarter of FY 2021 due to COVID-19 impacts and the loss of the originally selected telescope vendor. The SIRs for SWOT and NISAR also were delayed until FY 2021 due to COVID-19 impacts. In addition, the Europa Clipper CDR was postponed to December 2020 due to delays in finalization of the launch vehicle selection for the mission and the associated uncertainties in the design of launch vehicle-specific mission elements.

The Lucy CDR was completed in October 2019 and the KDP-B review for IMAP was completed in January 2020. NASA awarded the second CLPS mission task order in April. The Psyche CDR and Landsat-9 KDP-D review were completed in May, and the KDP-D review for the DART mission and the Flight Acceptance Review, now referred to as the Qualification and Acceptance Review, for Sentinel-6 Michael Freilich were in July. Mars 2020 Perseverance launched on July 2020 on its way to the Red Planet. (Watch the launch on YouTube.)

Below: Family members of Dr. Michael Freilich, for whom the Sentinel-6 Michael Freilich satellite is named, gather at Vandenberg Air Force Base in California on November 20, 2020, the day before the spacecraft's launch atop a Falcon 9 rocket. Freilich served as director of NASA's Earth Science Division in the Science Mission Directorate at the Agency's Headquarters from 2006 until his retirement in 2019. A tireless advocate for advancing satellite measurements of the ocean, he was instrumental in advancing ocean altimetry and helped drive the evolution of NASA Earth science from a program that launched an Earth-observing space mission every few years to one that launches several missions each year. Freilich died August 5, 2020, of pancreatic cancer. Image credit: NASA/Ben Smegelsky



1.2.10: Complete commissioning 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)

Number of critical milestones completed.

Fiscal Year	2020 (APG)	2021	2022	2023	2024	2025
Target	4	4	4	4		
Achieved	3	3				
Rating	Yellow	Yellow				

2015	2016	2017	2018	2019
Green	Yellow	Yellow	Green	Green

List of development milestones for FY 2021

1. Initiate observatory post-environment testing deployments.
2. Complete final comprehensive system test.
3. Complete sunshield folding in preparation for final stow for shipment.
4. Complete shipment of observatory to launch site.

List of critical milestones for FY 2022

1. Launch James Webb Space Telescope.
2. Perform all deployments of the observatory.
3. Initiate commissioning and operations for all science instruments.
4. Complete science instrument commissioning and begin normal operations.

List of critical milestones for FY 2023

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

This Performance Goal aligns to 1.1.11 under the 2018 Strategic Plan.

FY 2021 Performance Progress

NASA fell short of achieving the last FY 2021 milestone for this Performance Goal, resulting in a Yellow rating.

Engineers for Webb initiated the post-environmental testing deployments for Webb in October 2020. The deployments were to demonstrate that the observatory would move and unfold as planned, like a giant origami, after its journey to the second

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Lagrange point between Earth and the Sun. The engineers completed the final comprehensive system test in February 2021 and the deployment test for the mirror in March.

In April, the engineers began packing the five-layer sunshield, which is roughly the size of a tennis court, to fit within the confines of the launch vehicle. The careful process of folding the silver material took about a month. (Watch as engineers and technicians prepare Webb for its launch vehicle.)

Webb left by cargo ship from Seal Beach in California on September 24 and began its 16-day journey to the launch site in Kourou, French Guiana. Webb was shipped in a custom-built, environmentally controlled container. It didn't arrive at its destination until October 12 (in FY 2022).

1.2.1 [Completed at the end of FY 2021]: Advance scientific research with the potential to understand the responses of physical and biological systems to spaceflight.

Number of peer reviewed published studies.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	500	360		PG Completed		
Achieved	360	455				
Rating	Red	Green				

2015	2016	2017	2018	2019
Yellow	Red	Yellow	Green	Red

This Performance Goal was achieved through work by the Division of Biological and Physical Sciences, part of NASA's Science Mission Directorate, and the Human Research Program (HRP), under the former Human Space Exploration and Operations Mission Directorate.

FY 2021 Performance Progress

NASA-supported researchers published 455 peer-reviewed studies on physical and biological sciences, exceeding the FY 2021 target of 360. This target was based on FY 2020 performance, which was affected by the COVID-19 pandemic. The pace of publication returned to pre-pandemic normal during FY 2021.

Strategic Objective 1.3

Ensure NASA's science data are accessible to all and produce practical benefits to society.

LEAD OFFICE
Science Mission Directorate (SMD)

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

	Budget	
	FY	$M
Op Plan	2021	$368.6
Requested	2022	$417.9
Requested	2023	$444.3
Outyear	2024	$488.5
	2025	$486.7
	2026	$505.9
	2027	$524.7

NASA's missions and research activities inspire curiosity and increase the understanding of our planet, the solar system, and the universe. One of our core capabilities is the ability to collect, store, manage, analyze, and distribute data and information for scientists, international partners, learners of all ages, decision-makers, and industry to further science, improve modeling, increase knowledge, and spur economic innovation.

NASA generates, analyzes, activates, and archives large amounts of data to support science objectives and deliver data and scientific results to users around the world. Over the next 5 years, NASA will substantially increase the size of data archives as the volume of data generated by new missions increases from approximately 10 petabytes per year today to over 100 petabytes per year in 2026. This growth of NASA's science archives presents unique opportunities for new scientific discovery and partnerships, as well as significant challenges for data management,

Below: Image shows a map of potential landslide risk output by NASA's Landslide Hazard Assessment Model (LHASA) in June 2021. These timely, targeted, and customizable "nowcasts" are estimates of potential landslide activity in near-real time for each 1-square-kilometer area between the poles. Red indicates the highest risk and dark blue indicates the lowest risk. Image Credit: NASA

curation, access, analysis, computing, and computational modeling.

As part of this effort, we plan to undertake investments and initiatives that will accelerate the accessibility and use of NASA data by its existing and new user communities. NASA's data initiatives are focused on making actionable data accessible to other Federal agencies, relevant decision-makers, stakeholders, and the public. This will be done by investments in three key areas: 1) capabilities to enable open-source science; 2) continuous evolution of data and computing systems; and 3) community and strategic partnerships for innovation.

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

Number of critical milestones completed.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	N/A	N/A	1	1		
Achieved	N/A	N/A				
Rating	N/A	N/A				

List of activities for FY 2022

1. Develop and release a prototype interdisciplinary science data search engine that allows users to discover 70 percent of NASA's scientific data.

List of activities for FY 2023

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

NASA's **Science Mission Directorate** uses the vantage point of space to achieve a deep scientific understanding of our planet, other planets and solar system bodies, the interplanetary environment, the Sun and its effects on the solar system, and the universe beyond.

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.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	N/A	N/A	2	2		
Achieved	N/A	N/A				
Rating	N/A	N/A				

List of activities for FY 2022

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. Deliver an Earth science applications guidebook to share knowledge in using Earth science information to inform decisions and provide benefits to society.

List of activities 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.

NASA's Science Mission Directorate uses the vantage point of space to achieve a deep scientific understanding of our planet, other planets and solar system bodies, the interplanetary environment, the Sun and its effects on the solar system, and the universe beyond.

Strategic Goal 2

Extend Human Presence to the Moon and on towards Mars for Sustainable Long-term Exploration, Development, and Utilization.

The Orion spacecraft for NASA's Artemis I mission, fully assembled with its launch abort system, is lifted above the Space Launch System (SLS) rocket in High Bay 3 of the Vehicle Assembly Building at Kennedy Space Center in Florida on October 20, 2021. The stacking of Orion on top of the SLS completes assembly for the Artemis I flight test. Teams will begin conducting a series of verification tests ahead of rolling out to Launch Complex 39B for the Wet Dress Rehearsal. Artemis I will be an uncrewed test flight of the Orion spacecraft and Space Launch System rocket as an integrated system ahead of crewed flights to the Moon. Under Artemis, NASA aims to land the first woman and first person of color on the Moon and establish sustainable lunar exploration. Image credit: NASA/Frank Michaux

Strategic Objective 2.1

Explore the surface of the Moon and deep space.

LEAD OFFICE
Exploration Systems Development Mission Directorate (ESDMD)

GOAL LEADER
Altonell (Toni) Mumford, Deputy Associate Administrator for Management, ESDMD

Budget

	FY	$M
Op Plan	2021	$5,017.4
Requested	2022	$5,361.4
Requested	2023	$6,153.0
Outyear	2024	$7,215.9
	2025	$7,669.2
	2026	$7,897.5
	2027	$8,092.3

Artemis missions, and future human exploration of Mars, will expand opportunities for Americans, increase our global standing, and inspire the next generation of leaders in STEM. Long-term exploration and scientific utilization present unique opportunities for major discoveries impacting critical fields like medicine, energy, and manufacturing that will benefit society worldwide.

NASA will work closely with international partners to achieve Artemis objectives and grow the global space economy. These relationships will reinforce America's position as the global leader in space exploration and provide new avenues for partnership with nations around the world. NASA's deep space exploration efforts will continue to act as a beacon of peace and scientific partnership around the globe.

Artemis missions will be driven by scientific objectives like collecting new information on planetary processes and the character and origin of volatiles. NASA will uncover the history of our Earth-Moon system and new information about our Sun. The human data collected as mission durations increase will make future work in deep space safer and more efficient. What we learn will also help us protect our home planet and improve daily life for people around the world.

Below: Artist's concept of the Artemis Base Camp, a science and technology outpost at the lunar South Pole. The base camp would include rovers, a fixed habitat, fission surface power, and an in-situ resource utilization pilot plant to demonstrate the ability to harvest resources from the Moon. Image credit: NASA

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 milestones met.

Fiscal Year	2020 (APG)	2021	2022 (APG)	2023 (APG)	2024	2025
Target	4	4	4	4		
Achieved	3	4				
Rating	Yellow	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Yellow	Red

List of milestones for FY 2021

1. Complete Artemis I booster segment installations on the Mobile Launcher.
2. Complete the Space Launch System (SLS) Core Stage Green Run hot fire testing.
3. Complete SLS Core Stage mate at the Kennedy Space Center.
4. Award the Human Launch System (HLS) Option A.

List of milestones for FY 2022

1. Complete the Artemis II Crew Module/Service Module mate.
2. Complete the Artemis II Interim Cryogenic Propulsion Stage.
3. Deliver the Artemis III Core Stage Forward Skirt.
4. Launch Artemis I.

List of milestones for FY 2023

1. Complete Artemis II Booster Segment stacking.
2. Announce awards for sustaining lander development.
3. Deliver the Artemis II Core Stage to Kennedy Space Center.
4. Hold for a Gateway initial capability milestone (i.e., HALO, PPE and iHAB)

This Performance Goal aligns to 2.2.1 under the 2018 Strategic Plan.

FY 2021 Performance Progress

The three programs that support the Artemis made appreciable progress in FY 2021. NASA completed the four annual milestones and successfully completed this Performance Goal.*

NASA stacked the SLS solid rocket boosters for Artemis I onto the Mobile Launcher over several weeks. On November 21, 2020, we used massive cranes to lift the first booster segment into place. The installation was complete on March 2, 2021.

NASA's Artemis activities are led by the Exploration Systems Development Mission Directorate (formerly led by the Human Exploration and Operations Mission Directorate).

NASA successfully completed the final Green Run test of the SLS Core Stage on March 18, 2021. (Video of the final test available on YouTube.) This series of eight tests verified that the Core Stage is ready for Artemis I. Each test was a check of the hardware and system that culminated with the hot fire of all four RS-25 engines on March 18.

Following that milestone activity, NASA transferred the SLS Core Stage from Stennis Space Center in Mississippi to the Vehicle Assembly Building at Kennedy Space Center in Florida. Vehicle assembly and integration proceeded as expected, despite COVID impacts to workforce personnel.

In support of lunar surface activities, NASA awarded the Human Landing System Option A contract in April 2021. We selected SpaceX to develop the first commercial human lander to transport astronauts to the lunar surface. Although a protest was filed, the U.S. Court of Appeals upheld the award nearly six months later, in November 2021.

NASA publicly announced in FY 2021 that despite the progress being made in several areas, a crewed Moon landing in 2024 was no longer possible due to extensive delays in other areas, including the first launch of the SLS rocket and Orion crew capsule. The next crewed Moon landing is now scheduled for no earlier than 2025.

*In January 2021, the Office of Management and Budget (OMB) discontinued public reporting Government-wide on Agency Priority Goals. NASA continued performance tracking and reporting on the Artemis high-priority area as a Performance Goal with some changes approved by OMB.

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

Percent of milestones or activities completed, as identified on the Enterprise Cross-Program Integration Teams Schedule.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	N/A	N/A	5	5		
Achieved	N/A	N/A				
Rating	N/A	N/A				

List of milestones for FY 2022

1. Mate the Artemis II Crew Module (CM) Adapter to the European Service Module (ESM).
2. Exploration Ground Systems break ground on the Emergency Egress System at Pad-B.
3. Complete the Core Stage 2 Liquid Hydrogen tank.
4. Complete integration of Artemis II Crew Module Part 1.
5. Complete the Artemis II Core Stage liquid hydrogen (LH2) tank and forward section mate.

List of milestones for FY 2023

1. Complete the Artemis II Orion Launch Abort System integration.
2. Complete the Artemis II Exploration Ground Systems pad liquid hydrogen (LH2) storage tank standalone verification and validation.
3. Complete the Artemis III Crew Module Adapter (CMA).
4. Complete fabrication of the Artemis III Orion Stage Adapter.
5. Artemis IV Space Launch System Core Stage engines available.

NASA's Artemis activities are led by the Exploration Systems Development Mission Directorate (formerly led by the Human Exploration and Operations Mission Directorate).

Right: In the early morning on October 20, 2020, the mobile launcher for the Artemis I mission begins its rollout atop crawler-transporter 2 from the Vehicle Assembly Building at NASA's Kennedy Space Center in Florida. The nearly 400-foot-tall mobile launcher was being rolled to Launch Pad 39B. During its two-week stay at the pad, engineers with Exploration Ground Systems and Jacobs performed several tasks, including a timing test to validate the launch team's countdown timeline, and a thorough, top-to-bottom wash down of the mobile launcher to remove any debris remaining from construction and installation of the umbilical arms. Photo credit: NASA/Ben Smegelsky

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

Percent of milestones or activities completed, as identified on the Enterprise Cross-Program Integration Teams Schedule.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	N/A	N/A	5	5		
Achieved	N/A	N/A				
Rating	N/A	N/A				

List of milestones for FY 2022

1. Complete the Exploration Extravehicular Activity (xEVA) development validation testing unit.
2. Execute the Human Landing System (HLS) Option A contract after the stay of performance.
3. Award xEVA contract(s).
4. Issue sustaining lander development Request for Proposals.
5. Establish Key Decision Point (KDP)-1 and the Agency baseline commitment for lifecycle cost, schedule, and technical parameters for Gateway.

List of milestones for FY 2023

1. Complete the HLS Option A (SpaceX) propulsion transfer flight test.
2. Complete the primary structure build for the Habitation and Logistics Outpost (HALO).
3. Conduct xEVA contractor design review.
4. 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).

NASA's Artemis activities are led by the Exploration Systems Development Mission Directorate (formerly led by the Human Exploration and Operations Mission Directorate).

Strategic Objective 2.2

Develop a human spaceflight economy enabled by a commercial market.

LEAD OFFICE
Space Operations Mission Directorate (SOMD)

GOAL LEADER
Altonell (Toni) Mumford, Deputy Associate Administrator for Management, SOMD

	Budget	
	FY	$M
Op Plan	2021	$4,599.3
Requested	2022	$4,589.2
Requested	2023	$4,616.6
Outyear	2024	$3,731.9
	2025	$3,496.7
	2026	$3,545.8
	2027	$3,671.7

NASA will maintain access to a human-rated platform in low Earth orbit (LEO) to continue U.S. human presence and expand the American foothold in space. The continuous operation of a research and technology demonstration platform in space is critical to achieving NASA's and the Nation's goals in science, technology, and human space flight. As such, we are investing resources to foster a robust human spaceflight economy.

Since its inception, industry, academia, and our international partners have used the International Space Station (ISS) as a testbed for research and the development and maturation of state-of-the-art systems that increase access to space. NASA is supporting new space stations from which we and other customers can purchase services and stimulate the growth of commercial human spaceflight activities. As commercial LEO destinations become available, we intend to implement

Below: Four Expedition 64 flight engineers, who also are the NASA's SpaceX Crew-1 astronauts, gather around a laptop computer to join a video conference on February 7, 2021. Image Credit: NASA

an orderly transition from current ISS operations to these new commercial destinations.

The ISS is the prime example of American leadership in global space exploration, enabling a U.S.-led multinational partnership to advance shared goals in space. The ISS supports a robust commercial marketplace, with more than 20 commercial facilities operating and generating revenue, including in-space manufacturing facilities and a commercial airlock. As NASA increases the opportunities for business on the ISS, the number and types of companies taking advantage of those opportunities will likely increase, which will in turn create more demand.

Right: On July 29, 2021, Boeing's CST-100 Starliner spacecraft and the United Launch Alliance Atlas V rocket begins rollout from the Vertical Integration Facility to the launch pad at Space Launch Complex-41 on Cape Canaveral Space Force Station in Florida. Starliner will launch on the Atlas V for Boeing's second uncrewed Orbital Flight Test (OFT-2) for NASA's Commercial Crew Program. OFT-2 is an important uncrewed mission designed to test the end-to-end capabilities of the new system for NASA's Commercial Crew Program. Photo credit: NASA/Kim Shiflett

Left: NASA completed the signing of the Human Rating Certification Plan on November 10, 2020, for SpaceX's crew transportation system after a thorough Flight Readiness Review ahead the Agency's SpaceX Crew-1 mission with astronauts to the ISS. On November 8, the astronauts for the Crew-1 mission posed for a photo in front of the Crew Dragon spacecraft, named Resilience by the crew, inside the SpaceX hangar at NASA Kennedy Space Center's Launch Complex 39A. From left, JAXA astronaut Soichi Noguchi, mission specialist; NASA astronaut Michael Hopkins, spacecraft commander; NASA astronaut Shannon Walker, mission specialist; and NASA astronaut Victor Glover, pilot. Image credit: SpaceX

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 milestones met.

Fiscal Year	2020 (APG)	2021	2022	2023	2024	2025
Target	4	3	3	4		
Achieved	2	3				
Rating	Red	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

List of development milestones for FY 2022

1. Complete required partnership agreements with other government agencies for commercial activities.
2. Initialize the free-flyer project milestones.
3. Successfully complete the second provider commercial test flight launch.

List of development milestones for FY 2023

1. Award Commercial LEO Development-funded Space Act Agreements.
2. Release draft of Commercial LEO Development Crew and Service Requirements document.
3. Execute a private astronaut mission to the International Space Station.
4. Announce a new commercial space capabilities competition.

This Performance Goal aligns to 2.1.2 (Agency Priority Goal) under the 2018 Strategic Plan.

2.1.2: Enable a robust commercial low Earth orbit economy in which transportation, habitation, and on-orbit services are available for purchase by NASA and other customers.

List of development milestones for FY 2020

1. Make awards for the port solicitation – NextStep 2 Broad Agency Announcement (Appendix I).
2. Make awards for the free-flyer solicitation – NextStep 2 Broad Agency Announcement (Appendix K).
3. Initiate astronaut training for initial private astronaut mission under a reimbursable space act agreement.
4. Both commercial crew industry partners complete demonstration missions.

FY 2021 Performance Progress

NASA has made the ISS available to private entities to enable commercial and marketing opportunities in low Earth orbit. As a result of these continued efforts, we completed the three FY 2021 milestones and successfully achieving this Agency Priority Goal.*

The work for this Performance Goal was accomplished by the ISS, LEO Commercialization, and Commercial Crew Programs under the former Human Exploration and Operations Mission Directorate.

In February 2021, NASA updated its pricing policy for commercial activities conducted on the ISS to reflect full reimbursement for the value of NASA resources. In April 2021, NASA clarified updates to the pricing policy associated with services for private astronaut mission providers.

A private astronaut mission is defined as a commercial mission consisting of activities conducted by private astronauts aboard the ISS or in a commercial element attached to the ISS, transported on a U.S. commercial spacecraft dedicated to this private mission. In May 2021, NASA and Axiom Space signed an order for the first private astronaut mission to the ISS, scheduled to take place in 2022.

NASA finalized the acquisition strategy to enable partnerships for the development and space flight demonstrations of Commercial Destination Free Flyers (CDFF), commercially owned and operated destinations in low Earth orbit. CDFF will utilize multiple funded Space Act Agreements and is expected to last approximately four years, culminating in at least a preliminary design level of maturity. NASA released a final Announcement for Proposals for Phase 1 in July 2021, and proposals were received in August.

*In January 2021, the Office of Management and Budget (OMB) discontinued public reporting Government-wide on Agency Priority Goals. NASA continued performance tracking and reporting on the Webb high-priority area as a Performance Goal with some changes approved by OMB.

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 commercial facilities launched and operating.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target			20	20		
Achieved						
Rating						

The **International Space Station Program**, part of NASA's **Space Operations Mission Directorate** (formerly part of the **Human Exploration and Operations Mission Directorate**), plans, develops, and manages the capabilities that support Artemis human lunar exploration missions and the expanding commercial use of the ISS.

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

Number of research and technology demonstrations conducted.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	5	5	5	6		
Achieved	5	5				
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Yellow

This Performance Goal aligns to 2.1.1 under the 2018 Strategic Plan.

2.1.1: Initiate technology demonstrations on the International Space Station to advance deep space exploration.

The International Space Station (ISS) Program, part of NASA's Human Exploration and Operations Mission Directorate, plans, develops, and manages the capabilities that support the expanding commercial use of the ISS.

FY 2021 Performance Progress

The International Space Station is an unprecedented achievement in global human endeavors to conceive, plan, build, operate, and utilize a research platform in space. The ISS Program is utilizing the station as a testbed to demonstrate operational techniques and capabilities and demonstrate technologies and advanced systems that benefit space science capabilities and human and robotic exploration beyond LEO.

NASA met the FY 2021 target by demonstrating seven technologies aboard the ISS:

- RFID-Enabled Autonomous Logistics Management 2 (REALM-2) tested the use of a radio frequency identification (RFID) reader and antennas attached to a robotic free-flyer named Astrobee to identify RFID-tagged cargo on the ISS to determine its presence and location in order to help the crew find items quickly and efficiently.
- Spacesuit Evaporation Rejection Flight Experiment (SERFE) demonstrated a new technology to remove heat from spacesuits and maintain appropriate temperatures for crew members and equipment during space walks.
- Spacecraft Fire Safety V (Saffire V) studied how fires spread in space.
- Airborne Particulate Monitoring (APM) demonstrated an instrument for measuring and quantifying the concentration of both small and large particles in spacecraft air. The data can be used to create a map of air quality in terms of particles and shed light on the sources of such particles.
- Collapsible Continency Urinal (CCU) tested the fluid dynamics and stability of liquid of the system, which is scheduled to be used in Orion.
- Brine Processor Assembly (BPA) demonstrated increased efficiency for recycling water from crew urine.
- The 4 Bed CO2 Scrubber (4BedCO2) demonstrates engineering and efficiency changes to improve durability and maintainability

2.2.4: Provide transportation through commercial partners to support the International Space Station (ISS) and low Earth orbit.

Number of Commercial Crew missions launched.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	2	2	2			
Achieved	1	2				
Rating	Yellow	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Yellow	Yellow

The Crew and Cargo Program, part of NASA's **Space Operations Mission Directorate**, provides for crew rotation and cargo resupply missions to the ISS. The Commercial Crew Program continues NASA's collaboration with the U.S. commercial space industry to develop safe and reliable crew transportation.

This Performance Goal aligns to 4.2.2 under the 2018 Strategic Plan.

2.2.5 [Completed at the end of FY 2022]: Provide NASA crew transportation through commercial partners to low Earth orbit.

FY 2021 Performance Progress

NASA successfully executed the goal of two crewed missions in FY 2021. NASA's SpaceX Crew 1 mission launched to the ISS on November 15, 2020. Crew 2 launched on April 23, 2021.

2.2.4 [Completed at the end of FY 2021]: Provide cargo transportation through commercial partners to support the International Space Station (ISS).

Number of Commercial Cargo missions launched/delivered to ISS.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	4	4	4	4		
Achieved	4	6				
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Yellow	Green	Green	Green

List of development milestones for FY 2023

1. Award Commercial LEO Development-funded Space Act Agreements.
2. Release draft of Commercial LEO Development Crew and Service Requirements document.
3. Execute a private astronaut mission to the International Space Station.
4. Announce a new commercial space capabilities competition.

This Performance Goal aligns to 4.2.1 under the 2018 Strategic Plan.

Commercial cargo missions transitioned from International Space Station to the Crew and Cargo Program, part of NASA's Space Operations Mission Directorate. The Crew and Cargo Program provides for crew rotation and cargo resupply missions to the ISS.

FY 2021 Performance Progress

NASA achieved the FY 2021 target for this Performance Goal by executing four Commercial Resupply Services (CRS) missions to support the ISS: Northrup Grumman (NG)-14 in October 2020; SpaceX (SpX)-21 in December 2020; NG-15 in February 2021; SpX-22 in June 2021; NG-16 in August 2021; and SpX-23 in Sept 2021.

Strategic Objective 2.3

Develop capabilities and perform research to safeguard explorers.

LEAD OFFICE
Space Operations Mission Directorate (SOMD)

GOAL LEADER
Altonell (Toni) Mumford, Deputy Associate Administrator for Management, SOMD

	Budget	
	FY	$M
Op Plan	2021	$212.8
Requested	2022	$232.0
Requested	2023	$252.7
Outyear	2024	$254.8
	2025	$256.2
	2026	$251.3
	2027	$251.4

Humans worked briefly on the Moon 50 years ago and have pioneered technological advances in low Earth orbit for the past 40 years. The activities that NASA leads that will return humans to the Moon, and from there on towards Mars, are focused on "buying down" risk through research and the development of tools and techniques to protect humans during deep space exploration. NASA is working to overcome radiation, crew isolation, and deep space communications delays, as well as food, medicines, and shelf-life constraints. Each of these challenges must be solved to ensure crew members are safe and healthy as we move beyond low Earth orbit.

NASA is pursuing new technologies that will help manage the effects of extended stays in space on human health and performance. Each advance in our knowledge can provide basic human needs, including oxygen and water, along with the ability to maintain and repair critical systems. NASA will demonstrate the performance of emergent tech-

Below: NASA astronaut Mark Vande Hei works on Celestial Immunity, an investigation of how gravity affects immune response, potentially supporting development of new vaccines and drugs to prevent and treat existing and emerging human diseases. Celestial Immunity evaluates the effects of gravity on functional immune response and the role of age in regulating immune pathways, using cells from elderly and younger adult donors. It builds on earlier space station studies that evaluated the function of white blood cells, extending the observation period from hours to days and expanding the analysis to an array of activated immune pathways. Gravity, convection, and buoyancy interfere with cell behavior in laboratory-based studies on Earth, but microgravity eliminates these factors. Results could support development of new vaccines and drugs to prevent and treat existing and emerging human diseases. During the week, crew members processed samples for the investigation. Image Credit: NASA

nologies in an environment where the risk to the safety of human or vehicle operations can validate the performance of the technology without risking the crew or mission, and prior to their use in an operational environment.

