National Aeronautics and Space Administration

FY 2020
Volume of Integrated Performance

FY 2018 Annual Performance Report
FY 2019 Annual Performance Plan Update
FY 2020 Annual Performance Plan

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Letter from the Chief Financial Officer

I have learned a lot about NASA and working in the Federal Government since I arrived at the Agency back in April 2018. I have learned that working in Washington, D.C., means adapting to a culture unlike any I have ever experienced, to include a lifetime's worth of acronyms. What I have enjoyed most has been learning from the people across NASA as they plan new missions, build hardware, conduct testing, analyze scientific data, and assess ongoing business operations to become more efficient. I have had the pleasure of seeing NASA accomplish amazing achievements against the most challenging odds. I have also experienced the pain when something did not go as well as we wanted it to, when we had to dig in, learn what went wrong, and figure out how we are going to fix it.

In the process, I have also learned something about the NASA family. We aim high and our successes are simply phenomenal. We recently landed Insight on the surface of Mars, an instrument we will use to study the core of the planet by creating mini "Mars-quakes." The engineering it takes to land on Mars is as impressive as the spacecraft itself, as well as the scientific knowledge we will gain as Insight continues sending data back to Earth. In FY 2018, we launched the Parker Solar Probe, our first ever attempt to "touch the Sun," and TESS, which will study extra-solar planets as never before. Our scientists found evidence of what could be liquid water on Mars, and we launched Earth observing satellites—GRACE-FO and ICESat-2, which will use different techniques to observe the changing landscape of Earth. Our commercial partners saw some amazing successes too, like the SpaceX Falcon Heavy test launch. Working with our partners, we developed plans and contracted with Boeing to develop a quieter supersonic aircraft. It really has been an amazingly successful year.

In FY 2018, we also had the opportunity to learn from our mistakes. As a bunch of "top of the class students," we do not give up on a good idea when things go wrong. We study, we analyze, we reassess, and we rework our plans with the knowledge we have gained. This year, we learned valuable lessons on managing our largest missions—the really complex efforts that pose science and engineering challenges that come with the first attempt to do anything completely new. For example, the James Webb Space Telescope Independent Review Board highlighted technical challenges that we could have worked differently. Importantly, the findings also included lessons that we can apply to all of our work—that we can more actively and aggressively manage our contracts, we can better understand and manage risk, and we must better communicate within the Agency and with our partners and stakeholders. Can NASA apply these lessons? Of course. Will we apply these lessons? Absolutely!

In the FY 2020 Volume of Integrated Performance, NASA presents a performance framework for how the Agency will accomplish its Mission. Our strategic goals, as outlined in the NASA 2018 Strategic Plan, are supported by strategic objectives, multi-year performance goals, and annual performance indicators against which we can measure steady progress of our scientific and engineering ventures. The document also demonstrates how our FY 2018 performance fared compared to our plans and expectations. It also describes some of the approaches the Agency will take to strengthen our activities in acquisition management, cost and schedule estimating, and management and control. We are committed to stewardship of taxpayer dollars, to safety, and to security. We must do better in areas that have traditionally been challenging to manage, and with our new action plans in place, we will.

You will see the Agency's commitment to "doing better" throughout the *FY 2020 Volume of Integrated Performance*. We have updated our plans and milestones for the Lunar Gateway, an early step in using the Moon as a testing ground for eventual human exploration of Mars and beyond. We are strengthening our planning for the Space Launch System and Exploration Mission-1, applying management lessons learned in development of NASA's heavy-lift Earth-to-space transport. We have reprioritized our technology investments, seeking better and more efficient solutions for exploration. We are aggressively managing research aboard the International Space Station, applying what we learn to protect human health for future long-duration space travel. We are reworking a plan to complete and launch the James Webb Space Telescope, a long-standing priority of astrophysicists seeking answers to the mysteries of the universe. Finally, we have renewed our intent to serve national interests by more thoughtfully managing all of our contracts, grants, investments, and partnerships.

I have been NASA's Chief Financial Officer for almost a year now. My team has come to know that I like to challenge the old ways of doing things, to ensure that what we are doing is a "value add" to the Agency, and to identify better and more effective ways of working. I have learned since last April that we do have the right goals, as outlined by the National Space Council and the Administration. I have also seen that we have the right tools in place to do the job, and more importantly, we have the right workforce—an extremely capable and dedicated corps of people committed to mission success.

I am proud to release NASA's *FY 2020 Volume of Integrated Performance*. This document represents the performance plan that ties directly to NASA's FY 2020 Budget Estimates. In this volume, we have applied the Agency's continuous learning and improvement philosophy as we upgraded several features of this year's report. For example, we have condensed and tightened up several of the performance goals to remove functional stovepipes and foster cross-pollination of ideas and infrastructures. We have also revised several of our narrative sections to better show how our performance investments and activities interconnect and come together as a system of measures, assessments, and evaluations. These feedback loops progressively drive the Agency to an ever-higher level of achievement and accomplishment.

We view it as an honor that we have been chosen, on behalf of the Nation, to pursue the exploration of space and the advancement of science and aeronautics.

Jeff DeWit
Chief Financial Officer

Overview

FY 2018 Performance Overview

Performance Goals

90% achieved or on track

9% slightly behind schedule or below target

1% significantly behind schedule or below target

Annual Performance Indicators

89% achieved or on track

9% slightly behind schedule or below target

2% significantly behind schedule or below target

Above: A structural test version of the intertank for the Space Launch System arrives at the Marshall Space Flight Center aboard the barge Pegasus on March 7, 2018. Image credit: NASA/Emmett Given

The National Aeronautics and Space Administration's (NASA's) *FY 2020 Volume of Integrated Performance*[1] reports on performance over the course of the last fiscal year (2018), provides the performance plan for the current fiscal year (2019), and presents the initial performance plan for the coming budget year (2020). The information reported in this document is aligned with the performance framework established by the *NASA 2018 Strategic Plan* and aligns with NASA's *FY 2020 Budget Estimates*,[2] in accordance with the requirements of the Government Performance and Results Act (GPRA) Modernization Act of 2010. This information provides a holistic view of NASA's past, present, and future performance, grounded in sound management practices, rigorous internal and external review and evaluation, and proactive management of risks and challenges.

Executive Summary

In February 2018, NASA unveiled a new strategic plan to guide a new era of exploration and discovery. This report summarizes the results of NASA's first year executing the performance framework introduced in the strategic plan. NASA's strong management of operational and business activities is reflected in performance assessments. Management of small research and development missions and projects also shows steady positive performance, almost across the board. Development of a commercial space industry through cooperation with commercial partners was

1 The FY 2020 Volume of Integrated Performance is produced by NASA's Office of the Chief Financial Officer with contractor support provided by Deloitte Consulting LLP.

2 NASA's FY 2020 Budget Estimates, which combines the President's budget request and the budget justification, can be found on NASA's *Budget Documents, Strategic Plans and Performance Reports* website.

generally strong in FY 2018. Performance associated with large flagship missions (i.e., James Webb Space Telescope) and major systemic Agency restructuring initiatives (e.g., enterprise protection), remain priority areas for improvement. Annual performance plans for FY 2019 and FY 2020 reflect Administration priorities for an increased emphasis on exploration, with lunar research in the nearer term, and Mars and still-farther destinations to follow.

Document Organization

- **Part 1–Performance Management at NASA** summarizes how NASA conducts performance. It provides an overview of the strategic framework established in the *NASA 2018 Strategic Plan*. It describes how the Agency manages performance and uses data, evidence and evaluations, and reporting. Part 1 also discusses how NASA is addressing identified management challenges and high-risk activities.
- **Part 2–Performance Planning and Reporting** presents NASA's FY 2018 Annual Performance Report, the FY 2019 Annual Performance Plan Update, and the FY 2020 Annual Performance Plan organized by strategic goal and strategic objective, including the summary of progress stemming from the 2018 Strategic Reviews for each strategic objective. Each strategic objective includes performance goals and annual performance indicators, their FY 2018 performance ratings, as well as rating explanations for the performance goals. Depending on when they started, measures show five years of historical performance ratings alongside the two years of plans for future performance goals and annual performance indicators. Where NASA did not achieve its target or milestone for a performance goal or annual performance indicator, an explanation describes why the target wasn't met, and when appropriate, the corrective actions the Agency intends to take to complete the target or milestone.
- **Appendices** include two elements. The first is Changes to the FY 2019 Performance Plan. The second appendix, Data Quality Elements, provides the verification and validation information supporting the performance goals reported in Part 2.
- NASA's Statement of Assurance is available online in the *FY 2018 Agency Financial Report*.

Above: The USS John P. Murtha recovers the test version of the Orion capsule at sunset in the Pacific Ocean. This is one in a series of tests that will verify and validate procedures and hardware that will be used to recover the Orion spacecraft after it splashes down in the Pacific Ocean following deep space exploration missions. Image credit: NASA

Summary of Changes from the FY 2019 Volume of Integrated Performance

The FY 2020 report includes some significant differences from the prior year's volume.