NASA emphasizes partnering with industry and academia to develop new technologies that will enable future space travel that is less reliant on resupply and communications from Earth. The resultant reduction in logistics costs and increase in system capabilities and reliability are designed to safeguard humans on missions beyond low Earth orbit. The knowledge gained though research on the effects of reduced gravity on the systems in the body—including studying research areas that are unique to the Moon, Mars, and other destinations—will help quantify the best methods and technologies to support safe and productive human missions in deep space.

Below: Megan McArthur removes Kidney Cells-02 hardware inside the Space Automated Bioproduct Laboratory and swaps media inside the MSG. The experiment uses a 3D kidney cell model known as a tissue chip to study the effects of microgravity on formation of microcrystals in kidney tubules. Results could support design of better treatments for conditions such as kidney stones and bone loss for astronauts and osteoporosis for people on Earth. Photo credit: NASA

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

Funded investigations and/or published papers.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target			6 new funded investigations and 160 peer-reviewed published papers			
Achieved						
Rating						

Human Space Flight Operations, Human Research Program, and Exploration Capabilities are part of the Space Operations Mission Directorate .

Strategic Objective 2.4

Enable space access and services.

LEAD OFFICE
Space Operations Mission Directorate (SOMD)

GOAL LEADER
Altonell (Toni) Mumford, Deputy Associate Administrator for Management, SOMD

Budget

	FY	$M
Op Plan	2021	$668.9
Requested	2022	$715.2
Requested	2023	$722.2
Outyear	2024	$776.8
	2025	$796.8
	2026	$768.8
	2027	$697.2

NASA provides safe, reliable, and cost-effective launch services for NASA and NASA-sponsored payloads seeking access to space on U.S. commercial launch vehicles. As the launch agent of 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 spacecraft, and direct vital launch mission assurance efforts to ensure the greatest probability of launch mission success. LSP's primary responsibility is to meet the needs of a diverse customer base spanning our Mission Directorates, a wide range of educational organizations, and other customers. LSP is the Agency's recognized expert in all aspects of commercial launch services, including acquisition, certification, and mission management.

NASA provides the critical communications and navigation services to our operational missions, and we will continue to invest in critical technologies that will increase reliable communications capabilities. NASA engages with the satellite com-

Below: In March 2021, NASA tested the largest rocket element it has ever built, the core stage of the Space Launch System (SLS). Four RS-25 engines fired for 8 minutes and 19 seconds on the test stand at Stennis Space Center in MIssissippi.Image Credit: NASA/JPL-Caltech

munications industry to develop communications capabilities that supports U.S. needs, are globally competitive, and advance U.S. leadership in the generation of new markets. Today, commercially provided satellite communications continue to mature, and NASA envisions a commercial communications market where near-Earth customers will have access to suitable commercial services and where NASA is one of many customers.

Developing and testing rocket propulsion systems is foundational to spaceflight. Whether the payload is a robotic science experiment or a crewed mission, the propulsion system used to launch it must be safe and reliable. Utilizing unique test facilities, NASA ensures the safe and effective execution of a rigorous engine test program, critical to any rocket propulsion development activity.

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 expendable launch objectives successfully completed.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	100%	100%	100%	100%		
Achieved	100%	100%				
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

NASA's **Launch Services Program**, part of the **Space Operations Mission Directorate** (formerly part of **Human Exploration and Operations Mission Directorate)**, is responsible for acquiring and launching expendable launch vehicles.

This Performance Goal aligns to 4.2.4 under the 2018 Strategic Plan.

FY 2021 Performance Progress

NASA provided launch services, test services, and communications support to internal and external customers throughout FY 2021.

NASA is successfully managing launch service capabilities across the civil space sector and managed two launches from Vandenberg Space Force Base in California, in FY 2021. The Sentinel-6 Michael Freilich launched November 21, 2020, and Landsat-9 launch on September 27, 2021, with both launch campaigns conducted during difficult personnel and supply chain challenges due to COVID-19. NASA also managed multiple commercial launch services contract awards, including the Gateway Program's Habitation and Logistics Outpost (HALO) + Power and Propulsion Element (PPE) and the Science Mission Directorate's Europa Clipper missions, and conducted additional launch service acquisitions for NASA and other civil sector customers.

Above: The United Launch Alliance Atlas V rocket with the Landsat 9 satellite onboard launches on September 27, 2021, from Space Launch Complex 3 at Vandenberg Space Force Base in California. Photo Credit: NASA/Bill Ingalls

2.4.2: Maintain the proficiency of Space Communications network services.

Percentage of network proficiency.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	96%	96%	95%	95%		
Achieved	96%	99.4%				
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

Space Communications and Navigation, part of the **Space Operations Mission Directorate** (formerly part of **Human Exploration and Operations Mission Directorate**), manages NASA's ground-based communications facilities and services and the Tracking and Data Relay Satellites.

This Performance Goal aligns to 4.2.5 under the 2018 Strategic Plan.

4.2.5: Maintain the delivery of Space Communications network services.

FY 2021 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 99.4 percent service delivery, exceeding the FY 2021 target of a minimum 95 percent network proficiency. The final FY 2021 average delivery was:

- NSN relay – 99.9 percent
- NSN Direct-to-Earth (DTE) – 99.8 percent (visit Near Space Network DTE Now to see real-time activity between spacecraft and antennas around the world)
- DSN – 98.5 percent (visit Deep Space Network Now to see real-time activity between deep-space spacecraft and antennas around the world)

2.4.2: Ensure a core capability (personnel and assets) of propulsion test assets are maintained and are available to meet Agency propulsion test requirements and support Agency mission needs, as well as other customers' test requests.

Percentage availability.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	90%	90%	90%	90%	90%	90%
Achieved	99.7%	99.7				
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

NASA's **Rocket Propulsion Test program**, part of the **Human Exploration and Operations Mission Directorate**, manages rocket propulsion test facilities, activities, and resources.

This Performance Goal aligns to 4.2.3 under the 2018 Strategic Plan.

4.2.3: Maximize the availability of propulsion test facilities that support NASA's planned test requirements

FY 2021 Performance Progress

NASA exceeded the FY 2021 target of 90 percent availability for this performance goal with 511 tests conducted with only one facility delayed, resulting in 99 .8 percent availability for the fiscal year. Significant accomplishments included the successful hot fire of the Space Launch System (SLS) core stage on the B-2 test stand at Stennis Space Center in Mississippi, a critical milestone ahead of the Agency's Artemis I mission, and the completion of all seven of the Retrofit-2 RS-25 series tests providing data to enhance production of new RS-25 engines and several engine components that are being manufactured with cutting-edge and cost-saving technologies. RPT facilities continued to evaluate and implement high-risk/high-priority facility maintenance and modernization projects to assure propulsion test assets are available to support current and future propulsion test requirements.

Strategic Goal 3

Catalyze economic growth and drive innovation to address national challenges.

Joby's all-electric vertical takeoff and landing (eVTOL) aircraft is pictured at the company's Electric Flight Base, located near Big Sur, California. NASA began flight testing with the aircraft as part of the Agency's Advanced Air Mobility (AAM) National Campaign. This test runs through September 10, 2021. Image Credit: Joby Aviation

Strategic Objective 3.1

Innovate and advance transformational space technologies.

LEAD OFFICE
Space Technology Mission Directorate (STMD)

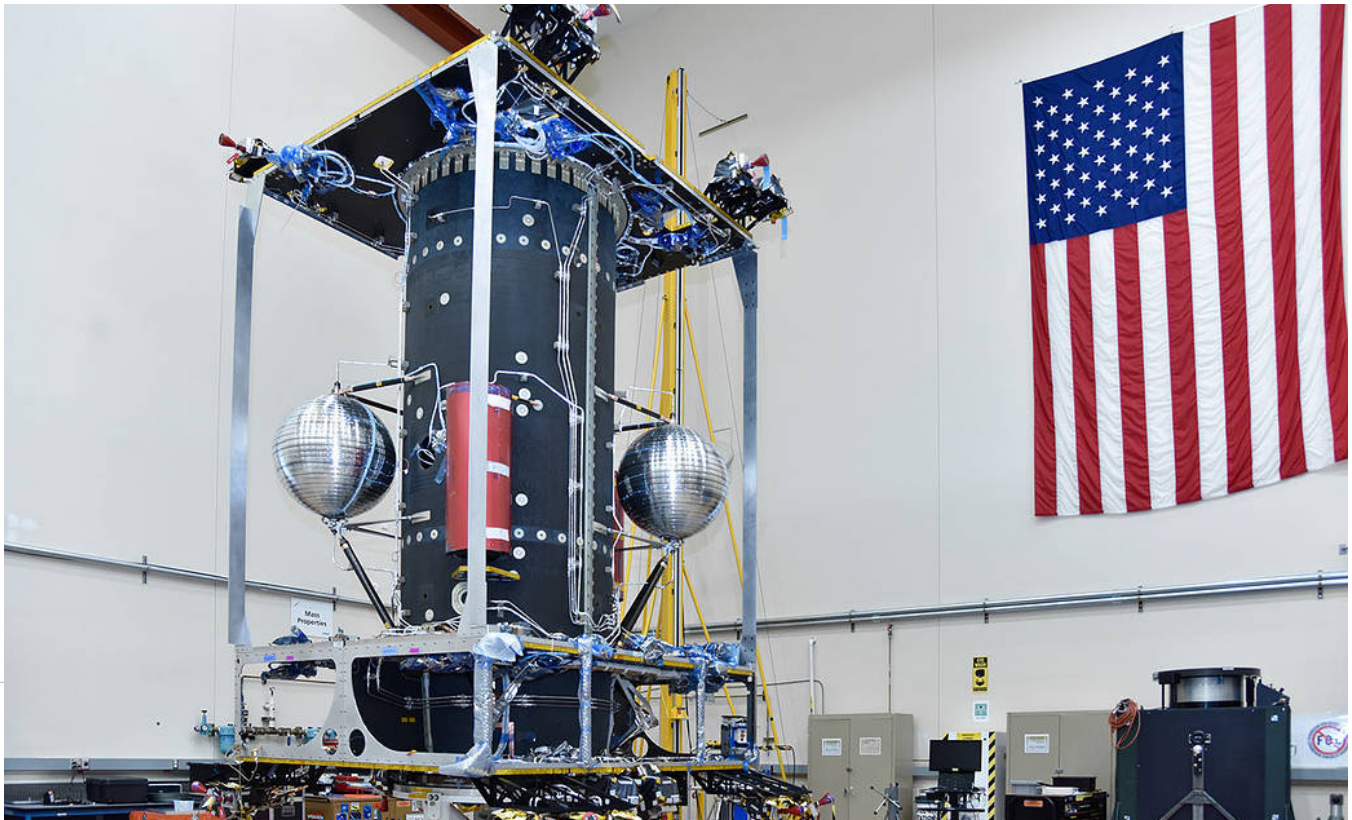
GOAL LEADER
Mike Green, Deputy Associate Administrator for Management, STMD

	Budget	
	FY	$M
Op Plan	2021	$1,100.0
Requested	2022	$1,425.0
Requested	2023	$1,437.9
Outyear	2024	$1,466.7
	2025	$1,496.0
	2026	$1,525.9
	2027	$1,556.4

Technological leadership remains vital to our national security, economic prosperity, and global competitiveness. The Nation's continued economic leadership is due in part to the technological investments made over time that enabled our country to emerge as a global technological leader. That commitment accelerated the economy with the creation of new industries, products, and services that yielded lasting benefits. Moving forward, a technology-driven NASA will continue to help fuel our Nation's economic engine and support the creation of jobs for decades to come, while also providing valuable breakthroughs for NASA's missions and the commercial space industry. In short, technology drives the space economy.

As NASA embarks on its next era of discovery and exploration, the advancement of transformational space technologies guides the journey ahead. We invest in crosscutting and transformational technologies that have high potential for offset-

Below: In April 2021, NASA and Maxar Technologies successfully completed the On-orbit Servicing, Assembly, and Manufacturing 1 (OSAM-1) mission spacecraft accommodation Critical Design Review (CDR). This milestone demonstrates that the maturity of the design for the OSAM-1 spacecraft bus is appropriate to support proceeding with fabrication, assembly, integration, and testing. Image credit: Maxar Technologies



ting mission risk, reducing cost, and advancing existing or creating new capabilities. In the coming years, NASA will advance technologies that enable rapid, safe, and efficient transportation as well as expanded access to diverse surface destinations.

We seek to enable a vibrant space economy with supporting utilities and commodities through investments in in-situ resource utilization, sustainable power systems, and autonomous construction. These technological advancements will foster U.S. innovation and competitiveness, drive economic growth and the creation of good-paying jobs, and ensure national leadership in space. In addition, NASA recognizes the United States' ability to utilize space safely and sustainably is paramount. NASA will continue to advance early research and development technology solutions in orbital debris mitigation, tracking, and remediation.science observations; and harnessing data for climate research. We will formulate new prizes, targeted topics within the Small Business Innovation Research and Small Business Technology Transfer programs, and grant opportunities to address climate challenges and the clean energy economy. In addition, NASA will be supporting Earth-observing capabilities for Small Spacecraft platforms to support breakthrough science and National efforts to address climate change.

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.

NASA's Space Technology Mission Directorate nurtures innovative and high-risk/high-payoff technologies and concepts, including early stage ideas, that could transform future NASA missions, as well as the aerospace industry.

Critical activities completed for Early Stage Innovation and Partnerships (ESIP) program supporting the Performance Goal.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	N/A	N/A	At least 4 completed			
Achieved	N/A	N/A				
Rating	N/A	N/A				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

List of development milestones for FY 2022

1. Achieve at least 1 knowledge transition for a minimum of 75 percent of research grants.
2. Offer 45 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. Complete benchmarking of diversity, equity, and inclusion data for ESIP portfolio.

List of development milestones for FY 2023

1. Achieve at least 1 knowledge transition for a minimum of 75 percent of research grants.
2. Offer 45 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 10 strategic engagement opportunities to underserved and underrepresented communities.

3.1.1 [Completed at the end of FY 2021]: Encourage creative and innovative solutions to space technology challenges by investing in early stage technologies and concepts from U.S. innovators.

Number of new early stage technologies and concepts invested in.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	210	210				
Achieved	253	242				
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

NASA's Space Technology Mission Directorate nurtures innovative and high-risk/high-payoff technologies and concepts, including early stage ideas, that could transform future NASA missions, as well as the aerospace industry.

FY 2021 Performance Progress

NASA achieved the FY 2021 target for this multi-year Performance Goal as the Agency continued to advance early stage innovation. In FY 2021, NASA invested in 242 new early stage technologies and concepts, exceeding the target of 210. These investments ensure a healthy base of promising early stage solutions for further development by other programs and organizations.

NASA leveraged the country's spectrum of academic researchers to accelerate the development of low technology readiness level (TRL) space technologies to support future space science and exploration needs of NASA, other government agencies, and the commercial space sector. This included selecting 14 Early Stage Innovation awards, six Lunar Surface Technology Research Opportunities, two Space Technology Research Institutes, 58 Space Technology Graduate Research Opportunities, and six Early Career Faculty awards through NASA's Space Technology Research Grants (STRG) program.

In addition, the Agency continued to engage America's innovators and entrepreneurs to nurture visionary concepts that could lead to future aerospace breakthroughs. NASA Innovative Advanced Concepts (NIAC) awarded 23 new concept studies in FY 2021. NASA's early stage investments continue to offer promising ways to bolster technology development, economic growth, and expansion of the aerospace industry. For example, NIAC Fellow David Kirtley's work on nuclear propulsion has not only transitioned to the Department of Energy, but has also impacted commercial development of fusion energy. Helion Energy is currently building a cost-effective, zero-carbon electrical power plant in Everett, Washington, to test the latest version of its non-ignition fusion technology that Helion says will provide "flexible, scalable, baseload power that is affordable, providing the world a new path to full decarbonization of electricity generation."

NASA also encouraged creativity and innovation within NASA Centers and its brightest early career technologists by supporting emerging technologies and creative initiatives, selecting 128 Center Innovation Fund (CIF) projects and making five Early Career Initiative awards.

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

Percentage of key performance parameters completed for Technology Maturation projects.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	60%	60%	60%	60%		
Achieved	64%	59%				
Rating	Green	Yellow				

2015	2016	2017	2018	2019
Green	Green	Green	Yellow	Green

This Performance Goal aligns to 3.1.2 under the 2018 Strategic Plan.

NASA's Game Changing Development program, part of the Space Technology Mission Directorate, guides innovative, high-impact technologies and capabilities from proof of concept through component or breadboard testing in a relevant environment.

FY 2021 Performance Progress

NASA missed achieving this performance goal target (i.e., 60 percent of planned key performance parameter (KPP) events) by a single percentage point. The KPPs' thresholds that NASA met or exceeded during FY 2021 each represent technology advancement that may lead to entirely new mission approaches and provide solutions to national needs. COVID-19 effects, along with project-specific technology development challenges, impacted NASA's ability to meet the desired performance thresholds for some KPPs.

NASA met KPPs in projects such as Autonomous Pop-Up Flat Folding Explorer Robot (A-PUFFER), Automated Reconfigurable Mission Adaptive Digital Assembly Systems (ARMADAS), and Rapid Analysis and Manufacturing Propulsion Technology (RAMPT). A-PUFFER demonstrated multiple small rovers that cooperated to explore an unmapped environment without a human in-the-loop. We successfully transitioned A-PUFFER to the Cooperative Autonomous Distributed Robotic Exploration (CADRE) lunar technology demonstration project, which will deliver a system of multi-agent autonomous robotic rovers for launch by a Commercial Lunar Payload Services (CLPS) provider in 2024.

Additionally, Mars Entry, Descent, and Landing Instrumentation (MEDLI) 2 and the Mars Environmental Dynamics Analyzer (MEDA), which launched on the 2020 Mars Perseverance rover, operated successfully in their respective demonstrations.

MEDLI2 was one of the crucial technologies on the rover's protective aeroshell that helped document the entry, descent, and landing of the spacecraft. Its role in collecting critical data about the harsh environment during Perseverance's entry through the planet's atmosphere gave NASA a bird's eye view of what was happening to the aeroshell as it flew through the Martian skies. The data provided was essential to understanding how much margin remained on the Perseverance entry, along with data that will be used to improve prediction models and tools for future missions.

MEDA has continued to operate successfully, providing daily and seasonal reports on atmospheric pressure, humidity, ultraviolet radiation at the Martian surface, air temperature, and ground temperature around the rover. The data will support predictions for future science and exploration missions: dust lifting and transport; how storms evolve into large ones encircling Mars; how dust particles interact with light; and temperature, heat, and dust cycles.

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.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	N/A	N/A	40	40		
Achieved	N/A	N/A				
Rating	N/A	N/A				

Small Spacecraft Technology develops and demonstrates new small spacecraft technologies for NASA's missions in science, exploration, and space operations. **Technology Demonstration Missions** bridge the gap between laboratory-proven and final infusion by providing ground and flight test for promising technologies. Both programs are part of the **Space Technology Mission Directorate**.

3.1.3 [Completed at the end of FY 2021]: Demonstrate new technology and capabilities to support NASA's missions and space industry growth.

Critical activities completed for two programs supporting the performance goal.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	6 milestones for each of 2 contributing programs					
Achieved	13 milestones for Small Spacecraft; 7 milestones for Tech Demo	15 milestones for Small Spacecraft; 5 milestones for Tech Demo				
Rating	Green	Yellow				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

Planned Critical milestones for FY 2021

1. Achieve a key milestone in 6 Small Spacecraft Technology projects.
2. Achieve 6 key milestones for the Technology Demonstration program.

Small Spacecraft Technology develops and demonstrates new small spacecraft technologies for NASA's missions in science, exploration, and space operations. **Technology Demonstration Missions** bridge the gap between laboratory-proven and final infusion by providing ground and flight test for promising technologies. Both programs are part of the **Space Technology Mission Directorate**.

FY 2021 Performance Progress

During FY 2021, NASA had several impactful successes in its technology demonstration portfolio, but the Agency fell short of achieving this Performance Goal. We completed key milestones in 15 Small Spacecraft Technology projects, exceeding the targeted six. We also achieved five key milestones and key decision points (KDP), falling just short of the target of six, in Technology Demonstration Missions, major reviews that serve as gateways to the next lifecycle phase. A crowded launch manifest led to a delay in the launch window for the Laser Communications Relay Demonstration (LCRD) project, pushing it out into early FY 2022. Several other missions in development, including On-Orbit Servicing, Assembly and Manufacturing (OSAM)-1 and OSAM-2, were impacted by the COVID-19 pandemic and technical challenges.

NASA's FY 2021 achievements in Small Spacecraft Technology included four milestones towards launch of the Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) lunar mission, which will reduce risk for future spacecraft by validating innovative navigation technologies and verifying the dynamics of a unique orbit for human exploration missions. We also met milestones for Dual Propulsion Experiment (DUPLEX);; Tiled Ionic Liquid Electrospray (TILE) e ngine;, Pathfinder Technology)-1 Hydros;Terabyte Infrared Delivery; Courier Solar Electric Propulsion Module; ; Intrepid particle detector; CubeSat Laser Infrared CrosslinK (CLICK) B/C, Tipping Point with Blue Canyon Technologies; and the Lunar Flashlight Propulsion System.

The Technology Demonstration Missions Low-Earth Orbit Flight Test of an Inflatable Decelerator (LOFTID) passed its KDP-D in preparation for delivery in 2022. Additionally, the OSAM-2 mission completed its post-PDR and associated KDP, and our Cryogenic Fluid Management activities were consolidated into a portfolio project for the benefit of strategic decision making, accounting, and streamlining the execution of work.

NASA also conducted technology demonstrations on the surface of Mars, such as Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE) and Terrain Relative Navigation (TRN). 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 breathable air for astronauts. The TRN system successfully used a camera on the bottom of the rover to compare the features on the Martian surface to an onboard map to determine its exact trajectory and landing site, assisting Perseverance to touch down in a safe location within Jezero crater.

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

Major milestones (e.g., key decision points, major reviews, and technology demonstrations) completed.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	N/A	N/A	7	6		
Achieved	N/A	N/A				
Rating	N/A	N/A				

NASA's Space Technology Mission Directorate (STMD) offers prizes for meeting key technology challenges, while reaching out to non-traditional NASA partners. STMD also provides an opportunity for small businesses and research institutions to participate in government-sponsored research and development efforts in key technology areas.

3.1.4 [Completed at the end of FY 2021]: Spur technology development through engagement with the commercial sector and the general public.

Critical milestones achieved for two programs supporting the performance goal.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	3	3				
Achieved	3	3				
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

Critical milestones for FY 2021

1. Conduct 42 NASA challenges, prize competitions, and crowdsourcing activities.
2. Advance 45 Small Business Innovative Research/ Small Business Technology Transfer (SBIR/STTR) technologies beyond Phase II.
3. Manifest 16 payloads on commercial suborbital flights for testing.

NASA's Space Technology Mission Directorate (STMD) offers prizes for meeting key technology challenges, while reaching out to non-traditional NASA partners. STMD also provides an opportunity for small businesses and research institutions to participate in government-sponsored research and development efforts in key technology areas.

FY 2021 Performance Progress

NASA achieved the FY 2021 target for this Performance Goal by exceeding the targets for all three supporting critical activities.

NASA started 52 new Prize, Challenge, and Crowdsourcing (PCC) activities and continued 13 activities that started prior to FY 2021. Of the new challenges started, 28 were through the NASA@ WORK platform, which provides NASA employees an unconventional and inventive way to share knowledge and advance projects. Exciting public challenges that started in FY 2021 included the Break the Ice Lunar Challenge designed to help NASA excavate ice on the Moon; 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; and 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 SBIR/STTR program. We created 110 post-Phase II opportunities, compared to the targeted 45 opportunities, including 35 Phase II-E awards, six Civilian Commercialization Readiness Pilot Program opportunities, five Lunar Sequential Phase II awards, and 64 Phase III awards. Our investments continue to demonstrate examples of infusion into NASA missions and other applications. For example, the Roll-Out Solar Array (ROSA) was awarded several funding opportunities, including numerous SBIRs that allowed a small company to go from an innovative idea to designing successful ground and flight demonstrations on the International Space Station (ISS). Since then, ROSA has been deployed on the ISS to supplement the legacy arrays, will be the main power source for Power and Propulsion Element/Gateway, and has been infused into the Double Asteroid Redirection Test (DART) mission.

NASA also competitively selected 36 payloads from industry and academia for flight on commercial flight vehicles to achieve Agency priorities through its Flight Opportunities program, exceeding the target of 16. One example of these payloads was a that flew to suborbital space on Virgin Galactic's first fully crewed spaceflight.

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)

Critical milestones achieved for two programs supporting the performance goal.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	N/A	N/A	4	4		
Achieved	N/A	N/A				
Rating	N/A	N/A				

Critical activities for FY 2022

1. Final assembly of the Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) spacecraft in preparation for pre-shipment testing.
2. Complete Solar Electric Propulsion (SEP) Critical Design Review (CDR).
3. Deliver the Polar Resources Ice Mining Experiment (PRIME)-1 to Intuitive Machines for integration with their Commercial Lunar Payload Services (CLPS) lander, in preparation for their mission.
4. Complete 3 early design milestones for Cryogenic Fluid Management (CFM) Tipping Point projects.

Critical activities for FY 2023

1. Transition 3 SBIR/STTR sequentials planned to be completed in CY 2022 to stakeholder programs for planned follow-on use/development and integration into future systems and demonstrations.
2. Deliver the LTE Proximity Communications Tipping Point with Nokia to Intuitive Machines for integration to their CLPS Lander.
3. Complete Environmental Testing for the Cooperative Autonomous Distributed Robotic Explorers (CADRE).
4. Initiate primary mission operations of the Deep Space Optical Communications (DSOC).

NASA's Space Technology Mission Directorate (STMD) offers prizes for meeting key technology challenges, while reaching out to non-traditional NASA partners. STMD also provides an opportunity for small businesses and research institutions to participate in government-sponsored research and development efforts in key technology areas.

2.2.2 [Completed at the end of FY 2021]: Commence lunar surface technology demonstrations to enable a sustainable lunar surface exploration strategy.

Critical milestones achieved for two programs supporting the performance goal.

Fiscal Year	2020 (APG)	2021	2022	2023	2024	2025
Target	3	2				
Achieved	3	1				
Rating	Yellow	Yellow				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

List of development milestones for FY 2021

1. Complete Precision Landing suborbital demonstration.
2. Prepare hardware for flight demonstration for lunar polar water mining technology.

NASA's Space Technology Mission Directorate (STMD) offers prizes for meeting key technology challenges, while reaching out to non-traditional NASA partners. STMD also provides an opportunity for small businesses and research institutions to participate in government-sponsored research and development efforts in key technology areas.

FY 2021 Performance Progress

NASA completed one of the two targeted milestones in FY 2021, resulting in a Yellow rating for this Performance Goal.* We anticipate completing the second milestone during FY 2022.