NASA Reorganization

- The Space Technology Mission Directorate did not provide a performance plan for FY 2018 or 2019 in the *FY 2019 Volume of Integrated Performance*, as NASA was anticipating a reorganization for their activities. NASA is in the process of realigning components of its space technology development activities to better leverage synergies across organizations, which promises to better enable deep space exploration. As planning and implementation of the reorganization is now underway, this document reports upon progress for a set of intermediate performance measures selected at the beginning of FY 2018, NASA's current Performance Plan for FY 2019, and FY 2020 to support exploration-focused goals. These plans may be later updated to reflect closer alignment with the reorganization as necessary. Performance information is included under Strategic Objective 3.1. A further discussion of the new organization is provided in *NASA's FY 2020 Budget Estimates*.

Above: Technicians examine streaks made by oil along the body of amodel of the QueSST X-plane after a test in the 14 x 22 wind tunnel at Langley Research Center. The oil, which was released into the wind tunnel's airstream,shows how the air moved around the shape of this design for a quieter supersonic aircraft. Image credit: NASA

- In FY 2018, NASA replaced the Office of Education with the Office of STEM Engagement. As proposed in the FY 2018 and FY 2019 budgets, the FY 2020 budget proposes the termination of funding for this office. In this volume, FY 2018 performance was assessed against measures implemented by the new office. The Office of STEM engagement also developed stronger, outcome-oriented performance measures for FY 2019. These performance measures are presented in Strategic Objective 3.3.

Revised Performance Measures

- The Science Mission Directorate has revised its measurement strategy to better demonstrate the common, synergetic approach to research and mission management employed within the Science Mission Directorate. Starting in FY 2020, new performance measures and groupings under Strategic Objective 1.1 reflect common outcome characteristics, rather than the previous and long-standing approach of grouping measures by scientific themes (Earth science, heliophysics, astrophysics, James Webb Space Telescope, planetary science).
- The *FY 2019 Volume of Integrated Performance* included legacy performance goals, FY 2017 performance goals that were discontinued when the Agency transitioned to the *NASA 2018 Strategic Plan* framework. These legacy performance goals are not included in this document.

Changes from the FY 2018 Volume

- Part 1 of the FY 2020 volume references new activities resulting from the Program Management Improvement Accountability Act (PMIAA).
- Information on Management Challenges identified by NASA's Office of Inspector General (OIG), is presented in Part 1. In FY 2020, this section also provides an overview of NASA's new corrective action plan designed to proactively address NASA's inclusion on the Government Accountability Office High Risk List.
- Budget tables were not included in the *FY 2019 Volume of Integrated Performance* due to the delayed release of the President's budget request. A budget table, consistent with the *NASA FY 2020 Budget Estimate*s, is once again included for each strategic objective in Part 2.
- The Data Quality Elements, which provide verification and validation information for the FY 2018 performance goals, have been moved from Part 2 to Appendix B to improve readability.

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Above: An Orbital ATK Antares rocket, with the Cygnus spacecraft onboard, is seen on the launch pad at NASA's Wallops Flight Facility on November 11, 2017. Image credit: NASA/Bill Ingalls

Part 1

Performance Management at NASA

NASA's Orion spacecraft test article that flew on the uncrewed Exploration Flight Test-1 on December 5, 2014, is seen on the south lawn of the White House during a "Made in America" product showcase on July 23, 2018, in Washington, DC. NASA and prime contractor, Lockheed Martin, are working on a more complete spacecraft to fly aboard the uncrewed Exploration Mission-1. More than 1,000 companies from across the the United States have manufactured or contributed elements to the spacecraft. Image credit: NASA/Aubrey Gemignani

Foundations for Performance

Vision

To discover and expand knowledge for the benefit of humanity.

Mission

Lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and bring new knowledge and opportunities back to Earth. Support growth of the Nation's economy in space and aeronautics, increase understanding of the universe and our place in it, work with industry to improve America's aerospace technologies, and advance American leadership.

Above: The crew of the International Space Station (ISS) snapped this image of the full Moon on April 30, 2018, as the ISS passed over the coast of Newfoundland, Canada. Image credit: NASA

For six decades, 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.

NASA's continued success is predicated on a solid foundation of performance. The Agency uses common business and development practices to proactively establish expectations and assess and improve performance on an ongoing basis. These practices are strengthened by the Agency's diversity in technical and operational expertise. NASA uses 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 Results Act (GPRA) Modernization Act of 2010. NASA's commitment to performance reaches further than compliance. The Agency has an ingrained culture of self-evaluation and continuous improvement, using findings from these studies and assessments to improve the Agency is the short term, and position NASA for long-term success and sustainability.

The *NASA 2018 Strategic Plan* outlines NASA's plans for the future, provides a clear and unified direction for all of its activities, and sets the foundation on which the Agency can build and measure the success of its programs and projects. This direction is captured in NASA's Vision and Mission statements—why NASA exists, what it aspires to achieve, and how it expects to make a difference that benefits all Americans.

Strategic Themes and Goals

NASA's Mission is aligned to four major themes, characterized by a single word, that are reflected in the Agency's activities. These four themes are described in more detail in the *NASA 2018 Strategic Plan*.

Discover

Expand human knowledge through new scientific discoveries.

Explore

Extend human presence deeper into space and to the Moon for sustainable long-term exploration and utilization.

Develop

Address national challenges and catalyze economic growth.

Enable

Optimize capabilities and operations.

Strategic Plan Framework

The *NASA 2018 Strategic Plan* established a framework that consists of NASA's priorities, approaches, and top-level objectives for evaluating and improving progress toward these priorities at varying levels throughout the Agency. At the top of the framework are strategic goals and long-term strategic objectives, which are set in the strategic plan. They are supported by performance goals and annual performance indicators, which are set annually in the Annual Performance Plan. Assessments of performance goals and annual performance indicators help the Agency demonstrate progress toward higher-level, long-term objectives, and when necessary, take corrective action to improve incremental and long-term performance.

NASA's Strategic Plan Framework

Set in the Strategic Plan

Strategic Goals are far-reaching and ambitious. Forming the top of the strategic plan framework, strategic goals articulate clear statements of what the Agency wants to achieve to advance its Mission.

Strategic Objectives typically span up to 10 years. They express the outcome or management impact NASA plans to achieve for a strategic goal. Through the annual Strategic Reviews, NASA reviews progress toward achieving the strategic objectives at a portfolio level.

Set in the Annual Performance Plan

Performance Goals span two to five years and measure the performance of investments towards strategic objectives and strategic goals.

Agency Priority Goals, a subset of performance goals, receive additional senior management focus and have additional reporting to external stakeholders. Agency priority goals represent NASA's high-priority, high-profile programs.

Annual Performance Indicators describe the smaller, achievable measurements that serve as NASA's basic unit of performance measurement. They reflect progress achieved during the budget year, and NASA uses them to assess progress made towards achieving the performance goals.

Cross-agency priority goals focus on major Administration priorities that benefit from collaboration across multiple Federal agencies. NASA contributes to cross-agency priority goals through relevant annual performance indicators.

Annual Performance Plan

The Annual Performance Plan builds on the strategic plan framework by adding multi-year performance goals and annual performance indicators to the strategic goals and objectives set in the *NASA 2018 Strategic Plan*. NASA develops its Annual Performance Plan in concert with the upcoming fiscal year budget request. The performance goals and annual performance indicators include targets and key milestones that reflect the contents of the budget at the program and project level. The Annual Performance Plan is released to the public on the same date that the Administration releases the annual President's budget request. Part 2 includes the FY 2020 Performance Plan.

Annual Performance Plan Update

In addition to performance planning for the budget year, NASA also evaluates the performance goals and annual performance indicators included in the Annual Performance Plan. The performance plan is issued with the previous fiscal year's budget (i.e., the FY 2019 Performance Plan) to ensure that the plan still accurately reflects the budget and programmatic plans. NASA may revise performance measure descriptions, add new measures, or delete unneeded measures due to strategic, budgetary, or programmatic changes that have occurred since the plan was originally submitted the year before. Updates to the FY 2019 Performance Plan are integrated into Part 2, with a list of changes located in Appendix A.

Cross-Agency Priority Goals

The President's Management Agenda, released on March 20, 2018, set a plan for modernizing and reforming the Federal Government centered around three key areas for improvement: modern information technology; data, accountability, and transparency; and the workforce for the 21st century. Cross-agency priority goals have been created to implement the President's Management Agenda and address these three key areas. Cross-agency priority goals drive cross-government collaboration to tackle government-wide management challenges affecting most agencies.

Although NASA does not lead any cross-agency priority goals, NASA's improvements feed into several measures. Per the GPRA Modernization Act requirement to address cross-agency priority goals in the Agency strategic plan, the Annual Performance Plan, and the Annual Performance Report, please refer to *Performance.gov* for the Agency's contributions to those goals and progress.

Left: Mission Specialist Ricky Arnold and ISS Commander Drew Feustel completed the sixth spacewalk at the ISS this year, which lasted 6 hours, 49 minutes. The two astronauts installed new high-definition cameras that will provide enhanced views during the final phase of approach and docking of commercial crew spacecraft that will soon begin launching to the ISS. Image credit: NASA

Agency Priority Goals

In accordance with the GPRA Modernization Act, NASA identified five agency priority goals for the FY 2018 through FY 2019 reporting cycle. The agency priority goals represent key NASA projects, and achievements in these priority areas will benefit the United States in the areas of human spaceflight, space operations, astrophysics, and planetary science.

	Agency Priority Goals and Statements	Responsible Program	FY 2018 Rating
Discover	**1.1.5: Launch the James Webb Space Telescope.** *Revolutionize humankind's understanding of the Cosmos and humanity's place in it. The James Webb Space Telescope (Webb) 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, 2019, NASA will initiate on-orbit commissioning of Webb after launch.*	James Webb Space Telescope Program, Science Mission Directorate (SMD)	Red Not on track; launch date delayed more than a year
Discover	**1.1.15: Deliver the Mars 2020 instrument payload for spacecraft integration.** *Explore a habitable environment, search for potential biosignatures of past life, collect and document a cache of scientifically compelling samples for eventual return to Earth, and contribute to future human exploration of Mars. By August 5, 2020, NASA will launch the Mars 2020 rover. To enable this launch date, NASA will deliver the instrument payload for spacecraft integration by September 30, 2019.*	Mars Exploration Program, SMD	Green On track to complete all milestones by planned launch date
Explore	**2.2.1: Achieve critical milestones in development of new systems for the human exploration of deep space.** *By September 30, 2019, NASA will conduct the Ascent Abort-2 test of the Orion Launch Abort System, perform the green run hot-fire test of the Space Launch System's Core Stage at the Stennis Space Center, and roll the Mobile Launcher to the Vehicle Assembly Building to support the start of Exploration Mission-1 stacking operations.*	Exploration Systems Development, Human Exploration and Operations Mission Directorate (HEOMD)	Yellow One milestone delayed; no anticipated impact on agency priority goal completion
Explore	**2.2.3: Use the International Space Station (ISS) as a testbed to demonstrate the critical systems necessary for long-duration missions. Between October 1, 2017, and September 30, 2019, NASA will initiate at least eight in-space demonstrations of technology critical to enable human exploration in deep space.**	International Space Station Program, HEOMD	Green On track to achieve target
Enable	**4.2.2: Facilitate the development of and certify U.S. industry-based crew transportation systems while maintaining competition.** *By September 30, 2019, the Commercial Crew Program, along with its industry partners, will complete at least one Certification Review, following un-crewed and crewed test flights to the ISS.*	Commercial Crew Program, HEOMD	Yellow Two milestones delayed; no anticipated impact on agency priority goal completion

More information on NASA's agency priority goals is available at *Performance.gov*.

Performance Management in Action

NASA aims to be a good steward of the taxpayer's money and has a culture of data-driven performance management to continually improve its performance management systems and increase accountability, transparency, and oversight. This approach leads to more consistent performance reporting across NASA's missions and ensures the optimal use of the resources entrusted to the Agency by its stakeholders.

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

Performance Assessments and Reporting

During the third and fourth quarters of each fiscal year, program officials assess progress towards achieving the performance goals and annual performance indicators listed in the Annual Performance Plan. They determine whether targets and milestones were met as anticipated and rate the measures accordingly. They also provide an explanation supporting the rating.

Above: Astronaut Drew Feustel swaps the thermal control gear during a spacewalk outside the International Space Station on May 16, 2018. Image credit: NASA

NASA's Chief Operating Officer and the Performance Improvement Officer review the performance assessments results and provide feedback allowing for course corrections throughout the year to maintain alignment with strategic goals and objectives and to inform budget discussions.

NASA publishes a summary of preliminary fiscal year performance ratings in the annual Agency Financial Report, using available fourth quarter data. NASA publishes the final fiscal year performance ratings in the Annual Performance Report, which becomes part of the Volume of Integrated Performance. Part 2 provides NASA's final FY 2018 performance ratings and supporting explanations.

Annual Strategic Reviews

The annual Strategic Review process encompasses a comprehensive analysis of each of NASA's 13 objectives, along with the performance measures that support each objective. Using the *NASA 2018 Strategic Plan*, Agency leaders assess progress on achieving mission, management, and crosscutting strategic objectives. The assessment considers performance goals and other indicators the Agency tracks for each strategic objective, as well as challenges, risks, external factors, and other events that may have affected the outcomes.

Based on this assessment, one of three independent ratings is assigned for each strategic objective: demonstrating noteworthy progress; demonstrating satisfactory performance; or being a focus area for improvement. The Chief Operating Officer reviews the summary of the self-assessments and the cross-cutting assessment, then decides on final ratings for the strategic objectives and next steps for the Agency. NASA uses Strategic Review inputs, findings, and results throughout the Agency's budget process and as an input to the annual performance planning process. A summary of progress and rating for each strategic objective is included in Part 2.

Enterprise Risk Management

The enterprise risk management process provides better insights on how to most 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 implements enterprise risk management in

accordance with the update to Office of Management and Budget (OMB) Circular A-123, and its update M-16-17, and Circular A-11. NASA's governing councils serve as the Agency's risk management platform and the Chief Operating Officer serves as the senior official accountable for risk management.

While NASA cannot mitigate all risks related to achieving its 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, providing an analysis of the risks and opportunities NASA faces towards achieving its strategic objectives.

Program and Project Management for Executive Agencies

The Program Management Improvement Accountability Act of 2016 (PMIAA) established 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 has established a Program Management Improvement Officer and a permanent program management working group to address PMIAA requirements and develop implementation plans. NASA has met the direct requirements for PMIAA, and contributes to national goals.

- **Assigning a Program Management Improvement Officer.** This senior official will implement program management policies and develop strategies to enhance the role of program management throughout the Agency.
- **Federal standards for program and project management.** OMB provided additional PMIAA guidance, requiring development of common, principle-based Government-wide program management standards.
- **Training and development.** PMIAA recognizes program and project management as a specialized skill set, requiring training and development. NASA will continue to implement a variety of formal and informal practices to continue employee development in this area.

NASA developed a five-year PMIAA strategic implementation plan and delivered it to OMB for review on November 30, 2018. NASA expects the document to be finalized in late 2019.

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 has three Agency-level councils that establish strategic direction and provide oversight of Agency activities. The Executive Council focuses on major Agency-wide decisions by providing strategic guidance and top-level planning. The Mission Support Council is a functional council focused on mission-enabling decisions, threshold operational decisions, and internal controls as well as liability. The Program Management Council is an integral part of NASA's program and mission decisions, ensuring acceptable performance as programs reach key decision points, and to determine the readiness of a program or project to progress to the next phase of the life cycle.

The Senior Management Council, a fourth council comprised of NASA senior leaders, provides advice and counsel to the Executive Council on Agency issues and input on the formulation of Agency strategy.

Technical Authorities

NASA has several technical authorities to ensure independent oversight of critical performance areas that affect numerous organizations and activities across the Agency. These senior officials have direct lines of reporting to the Administrator, ensuring work on these priority areas adheres to Agency policy and performance standards. NASA's technical authorities are responsible for safety and mission assurance, engineering, and health and medical issues. Approval

Above: The Parker Solar Probe is lowered into the 40-foot-tall thermal vacuum chamber at the Goddard Space Flight Center on July 19, 2018. The vacuum chamber simulates the conditions the spacecraft will experience during its journey through space, including near-vacuum conditions and severe hot and cold temperatures. Image credit: NASA/JHUAPL/Ed Whitman

from NASA's technical authorities is required at each phase of major mission development or project implementation.

Baseline Performance Reviews

The Chief Operating Officer conducts a monthly internal assessment and reporting forum by which to track and assess performance of the Agency's work against established plans. The baseline performance review is a bottom-up review of how well the Agency has performed against its strategic goals and other performance metrics, such as cost and schedule estimates, contract commitments, and technical objectives. Each project/activity manager provides a performance assessment. Analysts outside of the performing organization provide independent assessments. NASA's technical authorities provide oversight and an additional level of control.

Program and Project Key Decision Point Reviews

The Agency requires internal independent assessments on the progress of programs. For major projects, senior leaders convene a series of formal gatekeeping key decision point reviews, requiring managers to provide assessments of how the project and programs are performing in key areas.[1] Such key decision points are specific milestones at which managers must provide Agency leadership with information about the program's maturity and readiness to progress to the next stage of the life cycle.

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, depending on the formulation, development implementation, or construction plan. Additionally, NASA senior leaders continually monitor overall performance monthly through the Baseline Performance Review. Additionally, NASA provides Congress, OMB, and Government Accountability Office (GAO) with cost and schedule updates for major projects.

Investment Reviews and Technology Readiness Reviews

In a manner similar to assessing project development through key decision points, experts in technology development use technology readiness levels to assess the progress of new concept advances in maturity. Technology readiness levels represent a set of progressively sophisticated criteria and milestones for which each individual technology investment must progress as it matures from concept, to development, to adoption, to integration, and use by NASA missions. Routine progress reviews measure the advancement of the work, but also serve as checkpoints to ensure the technology remains relevant to and of significant benefit to the Agency. An annual assessment of the technology development portfolio ensures that investments continue to align to future Agency needs and that a balance of desirable technologies remain in the pipeline.