In a great example of NASA and industry working together, Blue Origin's Deorbit, Descent and Landing Sensors Tipping Point (BODDL-TP) and Safe and Precise Landing – Integrated Capabilities Evolution (SPLICE), both successfully launched and landed aboard Blue Origin's New Shepard (NS-13) mission in October 2020 and August 2021. These two flight tests were under the Tipping Point partnership and demonstrated successful flight performance of a Blue Origin Navigation system, a camera-based system for Terrain Relative Navigation (TRN), a commercial Doppler lidar velocimeter, and a dedicated computing system hosting advanced guidance and navigation algorithms for precision landing. One of the five technologies tested, a NASA Doppler lidar sensor, experienced an anomaly; a review board has been formed to identify the underlying anomaly cause, recommend a resolution, and document lessons-learned to better inform future flights. The overall success of these demonstrations increases the maturity of precision landing technologies for use onboard future missions to the Moon and beyond.

Due to a delayed vendor selection for Commercial Lunar Payload Services (CLPS), NASA adjusted Polar Resource Ice Mining Experiment (PRIME)-1 hardware completion and delivery deadlines accordingly, extending this milestone to late FY 2022. PRIME-1 is currently preparing hardware for a flight demonstration on the second Intuitive Machines (IM-2) CLPS mission to the south polar region near Shackleton crater. The hardware for the flight consists of two instruments with high technology readiness levels (TRLs); Mass Spectrometer observing lunar operations (MSolo) and The Regolith and Ice Drill for Exploring New Terrain (TRIDENT). Both instruments, which are not currently experiencing any technical delays, are being fabricated and assembled, with completion expected in the third quarter of FY 2022. Following completion, the instruments will go through verification and validation testing and will be delivered to the CLPS vendor in the fourth quarter of FY 2022.

*In January 2021, the Office of Management and Budget (OMB) discontinued public reporting Government-wide on Agency Priority Goals. NASA continued performance tracking and reporting on the Lunar Surface Technology Demonstrations high-priority area as a Performance Goal with some changes approved by OMB.

Strategic Objective 3.2

Drive efficient and sustainable aviation.

LEAD OFFICE
Aeronautics Research Mission Directorate (ARMD)

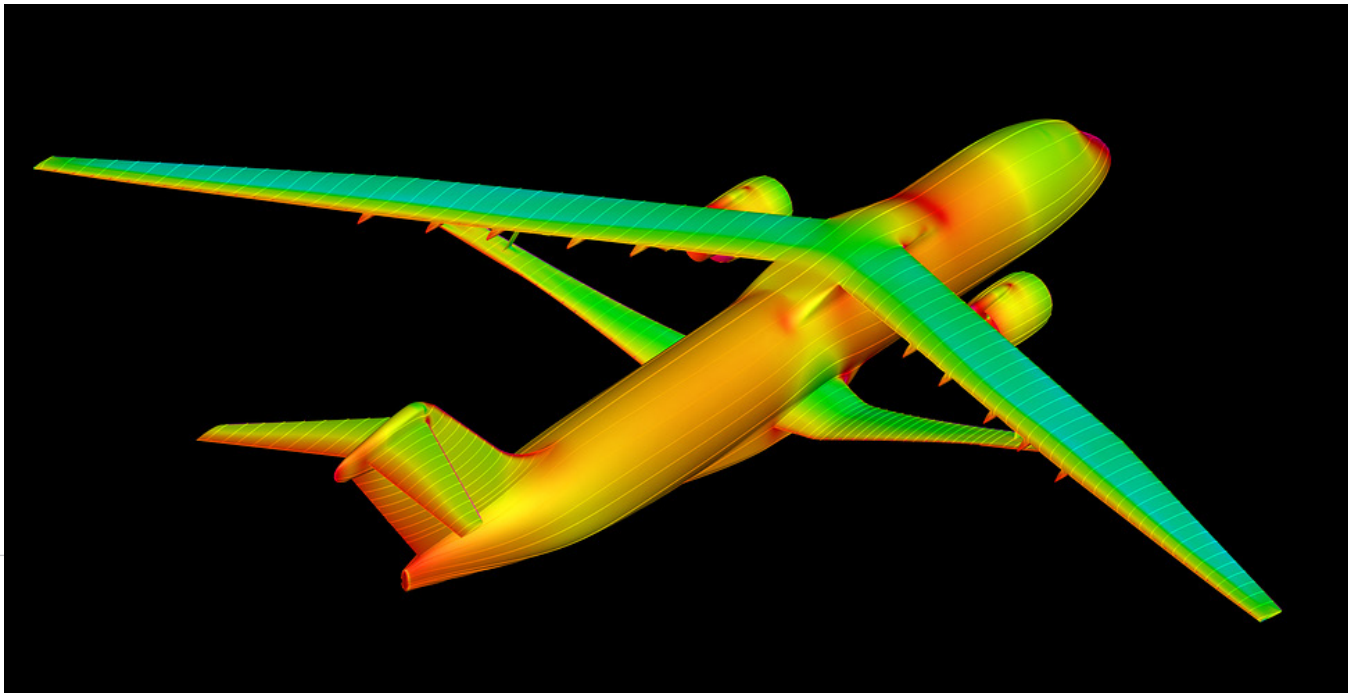
GOAL LEADER
William Harrison, Portfolio Analysis & Management Office, Director, ARMD

Budget

	FY	$M
Op Plan	2021	$828.7
Requested	2022	$914.8
Requested	2023	$971.5
Outyear	2024	$990.9
	2025	$1,010.7
	2026	$1,030.9
	2027	$1,051.5

Air transportation is an integral part of modern life, providing safe, affordable, and convenient travel to the public. Consequently, it has become an integral part of the U.S. and global economy. In a 2020 economic impact report published by the Federal Aviation Administration, air transportation provided $78 billion of positive trade balance for the U.S. manufacturing sector, 10.9 million direct and indirect jobs and 21.3 billion tons of freight by the U.S. airlines culminating in $1.8 trillion of total U.S. economic activity (8.6 percent of the 2018 U.S. Gross Domestic Product). Of the 10.9 million jobs, over one million were high-quality manufacturing jobs. Nearly every product created and purchased today (from toys to groceries) is touched by aviation in some way. Speed, convenience, and economic benefits from air transportation are the primary factors in its rapid growth; benefits that have been even more important during the COVID-19 pandemic.

Below: NASA and industry partners are working towards a future that sees aviation meet cleaner sustainability standards. To that end, new designs for the airplanes of tomorrow, such as the Transonic Truss-Braced Wing (TTBW) concept shown in the image above, are currently being tested by researchers and engineers. The TTBW is essentially a classic tube-and-wing passenger aircraft whose wings are extremely long and thin – so much that they need a little help to hold them up. By narrowing the thickness of the wings and extending their length, drag is reduced, and 5-10% less fuel is burned than comparable narrowbody aircraft. This image was created using data from a computational fluid dynamics simulation – essentially a virtual wind tunnel test. The red and orange areas represent higher drag, and the green and blue areas represent lower drag. Note the beautifully sleek green-blue color of the wings – the colors of Earth. Image Credit: NASA/Craig Hunter



NASA's research contributes significantly to the aviation sector in improving its safety, efficiency, and resulting economic well-being of the Nation. Our role is to reduce the risk inherent in innovative concepts. We explore early-stage concepts and ideas, develop new aviation technologies and air traffic operational procedures, and demonstrate their potential in a relevant environment. The Agency is steadfast in its commitment to cutting-edge research and technology development and demonstration to assure U.S. competitiveness in the aviation sector.

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.

Annual performance activities completed.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	2	1	2	1		
Achieved	1	1				
Rating	Yellow	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

Development milestones for FY 2021

1. Transfer knowledge and technology (i.e., digital services) that enable broad adoption of a NASA-developed Trajectory Option Set (TOS) based digital re-routing concept.

Performance activities for FY 2022

1. Develop a community-supported Sky for All Vision of the future aviation system.
2. Conduct National Campaign-1 (NC-1) and demonstrate operational scenarios with industry partners across vehicle, airspace, and infrastructure to inform requirements for a UAM Maturity Level-1 (UML-1) system.

Performance activities for FY 2023

1. Identify and test community-based rules for strategic conflict management.

This Performance Goal aligns to 3.2.1 under the 2018 Strategic Plan.

FY 2021 Performance Progress

In FY 2021, the NASA Aircraft Technology Demonstrations (ATD)-2 project successfully completed formal data collection for the 2021 stormy season, ending as planned in September 2021, with 107 flights re-routed using the ATD system.

The ATD-2 system is an Integrated Arrival Departure Surface (IADS) Metroplex Coordinator, which is a tool designed to provide benefits when the aircraft demand exceeds the capacity of an airport. Testing was conducted in the Dallas-Fort Worth Metroplex environment during the stormy season and allowed airline dispatchers to easily propose in-flight reroutes by selecting from system-generated Trajectory Option Sets (TOS), which are a list of potential trajectories that a flight crew may accept, in this case they generally looking for the either the most fuel efficient route or an option that gets them on the trajectory that will meet their time constraints. Once accepted by air traffic control, the reroute would be issued via the Federal Aviation Administration's Airborne Reroute system. These reroutes produced 12.4 hours of delay savings while saving more than 50,800 pounds of fuel.

The Airspace Operations and Safety Program, part of the Aeronautics Research Mission Directorate, is working with partners to conceive and develop the Next Generation Air Transportation, or NextGen, technologies to further improve safety, capacity, and efficiency in the national airspace.

NASA presented field demonstration results during the September 2021 ATD-2 / Multi-Airport session of the ATD Project Technical Interchange Meeting (TIM). Panelists for this TIM session included Field Demo Partners (i.e., airlines and NATCA) and stakeholders from the Collaborative Decision Making (CDM) community. During the session, panelists described their experience using the ATD-2 system, positive impacts on North Texas airspace operations and their desire to see the technology further developed and implemented on a nation-wide basis. Six Machine Learning services developed and publicly released under this effort were described during the ATD-2 / Digital Services session of the ATD Project TIM.

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

Annual performance activities completed.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	1	2	2	1		
Achieved	0	0				
Rating	Red	Red				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

Development milestone for FY 2021

1. Low Boom Flight Demonstrator aircraft ready to ship from Palmdale to Lockheed Martin (LM) Fort Worth.
2. Deliver a validated F-15-based test capability that enables precise, near-field probing of the LBFD shock wave structure.

Performance activities FY 2022

1. First flight of the Low Boom Flight Demonstrator (LBFD) aircraft.
2. Deliver a validated F-15-based test capability that enables in-flight Schlieren images of the LBFD shock structure.

Performance activities FY 2023

1. Demonstrate the ability of the X-59 aircraft to produce an acceptably low perceived sonic boom level that allows the community response testing phase of the LBFD mission to commence.

This Performance Goal aligns to 3.2.2 under the 2018 Strategic Plan.

FY 2021 Performance Progress

NASA did not complete either annual performance activities as planned for the LBFD aircraft largely due to contractor challenges and, to a lesser degree, COVID-19 pandemic impacts, resulting in a red rating. According to NASA's assessment, there is still margin in the schedule for aircraft acceptance and completion of acoustic validation by the end of this multiyear Performance Goal in FY 2024.

Contractor delays resulted in a slip of the LBFD aircraft milestone to ship the aircraft from Palmdale to Lockheed Martin (LM) Fort Worth, Texas for structural proof loads and fuel systems calibration testing. The date shifted from August 2021 to December 2021. Challenges included prime contractor workforce staffing and performance, slow progress on wiring installations, system checkout schedule slips, COVID-19 related on-site limitations, and supply chain delays. Despite these challenges, the build quality of the LBFD aircraft is excellent and all the key performance parameters are being met. NASA mitigation actions included teaming with the prime contractor to assist with some design and testing tasks, negotiating incentive fee and cost sharing features in the contract, supporting replanning with more realistic assumptions, providing NASA experts on-site, and inserting significant NASA executive-level engagement with prime contractor counterparts.

The Integrated Aviation Systems and Advanced Air Vehicles programs, part of NASA's Aeronautics Research Mission Directorate, are working together to validate design approaches for quiet supersonic aircraft and develop data to support the definition of a standard for acceptable noise.

NASA remains highly engaged with the prime contractor at executive and project levels to assess risks to First Flight. Prime contractor plans target First Flight for the LBFD aircraft in August 2022. According to NASA's assessment, a First Flight in December 2022 is likely if prime contractor performance does not improve and COVID-19 impacts continue.

The COVID-19 pandemic also impacted shock sensing probe (SSP) system development, work on F-15D wing fatigue inspections, and instrumentation system development and integration. Factors included Center access and external vendor workforce restrictions due to COVID-19 and supply chain delays. The SSP will be used to accurately probe and collect data on the characteristics of X-59 shockwaves and confirm whether they match Agency models to be able to reduce the sound of a sonic boom to a "quiet thump".

Initial SSP flights, using the Airborne Location Integrating Geospatial Inertial Navigation Systems (ALIGNS) used to precisely position the aircraft for SSP measurements, started in the fourth quarter of FY 2021, and demonstrated that SSP meets the X-59 static pressure resolution requirement and

that ALIGNS provided sufficient coverage and range between two aircraft.

By the end of FY 2021, 87 percent of major F-15D instrumentation components and pallet assemblies were completed or in-work. F-15D wing inspections, repairs and painting will be completed at Warner Robins Air Logistics Complex and will be received by NASA Armstrong shortly after FY 2021, where fuselage inspections and repairs continue.

Right: The X-59 QueSST (Quiet SuperSonic Technology) aircraft will fly at supersonic speeds above communities during the Low-Boom Flight Demonstration mission, generating sonic "thumps" instead of booms. Image credit: NASA/Lockheed Martin

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.

Annual performance activities completed.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	5	2	5	3		
Achieved	2	1				
Rating	Yellow	Yellow				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Yellow

Development milestones for FY 2021

1. Design and fabricate a low-noise variant of the High-Lift Common Research Model and conduct a wind tunnel experiment to perform acoustic measurements of innovative slat noise reduction concepts entailing realistic materials and component sizes.
2. Award industry contract(s) for 1MW powertrain flight demonstration(s).

Performance activities for FY 2022

1. Establish feasibility for megawatt, kilovolt fault management devices for electrified aircraft propulsion (Technology Readiness Level [TRL]-4).
2. Design and fabricate a semi-span model of an advanced Transonic Truss Braced Wing (TTBW) configuration, conduct a wind tunnel test to further investigate the buffet boundary of the configuration, and compare experimental results with the computational predictions of structural response and buffet boundary to improve (or calibrate) methods for this non-traditional wing architecture.
3. Complete screening of materials and manufacturing technologies to be considered under the High-rate Composite Aircraft Manufacturing (HiCAM) effort; requirements definition for a full-scale, component-level test article; and evaluate high-rate materials and manufacturing concepts at the coupon and element levels.
4. Preliminary design complete for at least one integrated, 1MW class electric powertrain flight demonstration.
5. Complete X-57 Mod II flight campaign and release performance analysis.

Performance activities for FY 2023

1. Design, build, test, evaluate a suite of electrified aircraft propulsion (EAP) components to TRL-6 that are relevant for demonstrators and small EAP aircraft.

The Advanced Air Vehicles and Transformative Aeronautics Concepts programs, part of NASA's Aeronautics Research Mission Directorate, evaluate, develop, and test technologies and capabilities for ultra-efficient aircrafts.

2. Design, build, test, evaluate a suite of novel manufacturing technologies to TRL-5 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.

This Performance Goal aligns to 3.2.3 under the 2018 Strategic Plan.

FY 2021 Performance Progress

NASA partially achieved the FY 2021 target for this Performance Goal to advance airframe and engine technologies by fully achieving annual performance activity 1 and being slightly behind the planned schedule for annual performance activity 2.

In FY 2021, NASA completed a wind tunnel test of a high efficiency aircraft configuration known as the Transonic Truss-Braced Wing (TTBW). The test results will reduce uncertainty in TTBW performance and increase confidence in the estimated fuel burn benefits. In addition, an independent assessment of the configuration was completed by NASA that corroborates industry's fuel-burn estimate.

During the fiscal year, a viable airframe noise-reduction concept was designed, fabricated, and demonstrated in a large-scale wind tunnel test where it was shown to have significant acoustic benefits. In the area of advanced aircraft engine technologies, NASA demonstrated improvements in compressor efficiencies that could enable a 12. percent reduction in fuel consumption.

NASA also made significant progress in enabling fuel burn reductions through propulsion system electrification. This work included first-of-a-kind altitude tests of Megawatt (MW)-class components

and integrated powertrains and completion of the FY 2021 Electric Powertrain Flight Demonstration (EPFD) annual performance activity. The Source Evaluation Board selection process is complete with awards made in the fourth quarter of FY 2021. NASA selected two U.S. companies to perform integrated MW-class powertrain system ground and flight demonstrations to validate their concepts. The awards are hybrid firm fixed-price/cost-share for work conducted over the next five years. NASA rated this activity Yellow because the planned schedule was to complete the awards during the third quarter of FY 2021.

Below: Instrumentation technician Michael Hodgins performs installation measures on the trans-sonic truss-braced wing (TTBW) model at Langley Research Center's 14x22 subsonic wind tunnel. The unique design of the aircraft's wings reduces drag during flight, which in turn reduces fuel consumption by up to 10 percent. This concept is part of an ongoing initiative by NASA, industry partners, and academia to make the future of aviation more environmentally friendly through the Sustainable Flight National Partnership (SFNP). The SFNP will expand research for sustainable aviation by developing and testing new technologies for aircraft, new automation tools for greener and safer airspace operations, and sustainable energy options for aircraft propulsion. The TTBW will undergo a variety of aerodynamic testing as researchers continue to test key flight components such as increased lift and reduced drag. Image Credit: NASA/Langley Research Center/David Meade

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.

Annual performance activities completed.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	1	1	1	1		
Achieved	1	1				
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Yellow	Green

Development milestone for FY 2021

1. Complete conceptual design and sizing trade studies for Vertical Take Off and Landing (VTOL) Urban Air Mobility (UAM) configurations.

Performance activities for FY 2022

1. Assessment of Urban Air Mobility vehicle noise operating in realistic trajectories with a second generation (Gen-2) noise-power-distance database that includes loading, thickness, and broadband self-noise for a mix of vehicles.

Performance activities 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.

This Performance Goal aligns to 3.2.4 under the 2018 Strategic Plan.

FY 2021 Performance Progress

NASA made planned progress on this Performance Goal by completing design trade studies of noise versus performance for three UAM aircraft configurations.

In FY 2021, NASA continued development of a conceptual design toolchain that enabled the assessment of performance and noise of UAM aircraft compared with a quiet, single main-rotor helicopter. The UAM aircraft included a quadrotor, side-by-side helicopter, and lift+cruise aircraft, all designed to carry six passengers. These aircraft represent characteristics of emerging UAM aircraft being developed by UAM companies. The Federal Aviation Administration (FAA)/ European Union Aviation Safety Agency (EASA) certification Effective Perceived Noise Levels for takeoff, flyover, and approach were used for the noise metrics of the trade studies.

The Advanced Air Vehicles and Integrated Aviation Systems programs, part of NASA's Aeronautics Research Mission Directorate, demonstrate and deliver tools, technologies, and flight operations methods for safe, quiet, and affordable vertical lift air vehicles.

The concept aircraft in this study are shown to achieve reductions in noise relative the initial design points, with changes in mission performance and cost as a consequence. Many of the designs are predicted to be tens of effective perceived noise decibels (EPNdB) quieter in the certification metrics than existing helicopters. The results were documented in a paper, "Practical Conceptual Design of Quieter Urban VTOL Aircraft," written by Chris Silva and Wayne Johnson, which was presented at the Vertical Flight Society Forum 77, May 2021. The paper will provide valuable design guidance for the UAM industry

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.

Annual performance activities completed.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	2	1	1	1		
Achieved	2	1				
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

Development milestones for FY 2021

1. Evaluate costs and benefits given a demonstrated automated evaluation of safety risk over multiple simultaneous events utilizing non-traditional data.

Performance activities for FY 2022

1. Complete simulations and flight tests of automated in-flight safety/risk assessment with alternate proactive and fail-safe mitigation methods.

Performance activities for FY 2023

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

This Performance Goal aligns to 3.2.5 under the 2018 Strategic Plan.

The Airspace Operations and Safety Program, part of the Aeronautics Research Mission Directorate, develops real-time safety monitoring and assurance system technologies and capabilities to enhance air transportation safety, capacity, and efficiency.

FY 2021 Performance Progress

NASA made planned progress on this Performance Goal by completing the FY 2021 activity. During the fiscal year, NASA's System Wide Safety (SWS) project successfully developed a framework that integrates risk across hazards as part of the in-time system-wide safety assurance capabilities for highly autonomous emerging operations. NASA has incorporated multiple key hazards, such as wind gusts, propulsion degradations, and proximity to buildings and populated areas, into the computation of a set of risk metrics and algorithms that may be used during pre-flight planning or in-flight. The project tested these automated risk assessment techniques in simulation using flight logs. A subset will be demonstrated during live flight testing in FY 2022. Costs, benefits, and gaps were identified for the most mature of the techniques and a technology transfer path was established to enable external use and evaluation by partners and the industry.

For traditional airline operations, the project demonstrated utilizing two anomaly detection algorithms that allow for identification of previously unknown anomalies/risk types. These demonstrations used historical airline flight data. The SWS project continues to pursue access to active data feeds going to an airline partner's operations center and will determine how those data can be used to identify anomalies and precursors using the algorithms that the project has developed. A NASA partner is developing airline operations center software with appropriate anomaly detection algorithms integrated into it and ways to visualize the resulting anomalies and risks

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.

Annual performance activities completed.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	N/A	3	3	3		
Achieved	N/A	3				
Rating	N/A	Green				

Performance activities for FY 2021

1. Develop an initial Urban Air Mobility airspace management system.
2. Evaluate the use of run-time monitoring as a tool for the assurance of untrusted components in a system.
3. Conduct National Campaign (NC) Developmental Testing (or NC-DT), perform demonstration of NC operational scenarios, and collect data from flight demonstrations and simulations in preparation for NC-1.

Performance activities for FY 2022

1. Enable informed investment decisions for future development of increasingly automated vehicles and airspace operations.
2. Delivery of draft evidence and recommendations for the robustness of failover plans; and the use of run-time monitoring to the FAA, Unmanned Aircraft Safety Team, and Flight Safety Foundation that can be used in regulatory guidance to industry and in standards committees.
3. Demonstration through flight testing of automated aircraft vertiport operations using operational scenarios.

Performance activities for FY 2023

1. Develop requirements for future Air Traffic Management systems of increasingly automated vehicles and airspace 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 in the Integrated Automation Systems-1 (IAS-1) flight test.

This Performance Goal was aligned to 3.2.6 under the 2018 Strategic Plan.

The Integrated Aviation Systems and Advanced Air Vehicles programs, part of NASA's Aeronautics Research Mission Directorate, are developing technologies and capabilities to enable autonomous aircraft and urban air mobility.

FY 2021 Performance Progress

NASA achieved the FY 2021 target for this multi-year performance goal by completing analysis of the performance data of the UAS traffic management (UTM) system and related technologies, which demonstrated that a highly automated, cloud-based architecture that safely enables low-altitude UAS operations is feasible. Over the previous four years, the project followed a risk-based approach to develop and test the UTM system and matured it through successively more capable Technical Capability Levels (TCLs). This culminated in the TCL 4 testing in the highly complex urban environments of Reno, Nevada, and Corpus Christi, Texas, as well as focused in-board technology evaluations at NASA centers in FY 2019.

The results from those tests confirmed the concept and provided new insights into industry's ability to develop and provide traffic management services for UAS operations, and to interface with new FAA systems that can integrate into the traditional air traffic management infrastructure. Through technology transfers, the UTM results are now informing the FAA in their testing in this year's UTM Pilot Program, as well as the longer-term UTM implementation plan for the Nation. Industry standards bodies, such as American Society for Testing and Materials (ASTM) and Joint Authorities for UAS Rulemaking on Unmanned Systems (JARUS), are also incorporating the UTM results. Additionally, the UTM service-based architecture is serving as the foundation for enabling advanced air mobility solutions in urban environments and high-altitude UAS traffic.

As part of project closeout, the UTM project has completed an extensive lessons-learned collection and archived key documentation that will benefit current and future projects and research efforts.

Strategic Goal 4

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

An aerial view of the Central Campus Headquarters Building and a close-up view the NASA insignia in front of the entrance in the industrial area at NASA's Kennedy Space Center in Florida on Jan. 13, 2021. The facility anchors the multi-user spaceport's Central Campus. More than 500 civil service and contractor employees will be based in the 200,000-square-foot buildingImage credit: NASA/Ben Smegelsky/Cory Huston

Strategic Objective 4.1

Attract and develop a talented and diverse workforce.

LEAD OFFICE
Mission Support Directorate (MSD) and the Office of Diversity and Equal Opportunity (ODEO)

GOAL LEADER
Robert Gibbs, Associate Administrator, MSD

Budget

	FY	$M
Op Plan	2021	$97.4
Requested	2022	$104.3
Requested	2023	$108.4
Outyear	2024	$110.6
	2025	$112.8
	2026	$115.0
	2027	$117.3

NASA will modernize how we attract, hire, support, lead, and retain the quality, diversity, and depth of talent necessary for mission success. Recent experiences and lessons from the pandemic, as well as nationwide workforce and workplace trends, will inform and help NASA institutionalize and improve our hybrid work practices. NASA's modernization strategy will also address other factors such as an increasing number of retirement-eligible civil servants over the next five years and increasing competition for highly qualified science, technology, engineering, and mathematics (STEM) talent, especially as more commercial entities enter the field.

While NASA has long enjoyed a reputation of attracting top talent; we recognize the value of recruiting and employing a diverse workforce cannot be understated. The Agency is better positioned to fulfill its current and future missions when we intentionally invite people with different backgrounds, who show promise and potential,

Below: Kathryn Oriti of the Science and Space Technology Systems Branch at NASA's Glenn Research Center in Cleveland, left, oversees 2017 Pathways intern Naia Butler-Craig as she builds hardware for the Advanced Electric Bus CubeSat. We strategically hire our Pathways Interns based on long-term potential and alignment with NASA's future workforce needs. Specializing in multi-semester experiences, the Pathways Internship Program prepares students for a career at NASA and offers a direct pipeline to full-time employment at NASA upon graduation. Image Credit: NASA/Bridget Caswell

into spaces to inspire and challenge us to think and work differently.

In 2020, NASA added Inclusion to our Core Values, recognizing that inclusion is intrinsic to our work, our relationships, and our achievements. Inclusion increases collaboration and productivity. Additionally, it encourages employees to go above-and-beyond to achieve our goals. Also, all people want to feel a sense of inclusion and belonging. Inclusion happens when people can have psychological safety in being their authentic selves, sharing their ideas, knowledge, creativity, and innovation. The combination of all our values and the emphasis on Inclusion lets NASA strive to have a healthy culture and be an employer of choice.

4.1.1: Improve diversity in the Agency's overall civil service workforce composition and occupations and across employee lifecycles.

Number of efforts completed (plans and analyses, as well as assessments of their impact on reducing triggers and barriers).

Fiscal Year	2020	2021	2022	2023	2024	2025
Target			3	2		
Achieved						
Rating						

Efforts for FY 2022

1. Complete the multi-phase barrier analysis[1] of (1) Asian American and Pacific Islanders and (2) women in NASA physical science occupations and produce a final report identifying challenges and corrective actions addressing each challenge.[2]
2. Complete a baseline assessment of diversity in NASA's Mission Directorates based on staffing (including leadership positions).[3]
3. Complete an analysis of responses to the Federal Employee Viewpoint Survey question on preventing harassment in the workplace4 to identify triggers affecting an inclusive, fair, and safe work environment important for workforce retention.