Operations and Mission Support Assessments

Assessments of the Agency's operations and administrative programs are performed, at least annually, to measure if they are meeting their functional and operational goals. In addition to accomplishing the work, an activity may be assessed for improving oper-

1 Requirements for flight programs and projects are detailed in in NASA Procedural Requirements 7120.5E, *NASA Space Flight Program and Project Management Requirements* and NASA Procedural Requirements 7120.8, *NASA Research and Technology Program and Project Management Requirements*.

ations, customer satisfaction, and efficiency. These measures typically include improvements in output or capacity, increased customer satisfaction, or other quantifiable estimates of improvement, such as to reduce spending on unscheduled maintenance by at least one percent annually on NASA's equipment for maintenance and testing.

Performance Results at Work

NASA actively promotes a strong culture of achieving results, and leaders rely on data from numerous sources as they establish plans and make decisions.

Internal but Independent Cost and Schedule Estimating

NASA employs independent analysts with specialized skills to engage in formative planning with mission managers throughout the mission development process. These analysts help mission planners to craft and manage to realistic cost and schedule estimates, but also provide an independent perspective in establishing baselines and stakeholder expectations. Other analysts use earned value management expertise to help mission planners establish meaningful milestones for performance for acquired products and technology.

External Independent Verification and Validation of Flight Software

Independent verification and validation are part of an Agency-wide strategy to provide the highest achievable levels of safety and cost-effectiveness for mission critical software. Overseen by the Office of Safety and Mission Assurance, the Independent Verification and Validation Program applies system and software engineering best practices to evaluate the correctness and quality of critical and complex software systems throughout the software's system life cycle.

Peer and Subject Matter Expert Community Review

NASA relies on evaluations by external communities with expertise in areas of major scientific and academic disciplines. The Agency uses external peer review panels to objectively assess and evaluate proposals for new work in science, technology, and education. The Science Mission Directorate also draws from external senior scientist reviews when determining either operational extension or closeout for a science mission that has completed its objectives. Papers from NASA-supported research undergo independent peer review for publication in professional journals. NASA often leverages internal and external evaluators to assess specific initiatives for benefit, cost, and overall impact.

External Advisors

The NASA Advisory Council provides the NASA Administrator with recommendations on major issues related to programs, policies, plans, financial controls, proposed associate administrators, and other matters pertinent to the Agency's responsibilities. The Aerospace Safety Advisory Panel evaluates NASA's safety performance and advises the Agency on ways to improve performance. The panel bases its advice on direct observation of NASA operations and decision-making.

NASA's Science Mission Directorate has goals that reflect broad scientific objectives, such as "demonstrate progress in improving the capability to predict weather and extreme weather events." To measure progress toward achieving these goals, the Science Mission Directorate uses five Science Advisory Committees managed under the Federal Advisory Committee Act: Astrophysics Advisory Committee, Earth Science Advisory Committee, Heliophysics Advisory Committee, Planetary Science Advisory Committee, and Applied Sciences Advisory Committee. The committees are comprised of subject matter experts in each scientific discipline. Among other duties, the committees assess mission results, published peer-reviewed science, and progress on mission development to recommend performance ratings to NASA management.

NASA receives expert advice from the National Academies of Sciences, Engineering, and Medicine, which guides planning and helps ensure that the Agency's research and development priorities align with the needs of the exploration and science communities. The National Academies lead a series of decadal surveys and other analyses that help inform Agency decisions on the balance and direction of the Science Mission Directorate's investment portfolio. These decisions are reflected in the Annual Performance Plan.

NASA's Aeronautics Research Mission Directorate enlists experts in the aeronautics community to assess progress along six major research thrusts, ensuring that NASA is developing and maturing the technologies and capabilities according to the Agency's aviation research agenda. See the *NASA Aeronautics Strategic Implementation Plan* for more information.

Strategies for Success

NASA's commitment to good governance and stewardship of taxpayer funds means that the Agency routinely conducts internal assessments and evaluations to aid in maintaining, managing, and improving operations. Periodic external assessments also 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 formulating recommendations for addressing them. Issues raised by the GAO and OIG represent high-priority areas for strategic rework or management attention.

A summary of the challenge areas, recently identified by GAO and OIG, are included below. Each is followed by a short description of actions to be implemented by the Agency. For each, NASA has identified strategic objectives that will contribute to the mitigation of these challenges.

High Risk Challenges Identified by GAO

GAO assesses management activities across the Federal Government and identifies practices and potential shortcomings that put agencies at risk. 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, GAO established five criteria that, if addressed, would substantively improve operations and clear GAO's concern about high-risk activity:

- A demonstrated strong commitment to, and top leadership support for, addressing problems;
- The capacity to address problems;
- A corrective action plan;
- A program to monitor corrective measures; and
- Demonstrated progress in implementing corrective measures.

Above: In the high bay of the Kennedy Space Center's Space Station Processing Facility, technicians prepare the integrated the TSIS-1 payload and the EXPRESS Pallet Adapter for launch. NASA launched TSIS-1 to the International Space Station on December 15, 2017. Image credit: NASA/Cory Huston

As part of the 2019 update, High-Risk Series: Substantial Efforts Needed to Achieve Greater Progress on High-Risk Areas (GAO-19-157SP), 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 criterion for a corrective action plan, and has partially met the criteria for leadership, monitoring, capacity, and demonstrated progress. NASA is one of only three (out of 35) high risk areas that saw a deterioration in ratings from the prior 2017 report.

NASA's management changes have yielded more credible cost and schedule baselines, and both 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 do better at managing its larger, more complex projects, which typically involve the development of a significant number of new technologies, greater risk, and early cost and sched¬ule estimation challenges. GAO observed that risks remain for NASA's largest and flagship-type projects, such as the James Webb Space Telescope (Webb)(see Agency Priority Goal 1.1.5), the Space Launch System (SLS), and Orion (see Agency Priority Goal 2.2.1).

A Corrective Action Plan for Acquisition Management

In 2018, NASA established a new corrective action plan to accomplish two principal objectives: 1) to strengthen the Agency's cutting-edge program and project management efforts across the board and improve transparency to stakeholders; and 2) improve the Agency's surveillance of contractors through appropriate insight and oversight. In December 2018, the Agency Program Management Council approved the proposed plan, *Corrective Action Plan: In Response to Recent Programmatic Performance and NASA's Designation on GAO's High Risk List*. Recommendations and strategies informing the plan included previous GAO high risk reports, GAO's 2018 Priority Recommendations Letter, reports issued by GAO during its annual programmatic reviews of NASA's major projects, and numerous internal analyses conducted by the Agency. Direction from senior leadership, the advice of subject matter experts drawn from across NASA, and feedback from GAO were also considered.

The NASA Associate Administrator assumes ownership of the corrective action plan. The Office of the Chief Financial Officer is responsible for maintaining documentation, tracking and reporting progress against the plan on an annual basis. Mission directorates and mission support offices are responsible for executing the plan and reporting progress.

Several initiatives are anticipated to strengthen Agency acquisition management. The initiatives are categorized by the following actions.

- **Implement:** Initiatives that NASA has determined should proceed and become part of regular Agency business cadence. Any actions taken to support execution of the described initiatives will follow all established Agency control and oversight boards, as applicable, to ensure no unintended consequences are experienced.
- **Pilot:** Initiatives that NASA has determined show promise to provide value related to Agency acquisition management, but will initially be executed to a limited degree in scope and time until the Agency assesses and reaffirms continued execution.
- **Research:** Initiatives that are less conceptually mature but warrant dedicated effort to explore and develop with respect to generating value for Agency acquisition management.

Each initiative in the corrective action plan includes a history and current state (as of plan publication); near-term (two-year) anticipated next steps; output and outcome measurements by which progress can be assessed; and recognition of challenges, interdependencies, and required resources that must be actively managed by NASA leadership. The lead organization(s) identified for each initiative will pursue the objectives outlined in the plan. Assessments will occur on an annual or biennial basis; results of these assessments may result in goal or initiative addition, revision, or resolution. Lead organizations are accountable to the NASA Associate Administrator, and NASA will share results and progress with GAO annually at a minimum, and more often when possible. NASA will keep this corrective action plan current and up to date until the GAO removes the High Risk designation for the Agency.

See Performance Goal 4.1.2 for more information about NASA's performance in acquisition reforms.

Management Challenges Identified by the OIG

Each fiscal year, NASA's OIG issues a letter summarizing what the Inspector General considers to be the most serious management and performance challenges facing the Agency and briefly assesses the Agency's progress in addressing those challenges. NASA leverages the results of OIG audits to improve the overall efficiency and effectiveness of the Agency's programs, projects, and functional activities. NASA is also committed to ensuring timely and responsive final management decisions, along with timely and complete final management action on all audit recommendations issued by 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 OIG's recommendations is detailed in *NASA FY 2018 Agency Financial Report*.

The six findings from OIG's, *2018 Report on Top Management and Performance Challenges* are summarized below. NASA's response to the OIG findings is included in the final report.

Space Flight Operations in Low Earth Orbit

Primary Challenge Owner: Human Exploration and Operations Mission Directorate

This challenge encompasses concerns about the International Space Station (ISS) and commercial transportation to and from the ISS. The OIG audit identifies a disconnect between the anticipated resolution of human health risks and actual ISS research capacity. This problem is compounded by the proposed decommissioning of the ISS in 2024.

This challenge also includes concern about the cost, availability, and design risks associated with NASA's dependence on commercially available cargo and crew transportation. The OIG noted that recent commercial resupply service contracts are more expensive and deliver less upmass capability than anticipated.

See Performance Goals 1.2.1, 2.1.1, 2.1.2, 2.1.3, 4.2.1, and 4.2.2 for more information about NASA's performance towards achieving its ISS Program research goals, ISS operations, and commercial space transportation supporting ISS operations.

Deep Space Exploration

Primary Challenge Owner: Human Exploration and Operations Mission Directorate

OIG's concerns about NASA's plans for deep space exploration center around three main themes: the resources required to support development of a lunar gateway versus research necessary for Mars exploration; the increasing costs and schedule delays associated with the development of the Space Launch System (SLS), Orion Multi-Purpose Crew Vehicle (Orion), and Exploration Ground Systems (EGS); and technical challenges in each of these engineering programs.

OIG notes the tension between competing priorities to develop a lunar gateway for research and to develop the deep space transport necessary for a potential Mars crewed mission.

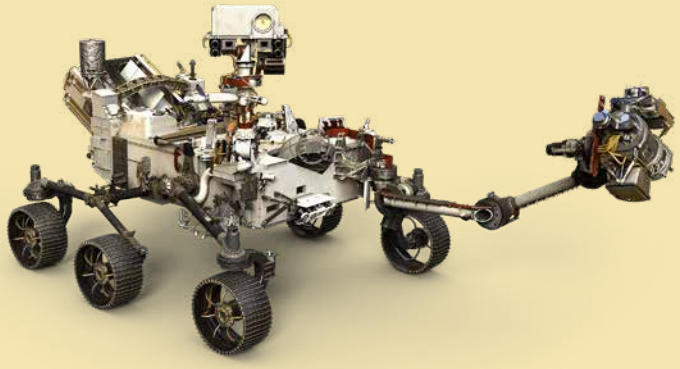
To achieve any deep space human exploration, NASA must address significant challenges in managing development of these three systems. Testing and delivery of the SLS Core Stage remains is on the critical path for development, but there is no schedule margin remaining to manage problems that may

Above: Engineers and technicians check fittings during installation of the heat shield to the Orion crew module July 25, 2018, at NASA's Kennedy Space Center. Image credit: NASA/Kim Shiflett

arise during the integration and test phase before an integrated SLS/Orion launch. The OIG cites poor contractor performance and poor NASA contract oversight as contributing to these problems, although the OIG does recognize some improvements have been made. Delivery of the European Service Module continues to be an issue, as it includes the primary power and propulsion elements for Orion.

The OIG also references concerns by the Aerospace Safety Advisory Panel that the first flight test of the complete Environmental Control and Life Support System will be during Exploration Mission (EM)- 2 with a crew aboard. Compounding these difficulties, furthermore, cost and schedule estimates for developing software to control these integrated systems have increased, to date, by approximately 77 percent and slipped by 14 months. The effort remains incomplete, as EGS will not be able to complete all necessary software validation and verification efforts until SLS and Orion complete development, testing, and delivery of their software. Development of EGS software is the third most critical task, schedule-wise, to meeting the current EM-1 launch date of June 2020.

See Performance Goals 2.2.1, 2.2.2, and 2.2.3 to find out more about NASA's performance towards achieving goals supporting a lunar gateway and deep space exploration.



Above: The Mars 2020 rover is car sized, about 10 feet long (not including the arm, 9 feel wide, and 7 feet tall. The Mars 2020 mission will use a parachute, descent vehicle, and an approach called a "skycrane maneuver" to lower the rover on a tether to the Mars surface during the final seconds prior to landing. This type of landing system provides the ability to land a very large, heavy rover on the surface of Mars in a precise landing area. Image credit: NASA/JPL-Caltech

NASA's Science Portfolio

Primary Challenge Owner: Science Mission Directorate

The OIG describes two major influencers of the Science Mission Directorate's portfolio: the adverse consequences to the portfolio at-large when a large flagship-type mission experiences cost increases and schedule delays (i.e. what the OIG terms internal influencers) and the direction received from sources outside the Agency that direct missions, and cost and schedule expectations (i.e., external influencers).

The OIG discusses scientific imperative and its troubled management history on Webb. The OIG cites overly optimistic planning, changes in launch vehicle, and long-standing cost management issues. The OIG acknowledges that in a relatively-flat budget environment, funds to cover new requirements are reallocated from other projects, thus spreading risk to cost and schedule throughout the portfolio.

The OIG identifies external drivers on the portfolio as including Congress, the Administration, other federal agencies and nations, and the advisory boards that help establish scientific (thus budgetary) priorities.

The Agency is mandated to follow direction from numerous sources, yet these directions are often misaligned, and can be in direct conflict. The OIG further describes how the appropriations process can adversely affect mission planning and execution, especially when the Agency is given direction to start up, scale down, or cancel a project, all within the span of one budget year. Such lack of cohesion stretches the Agency's limited resources, from funding dollars to technical personnel.

See Agency Priority Goal 1.1.5 for more information on Webb.

See the performance goals in Strategic Objective 1.1 to find out more about the performance of NASA's science portfolio.

Information Technology Governance and Security

Primary Challenge Owner: Office of the Chief Information Officer

The OIG continues to express concern about the governance and security of NASA's IT investments and data. The OIG believes that the Agency Chief Information Officer (CIO) and IT security officials have insufficient oversight over IT acquisition and security, caused in part by the distributed nature of IT activities at centers. Additional problems identified by OIG include a lack of definition of roles, changing man-

agement structures and personnel, strategic planning, and poor inventory practices.

The OIG recognizes that NASA has IT connections with educational institutions, research facilities, and other outside organizations. This diversity in IT users and customers provides cybercriminals a larger target than most other government agencies, and presents unique IT security challenges. The OIG cites a recent incident in which several security controls failed, user roles were misconfigured, and vulnerability scans were ineffective. A malicious attack was not identified until a year later, casting doubt on the Agency's threat detection abilities. The OIG questions the effectiveness of NASA's Security Operations Center, ongoing risks to supply chain risk management, and security related to the use and oversight of cloud computing services and systems. OIG acknowledges that many of NASA's IT systems must be interconnected and complex, but believes that the Agency hasn't established sufficient security.

See Performance Goals 4.5.1, 4.5.2, and 4.5.4 to find out more about NASA's performance in the area of IT risk management.

Infrastructure and Facilities

Primary Challenge Owner: Office of Strategic Infrastructure

In the OIG's review of facility maintenance, NASA estimated its deferred maintenance costs at $2.4 billion in 2017. The OIG believes major contributors to this issue stem from decentralized governance, intense political interest in center assets, and competition for budget resources. Infrastructure and facilities maintenance have long been of concern to the OIG, noting that throughout 8 years and 17 independent reviews, common criticisms have been slow implementation of corrective actions, inconsistent implementation of Agency policies, and a need for stronger lifecycle cost considerations in facility construction decisions. Despite special action teams to study the issue and make recommendations on capability and future needs, the OIG believes that these assessments were flawed, failed to make recommendations to achieve cost savings, and did not establish firm timeframes for completing actions.

See Performance Goals 4.2.8, 4.6.1, 4.6.2, and 4.6.3 to find out more about NASA's efforts to ensure that NASA's facilities are right-sized, efficient, and available when needed.

Contracting and Grants

Primary Challenge Owner: Office of the Chief Financial Officer and Office of Procurement

In FY 2017, NASA spent approximately $17.5 billion or 73 percent of its $24 billion of available resources, which includes reimbursable authority, on contracts to procure goods and services. The Agency awarded an additional $1 billion in grants and cooperative agreements.

To assist NASA in ensuring that the Government gets proper value for funds it expends, OIG examines Agency-wide procurement and grant-making processes; audits individual contracts, grants, and cooperative agreements; and investigates potential misuse of Agency contract and grant funds. Additionally, the OIG monitors the impact of awarded contracts and grants in accomplishing the Agency's missions and support services. The OIG continues to uncover fraud and misconduct related to NASA contracts and grants. The OIG states that its ongoing audit work has uncovered consistent issues in use of service contracts, effort duplication, use of inappropriate contract type, and lack of adequate management attention on service and professional contracts.

The OIG states that the Agency faces an ongoing challenge of ensuring grant and cooperative agreement funds are administered appropriately and that recipients are accomplishing agreed-upon goals. The OIG cites recent audits that indicate a lack of NASA oversight leading to potential duplication of efforts with other federal activities, a lack of coordination in release of data and findings, questionable acquisitions, inappropriate spending, and insufficient performance.