Efforts for FY 2023

1. Complete analysis of applicant flow data to determine if barriers exist in recruitment or hiring of individuals from underserved and underrepresented communities.
2. Issue updated badging and security procedures[5] (with NASA's Office of Protective Services) to remove any barriers to equal employment opportunity and accessibility for LGBTQIA+ individuals who require access to NASA facilities.

[1] NASA's processes for barrier identification and elimination are in accordance with Section II of the U.S. Equal Employment Opportunity Commission's Instructions to Federal Agencies for EEO MD-715.

[2] NASA will complete Phases 5-7 of a barrier analysis of women and Asian American and Pacific Islanders within physical science occupations when compared to the relevant civilian labor force, as described in Appendix B of the NASA Model Equal Employment Opportunity Program Status Report: FY 2020.

[3] NASA will collect and analyze the following: (a) data metrics, and targets that are used by the Mission Directorates to assess workforce diversity efforts; (b) demographics of newly hired or promoted personnel into Mission Directorate leadership positions (Division Directors, Deputy Division Directors, and Associate Directors, as well as front office hires) from 2017-2021, and a description of any efforts intended to increase the diversity of Mission Directorate leadership; (c) the extent to which policies and goals for increasing workforce diversity vary by Mission Directorate; (d) the people responsible and accountable for increasing workforce diversity for each Mission Directorate and a description of how they are accountable; (e) Mission Directorates' plans over the next year to increase diversity and inclusion in its staffing at NASA Headquarters.

The Office of Diversity and Equal Opportunity (ODEO) leads diversity and civil rights policies, programs and services, enabling the universe of available talent to contribute inclusively and equitably to NASA. Diversity, equity, inclusion, and accessibility efforts Agency-wide have been streamlined, and where appropriate, aligned to ODEO through the Mission Support Directorate's Mission Support Future Architecture Program (MAP).

[4] The 2020 and 2021 Federal Employee Viewpoint Survey (FEVS) included the question: "NASA leaders take proactive steps to prevent harassment in the workplace (for example, senior leadership messages to the workforce, use of posters and other communication materials, training, dialogues, or similar activities)." NASA will analyze the 2020 and 2021 employee responses to this question, provided on a five-point scale (e.g., Agree, Strongly Agree), by demographics and organizational code. Results will inform efforts for a second Agency-wide Anti-Harassment Campaign.

For 2020, 10,588 employees (64 percent of NASA's 16,549 eligible workforce) responded to the FEVS. For 2021, 12,094 employees (68 percent of NASA's 17,746 eligible workforce) responded to the FEVS.

[5] NASA will review badging and security procedures, developed in accordance with NASA Procedural Requirement 1600.1A (NASA Security Program Procedural Requirements), to determine where revisions should be made to remove barriers.

4.1.2: 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.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target			Decrease of 5% or more from baseline	Decrease of 5% or more from FY 2022 actual (TBD)		
Achieved						
Rating						

The Office of the Chief Human Capital Officer, part of the Mission Support Directorate, helps NASA maintain an adaptable and skilled workforce through strategic workforce planning, management services, and staff training and development. Visit NASAPeople for more information about the Human Capital Program, careers at NASA, and other workforce information.

4.4.1 [Completed at end of FY 2021]: Sustain NASA employees' perceptions of innovation climate, as measured by the Innovation-related questions on the Federal Employee Viewpoint Survey (FEVS), through Human Capital programs and tools that support NASA employees.

The Office of Diversity and Equal Opportunity (ODEO) leads diversity and civil rights policies, programs and services, enabling the universe of available talent to contribute inclusively and equitably to NASA. ODEO is an Administrator Staff Office.

Agency FEVS Innovation score.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	84%	84%	PG Discontinued			
Achieved	White	White				
Rating	White	White				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

FY 2021 Performance Progress

NASA was unable to assess progress toward achieving this Performance Goal in FY 2021 due to lack of data resulting from changes to the 2021 FEVS.

In June 2020, the Office of Personnel Management (OPM), which conducts the survey, announced that it had reworked the survey—a measurement of Federal employees' perceptions of workplace experiences, leadership, and culture—to cut some of the standard questions and add questions related to the COVID pandemic. Among the questions cut were the innovation-related questions used to assess this Performance Goal . The FEVS retained key content widely used for strategic workforce development, such as employee engagement and satisfaction, to allow comparison of survey results between 2021 and prior surveys.

4.4.2 [Completed at end of FY 2021]: Sustain or improve NASA employees' perceptions of unity and inclusion, as measured by the Unity Pulse Survey, the New Inclusion Quotient (New IQ) index scores on the annual Federal Employee Viewpoint Survey (FEVS), and through Diversity and Equal Opportunity programs and tools that support NASA employees.

Agency FEVS New IQ Index score.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	70%	70%				
Achieved	Unable to assess					
Rating	White	White				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

The **Office of Diversity and Equal Opportunity (ODEO)** leads diversity and civil rights policies, programs and services, enabling the universe of available talent to contribute inclusively and equitably to NASA. Diversity, equity, inclusion, and accessibility efforts Agency-wide have been streamlined, and where appropriate, aligned to ODEO through the Mission Support Directorate's Mission Support Future Architecture Program (MAP).

FY 2021 Performance Progress

NASA was unable to assess progress toward achieving this performance goal in FY 2021 due to lack of data. The FEVS historically was administered by the Office of Personnel Management in late spring or early summer. However, the 2021 FEVS was administered after the close of fiscal year 2021 in November and results will not be reported until spring 2022. As a result, we cannot use the 2021 FEVS to assess FY 2021 performance.

4.4.3 [Completed at end of FY 2021]: Improve employees' perception of NASA as an equal opportunity and anti-harassment workplace, as measured by the Federal Employee Viewpoint Survey (FEVS) questions focused on equal employment opportunity (EEO) and anti-harassment compliance, through customer service scores, and completion of NASA/MAP deliverables for EEO compliance.

The Office of Diversity and Equal Opportunity (ODEO) leads diversity and civil rights policies, programs and services, enabling the universe of available talent to contribute inclusively and equitably to NASA. ODEO is an Administrator Staff Office.

Agency FEVS New IQ Index score. (Percentage of NASA FEVS EEO and anti-harassment compliance scores).

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	75%	75%				
Achieved	Unable to assess					
Rating	White	White				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

FY 2021 Performance Progress

NASA was unable to assess progress toward achieving this performance goal in FY 2021 due to lack of data. The FEVS historically was administered by the Office of Personnel Management in late spring or early summer. However, the 2021 FEVS was administered after the close of fiscal year 2021 in November and results will not be reported until spring 2022. As a result, we cannot use the 2021 FEVS to assess FY 2021 performance.

While data is not available from FEVS for FY 2021, we have been working to improve our EEO complaints processing procedures and timeliness. As a result, we have decreased average processing times for Final Agency Actions for procedural dismissals and Final Agency Dismissals based on merits

Strategic Objective 4.2

Transform mission support capabilities for the next era of aerospace.

LEAD OFFICE
Mission Support Directorate (MSD)

GOAL LEADER
Robert Gibbs, Associate Administrator, MSD

	Budget	
	FY	$M
Op Plan	2021	$3,276.4
Requested	2022	$3,326.5
Requested	2023	$3,515.8
Outyear	2024	$3,586.2
	2025	$3,658.0
	2026	$3,731.1
	2027	$3,805.8

As NASA's missions evolve and increasingly integrate with industry, and hybrid workforces and workplaces become the norm, mission support requirements will change. In alignment with NASA's Core Values, mission support's top priority is ensuring mission success—safely and securely. This is increasingly challenging with the growing complexity of our missions. Much of NASA's infrastructure is from the Apollo-era. It is time to re-build, modernize, and right-size NASA's mission-enabling capabilities.

To advance an environment of inclusion, integrity, teamwork, and excellence required for the Artemis era, we must strengthen our and modernize our physical and information technology (IT) infrastructure. NASA will focus on the following three priority areas: strengthen NASA's Agency Technical Authorities; modernize infrastructure and technical capabilities, and support our workforce and programs with secure, innovative technology. This transformation will enable the success of the entire Agency and our workforce.

Below: Nzinga Tull, Hubble systems anomaly response manager at NASA's Goddard Space Flight Center in Greenbelt, Maryland, works in the control room on July 15, 2021, to restore Hubble to full science operations. Image Credit: NASA/Goddard/Rebecca Roth

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

Number of fatalities or permanent disabling injuries.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	0	0	0.7 TCIR 0.3 DART	TBD based on industry average		
Achieved	0	0				
Rating	Green	Green				

*NASA determines the industry average for each Center using the most recent Bureau of Labor Statistics data for the North American Industry Classification System code used by the Center to baseline safety performance. The target for this Performance Goal is the average of the 10 NASA Centers for the total case incident rate (TCIR) for injuries and illnesses and the days away, restricted, or transferred (DART) due to injuries or illnesses.

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

This Performance Goal aligns to 4.3.1 under the 2018 Strategic Plan.

4.3.1: Achieve zero fatalities or permanent disabling injuries to the public resulting from NASA activities.

The Office of Safety and Mission Assurance, Office of the Chief Health and Medical Officer, and Office of the Chief Engineer ensure safety and mission success by providing independent oversight of NASA's programs and projects. They are supported by the NASA Safety Center and the Katherine Johnson IV&V Facility.

FY 2021 Performance Progress

NASA achieved the FY 2021 target of zero fatalities or disabling injuries to the public or NASA employees during the fiscal year as a result of NASA activities. There was extensive planning and execution of risk mitigation controls prior to all aerospace flight operations and potentially hazardous operations to achieve this performance goal.

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

Level less than 5-year running average.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	$3.85M	$4.38M	At or below $3.8 million (5-year average)	At or below 5-year average (amount TBD)		
Achieved	$4.73M	$1.36M				
Rating	Green	Green				

*The NASA Safety Center analyzes non-mission damage mishaps reported by Centers to the NASA Mishap Information System. The 5-year median is based on this analysis.

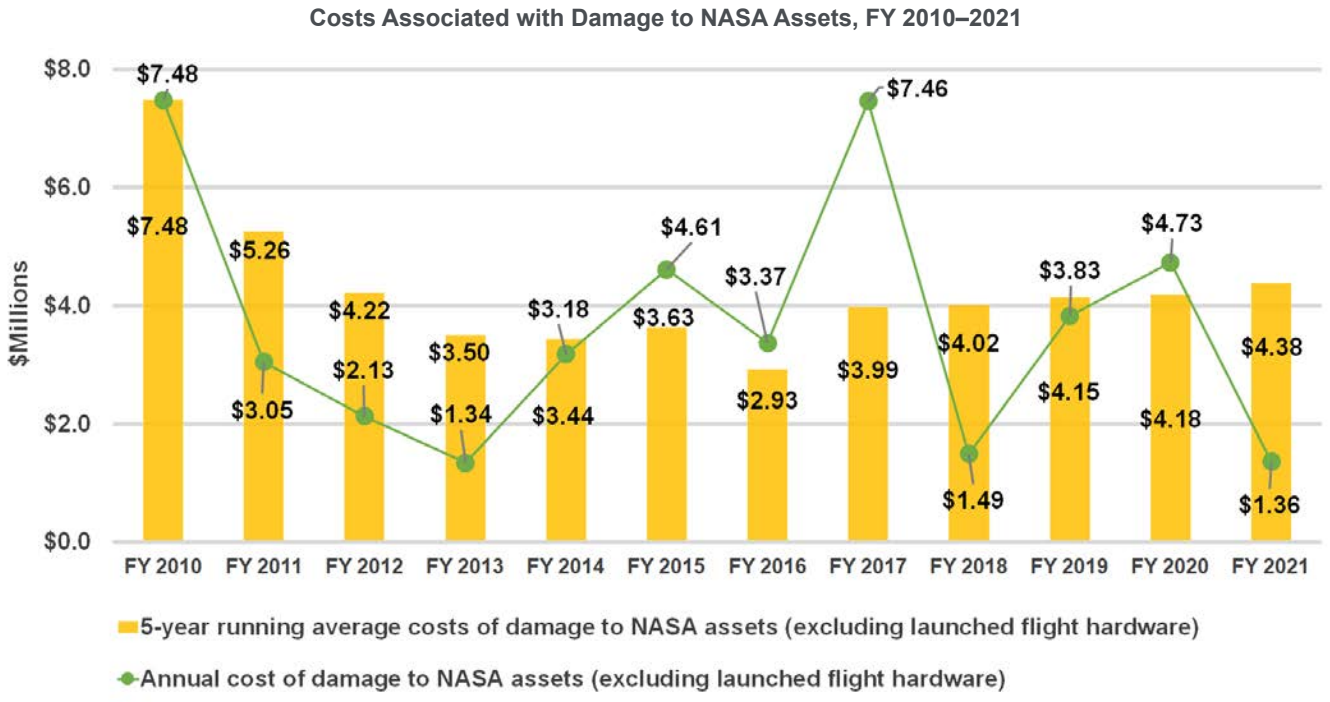
2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

This Performance Goal aligns to 4.3.2 under the 2018 Strategic Plan.

The Office of Safety and Mission Assurance, Office of the Chief Health and Medical Officer, and Office of the Chief Engineer ensure safety and mission success by providing independent oversight of NASA's programs and projects. They are supported by the NASA Safety Center and the Katherine Johnson IV&V Facility.

FY 2021 Performance Progress

In FY 2021, NASA's non-mission-related damage costs were $1.36 million. This is significantly below the historical average (and FY 2021 target) of $4.38 million.



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

Number of non-concurrence determinations and percentage of program variances.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	0 non-concurrences; 5% or fewer program variances		0 non-concurrences; 5% or fewer program variances			
Achieved	0 non-concurrence determinations; 0 program variances					
Rating	Green	Green				

*Successful execution of the mission requires adherence to health and medical policies and standards and indicates that the Health and Medical Technical Authority has successfully supported NASA flight programmatics through ongoing observation and documentation of spaceflight and aeronautics activities and evaluation processes, as well as effective implementation of health and medical standards and operations.

A concurrence is a documented agreement by a management official 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.

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

This Performance Goal aligns to 4.3.3 under the 2018 Strategic Plan.

The Office of Safety and Mission Assurance, Office of the Chief Health and Medical Officer, and Office of the Chief Engineer ensure safety and mission success by providing independent oversight of NASA's programs and projects. They are supported by the NASA Safety Center and the Katherine Johnson IV&V Facility.

FY 2021 Performance Progress

In FY 2021, the Health and Medical Technical Authority (HMTA) issued no non-concurrences with respect to major program milestones. In addition, the HMTA issued fewer than 5 percent program variances from the technical standards.

Meeting these targets enables NASA to accomplish all its missions safely and in the most cost-effective ways. In FY 2021, HMTA developed the appropriate standards, assessed and advised programs on implementation, prioritized amongst and between programs, or evaluated requests for waiver or risk mitigations for all NASA programs that are in development, in a time-critical manner.

In addition, all measures to prevent COVID-19 infection as directed by NASA's Office of the Chief Health and Medical Officer were carefully implemented by essential center civil service and contractor employees.

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

Scoring is based on the mean of three scores, expressed as a percentage, of NASA's critical priorities for implementing the Federal Information Security Modernization Act (FISMA):

1. High Value Asset (HVA) system access management
2. Advanced network and data protections through an Intrusion Prevention System (IPS) and an Intrusion Detection System (IDS)
3. Hardware asset management (HWAM) based on completed initiatives and projects

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	100%*	100%	100%**	100%**		
Achieved	70%	80%				
Rating	Green	Green				

*Target represents the long-term exemplar for this Performance Goal. NASA assesses annual progress based on interim targets.

**Achieve a 100% overall score,* using the mean of:

- HVA (FISMA requirement 2.7)
- IPS & IDS (FISMA 3.4, 3.5), and
- HWAM (FISMA 3.9)

2015	2016	2017	2018	2019
Yellow	Green	Red	Yellow	Yellow

This Performance Goal aligns to 4.5.1 under the 2018 Strategic Plan.

4.5.1: Safeguard NASA's data and IT assets by implementing cybersecurity and privacy capabilities.

The Office of the Chief Information Officer (OCIO) manages the information technology (IT) and data that enable NASA's missions. Through strategic partnering across NASA and with the Department of Homeland Security (DHS), the OCIO is ensuring that critical mission and infrastructure systems have resilient cybersecurity, back-up, and disaster recovery capabilities.

FY 2021 Performance Progress

NASA exceeded the incremental progress expected in FY 2021 for the multi-year Performance Goal target of 100 percent of cybersecurity CAP goal targets met.[1] Beginning in July 2021, NASA met 8 of 10 (80 percent) of the cybersecurity CAP Goal targets on Performance.gov, exceeding our target of meeting at least 70 percent in FY 2021.

NASA achieved this performance by meeting the Data Protection CAP Goal target and continued implementation of Continuous Diagnostics and Mitigation (CDM) cybersecurity capabilities across the Agency. CDM sensors enable cybersecurity personnel to identify assets on the network and vulnerabilities to remediate. As of September 2021, NASA completed 100 percent installation of CDM sensors on the Agency's corporate systems, 93 percent on the Jet Propulsion Laboratory's (JPL's) corporate systems, 94 percent on NASA mission systems, 74 percent on JPL's mission systems.

NASA is below target and is making progress on Hardware Asset Management and High Value Asset (HVA) System Access Management. In FY 2021, NASA implemented an HVA compliance dashboard in the Agency's Risk Information Security

Compliance System that allows Center and Agency leadership to view HVA compliance status. The increased visibility provided by the dashboard enables greater compliance enforcement for NASA's high value assets, which will lead to an improved HVA System Access Management score. Prior to availability of this dashboard, NASA did not have a consistent Agency-wide view of specific HVA compliance.

1 Targets were set according to the IT Modernization Cross-Agency Priority (CAP) Goal supporting the Trump administration President's Management Agenda. External reporting for the CAP Goal was discontinued in January 2021. Information on this CAP Goal can be found in the archives on Performance.gov.

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.

Percentage of test availability* of SETMO portfolio of Tier 1 assets**

*Test availability = (planned capacity – unplanned downtime)/planned capacity. Unplanned downtime is total downtime, including downtime that impacts a test.
**Tier 1 assets: portfolio of assets for which SETMO provides annual sustainment funding. Tier 2 assets: portfolio of assets for which SETMO does not provide annual sustainment funding.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	90%	90%	90%	90%		
Achieved	98%	98.7%				
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

This Performance Goal aligns to 4.2.6 under the 2018 Strategic Plan.

The Space Environments Testing Management Office, part of the Mission Support Directorate, manages NASA's shared capabilities and assets used to conduct testing in a simulated space environments.

FY 2021 Performance Progress

NASA achieved this multiyear Performance Goal by achieving 98.7 percent overall availability of our SETMO Tier 1 assets, exceeding the FY 2021 target of 90 percent availability.

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. Core capabilities include thermal vacuum chambers, simulators, and the Arc Jet Complex located at NASA's Ames Research Center in California. NASA implements strategic investment decisions to sustain, enhance, replace, modify, or dispose of facilities based on NASA's and national needs.

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

Square footage or facilities reduced.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	100k sq ft or 20 facilities					
Achieved	51 facilities (68,250 sq ft)	29 facilities (854k sq ft)				
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

The Office of Strategic Infrastructure, part of the Mission Support Directorate, strategically manages NASA's assets and capabilities to meet mission needs and support Agency operations.

This Performance Goal aligns to 4.6.1 under the 2018 Strategic Plan.

FY 2021 Performance Progress

NASA achieved this multiyear Performance Goal by demolishing 29 facilities or structures, for a total reduction of 854,000 square feet, exceeding both targets for FY 2021.

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. Demolishing these facilities also eliminates the deferred maintenance associated with them and saves operations and maintenance expenses. During FY 2021, our demolition program reduced deferred maintenance by more than $12 million and current replacement value by approximately $138 million.

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

The Office of Strategic Infrastructure, part of the Mission Support Directorate, strategically manages NASA's assets and capabilities to meet mission needs and support Agency operations.

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

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	≥70%	≥70%	100%	100$		
Achieved	71%	71%				
Rating	Green	Green				

2015	2016	2017	2018	2019
Yellow	Yellow	Green	Green	Yellow

This Performance Goal aligns to 4.6.2 under the 2018 Strategic Plan.

FY 2021 Performance Progress

NASA achieved the FY 2021 target for this multiyear Performance Goal by meeting 71 percent of the sustainability goals, with no Red ratings, as reported on the FY 2020 OMB Scorecard for Efficient Federal Operations/Management. Of the seven sustainability areas assessed by OMB, NASA received five Green and two Yellow ratings.

Performance in Efficiency Measures / Investment was Yellow because COVID-19 delayed energy/water evaluations at four of 12 sites, which caused the percentage of facilities evaluated over the past four years to be below the required 90 percent.

Performance in Transportation/Fleet Management was Yellow because a reporting issue in FY 2019 resulted in underreporting of petroleum fuel use in covered fleet vehicles. Because personnel were offsite due to COVID-19, the issue was not discovered on time to correct the error for FY 2019. That underreporting error caused an artificial year-over-year increase from FY 2019 to FY 2020. We have corrected the error.

The Federal Agency Progress Data and OMB Scorecards site provides data for each sustainability category and a link to our sustainability report.

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

The Office of Strategic Infrastructure, part of the Mission Support Directorate, strategically manages NASA's assets and capabilities to meet mission needs and support Agency operations.

Percentage of maintenance funds* dedicated to unscheduled maintenance.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	1% below 23.7%*	1% below 21.34%	20% or less	20% or less		
Achieved	21.34%	17.37%				
Rating	Green	Green				

*Includes Office of Strategic Infrastructure funds only.

2015	2016	2017	2018	2019
None	None	Red	Red	Green

This Performance Goal aligns to 4.6.3 under the 2018 Strategic Plan.

FY 2021 Performance Progress

NASA achieved this multiyear Performance Goal by keeping the ratio of unscheduled maintenance to total maintenance well below the FY 2021 target of 21.34 percent. NASA's achieved a performance of 17.37 percent which is the lowest ratio of unscheduled maintenance to total maintenance since the baseline was set at 31.6 percent in 2015.

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. As NASA increases the use of Condition Based Maintenance, unplanned failures become scheduled maintenance as potential failures are detected before they occur. This has also contributed to an improvement in this metric.

4.1.1 [Completed at end of FY 2021]: Maintain the number of active partnership agreements with domestic, interagency, and international partners that support and enable NASA's mission.

Number of milestones met.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	2,404	2,404				
Achieved	2,872	2,752				
Rating	Green	Green				

2015	2016	2017	2018	2019	2020
Green	Green	Green	Green	Green	Green

NASA's Partnership Office and the Office of International and Interagency Relations (OIIR) engage in non-procurement partnerships with international, intergovernmental, academic, industrial, and entrepreneurial entities, recognizing them as important contributors of skill and creativity to NASA missions. The Mission Support Directorate (MSD) oversees services provided by the Partnership Office.

FY 2021 Performance Progress

NASA achieved the Performance Goal for partnership agreements in FY 2021. At the end of FY 2021, NASA had 2,163 domestic and 589 international active partnership agreements, for a total of 2,752 agreements (exceeding the target of 2,404).

To expand the Agency's strategic partnerships and meet our mission objectives, we focused on outreach efforts to attract new, non-traditional organizations, while continuing to expand partnerships with existing partners. NASA personnel across the Agency conducted numerous outreach meetings and participated in virtual forums and conferences identifying and engaging with potential partners.

Due largely to these and other similar outreach initiatives, NASA entered into partnership agreements with 107 new (first-time) non-Federal partners. Reaching new audiences regarding NASA partnership opportunities and increasing the number and types of new partners benefits the Agency by cultivating new and innovative collaboration opportunities to help advance NASA's missions.

4.1.2 [Completed at end of FY 2021]: Procure common goods and services as an enterprise to eliminate redundancies, increase efficiency, and deliver more value and savings.

Percentage of NASA's total common spending obligated on Agency, government-wide, or best-in-class (BIC) contracts consistent with NASA's Category Management Plan and the Spend Under Management (SUM) key performance indicator.

NASA's Office of Procurement provides innovative, effective, and efficient acquisition solutions, optimizing Agency capabilities and operations and enabling NASA's missions.

Fiscal Year	2021	2022
Target	SUM = $4.8B (60%) BIC = $173.7M (5%)	
Achieved	SUM = $5.75B (75.4%) BIC = $150.6M (3.7%)	
Rating	Yellow	

FY 2021 Performance Progress

NASA exceeded the FY 2021 SUM target of $4.8 billion, indicating that NASA's Office of Procurement is committed to using Government-Wide Category Management principles (see the Federal guide to Category Management), eliminating contract redundancies, and using Best-in-Class contract vehicles. The BIC target has historically been a challenge due to most BIC contracts not being in key NASA mission areas. We were slightly below the FY 2021 target of $173.7 million: obligating $150.6 million.

4.5.2 [Completed at end of FY 2021]: Improve the security of the NASA operational technology (OT) systems that are part of NASA Critical Infrastructure (NCI) in order to ensure they operate safely and securely in the face of the changing threat environment.

The Enterprise Protection Program is works with the Office of the Chief Information Officer and offices across the Agency to ensure the security of NASA's operational technology.

Percentage of OT systems that are part of NCI that have been assessed and granted an Authorization to Operate (ATO) in accordance with the Risk Management Framework (RMF), as outlined in National Institute of Standards and Technology (NIST) 800-37 and NASA policies and requirements.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	100%*	100%				
Achieved	50%	64.6%				
Rating	Green	Green				

*Target represents the long-term exemplar for this performance goal. NASA assesses annual progress based on an interim target.

2015	2016	2017	2018	2019
None before FY 2019				Green

FY 2021 Performance Progress

NASA exceeded the incremental progress expected in FY 2021 toward the multi-year Performance Goal target of 100 percent operational technology systems receiving an ATO. We made progress on improving the security and resiliency of the Agency's operational technology systems and are on track to achieve the target for this multi-year Performance Goal to ensure safe and secure operation of NCI.

By the end of FY 2021, the Agency identified all operational technology systems that are part of NCI and validated that 64.6 percent of operational technology systems that are part of NCI were assessed and granted an ATO in accordance with Risk Management Framework as outlined in NIST 800-37 and NASA policies and requirements. This result exceeded our target of meeting at least 50 percent in FY 2021. The Agency continued implementing policy revisions to include requirements related to operational technology security.

Strategic Objective 4.3

Build the next generation of explorers.

LEAD OFFICES
Office of Science, Technology, Engineering, and Mathematics (STEM) Engagement (OSTEM)

GOAL LEADER
Kris Brown, Deputy Associate Administrator for Strategy and Integration, OSTEM

Budget

	FY	$M
Op Plan	2021	$135.5
Requested	2022	$155.7
Requested	2023	$158.9
Outyear	2024	$162.1
	2025	$165.3
	2026	$168.6
	2027	$172.0

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. Given the Nation's need for a skilled STEM workforce and projected demand, NASA clearly has a vested interest in attracting, engaging, and preparing its future STEM professionals. The national STEM ecosystem will benefit from NASA contributions to attract and retain students on STEM pathways, with increased attention on underserved and underrepresented students. Recent national and international tests show that in the last decade, U.S. students have demonstrated little or no growth in mathematics and remain ranked in the

Below:NASA astronaut Victor Glover speaks with students from Cardozo Educational Campus, Friendship Technology Preparatory High School, McKinley Technical High School, Phelps High School, and Wilson High School about his time aboard the International Space Station, November 18, 2021, at Ben's Chili Bowl in Washington, DC. Image Credit: NASA/Joel Kowsky

middle of advanced economies on international science and mathematics assessments[1].

NASA will implement strategies to broaden student participation to increase diversity, equity, inclusion, and accessibility (DEIA) in STEM through NASA opportunities and activities. While the number of women and underrepresented minorities earning STEM degrees has grown in broad science and engineering occupations over the last decade, significant underrepresentation remains in areas critical to NASA like engineering and computer and mathematical sciences[2]. NASA is committed to building a diverse, skilled future STEM workforce—our next generation of explorers with the technical skills needed to carry forward our Nation's vital mission and work in aeronautics and space into the future.

Below: SpaceX Crew-1 NASA astronauts, from left, Shannon Walker, Mike Hopkins, and Victor Glover read a book to students from the Learn DC public charter school at Joint Base Anacostia-Bolling (JBAB), November 19, 2021, in Washington, DC. Image Credit: NASA/Aubrey Gemignani

1 Science Board, National Science Foundation. 2020. Science and Engineering Indicators 2020: The State of U.S Science and Engineering. NSB-2020-1. https://ncses.nsf.gov/pubs/nsb20201/

2 National Science Foundation, National Center for Science and Engineering Statistics. 2019. Women, Minorities, and Persons with Disabilities in Science and Engineering: 2019. Special Report NSF 19-304.

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

Number of paper presentations and peer-reviewed research publications resulting from higher education students' engagement in STEM engagement investments.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target			1,800	1,800		
Achieved						
Rating						

NASA STEM Engagement encompasses all endeavors Agency-wide to attract, engage and educate K-12 and higher education students and to support educators, educational institutions and professional organizations in STEM fields.

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

Percentage of higher education significant awards in four categories of student diversity for NASA STEM enrollees compared to the national average.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	Baseline is measured for 4 categories		Meet or exceed targets for 2 of the 4 categories			
Achieved	Baseline is measured for 4 categories					
Rating	Green	Green				

**Higher education significant awards are made through the National Space Grant College and Fellowship Project, Minority University Research and Education Project, Internship and Fellowship programs, and Mission Directorates (funded internships). Note: NASA rates progress on this performance goal with the use of data reported on the academic calendar. Thus, the FY 2021 rating is based on data from the 2019-2020 academic calendar.

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

This Performance Goal aligns to 3.3.3 under the 2018 Strategic Plan.

3.3.3 [Completed at end of FY 2021]: Provide opportunities for students, especially those underrepresented in STEM fields, to engage with NASA's aeronautics, space, and science people, content, and facilities in support of a diverse future NASA and aerospace industry workforce.

FY 2021 Performance Progress

NASA met the target for Performance Goal 3.3.3. NASA set the following four baseline percentages for higher education significant awardees who self-identified belonging to an underrepresented category: 1) 17.3% race; 2) 16.9% ethnicity; 41.6% gender; 1.4% disability. The percentages were based on analysis of performance data on higher education awards (including internships, fellowships, and sustained engineering design challenge opportunities) NASA provided for the 2019-2020 academic year to students from groups historically underrepresented in STEM.

NASA established baseline percentages of higher education significant awards to students across all institution categories (e.g., 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) and levels (at least two but less than four years, and four or more years), as defined by the U.S. Department of Education.

NASA STEM Engagement encompasses all endeavors Agency-wide to attract, engage and educate K-12 and higher education students and to support educators, educational institutions and professional organizations in STEM fields.

Looking forward, NASA will continue to assess annual progress against national averages obtained from the U.S. Department of Education's National Center for Education Statistics. However, we will evaluate year-to-year progress based on actual results starting from this baseline.

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.

Complete milestone(s) to develop, pilot, and assess strategies and/or systems to improve access, navigability, and usability of NASA STEM Engagement products and learning opportunities aimed at attracting diverse groups of students to STEM.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target			1	1		
Achieved						
Rating						

Milestones for FY 2022

1. Develop and pilot strategies and/or systems to improve access, navigability, and usability of NASA STEM Engagement K-12 products and learning opportunities (including the Office of STEM Engagement's Next Gen STEM project and Mission Directorate K-12 activities) aimed at attracting diverse groups of students to STEM.

Milestones for FY 2023

1. Increase utilization of select NASA STEM Engagement products and/or learning opportunities (including the Office of STEM Engagement's Next Gen STEM project and Mission Directorate K-12 activities) by 10%.

NASA STEM Engagement encompasses all endeavors Agency-wide to attract, engage and educate K-12 and higher education students and to support educators, educational institutions and professional organizations in STEM fields.

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.*

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	90%	90%	100%	100%		
Achieved	90%	100%				
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Green	Green	Green	Green

*NASA reviews 2-3 grant recipient institutions annually (through on-site and desk audits), issuing recommendations and/or corrective actions where needed, to ensure compliance with equal opportunity laws and mandates.

The Office of Diversity and Equal Opportunity leads diversity and civil rights policies, programs, and services, enabling the universe of available talent to contribute inclusively and equitably to NASA.

This Performance Goal aligns to 3.3.2 under the 2018 Strategic Plan.

3.3.2: Promote equal opportunity and encourage best practices among NASA grant recipient institutions.

FY 2021 Performance Progress

NASA achieved the FY 2021 target for this Performance Goal. We determined that 100 percent of the three funding recipients for which compliance monitoring was completed in FY 2021 (Science Museum of Minnesota, University of Nebraska at Omaha, and Virginia Air and Space Center) were compliant with our equal opportunity recommendations and corrective actions.

During FY 2021, NASA also initiated compliance monitoring on a fourth funding recipient, Louisiana State University (LSU). While compliance monitoring of LSU continues into FY 2022, LSU implemented all of the corrective actions during FY 2021.

3.3.1 [Complete at end of FY 2021]: Increase NASA's public engagement through social media.

Percentage of annual social media audience growth as measured by the number of total followers across all flagship platforms. This metric is tracked on a recurring basis month-over-month.

Fiscal Year	2020	2021	2022	2023	2024	2025
Target	10%	10%				
Achieved	19.5%	14.5%				
Rating	Green	Green				

2015	2016	2017	2018	2019
Green	Yellow	Green	Green	Green

The Office of Communications serves as the corporate, Agency-wide communications function for NASA, providing a wide practicable and appropriate dissemination of information to news and media organizations and the public concerning the objectives, methods, and results of NASA programs. OCOMM connects people to NASA's missions and accomplishments as we explore the unknown, enable technologies for improving life on Earth, and inspire the world.

FY 2021 Performance Progress

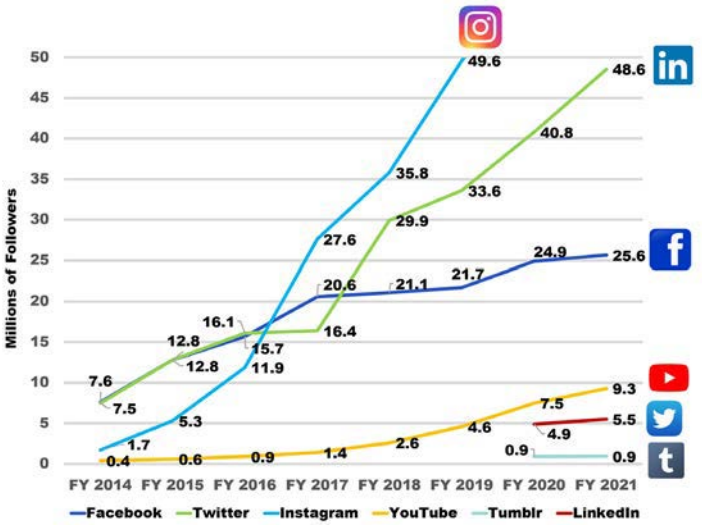
NASA's flagship social media platforms grew by 19.5 percent during FY 2021, exceeding the annual target of 10 percent for this Performance Goal. NASA continues to integrate metrics and use data to inform decisions on better reaching the public, engaging stakeholders, and evaluate outcomes. We also continue to use data to refine content and social media distribution platforms, targeted to audience preferences.

In FY 2021, large, popular events and major activities, including the OSIRIS-REx Touch-and-Go event, NASA's SpaceX Crew-1 launch and splashdown, Sentinel-6 Michael Freilich Satellite Launch, Green Run Hot Fire Test 1 and 2 (Artemis), Mars 2020 Perseverance Landing, Mars Ingenuity First Flight, Earth Day 2021 and Crew-2 Launch, drove an increase in followers of Agency flagship digital accounts.

Current growth numbers on flagship social accounts:

- Facebook: +3%
- Twitter: +19%
- Tumblr: +5%
- Instagram: +15%
- LinkedIn: +13%
- YouTube: +24%

In FY 2021, NASA also completed the design of an integrated Agency communications team through the Mission Support Future Architecture Program (MAP). Under this program, the Agency has aligned communications governance and resources to enable the communications enterprise to operate more efficiently and sustainably. The newly established communications enterprise management office is instituting business process improvements that will better enable the enterprise to keep the public informed about NASA's activities.



Teams at NASA's Kennedy Space Center in Florida are working to ensure the crawlerway, the path the crawler-transporter 2 (CT-2), mobile launcher, and Space Launch System rocket with Orion atop will take from the Vehicle Assembly Building to Launch Complex 39B, is strong enough to withstand the weight of, and provide stability for, Artemis I. In this view, taken on January 22, 2021, CT-2 carries the mobile launcher platform 1 that was used during the Shuttle program. It was driven back and forth on the crawlerway with several cement blocks, each weighing about 40,000 pounds, to strengthen the crawlerway for launch. Artemis I will be the first in a series of increasingly complex missions to the Moon. Under the Artemis program, NASA aims to land the first woman and the first person of color on the Moon and establish sustainable lunar exploration by the end of the decade. Image credit: NASA/Kim Shiflett

Appendixes

Appendix A: FY 2023 Annual Evaluation Plan

Appendix B: FY 2021 Summary of Progress by Strategic Objective

Appendix A: FY 2023 Annual Evaluation Plan

NASA's FY 2023 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 (OPEN) Government Data Act, and the Confidential Information Protection and Statistical Efficiency Act (CIPSEA). The Evidence Act Title I requires Chief Financial Officer (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 Agency 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.

Evaluation Culture

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.

Above: NASA astronaut Stephanie Wilson poses for a portrait, September 16, 2020, in the Blue Flight Control Room at NASA's Johnson Space Center in Houston, Texas. Image Credit: NASA/Bill Ingalls

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) 2200.2D – 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 5 of NPR 2200.2D 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.

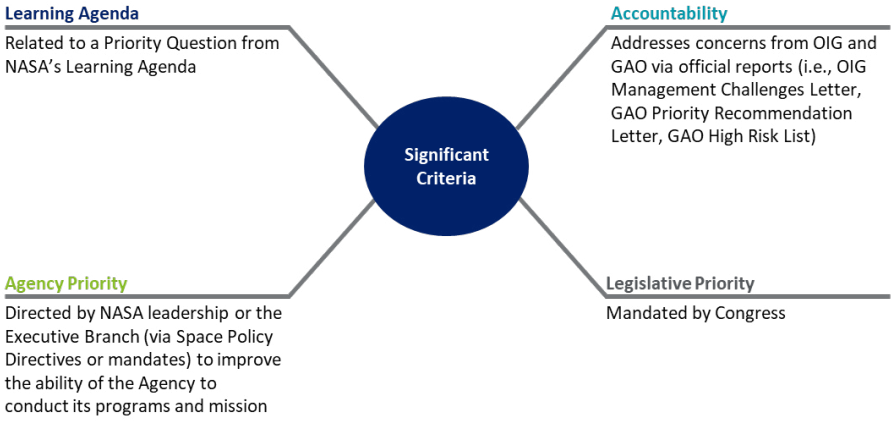
Table 1. Dissemination and Sharing Summary

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 2023 Significant Evaluations

Technology Investment

NASA invests in innovative early stage technology concepts that could lead to future breakthrough capabilities and enable new paradigms or new mission types in the longer-term. NASA is evaluating its strategy for investments in early stage innovation that help enable these potential breakthroughs of tomorrow. Diversity is a key aspect of an early stage investment and partnership strategy. Enabling technology breakthroughs of the future requires NASA to look to diverse sources for ideas and innovation. Companies—small and large, academia, research institutions, students, individual inventors and hobbyists, NASA researchers and others can all provide rich inputs to a thriving innovation ecosystem.

NASA's STMD early stage programs have encouraged participation from underserved and underrepresented communities—including women and women-owned businesses; socially and economically disadvantaged individuals, businesses, and research institutions; and entrepreneurs living in or whose businesses are located and operate in states with a lower number of awards—in technology development activities through outreach activities. For example, the Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR), NASA Innovative Advanced Concepts (NIAC), and the Space Technology Research Grants (STRG) programs have increased their outreach and communications to underserved and underrepresented communities, including Historically Black College and Universities (HBCU) and Minority Serving Institutions (MSI). The SBIR/STTR programs have supported 15 Technology Infusion Road tours which have attracted over 1,200 participants and have resulted in some increased participation in STTR proposals. From 2010-2020, approximately 10% of SBIR/STTR Phase I awards have been to minority owned firms. Additionally, NIAC has seen an increase in female grant awardees from 5.6% in 2013 to 12% in recent years. STRG's largest awards – the four Space Technology Research Institutes (STRIs) – all feature MSI participation. One STRI is now led by an MSI university, which recently achieved MSI status, post award. Despite these improvements, NASA believes that more MSIs and HBCUs could be engaged and contributing to space technology research and innovation.

Outreach alone does not sufficiently address the underlying factors that create challenges for underserved and underrepresented community participation, thus limiting NASA's community of innovation. Efforts to understand the core capabilities that exist at HBCUs and MSIs and to identify synergies between those capabilities and NASA core competencies will help NASA develop a more effective platform of information sharing and relationship building with HBCUs/MSIs. Additionally, working with a third party deeply familiar with the challenges HBCUs and MSIs face in securing government research funding and identifying small business partners will enable NASA to evaluate relevant factors related to its goals. Through these efforts, NASA seeks to develop a more diverse pipeline of innovative solutions and increase HBCU/MSI access to funding and small business partners.

Accordingly, over the last couple years, NASA has begun piloting new approaches to engagement with HBCUs and MSI. In August 2020, through the Minority University Research and Education Proj-

ect (MUREP) Space Technology Artemis Research (M-STAR) initiative, NASA awarded $604,000 to 15 HBCUs and MSIs to strengthen and develop research capacity in areas of strategic importance to NASA STMD. In August 2021, NASA then awarded 11, $50,000 planning grants through the MUREP-STTR (M-STTR) initiative specifically to foster partnerships between MSIs and small businesses and prepare them to submit technology proposals to NASA's annual STTR Phase I solicitation. Also during 2021, SBIR/STTR entered a five-year cooperative agreement with the MSI STEM Research and Development Consortium (MSRDC) to leverage their work in connecting HBCUs and MSIs with research and development sponsors, and to gain additional insights into specific factors that may influence HBCU and MSI participation in NASA SBIR/STTR.

During FY 2022, NASA anticipates that we will have evaluated the results of the aforementioned MUREP initiatives, with particular focus on M-STTR grantee participation and success in the STTR Phase I solicitation process. Also, during FY 2022, we anticipate that our partnership with MSRDC will have resulted in a formative evaluation, identifying an array of factors that potentially serve as challenges or barriers to entry for HBCU and MSI participation in NASA SBIR/STTR. The results of our FY 2022 evaluation activities will directly inform our FY 2023 evaluation.

Building on our FY 2022 results, NASA will select specific factor(s) that show significant potential to expand NASA's early stage innovation community through increased HBCU and MSI contribution. We will then design and implement at least one targeted impact evaluation in FY 2023 to test the impact of NASA intervention related to the identified factor(s). NASA plans to work closely with both the GSA Office of Evaluation Services (OES) and MSRDC to develop the experimental design and conduct the evaluation.

Theory of Change

If NASA can better understand the core capabilities that exist at HBCUs and MSIs, identify synergies between those capabilities and NASA core competencies, and directly address specific factors that serve as potential barriers to entry, then NASA will see increased HBCU and MSI participation in early stage innovation programs, which will ultimately lead to an expanded, more diverse innovation community and result in more novel ideas to seed tomorrow's space technology breakthroughs.

Data and Information

This evaluation will undertake active data collection through MSRDC, who will work directly with

HBCUs and MSIs as well as from customer experience surveys. In addition, existing data from the program's proposal processes, including M-STTR results, will be analyzed.

Source	Purpose
MSRDC data	Understand present trends from HBCUs and MSIs.
Existing data	Collect data from past awardees through annual STTR proposal processes that will supplement active data gathering to analyze and determine trends. Analyze results of the M-STTR initiative.
Section 280 customer experience clearance	Learn more about what made past awardees successful and what part of their customer experience with the STTR program may have discouraged participation or success, if any.

Methods to be used and Evaluation Design

NASA will undertake an experimental design process evaluation to understand strategies to increase HBCU and MSI contributions. This will be a mixed-method evaluation. Qualitative and quantitative approaches will be used in the implementation study. This evaluation design will be refined through a partnership with GSA's Office of Evaluation Science (OES) in FY 2022.

Inputs	Capture quantitative and qualitative data for research institution capabilities through an MSRDC. Quantitative data example: number of HBCUs/MSIs that submit capabilities and/or number that have technology areas where there is a great deal of synergy, some synergy, or little to no synergy with NASA core competency areas. Qualitative data example: Awareness of the existence of the capabilities submission database and understanding its benefits.
	Capture and analyze STTR past participation data.
	Consider insights from NASAs MUREP.
	Consider surveys past successful STTR awardees through our Section 280 customer experience clearance to see which parts of their experience with the program most contributed to successful partnering between RIs and small businesses.
Processes	Identify the factor(s) within NASA's span of control (outreach, networking, funding, technical and business assistance, etc.) that are most relevant when considering partnerships between HBCUs/MSIs and small businesses and any negative impacts.
	Analyze what synergies can be made to inform which mechanism might best support engagement and ways to experiment with incentives that encourage engagement.
	Conduct pilot/experiment to test NASA's ability to address identified factor(s) in HBCU/MSI participation.
Expected Outputs	Inform and update the policy to increase the number of HBCUs and MSIs that are awarded STTRs to bring diverse ideas to NASAs missions and expand NASA's economic impact in underrepresented communities.

Challenges
Since the HBCU/MSI community is small, getting enough participants will rely on active marketing through a well-connected community intermediary. The ability to get qualitative data about past successful STTR awardee partnership characteristics will be limited by the size of the pool and their willingness to provide information. NASA seeks to leverage MSRDC's long standing relationships with the HBCU/MSI community to communicate results and provide study data.

Dissemination Strategies
The results will be shared broadly within NASA to all programs concerned with increasing the participation of underserved and underrepresented communities, with the caveat that this evaluation will focus on the intersection of successful small business and research institution partnerships—a core part of lab-to-market efforts. These results could inform experiments as programmatic strategies to be considered by other programs that engage the small business, entrepreneur or research community within other early stage programs, the Office of STEM Engagement (OSTEM), and the Office of Small Business Programs (OSBP). Evaluation results would benefit other agencies' SBIR/STTR programs and the Small Business Administration on ways to increase participation.

Timeframe
The evaluation design will be finalized in FY 2022, and evaluation will occur by the end of FY 2023.

Industrial Base
NASA and the Department of Commerce's Bureau of Industry and Security (BIS), National Oceanic and Atmospheric Administration (NOAA), National Environmental Satellite, Data, and Information Service (NESDIS), will conduct an evaluation of the factors that drive efficiency in the NASA and United States civil space supply chain network.

This multi-year collaboration will build upon a substantial record of space sector analysis conducted between BIS, NASA and the broader U.S. Government (USG) to identify traits that benefit or impede the current health and competitiveness of the civil segment of the U.S. Space Industrial Base (SIB). Early findings will also inform the planning and execution of the civil space provisions of the 2020 National Space Policy (NSP). NASA and DOC (NOAA) seek visibility into the current and prospective performance of the civil space community to achieve enhanced situational awareness in times of uncertainty. Furthermore, survey responses from firms in the sector are expected help illuminate the impacts of COVID-19, M&A, disruptive

technology, changing workforce dynamics and other supply chain issues.

Theory of Change

If NASA can better understand the industrial base ecosystem in the civil space sector, then NASA may be able to better forecast pressures, anticipate risks, and mitigate against forces that obstruct the aerospace supply chain to drive adaptability and enhance decision making.

Evaluation Question(s)

What are the underlying factors and to what extent do these factors affect the aerospace industrial base to support Federal civil space acquisition and development?

NASA will evaluate this question through a survey and analysis that looks at the supply chain and underlying factors related to the aerospace industrial base. This evaluation seeks to address impacts to the aerospace supply chain through the following factors:

- Impacts from the COVID-19 pandemic;
- Corporate financial distress;
- Mergers and acquisitions;
- Costs related to foreign sourcing, offshoring of critical supply chain components, and alternatively, reshoring;
- Disruptive new technologies, including advances in artificial intelligence, quantum computing, and additive manufacturing;
- Changing workforce dynamics including emphasis on STEM practices;
- Cybersecurity investments and cybercrime impacts; and
- Constraints related to U.S. Federal acquisition reforms.

Data and Information

The survey instrument is currently in work and has not been finalized. Preliminary sources of data are outlined below.

Source	Purpose
Survey responses	Accurate responses from the firms regarding corporate operations, structure, financials, and tech development.
Publicly Available Information	Some publicly-traded firms file annual reports and 10-K filings, providing additional insight into the corporation.

Methods to be used and Evaluation Design

NASA will undertake a non-experimental formative evaluation design to analyze survey results, including a time series analysis of responses over the course of three observation years:

- FY 2021: Survey development, testing, distribution, and organization of mailing list and portal hosted by the Census Bureau;
- FY 2022: Survey analysis of roughly 500 completed survey responses in Wave 1 compiled, analyzed, briefed and shared;
- FY 2023: Survey analysis and comparison of roughly 500 – 1,000 completed survey responses in Wave 2 compiled, analyzed, briefed, and shared.

Further evaluation design details are under discussion, with several options, techniques, and tools under consideration. Final determination is expected to be made by the end of the calendar year 2021.

Challenges

Anticipated challenges include willingness of survey respondents to provide detailed current and historical information regarding performance, financials, and supply chain issues. Additional challenges include ability of analysts to evaluate large datasets and assess impacts to NASA and other space agencies.

Dissemination Strategies

A final dissemination plan has not yet been approved. Initial considerations suggest a wide dissemination within NASA to all impacted programs, the broader U.S. civil space community, including primary space

agencies and associated partners. In addition, a summary of findings is likely to be disseminated to relevant stakeholders including the Administration, Congress, industry, academia, and the public.

Timeframe
The timeframe for this evaluation is FY 2021–FY 2023.

Internship Outcomes
The purpose of the Internship Outcome Assessment Year 2 Study is to measure students' immediate outcomes of participating in a NASA internship and assess how and to what extent interns are contributing to NASA's missions. Additionally, this study will identify sources of group differences and address how NASA can continue to broaden participation of students from historically underrepresented groups in STEM fields. This study will build upon the Year 1 findings, expanding the scope of the pre-post assessment and comparing Year 1 findings to Year 2 findings. The results of this study are intended to be used for programmatic improvement.

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.

Evaluation Question(s)
The following evaluation questions may guide the approach and design of this outcome assessment:

1. To what extent is participation in NASA internships associated with
   a. intern satisfaction with the program?
   b. interns' self-reported gains in science and research-related outcomes?
   c. interns' likelihood to pursue future STEM-related activities, education, and careers?
2. Are there any differences in interns' reports based upon underrepresented group status?
3. What insight do mentors provide on the intern program?
4. How do mentors characterize interns' contributions to NASA's missions?
5. Do interns demonstrate growth toward mastery of 21st Century Skills across the duration of the internship as assessed by their mentor?

Data and Information

Source	Purpose
Intern Survey	The Intern Survey is a questionnaire adapted from the Department of Defense (DOD) Army Educational Outreach Program (AEOP). We modified the survey to fit the contextual circumstances, vision, goals, and objectives of NASA's internship program. The questionnaire addresses the following areas of interest: 1. Satisfaction with the internship program resources and features. 2. Experiences with promising teaching and mentoring practices. 3. Gains in science and research-related outcomes. 4. Likelihood to pursue future STEM-related activities, education, and careers.
Mentor Survey	The Mentor Survey is a questionnaire adapted from the Department of Defense (DOD) Army Educational Outreach Program (AEOP). We modified the survey to fit the contextual circumstances, vision, goals, and objectives of NASA's internship program. The questionnaire addresses the following areas of interest: 1. Satisfaction with the internship program resources and features. 2. Use of promising teaching and mentoring practices. 3. Perceived intern gains in science and research-related outcomes.

21st Century Skills Assessment	The 21st Century Skills Assessment is an objective assessment measure that is completed by each interns' mentor regarding their progress toward mastery of important 21st Century skills (Sondergeld & Johnson, 2016). Mentors assess each intern in a pre/post manner. The first assessment will be completed in the first days of the program (pre). The second assessment will be completed at the end of the program (post). The assessment is used to determine the growth toward mastery for each participant during their time in the internship. Mentors rate each participants' skills in six domains of 21st Century skills: 1. Creativity and Innovation 2. Critical Thinking and Problem Solving 3. Communication, Collaboration, Social, and Cross-Cultural Skills 4. Information, Media, & Technological Literacy 5. Flexibility, Adaptability, Initiative, and Self-Direction 6. Productivity, Accountability, Leadership, and Responsibility

Methods to be used and Evaluation Design

This study will use both quantitative and qualitative methods to analyze survey data. Quantitative data will be summarized using descriptive statistics such as numbers of respondents, frequencies and proportions of responses, average response when responses categories are assigned to a Likert scale (e.g., 1 = "Never Used" to 4 = "Used Every day"), and standard deviations. Emergent coding will be used for the qualitative data to identify the most common themes in responses.

Inferential statistics will be used to identify sources of group differences and in support of NASA's goal to broaden participation of historically underrepresented groups in STEM fields. Statistical significance will be determined with t-tests, chi-square tests, or various non-parametric tests as appropriate, with significance defined at $p < 0.05$. Because statistical significance is sensitive to the number of respondents, it is more difficult to detect significant changes with small numbers of respondents. Therefore, practical significance, also known as effect size, will be reported when differences are statistically significant.

21st Century Skills Assessment data will be analyzed using 2-Between, 2-Within Repeated-Measures ANOVAs to examine potential differences from pre- to post-observation by underrepresented group status and setting. Descriptive and inferential statistics will be included.

Inputs	Participation in NASA Internship Program
Processes	Engagement in authentic research experience
	Exposure to evidence-based teaching and mentor practices
Expected outputs	Gains in science and research-related outcomes
	Gains in 21st Century Skills

Challenges

We strive to execute a utilization-focused evaluation that provides data that is useful for continual programmatic improvement and evidence-based decision-making. Thus, we anticipate challenges related to the practical trade-offs that must be considered in less than ideal, or "real world" contexts. The table below identifies three common evaluation challenges for utilization-focused evaluation and corresponding pragmatic principles that are relevant to this study (Patton, 2015).