See Performance Goal 4.1.2 to find out more about NASA's acquisitions reform efforts.

Organizing 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 NASA's work is unified by an integrated performance culture that engages employees and stakeholders at all levels.

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

The NASA workforce of about 17,000 civil servants in 2018 is distributed among its centers, facilities, and Headquarters. NASA's centers and facilities manage and execute the mission work—engineering, operations, science, and technology development—and mission-enabling activities. Each location is supported by a contractor workforce providing technical and business operations services.

The Administrator and senior officials lead the Agency by providing top-level strategy, policy, and direction. Headquarters offices lead the Agency's budget development, execution, and performance assessment. Mission directorates and mission support offices at Headquarters manage decisions on programmatic investments and guide operations of the centers. Provided below are brief descriptions of NASA's mission directorates and select offices, current as of early 2019.

- The **Administrator's Staff Offices** lead the Agency by providing guidance and direction that cuts across all of NASA's work. These offices represent the Administrator with respect to safety and mission assurance, managing the workforce and its diversity, overseeing the acquisition and use of IT, conducting financial and procurement operations, as well as coordinating international partnerships and legislative affairs.

Above: A rainbow shines over the A-1 test stand at Stennis Space Center during a test of an RS-25 engine. The A-2 test stand is visible in the background. Image credit: KSC Unmanned Aerial Systems Team.

- The **Aeronautics Research Mission Directorate (ARMD)** designs, develops, and tests advanced technologies that will make aviation much more environmentally friendly, maintain safety in increasingly crowded skies, and ultimately transform the way the United States, air passengers, and these world-wide, travel between destinations. Research conducted by ARMD directly benefits today's air transportation system, the aviation industry, and the passengers and businesses who rely on aviation every day.
- The **Human Exploration and Operations Mission Directorate (HEOMD)** leads and manages NASA space operations related to human exploration in and beyond low Earth orbit. HEOMD oversees requirements development, policy, and programmatic oversight across its numerous programs. HEOMD's activities include the ISS, commercial space transportation, low Earth orbit spaceflight operations, deep space exploration systems, launch services, and space communications.
- The **Science Mission Directorate (SMD)** conducts scientific exploration enabled by observatories that view Earth from space, observe and visit other bodies in the solar system, and gaze out into the galaxy and beyond. NASA's science programs focus on three interdisciplinary objectives: discovering the secrets of the universe, searching for life in the solar system and beyond, and safeguarding and improving life on Earth.
- The **Space Technology Mission Directorate (STMD)** is in the process of being reorganized to better support NASA meeting its exploration priorities. To date, STMD has pursued transformational technologies that may offset future mission risk, reduce cost, and advance capabilities that enable exploration. STMD has used merit-based competition to identify and promote research and technology development, demonstrate applicability, and infuse these technologies into NASA's exploration missions.
- The **Mission Support Directorate (MSD)** enables the Agency's missions by managing institutional services and capabilities. 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.
- The **Office of STEM [science, technology, engineering, and mathematics] Engagement (OSTEM)** increases K-12 involvement in NASA projects, enhances higher education, supports underrepresented communities, strengthens online education, and boosts NASA's contribution to informal education. Note that funding for OSTEM is not included in the fiscal year 2020 request.
- NASA's **Office of Inspector General (OIG)** promotes economy, effectiveness, and efficiency within the Agency by conducting independent and objective audits, investigations, and evaluations of Agency programs and operations. The OIG safeguards taxpayer dollars and the integrity of the Agency by detecting and preventing fraud, waste, and abuse.

Performance Management Is a Team Effort

NASA's best asset for achieving mission success is a diverse, multi-disciplinary, and skilled workforce across all centers and facilities. NASA's approach to performance management is based on a philosophy that each team member brings unique experience and important expertise to projects. NASA is committed to

Above: Engineers power on the Orion test article, which will be used for the Ascent Abort-2 test, during the week of July 8 2018, at the Johnson Space Center. Throughout the week, they incrementally turned on power, checked power distribution, checked connections and voltage, and ensured that the vehicle was healthy and providing accurate data. Image credit: NASA/ Robert Markowitz

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.

For the seventh year in a row, NASA was named the "Best Place to Work" among large agencies in the Federal Government, as ranked by Federal employees. In the annual Federal Employee Viewpoint Survey, NASA employees expressed their satisfaction with and commitment to NASA's Mission. Part 2 of this document presents the results of their efforts, as well as those of NASA's contractors and partners, for FY 2018. Through teamwork and creativity, NASA had great successes and made notable progress in tackling the Agency's management challenges.

Reorganizing for Success and Sustainability

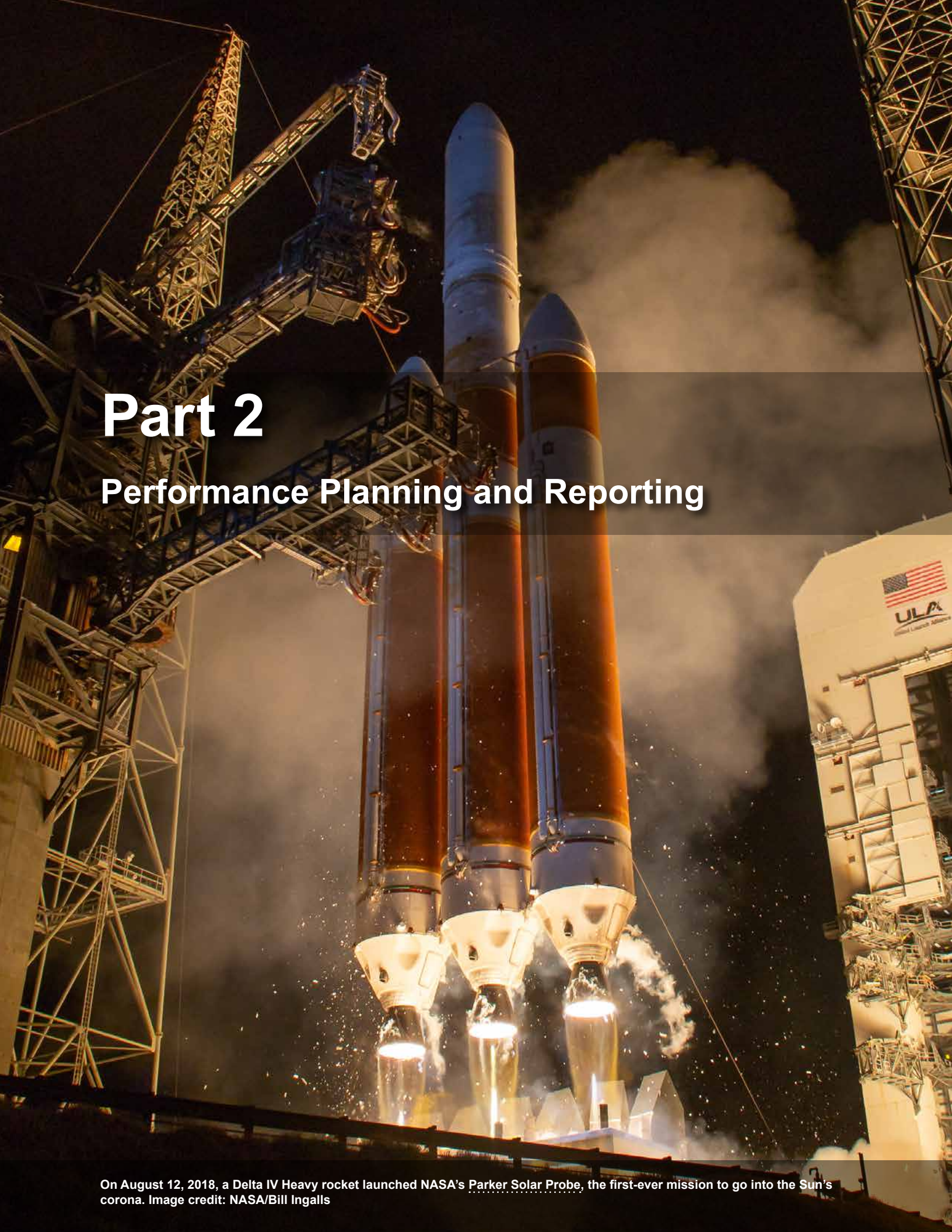
Regular assessment of the status quo for efficiency, and periodic assessment of the Agency's current versus desired future state is a hallmark of NASA's organizational commitment to achieving an innovative and sustainable program of exploration. This is particularly important as budgets for supporting infrastructures decrease, or remain flat—in effect, reducing buying power. Any cost efficiencies or improvements in conduct of day-to-day operations allows the Agency to better sustain strategic investments in NASA's core scientific, engineering, and exploration missions.

In October of 2018, NASA began rolling out a restructured approach to management of the Agency's support services, based on findings and recommendations from business service assessments conducted in 2016 and 2017. Among other strategies, the new business models reduce duplication of effort and competition for resources by combining separate support organizations at centers into Agency-wide services managed by functional leads. This approach will help ensure a common set of business practices across centers and facilities, consolidate and standardize management tools, and ensure that workforce or programming decisions made at local or at a regional level are also aligned with the long-term interest of the Agency as a whole. In 2018, the Agency realigned work flow and operations support under the Office of the Chief Human Capital Officer, the Office of the Chief Financial Officer, and the Office of Legislative and Intergovernmental Affairs.