Table 1. Challenges of utilization-focused evaluation (Excerpt from Patton, 2015, p. 156)

Evaluation Challenge	Pragmatic Principle
1. 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.
2. Providing methodologically rigorous data on important questions.	The meaning of "rigor" depends on context. Rigor includes not just validity and accuracy but whether the findings are actionable and useful.
3. Providing comprehensive findings.	Timeliness trumps comprehensiveness. Less is more when the evaluation can cut to the chase and focus on what is most useful.

Additionally, to ensure a high-quality evaluation is conducted, we have used the program evaluation standards for evaluator credibility (U1 Evaluator Credibility) and conflicts of interest (P6 Conflicts of Interest) to assess the evaluator's potential bias. To address evaluator credibility, the independent contractor conducting the evaluation, has selected highly qualified, experienced program evaluators to design and conduct this study. The individuals selected to design and conduct this evaluation are independent from the policies, decision-making, operations, and/or implementation of the activities which are the subject of this investigation.

Table 2 lists the primary risks associated with the study and the management strategies that will be used to minimize these risks.

Table 2. Risk mitigation strategy

Potential Issues & Risks	Management Strategies
1. Schedule Slippage	• A schedule of tasks and milestones will be created for the study. The schedule will be closely monitored by the evaluator and NASA. Any potential schedule slippage will be addressed.
2. Evaluator or Researcher Credibility	• This study will meet the Joint Committee on Standards for Educational Evaluation (JCSEE, 2011) Program Evaluation Standard U1: Evaluator Credibility – evaluations should be conducted by qualified people who establish and maintain credibility in evaluation context. • The Evaluators/Researchers are Ph.D.-credentialed staff with expertise in higher education STEM teaching and learning, education program evaluation, and education research. • The data collected during this investigation, data analysis, and findings will be reviewed by two experienced program evaluators.
3. Conflicts of Interest	• This study will meet the Joint Committee on Standards for Educational Evaluation (JCSEE, 2011) Program Evaluation Standard P6: evaluations should openly and honestly identify and address real or perceived conflicts of interests that may compromise the evaluation. • Potential conflicts of interest between the evaluator's (i.e. independent contractor) implementation and evaluation of NASA's STEM Engagement higher education activities 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 Advisory Council.

Timeframe

This study will take place in FY 2022-FY 2023.

Appendix B: FY 2021 Summary of Progress

On June 22, 2021, NASA held the last Strategic Review focused on the 13 Strategic Objectives aligned to our *2018 Strategic Plan*. The table below shows the results—Noteworthy Progress, Satisfactory Performance, or were a Focus Area for Improvement for 2018 through 2021. In April 2022, NASA will begin the first Strategic Review for the Strategic Objectives described in the *2022 Strategic Plan*.

2018 Strategic Objective	2018	2019	2020	2021
1.1: Understand the Sun, Earth, Solar System and Universe	Satisfactory	Satisfactory	Satisfactory	Satisfactory
1.2: Understand Responses of Physical and Biological Systems to Spaceflight	Noteworthy	Noteworthy	Satisfactory	Satisfactory
2.1: Lay the Foundation for America to Maintain a Constant Human Presence in Low Earth Orbit	Noteworthy	Noteworthy	Satisfactory	Satisfactory
2.2: Conduct Exploration in Deep Space, Including to the Surface of the Moon	Satisfactory	Focus Area	Focus Area	Satisfactory
3.1 Develop and Transfer Revolutionary Technologies to Enable Exploration Capabilities for NASA and the Nation	Satisfactory	Satisfactory	Satisfactory	Satisfactory
3.2: Transform Aviation Through Revolutionary Technology Research Development, and Transfer	Satisfactory	Satisfactory	Satisfactory	Satisfactory
3.3: Inspire and Engage the Public in Aeronautics, Space and Science	Satisfactory	Satisfactory	Satisfactory	Satisfactory

Above: NASA Administrator Bill Nelson talks to the Agency's workforce during his first State of NASA event on June 2, 2021, at NASA Headquarters Mary W. Jackson Building in Washington. Nelson remarked on his long history with NASA, and among other topics, discussed the Agency's plans for future Earth-focused missions to address climate change and a robotic and human return to the Moon through the Artemis program, as well as announcing two new planetary science missions to Venus, VERITAS and DAVINCI+. Image Credit: NASA/Bill Ingalls

4.1: Engage in Partnership Strategies	Satisfactory	Satisfactory	Satisfactory	Satisfactory
4.2: Enable Space Access and Services	Satisfactory	Satisfactory	Satisfactory	Noteworthy
4.3: Assure Safety and Mission Success	Satisfactory	Focus Area	Satisfactory	Focus Area
4.4: Manage Human Capital	Satisfactory	Noteworthy	Satisfactory	Satisfactory
4.5: Ensure Enterprise Protection	Focus Area	Satisfactory	Satisfactory	Satisfactory
4.6: Sustain Infrastructure Capabilities and Operations	Satisfactory	Focus Area	Focus Area	Focus Area

Below are summaries of the progress that occurred between the June 2021 assessment and the end of FY 2021.

Strategic Objective 1.1: Understand the Sun, Earth, solar system, and universe.

LEAD OFFICE

Science Mission Directorate (SMD)

GOAL LEADER

Karen Flynn, Deputy Associate Administrator for Management, SMD

Since NASA's inception, scientific discovery regarding Earth, the Sun, the solar system, and the universe beyond has been an enduring purpose of the Agency. NASA 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 protecting and improving life on Earth.

	2018	2019	2020	2021
Strategic Review Assessment	Satisfactory	Satisfactory	Satisfactory	Satisfactory

NASA's 2021 Strategic Review determined that Strategic Objective 1.1 showed Satisfactory Performance. Programs and projects within the science portfolio had clear strategies in place to achieve the objectives described in the *2018 Strategic Plan*. External experts again rated NASA's FY 2020 progress for the nine supporting science Performance Goals as having met or exceeded expectations. While the COVID-19 pandemic has had and will continue to have significant impacts, evaluations of near, mid, and long-term objectives provide sufficient evidence that SMD projects effectively support Strategic Objective 1.1.

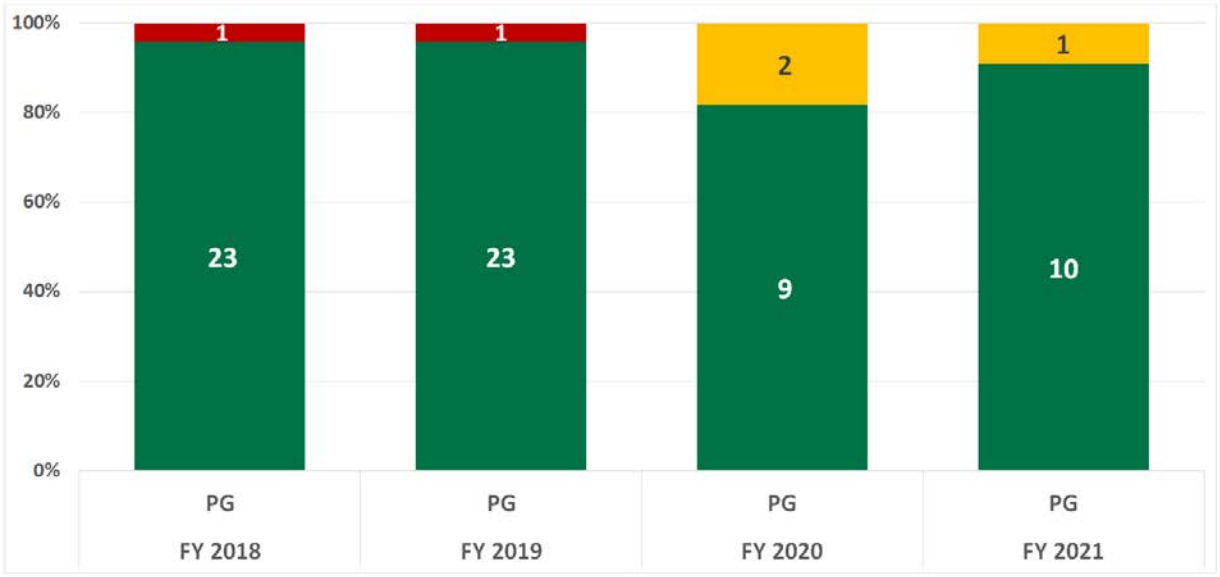
NASA uses the recommendations of the National Academies of Sciences, Engineering, and Medicine's decadal surveys as an important input in planning and prioritizing the future of its science programs. For almost 50 years, decadal surveys have proven vital in establishing a broad consensus within the national science community on the state of science, the highest priority science questions to address, and actions that can be undertaken to answer those questions. NASA uses these recommendations to prioritize future flight missions, as well as technology development and proposals for theoretical and suborbital supporting research. In determining the content of the science portfolio, NASA also considers national priorities and policies, actual budgets, existing technological capabilities, partnership opportunities, and other programmatic factors.

While COVID-19 has resulted in substantial cost and launch readiness impacts for missions in formulation and development, NASA has continually assessed changing needs in order to focus resources on critical activities. Such efforts enabled the on-time launch and successful landing of the Mars 2020 mission to seek signs of life on Mars. The mission's Ingenuity Mars helicopter performed the first powered, controlled flight of an aircraft on another planet, then transitioned into an operations demonstration that includes reconnaissance of scientifically interesting sites that are outside the areas planned for access by the Perseverance rover.

NASA also launched the Sentinel-6 Michael Freilich satellite to continue the multi-decadal observational record of ocean altimetry, conducted a successful asteroid sample collection at Bennu (OSIRIS-REx), and completed integration and test of the James Webb Space Telescope in preparation for launch in early Fiscal Year 2022. NASA confirmed the VIPER lunar rover project, which will conduct investigations of volatile distributions on the Moon, and completed the Critical Design Review for Europa Clipper, which will investigate the habitability of Jupiter's moon Europa. The Parker Solar Probe continued its prime mission as it flew within 16 Solar Radii of the Sun's surface in 2021.

Examples of the scientific advancements considered in the 2021 assessment are described in the FY 2021 performance explanations under Strategic Objectives 1.1 and 1.2 in Part 2.

Summary of Progress for Performance Goals Contributing to Strategic Objective 1.1, FY 2018—2021 Supporting the *2018 Strategic Plan*



Strategic Objective 1.2: Understand the responses of physical and biological systems to spaceflight.

LEAD OFFICE

Human Exploration and Operations Mission Directorate (HEOMD)*

GOAL LEADER

Altonell (Toni) Mumford, Deputy Associate Administrator, HEOMD

The International Space Station (ISS), conceived and constructed to be a laboratory in space, provides opportunities to understand the role of gravity in physical and biological systems. As a research and technology development facility, the ISS provides the capability for human-tended, long-duration space-based research, which is critical to the research and development of technologies supporting Artemis and future deep space exploration. ISS research also supports investigations in human physiology and biotechnology. As NASA's only current long-duration, crewed orbital testbed, the ISS is used by researchers to study the effects of long-duration exposure to the space environment on the crew and devise and test countermeasures to offset health risks.

	2018	2019	2020	2021
Strategic Review Assessment	Noteworthy	Noteworthy	Satisfactory	Satisfactory

The 2021 Strategic Review determined that Strategic Objective 1.2 showed Satisfactory Performance towards achieving the strategy described in the *2018 Strategic Plan*. NASA funded and is performing research studies that address the known risks as defined by the current human exploration plan. NASA also established broad-based partnerships with other U.S. government agencies, private industry, and international partners to advance scientific space-based research and technology development aboard the International Space Station (ISS).

NASA's strategy for prioritizing and enabling fundamental physical and biological systems research is guided by several studies released by the National Academies' over the past two decades, including the 2011 decadal survey *Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New*. We continued to develop the parameters of the next decadal survey on physical and life sciences; the outcome of the decadal survey will inform future research priorities. Mid-term goals will be established based on this new decadal survey and will be prioritized and executed as supported by the budget.

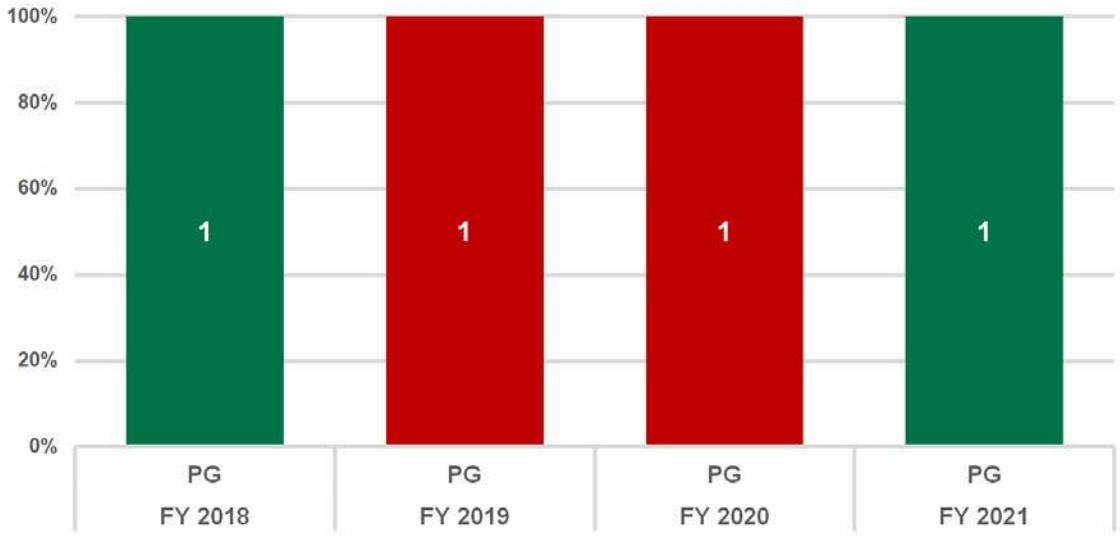
New Space Act agreements are testing the marketplace for commercially viable low Earth orbital platforms to advance human subject and biological and physical sciences research beyond the ISS program. NASA has well-established outreach to industry, academia, and international agencies and will continue to leverage these partnerships to advance NASA exploration goals and for enhancing space physical and biological studies.

Due to COVID-19 protocols, the Human Research Program (HRP) and Biological and Physical Sciences (BPS) personnel who contribute to achievement of this Strategic Objective have limited access to laboratories to conduct research as planned. However, during FY 2021, HRP has the highest priority for ISS utilization, and all HRP inflight requirements are being met, with nine ISS studies in progress. Consistent with the 2020 Strategic Review assessment, grant extensions were necessary and there were impacts to project development schedules and costs.

Beginning with the 2022 Strategic Review, the BPS portfolio contributes to the achievement of Strategic Objective 1.2 and the HRP portfolio will support achievement of Strategic Objective 2.3.

*The Human Exploration and Operations Mission Directorate was divided into the Exploration Systems Development Mission Directorate and Space Operations Mission Directorate (SOMD) on October 1, 2021.

Summary of Progress for Performance Goals Contributing to Strategic Objective 1.2, FY 2018—2021 Supporting the *2018 Strategic Plan*



Strategic Objective 2.1: Lay the foundation for America to maintain a constant human presence in low Earth orbit enabled by a commercial market.

LEAD OFFICE

Human Exploration and Operations Mission Directorate (HEOMD)

GOAL LEADER

Altonell (Toni) Mumford, Deputy Associate Administrator, HEOMD

NASA is enabling a space-based low Earth orbit economy by transitioning the International Space Station (ISS) operations and maintenance to commercial and international partners, while continuing to leverage ISS for research and technology development. NASA is maximizing ISS utilization and throughput, using diverse commercial acquisition strategies, and offering customers research capacity in both space and Earth-similar laboratories. NASA is also working to develop a healthy commercial supplier base for low Earth orbit activities and addressing acquisition policy by looking for ways to eliminate barriers to commercialization. All aspects of crew health are managed as part of this strategic objective, as well, including implementation of a comprehensive health care program for astronauts and the prevention and mitigation of negative, long-term health consequences of space flight.

	2018	2019	2020	2021
Strategic Review Assessment	Noteworthy	Noteworthy	Satisfactory	Satisfactory

The 2021 Strategic Review determined that Strategic Objective 2.1 achieved Satisfactory Performance. NASA continued the targeted strategy, which was sustainable, cost effective, safe, and built on and applied the many lessons learned from over a decade of work and experience with commercial companies. NASA established the Commercial LEO Development program office in the third quarter of FY 2020, and in FY 2021, we updated the commercial use and private astronaut pricing policy. NASA successfully released the final Commercial LEO Destinations solicitation and conducted a Pre-Proposal Conference in the third quarter, including one-on-ones with industry. Commercial LEO Destinations proposals were due in the fourth quarter, with awards made in December 2021.

The Commercial LEO Development program continued to execute the strategy focused on engagement with potential commercial providers. The first private astronaut mission (PAM) to the ISS was with Axiom Space's Ax-1 mission, which launched on April 8 aboard a SpaceX Crew Dragon vehicle. Proposals for the next two PAMs to the ISS were received in FY 2021 fourth quarter. In FY 2021, nearly a dozen Space Act Agreements and one PAM contract have been executed.

NASA plans to launch at least five technology demonstrations in FY 2021, further extending insight and knowledge into critical capabilities necessary for deep space exploration. NASA exceed expectations launching seven technology demonstrations to the ISS in FY 2021. Technology demonstrations initiated on orbit include Astrobee, Spacesuit Evaporation Rejection Flight Experiment (SERFE), Spacecraft Fire Safety (Saffire) V, Water Processor Assembly (WPA) Cat Reactor, Brine Processor Assembly (BPA), Universal Waste Management System (UWMS), Airborne Particulate Monitor, and the Collapsible Contingency Urinal (CCU).

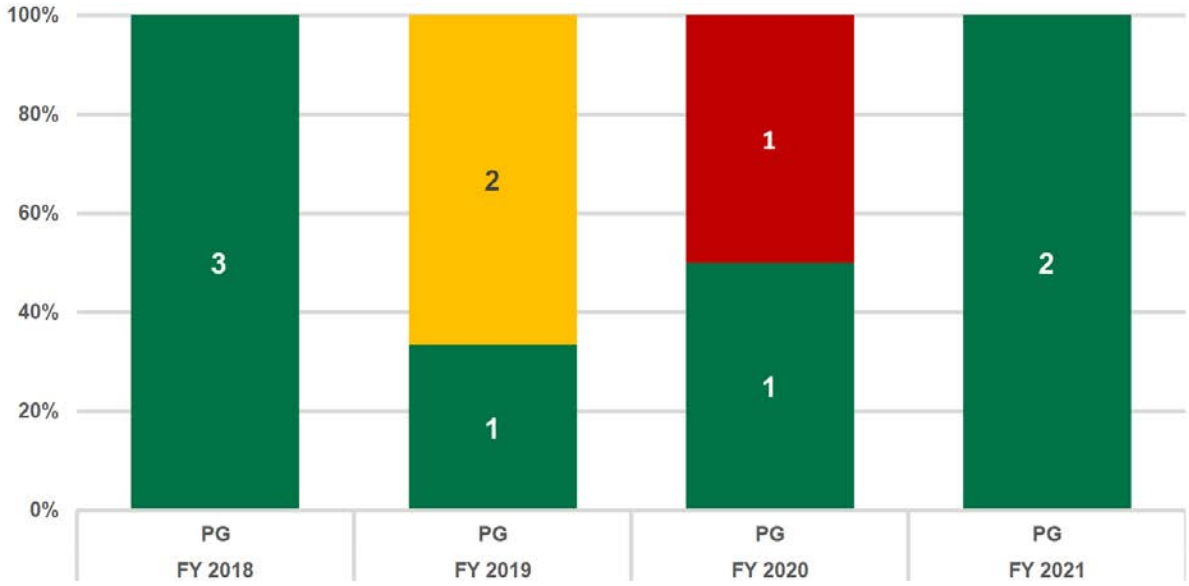
NASA is enabling a space-based low Earth orbit economy by transitioning the ISS operations and maintenance to commercial and international partners, while continuing to leverage ISS for research and technology development. NASA continues to work with the Center for the Advancement of Science in Space (CASIS) to implement the findings and recommendations of the 2020 Independent Review Team report. In FY 2021, NASA and CASIS initiated several actions designed to realign CASIS activities with NASA's evolving commercial goals, including the development of new metrics designed to measure CASIS performance, and the development of a new, more transparent selection model for proposals.

Commercial LEO Development program personnel were able to make appreciable progress towards this Strategic Objective in a work from home environment. COVID impacts to technology development include

requests from contractors for additional funds to mitigate the impact to several technologies' launch schedules.

*The Human Exploration and Operations Mission Directorate was divided into the Exploration Systems Development Mission Directorate and Space Operations Mission Directorate (SOMD) on October 1, 2021.

Summary of Progress for Performance Goals Contributing to Strategic Objective 2.1, FY 2018—2021 Supporting the *2018 Strategic Plan*



Strategic Objective 2.2: Conduct human exploration in deep space, including to the surface of the Moon.

LEAD OFFICE

Human Exploration and Operations Mission Directorate (HEOMD)

GOAL LEADER

Altonell (Toni) Mumford, Deputy Associate Administrator, HEOMD

Artemis will return American astronauts to the surface of the Moon. NASA will land the first woman and next man on the Moon** using innovative technologies to explore more of the lunar surface than ever before. This is a collaborative effort with commercial and international partners and establishes sustainable exploration. NASA will use what was learned on and around the Moon to take the next giant leap—sending astronauts towards Mars. We are designing mission capabilities that will support multiple objectives in deep space and enable increasingly complex missions to a range of destinations. These capabilities will form a sustainable architecture comprised of exploration ground systems, a launch system, a deep-space human-rated module, a lunar gateway around the Moon, lunar landers, and a new generation of spacesuits.

	2018	2019	2020	2021
Strategic Review Assessment	Satisfactory	Focus Area	Focus Area	Satisfactory

Space Launch System (SLS) and Exploration Ground Systems (EGS) rebaselined their Agency baseline commitments in FY 2020, prior to the COVID-19 pandemic; while the new Agency baseline commitments did not account for COVID impacts, both programs remain close to their rebaselined amounts. EGS is very slightly over their baseline costs, and both the SLS and EGS were on schedule for the Launch Readiness Date.

The Orion program has increased in scope to include development of a docking capability, supporting increasingly complex missions. As a result of this increase in scope, COVID-19 impacts, and other factors, the Orion program rebaselined.

Orion, SLS, and EGS, achieved major technical, programmatic, and acquisition milestones in FY 2021. The Orion crew capsule was delivered to the EGS program at Kennedy Space Center for processing activities on January 14, 2021, and SLS successfully completed the year-long Green Run series of tests at Stennis Space Center on March 18, 2021. On April 27, 2021, the SLS Core Stage was shipped from Stennis Space Center to Kennedy Space Center for integration and readiness activities that will lead to the Artemis I launch, which was planned for late 2021 at the time this update was written.

Development on Artemis II and III hardware progressed, with the Artemis II Crew module undergoing environmental and propulsion system processing at Kennedy Space Center. EGS completed their Artemis II checkpoint in late FY 2021 fourth quarter, successfully demonstrating that the program's plans and designs that will be used to process, launch, and recover the crewed Artemis II mission are at a Critical Design Review (CDR) level and meet requirements with acceptable margin, risk, and constraints.

Gateway program design and development activities also progressed, with a series of element-level design reviews in FY 2021. The Gateway program was developing initial cost and schedule estimates, in preparation for the scheduled program Key Decision Point (KDP)-I in FY 2022. In FY 2021, the Gateway program signed Memoranda of Understanding (MOUs) with the Canadian Space Agency (CSA), the Japan Aerospace Exploration Agency (JAXA), and the European Space Agency (ESA) for the development and provision of key Gateway elements and capabilities. In FY 2020, NASA announced that the Power and Propulsion Element (PPE) and the Habitation and Logistics Outpost (HALO) would be co-manifested on a single commercial launch vehicle, eliminating the need for two separate launch vehicles and on-orbit assembly. In February 2021, NASA selected SpaceX to launch the PPE/HALO co-manifested vehicle.

NASA is pursuing a strategy that engages with industry in developing a sustainable lunar landing capability. In FY 2021 first quarter, NASA completed the Human Landing System (HLS) Continuation Reviews and reviewed the HLS Option A proposals addressing the first lunar landing missions. The three HLS base period contracts were originally scheduled to complete at the end of February 2021; however, NASA issued no-cost extensions through April 30, 2021, to allow NASA to complete the Option A selection and award process and to preserve the ability to seamlessly transition from the base period contracts to the Option A contract vehicle.

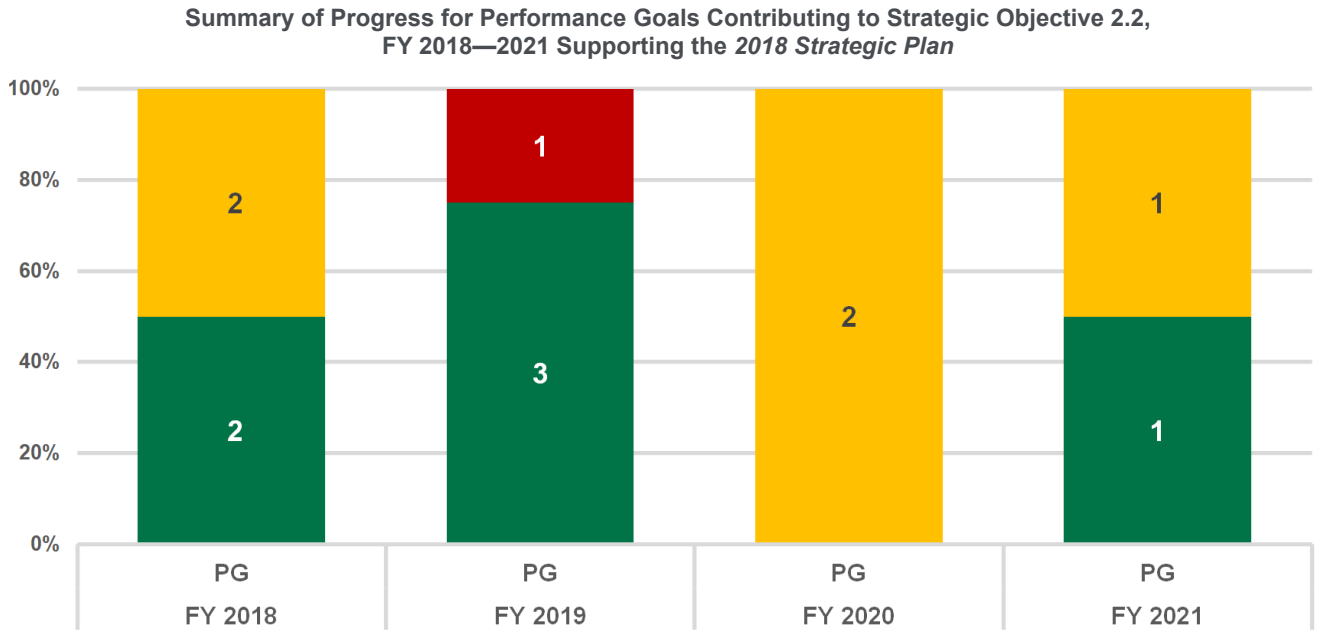
NASA announced on April 16, 2021, that we selected SpaceX to continue development of the first commercial HLS under the Artemis program. On April 26, we were notified that Blue Origin Federation and Dynetics filed protests challenging the HLS Option A selection with the Government Accountability Office (GAO). On April 30, we implemented a no-cost extension through August 9, 2021, to each of the base period HLS contracts (Blue Origin Federation, Dynetics, and SpaceX).

On July 30, GAO denied the Blue Origin Federation and Dynetics protests. NASA then completed HLS Option A Authorization to Proceed with SpaceX. We were notified on August 16 that the Blue Origin Federation had filed a protest with the U.S. Court of Federal Claims following the denial of their protest with the GAO. Subsequently, we voluntarily paused work with SpaceX for the HLS Option A contract, effective August 19 through November 1. All parties agreed to an expedited litigation schedule that concluded on November 1 with the U.S. Court of Federal Claims ruling in NASA's favor.

The COVID-19 pandemic impacted workforce availability and hardware development across the Exploration Systems Development Division (ESD) and Advanced Exploration Systems (AES) portfolio, reflecting significant COVID supplier and performance challenges. Early calculations showed up to 35 percent overall growth to baseline plans on multiple critical activities from March 2020 through September FY 2021. In certain critical activities, growth included general ongoing inefficiency impacts of approximately 10 percent.

*The Human Exploration and Operations Mission Directorate was divided into the Exploration Systems Development Mission Directorate (ESDMD) and Space Operations Mission Directorate (SOMD) on October 1, 2021.

**NASA refocused this effort on landing the first woman and first person of color on the Moon starting during FY 2021.



Strategic Objective 3.1: Develop and transfer revolutionary technologies to enable exploration capabilities for NASA and the Nation.

LEAD OFFICE

Space Technology Mission Directorate (STMD)

GOAL LEADER

Mike Green, Deputy Associate Administrator for Management, STMD

As NASA embarks on its next era of discovery and exploration, the advancement of transformational space technologies serves as a necessary trailblazer for the journey ahead. We invest in crosscutting and transformational technologies that have high potential for offsetting mission risk, reducing cost, and advancing existing or creating new capabilities. Our investments center around technologies that enable NASA's science and human exploration missions, as well as foster growth in the domestic industry and harnessing innovation and entrepreneurship through partnerships with universities, small businesses, and other government agencies. Through leadership in space technology, NASA will contribute to growing the U.S. industrial and academic base by transferring space technology into the space economy, continuing the Nation's economic leadership.

	2018	2019	2020	2021
Strategic Review Assessment	Satisfactory	Satisfactory	Satisfactory	Satisfactory

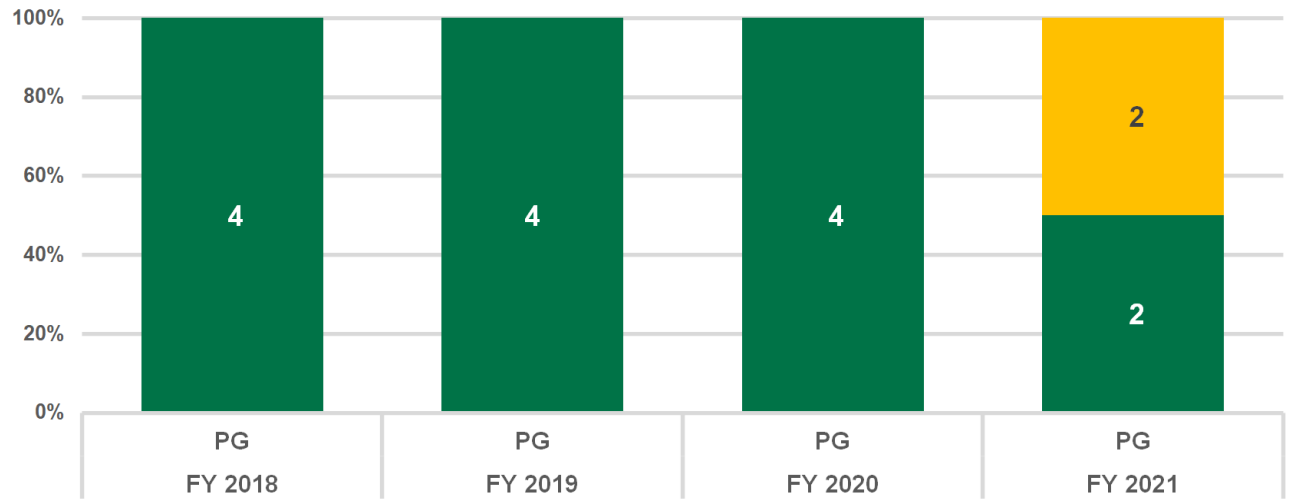
NASA's 2021 Strategic Review resulted in a continued rating of satisfactory performance. Even in the face of the COVID-19 pandemic, NASA has continued to develop and demonstrate technologies, as well as transfer and transition technologies within the Agency, throughout the Federal Government, and to a variety of academic institutions and industry partners. NASA remains focused on building public-private partnerships with the U.S.

aerospace industry to develop capabilities that support the needs of the varied mission architectures of its vast array of stakeholders. Specific examples of recent accomplishments under this Strategic Objective include the launch of 12 technologies on board the Mars 2020 Perseverance Rover, including successful demonstrations of the Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE) and Terrain Relative Navigation (TRN), 15 new industry-developed Tipping Point space technologies to develop commercial space capabilities and benefit future NASA missions, 30 patent licenses executed for the Ventilator Intervention Technology Accessible Locally (VITAL) ventilator design (i.e., to help meet health care needs in response to the COVID-19 pandemic), and significant progress made towards demonstration of a range of space technologies (e.g., Low-Earth Orbit Flight Test of an Inflatable Decelerator (LOFTID), Deep Space Optical Communications (DSOC), Laser Communications Relay Demonstration (LCRD)).

Although Strategic Objective 3.1 has a clear strategy for success, there have been impacts due to the COVID-19 pandemic. Some technology maturation and demonstration projects are experiencing cost and schedule impacts due to restricted facility access, supply chain disruptions, and testing delays. For example, restricted access to Jet Propulsion Laboratory facilities caused a delay to the final Autonomous Pop-Up Flat Folding Explorer Robot (A-PUFFER) test, leading to a delayed Agency Priority Goal FY 2020 milestone; this milestone was completed in May 2021. Some early-stage projects as well as commercial sector partnerships have experienced disruptions due to the inability to access research facilities. NASA's small business partners are facing similar disruptions due to facility closures, supply chain disruptions, and difficulties in teleworking. Additional delays could impact projects' abilities to secure partnerships with industry, academia, and other government agencies , thereby further eroding schedule and deliveries.

While some STMD projects were experiencing cost, schedule, technical, and/or programmatic challenges, the STMD portfolio were on track overall to meet its Strategic Objective and included several technology demonstrations planned for the next few years. Examples include Deep Space Optical Communications (DSOC), LOFTID, Polar Resources Ice Mining Experiment (PRIME)-1, On-Orbit Servicing, Assembly, and Manufacturing (OSAM) 2, Blue Origin Demo of Deorbit, Descent, and Landing Sensors (BODDL-TP), and the Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) small spacecraft demonstration. In the mid- to long-term, STMD has identified 16 long-term outcomes as priority areas of focus, each of which addresses anticipated gaps across multiple stakeholder architectures.

Summary of Progress for Performance Goals Contributing to Strategic Objective 3.1, FY 2018—2021 Supporting the *2018 Strategic Plan*



Strategic Objective 3.2: Transform aviation through revolutionary technology research, development, and transfer.

LEAD OFFICE

Aeronautics Research Mission Directorate (ARMD)

GOAL LEADER

William Harrison, Portfolio Analysis & Management Office, Director, ARMD

Envisioning the long-term plan for aeronautics research provides the basis for new concepts leading to industry innovation and societal benefits. The future holds new challenges for the aviation community, including the need to achieve continued growth that meets increasing global demand, safely integrate unmanned aircraft systems and other innovative vehicle concepts with myriad of applications, and proactively adapt to often rapidly changing conditions. NASA aims to solve these challenges in ways that minimize adverse impacts on the environment.

	2018	2019	2020	2021
Strategic Review Assessment	Satisfactory	Satisfactory	Noteworthy	Satisfactory

An analysis of global trends has led NASA to identify three "Mega Trends" which will shape our aeronautical research plans during the coming years. First, global growth in demand for high-speed mobility reflects rapid growth in demand for mobility and new modes of transportation. Second, affordability, sustainability, and energy use presents severe challenges in balancing economy with environment. Third, technology convergence points to convergence in sectors such as materials, manufacturing, energy, and information and communication technologies that will transform aeronautical capabilities and air transportation options.

NASA organizes the aeronautics research portfolio around six Strategic Thrusts, prioritizing aeronautics objectives in response to the above-mentioned Mega Trends and feedback from the aviation community. The six Strategic Thrusts are safe, efficient growth; commercial supersonic aircraft; ultra-efficient subsonic transport; safe, quiet, and affordable vertical lift air vehicles; in-time system-wide safety assurance; and assured autonomy for aviation transportation.

NASA focuses its aeronautics research on high-risk, high-payoff research investments that will enable the transformation of aviation to serve future needs, produce demonstrable benefits, and leverage technology advances outside of, as well as within, traditional aviation disciplines. Major technology emphases include electrified aircraft propulsion, low-sonic-boom supersonic flight, automation and autonomy, and fostering new aviation applications in Advanced Air Mobility (AAM). Collectively, these efforts, other technologies, and a focus on technology convergence will develop transformative solutions towards the ultimate goal of a safe, efficient, adaptive, scalable, and environmentally sustainable global aviation system.

NASA uses an active process and seeks continuous feedback on its overall strategy as well as performance. These efforts include: NASA Advisory Council (NAC) Aeronautics Committee reviews/reports; internal analysis for budget formulation; inter-agency coordination with partners including FAA and DOD; Interaction with international standard-setting groups such as ICAO (International Civil Aviation Organization); roundtables with subject matter experts convened by the National Academies; strategic planning efforts that include trend analysis (which led to ARMD's Three Mega Trends); gap analysis (which led to ARMD's 6 Strategic Thrusts); systems analysis by internal multi-center groups as well as ARMD-commissioned studies using external analytical groups; OMB and Congressional directions from the appropriations process; and AIAA (American Institute of Aeronautics and Astronautics) special conference sessions to obtain expert feedback. Performance review efforts include: Annual program reviews for all ARMD projects, which include external Independent Review Panels (IRPs) and Mission Directorate Reviews (four ARMD programs reporting to the Associate Administrator every December); relevant Key Decision Point (KDP) or similar reviews that occur for projects that within the scope of NASA Performance Requirements 7120.5 and 7120.8; Baseline Performance Review (BPR) quarterly presentations by ARMD; NASA's Annual Performance Report and

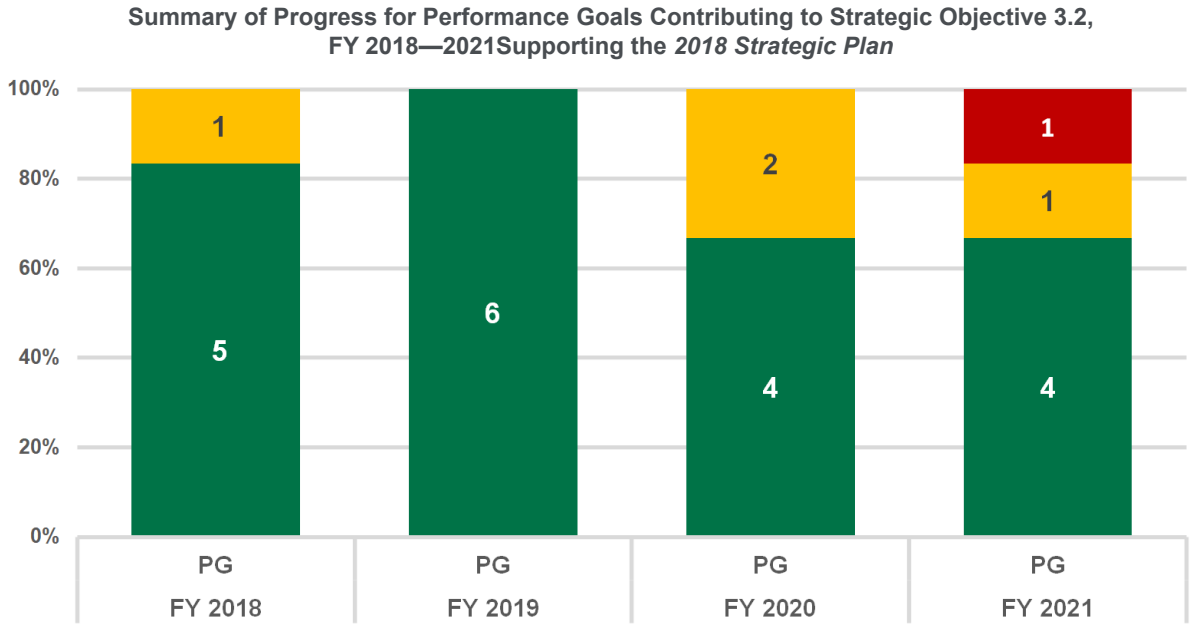
Agency Performance Plan published together as the Volume of Integrated Performance; external reviews such as GAO's annual Assessments of Major Projects; and other internal peer-reviews.

All four ARMD programs identified moderate to significant COVID-19 impacts. In the Advanced Air Vehicles Program (AAVP), impacts were primarily related to availability of wind tunnel testing and other research facilities at Ames Research Center, Glenn Research, and Langley Research Center and corresponding delays to experimental research activities. In the Airspace Operations and Safety Program (AOSP), researchers experienced dramatic reduction in air traffic volume resulting in lower availability of data and hardware/software facilities. In the Integrated Aviation Systems Program (IASP), the Low Boom Flight Demonstration (LBFD) project experienced manufacturing delays, many due to pandemic-related shutdowns. In the Transformative Aeronautics Concepts Program (TACP) program, the University Innovation project identified concerns with access to campus buildings and experimental facilities limiting ability of team members to complete research on schedule. In addition, the Aerosciences Evaluation and Test Capabilities (AETC) Office identified significant impacts to its 12 large wind tunnels and anticipated pandemic-related delays in maintenance activities, which would impact tunnel reliability for NASA and external customers. Within ARMD's four programs and AETC, expenses continued to accrue even though most of our experimental facilities were fully or partially shut down.

As of end of third quarter of FY 2021, 40 percent of ARMD's FY 2021 success measures were rated Yellow. ARMD used reserves to recover and complete these measures by the end of FY 2021.

Highlights of ongoing critical efforts include:

- Continuing work to complete final assembly of the aircraft for LBFD and deliver the aircraft for community response flight testing in FY 2024. The community response data will be delivered to ICAO, a United Nations specialized agency supporting diplomacy and cooperation in air transport, to allow supersonic aircraft flight over land. LBFD recently completed its Delta KDP-D.
- The Electrified Powertrain Flight Demonstration (EPFD) projectStarting Phase A formulation activities for the Electrified Powertrain Flight Demonstration project, which is focusing on flight demonstrations that advance the state-of-the-art in megawatt-class electric aircrafts.
- Completing system integration and verification and validation testing in preparation for flight test of the X-57 Maxwell Mod II electric aircraft.
- Completing formulation activities for the Advance Air Mobility project; developing an initial Urban Air Mobility airspace management system; and maturing System Concept, Architecture, and Book of Requirements.
- Closing out Airspace Technology Demonstration (ATD-1/2/3), Unmanned Aircraft Systems Integration in the National Airspace System (UAS-NAS), Unmanned Aircraft System Traffic Management (UTM), and Advanced Composites project activities and transferring the research results to stakeholders such as RTCA, the Federal Aviation Administration, and Advanced Composites Consortium.
- Continuing formulation activities to develop hybrid thermally-efficient small core gas turbine engines, ultra-efficient Transonic Truss-Braced Wing (TTBW) airplanes, and high-rate composite aircraft manufacturing processes.
- Continuing fundamental research and providing unique expertise and facilities to support commercial hypersonic interests.



Strategic Objective 3.3: Inspire and engage the public in aeronautics, space, and science.

LEAD OFFICES

Missions Support Directorate and Office of Communications (OCOMM)

GOAL LEADER

Johnny Stephenson, Associate Administrator, Office of Communications

NASA will inspire and engage the public and provide unique science, technology, engineering, and math (STEM) opportunities for diverse audiences. By increasing public knowledge about NASA's work, the Agency can contribute to science literacy and an improved national understanding and appreciation of the value of STEM work and careers. The Agency also believes that it can help strengthen diversity in STEM fields by ensuring that grantee universities comply with Federal requirements for minimizing and addressing issues related to discrimination and harassment. NASA is employing a strategy that seeks to inspire, engage, educate, and employ the next generation of explorers through NASA-unique STEM learning opportunities. NASA engages the public and students in its mission by providing authentic learning experiences with NASA's people, content, and facilities; building a diverse future workforce; and contributing to exploration missions. NASA's education and outreach functions each play a critical role in increasing public knowledge of NASA's work, fostering an understanding and appreciation of the value of STEM, and enhancing opportunities to teach and learn.

OCOMM serves as the corporate, Agency-wide communications function for NASA, providing a wide practicable and appropriate dissemination of information to news and media organizations and the general public concerning the objectives, methods, and results of NASA programs. OCOMM connects people to NASA's missions and accomplishments as we explore the unknown, enable technologies for improving life on earth and inspire the world.

	2018	2019	2020	2021
Strategic Review Assessment	Satisfactory	Satisfactory	Satisfactory	Satisfactory

In FY 2021, NASA completed the design of an integrated Agency communications team through the Mission Support Future Architecture Program (MAP). Under this program, the Agency realigned communications resources to enable the communications enterprise to operate more efficiently and sustainably. The newly

established communications enterprise management office is instituting business process improvements that will better enable the enterprise to keep the public informed about NASA's activities. Other benefits of the program include:

- Increased coordination of Agency communications efforts and messaging in partnership with Mission Directorates;
- Expanded focus on strategic planning, integration, and budgeting process;
- OCOMM budget aligned and monitored at a higher level, with increased planning and risk monitoring, and flexibility across functions and missions as needs change; and
- Enhanced workforce agility across the enterprise, reduced single-point-failures, greater collaboration across geographic boundaries.

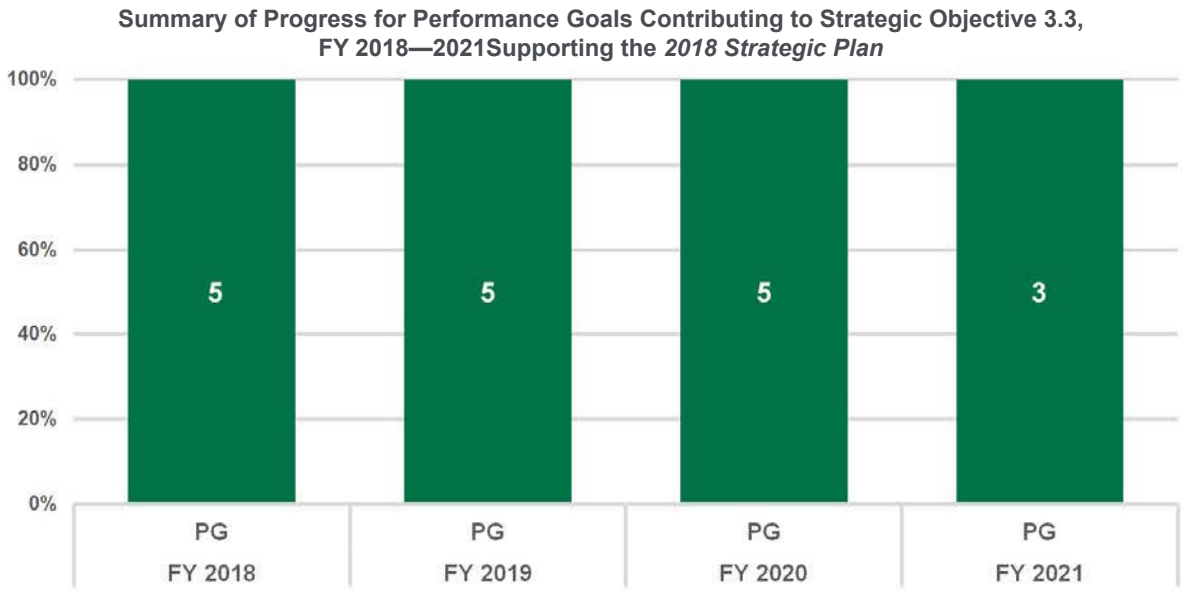
NASA continues to integrate metrics and using data to inform decisions on better reaching the public, engaging stakeholders and evaluate outcomes. The agency continues to use data to refine content and social media distribution platforms, targeted to audience preferences.

Large, popular events and major activities, including the OSIRIS-REx Touch-and-Go event, NASA's SpaceX Crew-1 launch and splashdown, Sentinel-6 Michael Freilich Satellite Launch, Green Run Hot Fire Test 1 and 2 (Artemis), Mars 2020 Perseverance Landing, Mars Ingenuity First Flight, Earth Day 2021, and Crew-2 Launch, drove an increase in followers of our flagship digital accounts. Growth in social media across its flagship accounts.

The Office of STEM Engagement (OSTEM) is enhancing the effectiveness of STEM engagement investments using performance assessment and evaluation-driven processes, including the execution of a Learning Agenda. The OSTEM Learning Agenda puts forth learning questions with associated sub-questions, learning activities, and assessment methodologies, and learning products that will inform OSTEM's understanding of the scope, methods, mechanisms, and outcomes from its investments. During 2020, OSTEM achieved 100 percent (3 of 3) of its Performance Goals and success criteria and executed four evidence-building activities in support of its comprehensive performance assessment and evaluation strategy. OSTEM shared findings and recommendations from learning activities, performance assessments, and evaluation activities with internal and external stakeholders in order to make programmatic evidence-based decisions and updates to the OSTEM Learning Agenda.

COVID-19 had an impact on the delivery of in-person STEM Engagement events, driving the need for OSTEM to transition to implementation of virtual student engagement activities (NASA STEM @ Home Resources). OSTEM implemented a risk-management strategy to ensure that all methods of participant engagement were captured for the purposes of 2020 and beyond.

The Office of Diversity and Equal Opportunity (ODEO) began utilizing voluntary resolution agreements to ensure compliance with civil rights laws under which the Agency is undertaking compliance review and assessment. In conducting a compliance assessment of Louisiana State University, ODEO determined the university was in non-compliance with Title IX and, therefore, unable to provide equal opportunity regardless of sex in its educational programs. ODEO required Louisiana State University to sign a voluntary resolution agreement to come into compliance with Title IX, principally relating to appropriate resources to conduct effective Title IX coordination and to ensure its Title IX procedures are prompt and equitable. In addition, ODEO received confirmation from two other grantees on which it had conducted compliance reviews under Title VI of the Civil Rights Act of 1964, and Section 504 of the Rehabilitation Act of 1973. These grantees, Science Museum of Minnesota and Virginia Air and Space Center, have undertaken 100 percent of NASA compliance recommendations and corrective actions.



Strategic Objective 4.1: Engage in partnership strategies.

LEAD OFFICE

Mission Support Directorate (MSD)

GOAL LEADER

Robert Gibbs, Associate Administrator, MSD

	2018	2019	2020	2021
Strategic Review Assessment	Satisfactory	Satisfactory	Satisfactory	Satisfactory

NASA is establishing appropriate partnerships to achieve the Agency's Mission using contracts to acquire property or services and/or partnership agreements using other statutory authorities to implement mutually beneficial activities for NASA and its partner. The strategy for the success of this Strategic Objective focuses on four areas: 1) Execute innovative, effective, and efficient procurement solutions and contracts that enable NASA's mission; 2) Implement education and outreach to small businesses on how to partner with NASA and its commercial partners; 3) Enable NASA's international and interagency partnerships through management of agreements, engagements, guidance; and 4) Enable domestic, non-Federal partnerships that are strategic and beneficial for NASA through transparency, education, awareness, and outreach opportunities, and identify partnership resources and capabilities for the public.

The Office of Procurement (OP) has established a Closeout Capability Group with representatives from across the Agency. This team provides a cohesive approach to closeout processes and procedures instead of a Center-by-Center approach. As a result of the data analysis and closeout process oversight provided by this team, OP now has a quarterly target of 1,500 contract closeouts and most recently surpassed the quarterly target. OP has engaged with mission partners to jointly develop short-term procurement strategies tailored to the 26 product service lines and begin the transition to long-term strategies. Sixteen product service lines have transitioned to long-term strategies.

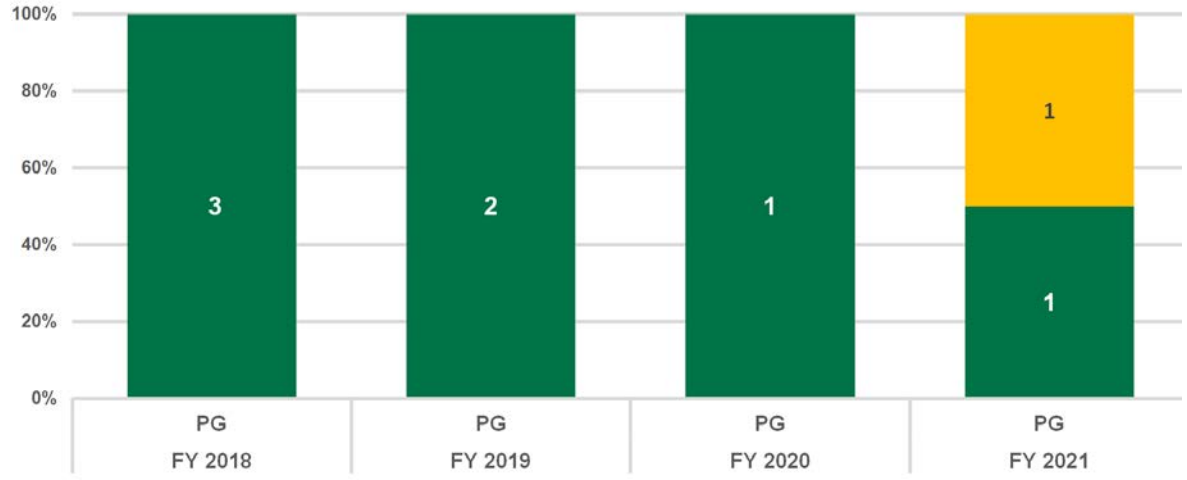
The Partnership Office is helping NASA expand our strategic non-procurement partnerships and meet mission objectives by increasing the number of new partners with whom we do business. Our public "NASA Partnerships" website and other outreach efforts are effective tools for accomplishing this objective. In FY

2021 (as of September 9, 2021), the Agency established partnerships with 107 new domestic, non-Federal partners with whom we had not had previous agreements, and we established 59 new international agreements.

The Office of Small Business Programs (OSBP) is meeting the percentage goal (as assigned by the Small Business Administration) of dollars obligated to small businesses on both the prime and subcontracting levels. OSBP also is refining the virtual outreach program.

The Office of International and Interagency Relations (OIIR) established a baseline of international partners and identified 778 new international partnerships in FY 2020 and it projected establishing 720 new partnerships in FY 2021. COVID-19 closures have led to delays in the ability to meet milestones initially established under some non-procurement partnership agreements. As a result, some existing partnership agreements with both Federal and non-Federal partners have had to be extended, and in some cases, agreements were terminated due to the inability to perform the work within the timeframe required by the partner.