The Agency is already realizing success with the new realignment from location-based activities to more strategic enterprise-wide services. In 2018, the Office of the Chief Financial Officer established horizontal inter-center portfolio leads to augment the existing vertical hierarchal organization. Each of these portfolios is managed by a Chief Financial Officer in the field, working at an Agency, not local, level. This portfolio lead is responsible for migrating to common, standard enterprise services by working with the stakeholder community to identify and implement improvements and efficiencies within their processes. Such improvements can, and have, included developing and applying a single set of policies, tools, directives, and decisions across all work areas in the area, while ensuring full compliance with Federal mandates, regulations, and appropriate business practices. Silos and inconsistent business processes are being eliminated.

This new structure began to prove its worth during the 2018-2019 lapse in appropriations. The Office of the Chief Financial Officer portfolio leads developed and applied consistent guidance, then applied ensured it was applied consistently across by all centers. This improved identifying exempt and excepted activities, streamlining the shutdown and reopening process (including accelerating crucial vendor payments to vulnerable small businesses), and responding to customers both inside and outside of the Agency. In 2019, the Agency-wide Office of the Chief Financial Officer will continue to realize improvements in budget management, financial reporting and monitoring, implementing agreements, and end user services. Performance in cost reduction and improved services will be assessed against 2018 baselines and future year targets. Several metrics are in use, but the most important one measures progress towards enterprise services, and the percentage of functions that are delivered using consistent processes, and providing a consistent quality of service to customers.

The success is not isolated; other realigned offices are also performing more efficiently and effectively. The shutdown services led by the Office of the Chief Human Capital Officer were well organized, and applied consistently across the Agency. Communications to staff, contractors, and vendors was viewed as a model by many agencies who directed those with inquiries to NASA communication sites. The Agency expects similar successes with other office realignments as the process continues. In 2019, NASA will begin similar efforts for activities related to procurement, small business, equal opportunity and diversity, and protective services.



Part 2

Performance Planning and Reporting

On August 12, 2018, a Delta IV Heavy rocket launched NASA's Parker Solar Probe, the first-ever mission to go into the Sun's corona. Image credit: NASA/Bill Ingalls

How to Read NASA's Performance Data

Part 2 of this volume presents an integrated view of NASA's FY 2018 Annual Performance Report, the FY 2019 Performance Plan Update, and the FY 2020 Performance Plan organized by strategic goal and strategic objective.

Performance Data within the Strategic Framework

Part 2 is organized according to the strategic plan framework established in the *NASA 2018 Strategic Plan*. the four themes and strategic goals and the strategic objectives shown below consist of NASA priorities, approaches, and metrics to evaluate and improve progress toward these priorities at varying levels throughout the Agency.

Discover

Expand human knowledge through new scientific discoveries.

Strategic Goal 1: Expand human knowledge through new scientific discoveries.

1.1 Understand the Sun, Earth, solar system and universe.

1.2 Understand responds of physical and biological systems to spaceflight.

Explore

Extend human presence deeper into space and to the Moon 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.

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

2.2 Conduct exploration in deep space, including to the surface of the Moon.

Develop

Address national challenges and catalyze economic growth.

Strategic Goal 3: Address national challenges and catalyze economic growth.

3.1 Develop and transfer revolutionary technologies to enable exploration capabilities for NASA and the Nation.

3.2 Transform aviation through revolutionary technology research development and transfer.

3.3 Inspire and enable the public in aeronautics, space, and science.

Enable

Optimize capabilities and operations.

Strategic Goal 4: Optimize capabilities and operations.

4.1 Engage in partnership strategies.

4.2 Enable space access and services.

4.3 Assure safety and mission success.

4.4 Manage human capital.

4.5 Ensure enterprise protection.

4.6 Sustain infrastructure capabilities and operations.

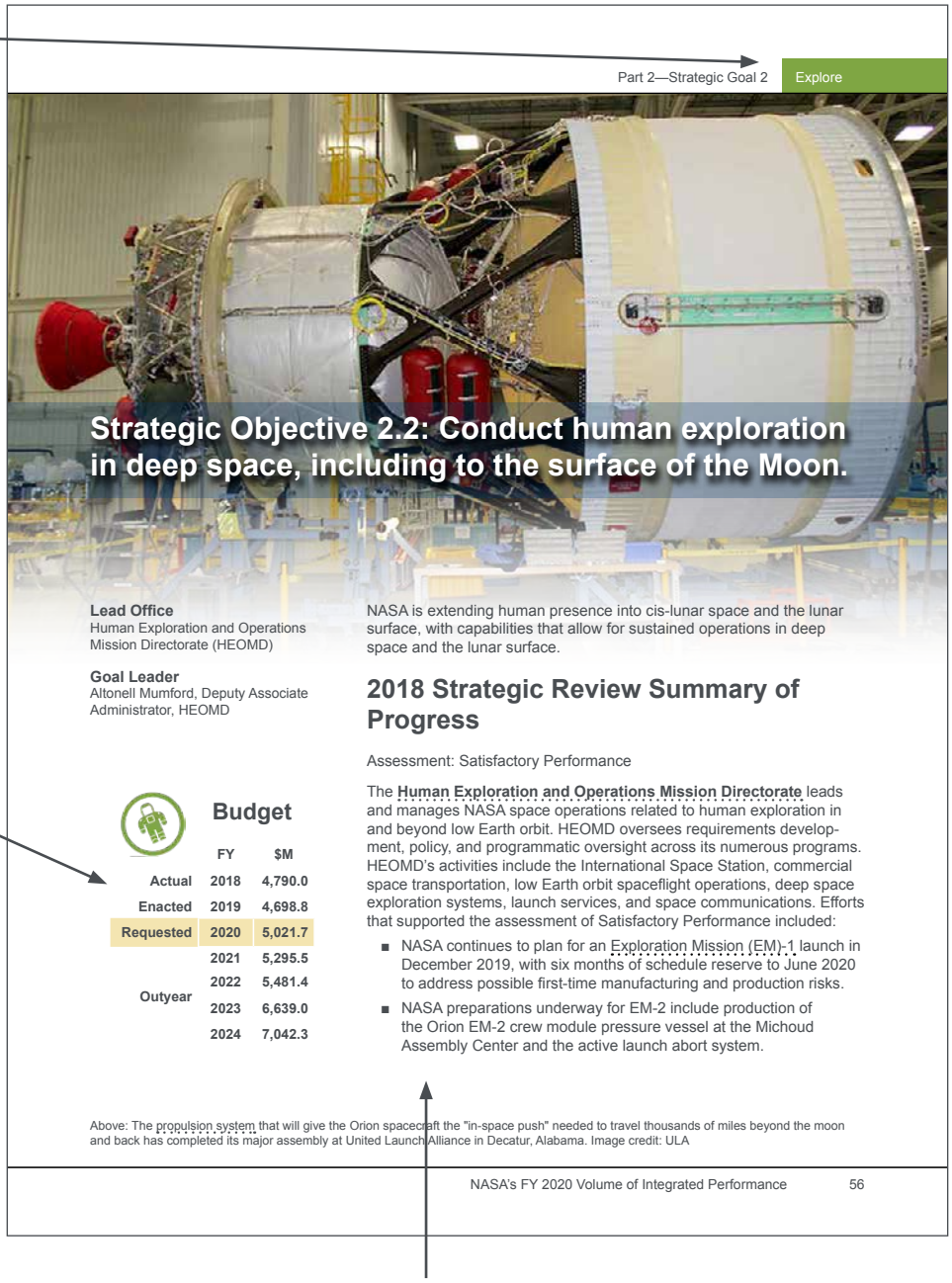
Each strategic objective includes performance goals (PGs) and annual performance indicators (APIs), associated FY 2018 performance ratings, and rating explanations for the performance goals. Where NASA did not achieve its target or milestone for a performance goal or annual performance indicator, an explanation describes why the target wasn't met, and when appropriate, the corrective actions the Agency intends to take to complete the target or milestone.

Walk Through an Example

The following sections explain how to read NASA's performance information presented in Part 2. Please reference the links provided for more detailed information.

Color-coded bookmarks on each page correspond to the strategic theme for the strategic objective.

The budget table shows the allocation of budget authority for each fiscal year, in millions. For FY 2018 and 2019, the figure represents actual budget authority distributed to investments supporting this strategic objective. Funding for FY 2020 is estimated, based on the budget requested. Budgets are provided for fiscal years 2021 through 2024. Note that totals of all budgets provided for strategic objectives are rounded to a single decimal point. Totals will not add to the NASA total budget request; funds associated with the Office of Inspector General do not map to specific strategic objectives and are not included in any strategic objective budget roll-up.



Part 2—Strategic Goal 2 Explore

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 Mumford, Deputy Associate Administrator, HEOMD

NASA is extending human presence into cis-lunar space and the lunar surface, with capabilities that allow for sustained operations in deep space and the lunar surface.