Summary of Progress for Performance Goals Contributing to Strategic Objective 4.1, FY 2018—2021Supporting the *2018 Strategic Plan*



Strategic Objective 4.2: Enable space access and services.

LEAD OFFICE

Human Exploration and Operations Mission Directorate (HEOMD)

GOAL LEADER

Altonell (Toni) Mumford, Deputy Associate Administrator, HEOMD

NASA uses private and government capabilities to ensure that people, payloads, and data can be delivered to and from space. NASA achieves this through a portfolio of services and strategic capabilities, including launch services for robotic missions, commercial space transportation for crew and cargo, ground- and space-based communications, and specialized test facilities.

	2018	2019	2020	2021
Strategic Review Assessment	Satisfactory	Satisfactory	Satisfactory	Noteworthy

Commercial Crew Program partner SpaceX launched Crew-1, their first post-certification mission (PCM), in November 2020, with crew returning on May 2, 2021. SpaceX's launched its second PCM mission, Crew-2, on April 23, and the Commercial Crew Program met the FY 2021 goal of flying two crew transportation missions

to the ISS. Boeing continued to make progress mitigating issues identified during their Orbital Flight Test (OFT) mission and is working to re-fly their uncrewed demonstration flight at the earliest opportunity.

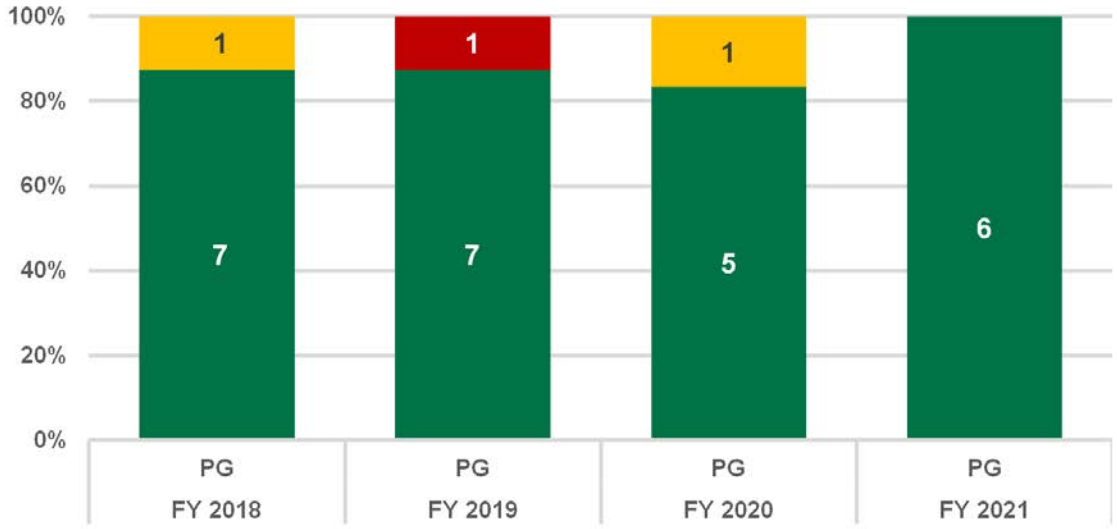
NASA is successfully managing launch service capabilities across the civil space sector, and is managing multiple NASA acquisitions, including the award of the Artemis Program Habitation and Logistics Outpost (HALO) + Power and Propulsion Element (PPE) and a one-off contract for Europa Clipper. New contract mechanisms are in development, including the award of new Venture Class acquisitions. The Launch Services Program (LSP) managed two launches in FY 2021, with 10 advisory and 7 primary missions manifested for launch in the next fiscal year. Four new commercial launch vehicle certifications are in progress in FY 2021, and LSP is providing early insight into several emerging vehicles through multiple contract mechanisms. LSP continues to support Commercial Resupply Services, Commercial Crew Program, and Artemis by providing advisory expertise and contract awards while evaluating HLS requirements and staffing needs.

The Rocket Propulsion Test (RPT) program provided test services to internal and external customers throughout FY 2021—most notably, the successful Space Launch System (SLS) Core Stage hot fire testing in March. To date, the RPT program has provided 99.7 percent on-time delivery of 288 tests conducted across multiple centers at the stage, engine, and component level under diverse test conditions. Artemis-related activities that RPT supported included testing of the RS-25 engine, Orion risk reduction, and European Service Module propulsion qualification testing. A significant level of demand from the commercial sector was also supported. The RPT program continues to maintain a test capacity "right sized" approach to meet Agency requirements; through strategically prioritized facility maintenance and modernization projects, RPT infrastructure continues to perform well beyond their design lifetime.

Space Communications and Navigation (SCaN) supported the Mars 2020 Perseverance rover landing, Cygnus NG-15, Emirates Mars Mission Mars Orbit Insertion, and OSIRIS-REx asteroid sample collection, providing the communications services necessary to support all NASA robotic and Commercial Crew Program missions. The Deep Space Network Aperture Enhancement Project (DAEP) in Madrid, Spain, went operational in FY 2021. The NASA networks continue to perform well above the 95 percent requirement and are aligning upgrades and development activities with both the new SCaN Architecture Study and the Artemis plans, with the initiation of the Commercial Services project.

The COVID operational environment has increased the risk of the RPT program's ability to address critical maintenance and modernization projects. DAEP antenna work continued throughout FY 2021, with the operational staff in Spain available at a reduced level due to very high local pandemic levels of COVID-19.

Summary of Progress for Performance Goals Contributing to Strategic Objective 4.2, FY 2018—2021 Supporting the *2018 Strategic Plan*



Strategic Objective 4.3: Assure safety and mission success.

LEAD OFFICE

Technical Authorities: Office of the Chief Engineer (OCE), Office of the Chief Health and Medical Officer (OCHMO), and Office of Safety and Mission Assurance (OSMA)

GOAL LEADER

Mark Weyland, Director, Medical Policy and Ethics

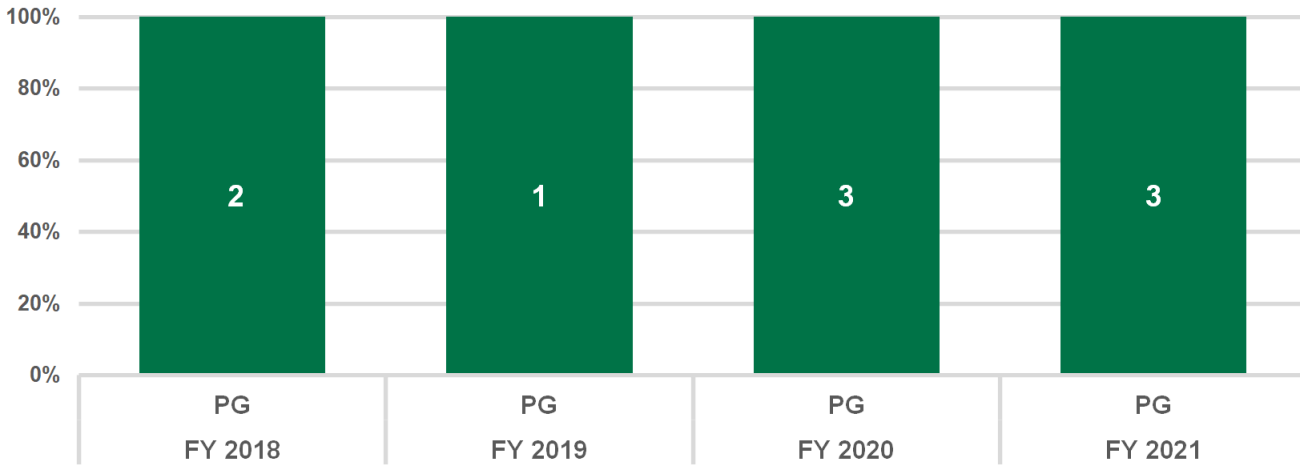
NASA uses discipline experts, known as Technical Authorities, to provide authoritative and independent decisions on application of requirements across our programs and projects. This includes evaluating hardware, software, environmental conditions, and human performance expectations. Technical Authorities identify hazards, including the impacts of new requirements and departures from existing requirements, and evaluate risk acceptability. NASA uses these decisions to assure that risks are addressed or mitigated to an acceptable level, improving the likelihood that missions, programs, and operations will be completed safely and successfully. NASA's Technical Authorities are increasing awareness and reducing risk across the Agency through their roles.

	2018	2019	2020	2021
Strategic Review Assessment	Satisfactory	Focus Area	Satisfactory	Focus Area

While Strategic Objective 4.3 has a clear strategy for success, there have been impacts due to the COVID-19 pandemic. The Office of the Chief Health and Medical Officer (OCHMO), a Technical Authority, is heavily involved in COVID-19 planning and operations at the Agency level along with the White House. Although no activities were dropped during FY 2021 due to the pandemic, and OCHMO was able to oversee execution of human-rated and robotic missions, some activities have been delayed due to competing priorities. In addition, occupational health audits at Centers were delayed due to travel restrictions and Center closures.

NASA's Technical Authorities increased awareness and reduced risk across the Agency through their roles. We continued to enhance training programs, knowledge sharing events, and communications to expand Safety and Mission Assurance awareness and technical expertise, while updating our guidance on orbital debris mitigation, planetary protection, and nuclear safety in accordance with presidential direction and advisory panel recommendations. The Agency also continued to establish early, consistent, and proper level of engagement (standards development and requirements definition, design, development, test, and evaluation) with NASA programs and commercial space industry to advise, advocate, and ensure the health and performance of astronauts and pilots.

Summary of Progress for Performance Goals Contributing to Strategic Objective 4.3, FY 2018—2021Supporting the *2018 Strategic Plan*



Strategic Objective 4.4: Manage human capital.

LEAD OFFICE

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

GOAL LEADER

Robert Gibbs, Associate Administrator, MSD

NASA is cultivating a diverse and innovative workforce with the right balance of skills and experience to provide an inclusive work environment in which employees that possess varying perspectives, education levels, life experiences, and backgrounds can work together and remain fully engaged in the Mission. NASA strategy for this objective is to equip NASA for mission success by supporting mission workforce planning, acquiring top talent quickly, enhancing how people work, and growing employees and leaders and to create an inclusive environment for all NASA employees to feel engaged and safe to raise concerns.

	2018	2019	2020	2021
Strategic Review Assessment	Satisfactory	Noteworthy	Satisfactory	Satisfactory

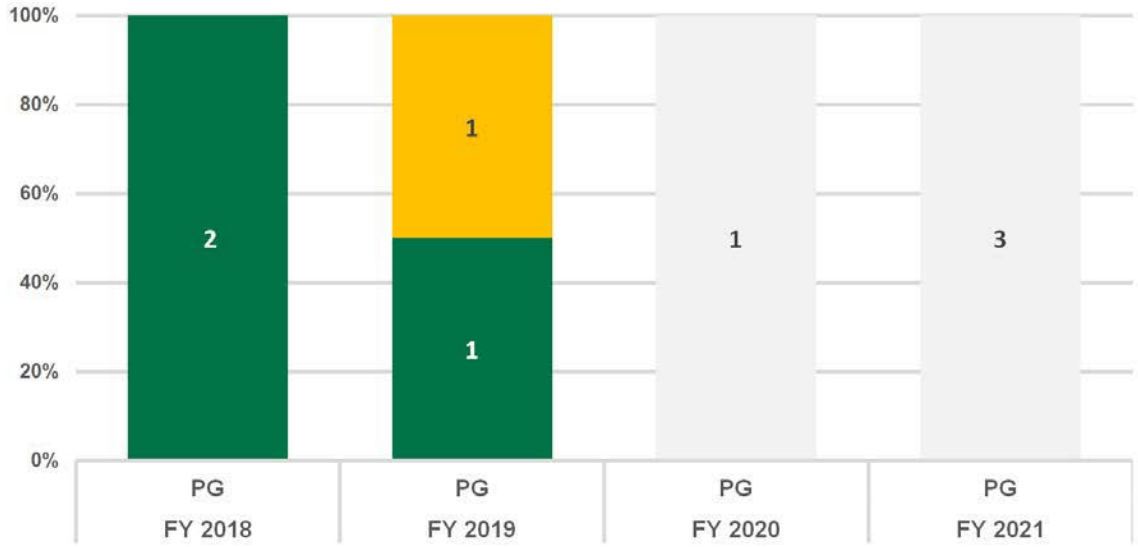
NASA formed the Talent Acquisition and Learning Office (TALO) to integrate all staffing services into a central enterprise-level office to provide direction and leadership for more efficient and effective hiring and development services. These changes in structure will work to address the increase in average time to hire for FY 2020. In order to address this increase in time to hire, NASA has taken advantage of several new hiring authorities and is migrating to the USAStaffing website. OCHCO is implementing process changes to reduce the workload for hiring managers and hiring specialists. For example, increasing the use of bundling hires allows multiple hires to be made from a single vacancy announcement, reducing the time spent on the earlier stages of the hiring process. NASA continues to track and monitor hires to ensure quality is not sacrificed for speed. We continue to have very high quality of hire ratings by managers and high 2-year retention rates to support this.

In response to COVID-19 impacts, additional support has been given to supervisors to ensure they have the skills and tools necessary to effectively manage their workforce through an uncertain and stressful time in a virtual environment. This includes training on managing a virtual workforce and providing directions on how to best utilize available collaboration tools. New processes have been implemented to shift to virtual on-boarding/off-boarding, which allowed for employees to onboard without having to physically visit a Center.

NASA has made progress in implementing strategies focused on creating an inclusive environment for all employees to feel engaged and safe to raise concerns. NASA has established a Diversity, Equity, and Inclusion Steering Committee (DEISC), which will be formulating and implementing Administration DEI initiatives through a DEISC Action Plan for the Agency. NASA has also established the DEI Strategic Partnership composed of the DEISC Members, officials in charge, and representatives from all Employee Resource Groups to socialize and refine our initiatives and share best practices. We took initial steps in implementation of Executive Order (EO) 13985, Advancing Racial Equity and Support for Underserved Communities Through the Federal Government, which revokes EO 13950. NASA issued a revocation of policy related to EO 13950 as it applied to NASA and its contractors. We are implementing an Agency Unity Campaign, which has resulted in NASA highlighting “Inclusion” as an Agency Core Value; implementation of a new Diversity, Equal Employment Opportunity (EEO), and Unity requirement for all Senior Executive Service performance plans, with work underway on a similar requirement for managers and supervisors; reissuance of 3 workforce policy statements for diversity and inclusion, EEO, and anti-harassment; 500 listening/dialogue sessions hosted with participation by well over 10,000 NASA personnel; development of new training courses on unconscious bias and unity; and increased communications to the NASA workforce on DEI and NASA’s missions and projects.

The ODEO Associate Administrator is developing a Gender Policy Strategy with the White House Interagency Working Group on Science, Technology and Climate, and ODEO has submitted its Initial Gender Policy Strategy directly to the working group.

Summary of Progress for Performance Goals Contributing to Strategic Objective 4.4, FY 2018—2021 Supporting the *2018 Strategic Plan*



Strategic Objective 4.5: Ensure enterprise protection.

LEAD OFFICE

Office of the Chief Information Officer (OCIO) and Enterprise Protection Program

GOAL LEADER

Jeff Seaton, Chief Information Officer, and David Adams, Principal Advisor for Enterprise Protection

NASA's enterprise protection approach requires collaboration across the Agency and our Federal and commercial partners. NASA assesses existing and planned architectures, requirements and policies, technology, systems, workforce, and other relevant protection factors. Analysis of these assessments inform strategic, actionable recommendations to reduce protection-related risk. As part of these efforts, NASA partners with the Department of Homeland Security to modernize, and consolidate where appropriate, the Agency's cybersecurity infrastructure in alignment with the National Institute of Standards and Technology (NIST) cybersecurity framework.

	2018	2019	2020	2021
Strategic Review Assessment	Focus Area	Satisfactory	Satisfactory	Satisfactory

We coordinated our efforts to increase the Agency's resilience. The Enterprise Protection Program (EPP) established a cross-cutting biweekly dialogue comprised of EPP, Mission Directorate representatives, the Independent Verification and Validation Facility, Centers, and the Jet Propulsion Laboratory. EPP instituted tracking at Enterprise Protection Board (EPB) meetings to ensure that the Cybersecurity Task Team recommendations and other assigned actions are accomplished. The EPB held 9 meetings from July 2020 through August 2021, addressing emerging protection topics that require strategic collaboration. EPP formed several working groups to address 6 goals under a zero-based review of critical Agencywide enterprise protection topics.

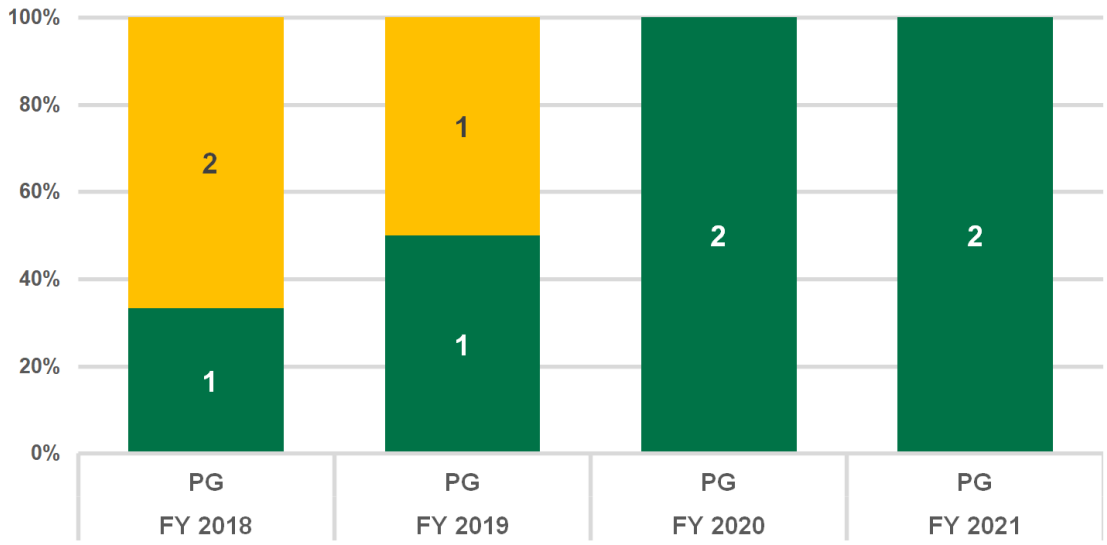
The Agency closed all remaining operational technology (OT) security recommendations from the Office of the Inspector General (OIG) in its 2017 report titled Industrial Control System Security within NASA's

Critical and Supporting Infrastructure. We identified all OT systems that are part of our critical infrastructure and validated that more than 50 percent of these systems have a current Authorization to Operate (ATO), achieving our annual Performance Goal target for a Green rating. NASA continued implementing policy revisions to include requirements related to OT security.

NASA maintained an overall rating of "Managing Risk" based on its quarterly Federal Information Security Management Act (FISMA) assessment reports, the highest score for Federal agencies to demonstrate progress toward implementing fundamental cybersecurity requirements. The Agency met 7 out of 10 cybersecurity targets for the IT Modernization Cross-Agency Priority (CAP) Goal, meeting NASA's annual Performance Goal target for a Green rating.

NASA continues to implement Continuous Diagnostics and Mitigation (CDM) cybersecurity capabilitiesAgency-wide. CDM sensors enable cybersecurity personnel to identify assets on the network and vulnerabilities to remediate. As of August 2021, NASA completed 100 percent installation of CDM sensors on the Agency's corporate systems, 98 percent on the Jet Propulsion Laboratory's corporate systems, 96 percent on the Agency's mission systems, 81 percent on the Jet Propulsion Laboratory's mission systems, and 100 percent on the NASA Communications System. Final operating capability is anticipated by the fourth quarter of FY 2022, delayed from the fourth quarter of FY 2021 target due to the COVID-19 pandemic.

Summary of Progress for Performance Goals Contributing to Strategic Objective 4.5, FY 2018—2021 Supporting the *2018 Strategic Plan*



Strategic Objective 4.6: Sustain infrastructure capabilities and operations.

LEAD OFFICE

Mission Support Directorate (MSD)

GOAL LEADER

Robert Gibbs, Associate Administrator, MSD

NASA is providing the facilities, tools, and services required to efficiently manage, operate, and sustain the infrastructure necessary to meet mission objectives. NASA has adopted a facilities maintenance and operation philosophy that proactively pursues and adopts the safest, most cost-effective blend of reliability-centered maintenance techniques, sustainability practices, and safety procedures. An Agency facilities master plan establishes priorities (over a 20-year projection) for construction, demolition, and

maintenance. NASA uses a centralized approach in providing standardized, timely, and accurate business support for services.

	2018	2019	2020	2021
Strategic Review Assessment	Satisfactory	Focus Area	Focus Area	Focus Area

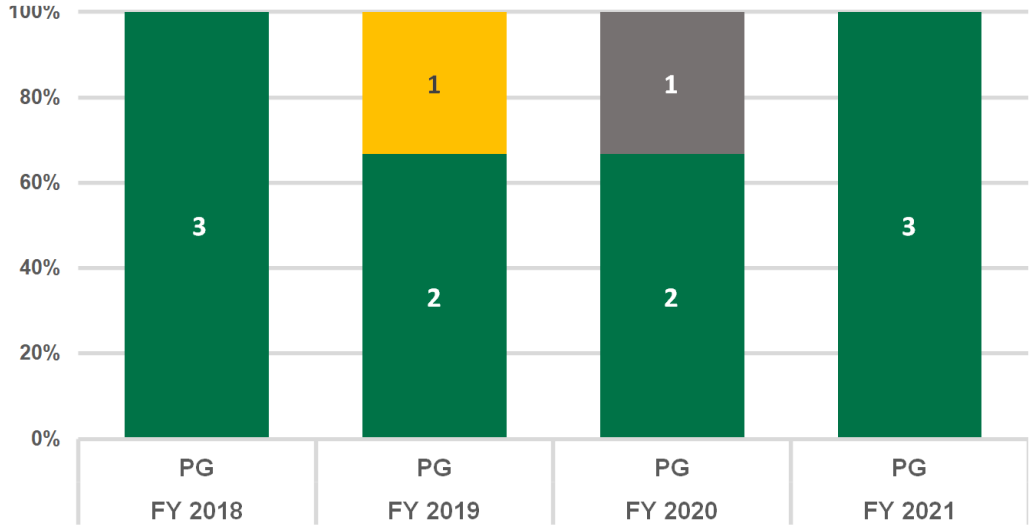
NASA has made progress towards meeting near-term success criteria, which are essential for developing an Agency master plan. However, we continue to face looming budget issues and challenges with our extremely aged infrastructure and increased unplanned maintenance, consuming as much as 30 percent of the maintenance budget, resulting in potential mission impacts. Right-sizing efforts are underway to reduce footprint and cost, but the pace of change is limited by our ability to invest in construction, demolition, and new technology to build a more resilient, reliable infrastructure.

NASA is making progress towards getting a Mission Dependency Index (MDI) score for all of our facilities, with a focus identifying the high-MDI facilities and correlate them to the Facility Condition Index (FCI). MDI and FCI correlation will guide prioritization for capital repair and renewal projects. NASA averages an annual unfunded maintenance liability of approximately $130 million to sustain our infrastructure, coupled with 80 percent of our facilities beyond their useful life, compounds the growing deferred maintenance backlog (currently $2.66 billion). This increases mission risk. Categorizing assets by MDI versus FCI will help NASA invest limited resources in the most mission critical assets.

We continue to demolish facilities with low MDI and low FCI, resulting in 51 facilities demolished in FY 2020, surpassing the target of 20 facilities. NASA's mid-term goal is to use this information to inform repair and renewal investments, maintenance prioritization through a tiered maintenance system, and leverage condition-based maintenance and reliability-centered maintenance. NASA continues to seek and implement courses of action to strategically mitigate risks and leverage opportunities. Nonetheless, investment in construction, renewal/revitalization, and maintenance of facilities is essential to ensure ready and reliable facilities to support mission requirements.

NASA has identified and quantified energy use in types/classes of facilities that are significant energy users. While exceeding statutory energy and water reduction goals (reducing energy use intensity in buildings subject to the goals by more than 43 percent in FY 2020, compared to the 2003 baseline, and reducing water use intensity over 33 percent, compared to the 2007 baseline), achieving continual year-over-year reductions, has become increasingly challenging. In order to meet this challenge, the Agency analyzed significant energy users that have not traditionally been included in energy conservation measures analyses due to their unique mission applications and identified and prioritized energy and water consumption reduction opportunities.

Summary of Progress for Performance Goals Contributing to Strategic Objective 4.6, FY 2018—2021 Supporting the *2018 Strategic Plan*



2022 Strategic Plan Mapping

	2022 Strategic Plan	*2018 Strategic Plan*
DISCOVER	**Strategic Goal 1: Expand Human Knowledge Through New Scientific Discoveries**	***Strategic Goal 1: Expand human knowledge through new scientific discoveries***
	Objective 1.1: Understand the Earth system and its climate	*Objective 1.1: Understand the Sun, Earth, solar system, and universe.*
	Objective 1.2: Understand the sun, solar system, and universe	*Objective 1.2: Understand responses of physical and biological systems to spaceflight*
	Objective 1.3: Ensure NASA's science data are accessible to all and produce practical benefits to society	
EXPLORE	**Strategic Goal 2: Extend Human Presence to the Moon and onto Mars for Sustainable Long-term Exploration and Utilization**	***Strategic Goal 2: Extend human presence deeper into space and to the moon for sustainable long-term exploration and utilization***
	Objective 2.1: Explore the surface of the moon and deep space	*Objective 2.1: Lay the foundation for America to maintain a constant human presence in low Earth orbit enabled by a commercial market*
	Objective 2.2: Develop a space economy enabled by a commercial market	*Objective 2.2: Conduct exploration in deep space, including to the surface of the Moon*
	Objective 2.3: Develop capabilities and perform research to safeguard explorers	
	Objective 2.4: Enhance space access and services	*Objective 4.2: Enable space access and services*
INNOVATE	**Strategic Goal 3: Catalyze Economic Growth and Drive Innovation to Address National Challenges**	***Strategic Goal 3: Address societal challenges and catalyze economic growth***
	Objective 3.1: Innovate and advance transformational space technologies	*Objective 3.1: Develop and transfer revolutionary technologies to enable exploration capabilities for NASA and the Nation*
	Objective 3.2: Drive efficient and sustainable aviation	*Objective 3.2: Transform aviation through revolutionary technology research, development, and transfer*
ADVANCE	**Strategic Goal 4: Enhance Capabilities and Operations to Enable the NASA of Tomorrow**	***Strategic Goal 4: Optimize capabilities and operations***
	Objective 4.1: Attract and develop a talented and diverse workforce	*Objective 4.1: Engage in partnership strategies* *Objective 4.4: Manage human capital* *Objective 4.5: Ensure enterprise protection*
	Objective 4.2: Transform mission support capabilities for the next era of aerospace	*Objective 4.3: Assure safety and mission success* *Objective 4.4: Manage human capital* *Objective 4.6: Sustain infrastructure capabilities and operations*
	Objective 4.3: Build the next generation of explorers	*Objective 3.3: Inspire and engage the public in aeronautics, space, and science*