2018 Strategic Review Summary of Progress

Assessment: Satisfactory Performance

The **Human Exploration and Operations Mission Directorate** leads and manages NASA space operations related to human exploration in and beyond low Earth orbit. HEOMD oversees requirements development, policy, and programmatic oversight across its numerous programs. HEOMD's activities include the International Space Station, commercial space transportation, low Earth orbit spaceflight operations, deep space exploration systems, launch services, and space communications. Efforts that supported the assessment of Satisfactory Performance included:

- NASA continues to plan for an Exploration Mission (EM)-1 launch in December 2019, with six months of schedule reserve to June 2020 to address possible first-time manufacturing and production risks.
- NASA preparations underway for EM-2 include production of the Orion EM-2 crew module pressure vessel at the Michoud Assembly Center and the active launch abort system.

Budget

	FY	$M
Actual	2018	4,790.0
Enacted	2019	4,698.8
Requested	2020	5,021.7
Outyear	2021	5,295.5
	2022	5,481.4
	2023	6,639.0
	2024	7,042.3

Above: The propulsion system that will give the Orion spacecraft the "in-space push" needed to travel thousands of miles beyond the moon and back has completed its major assembly at United Launch Alliance in Decatur, Alabama. Image credit: ULA

NASA's FY 2020 Volume of Integrated Performance 56

The annual Strategic Review is a comprehensive analysis of each of NASA's 13 strategic objectives. Based on this assessment, one of three independent ratings is assigned: noteworthy progress; satisfactory performance; or focus area for improvement. More detailed information can be found in Part 1.

There are four possible ratings for each PG and API, as shown below. The mission directorates define their own success criteria for the ratings during the development of their performance measures, so the success criteria are unique to each performance goal or annual performance indicator. More information about the performance assessment process can be found in Part 1.

Green

On Track or Complete

NASA completed or expects to complete this performance measure within the estimated timeframe.

Yellow

Slightly Below Target and/or Behind Schedule

NASA completed or expects to complete this performance measure, but is slightly below the target and/or moderately behind schedule.

Red

Significantly Below Target and/or Behind Schedule

NASA did not or does not expect to complete this performance measure within the estimated timeframe. The program is substantially below the target and/or significantly behind schedule.

White

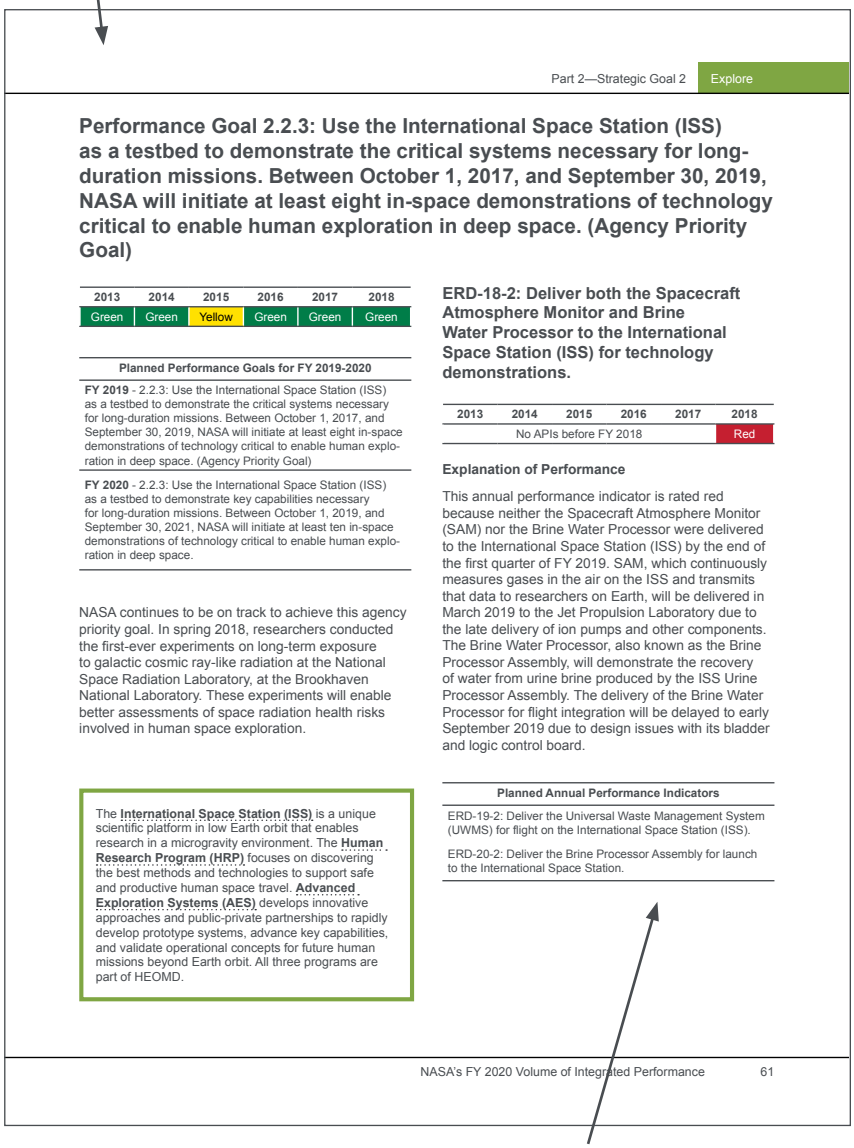
Canceled or Postponed

NASA senior management cancelled or postponed this performance measure. The Agency is no longer pursuing activities related to this performance measure or the program did not have activities and/or resources during the fiscal year.

Up to five years of historical performance ratings are provided, depending on when the goal started. The table will note where ratings are not available (e.g., in years where the goal did not exist) in previous years by saying “No PG” or “No API.”

Please note that the PG’s numbers changed over time due to strategic plan framework changes. Numbering change information is not available in this report.

PGs can be rated one color but its related APIs can be rated a different color. For example, the PG may be rated green but the supporting API is rated yellow. Every performance measure has success criteria that specify the amount of performance progress required for each color rating. For a PG, the success criteria for a fiscal year may be based entirely on the ratings of its API or they may be based on additional information. This scenario may indicate that that a project’s multiyear progress was not hindered by performance challenges in a single fiscal year.



Part 2—Strategic Goal 2 Explore

Performance Goal 2.2.3: Use the International Space Station (ISS) as a testbed to demonstrate the critical systems necessary for long-duration missions. Between October 1, 2017, and September 30, 2019, NASA will initiate at least eight in-space demonstrations of technology critical to enable human exploration in deep space. (Agency Priority Goal)

2013	2014	2015	2016	2017	2018
Green	Green	Yellow	Green	Green	Green

Planned Performance Goals for FY 2019-2020

FY 2019 - 2.2.3: Use the International Space Station (ISS) as a testbed to demonstrate the critical systems necessary for long-duration missions. Between October 1, 2017, and September 30, 2019, NASA will initiate at least eight in-space demonstrations of technology critical to enable human exploration in deep space. (Agency Priority Goal)

FY 2020 - 2.2.3: Use the International Space Station (ISS) as a testbed to demonstrate key capabilities necessary for long-duration missions. Between October 1, 2019, and September 30, 2021, NASA will initiate at least ten in-space demonstrations of technology critical to enable human exploration in deep space.

NASA continues to be on track to achieve this agency priority goal. In spring 2018, researchers conducted the first-ever experiments on long-term exposure to galactic cosmic ray-like radiation at the National Space Radiation Laboratory, at the Brookhaven National Laboratory. These experiments will enable better assessments of space radiation health risks involved in human space exploration.

The **International Space Station (ISS)** is a unique scientific platform in low Earth orbit that enables research in a microgravity environment. The **Human Research Program (HRP)** focuses on discovering the best methods and technologies to support safe and productive human space travel. **Advanced Exploration Systems (AES)** develops innovative approaches and public-private partnerships to rapidly develop prototype systems, advance key capabilities, and validate operational concepts for future human missions beyond Earth orbit. All three programs are part of HEOMD.

ERD-18-2: Deliver both the Spacecraft Atmosphere Monitor and Brine Water Processor to the International Space Station (ISS) for technology demonstrations.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Red

Explanation of Performance

This annual performance indicator is rated red because neither the Spacecraft Atmosphere Monitor (SAM) nor the Brine Water Processor were delivered to the International Space Station (ISS) by the end of the first quarter of FY 2019. SAM, which continuously measures gases in the air on the ISS and transmits that data to researchers on Earth, will be delivered in March 2019 to the Jet Propulsion Laboratory due to the late delivery of ion pumps and other components. The Brine Water Processor, also known as the Brine Processor Assembly, will demonstrate the recovery of water from urine brine produced by the ISS Urine Processor Assembly. The delivery of the Brine Water Processor for flight integration will be delayed to early September 2019 due to design issues with its bladder and logic control board.

Planned Annual Performance Indicators

ERD-19-2: Deliver the Universal Waste Management System (UWMS) for flight on the International Space Station (ISS).

ERD-20-2: Deliver the Brine Processor Assembly for launch to the International Space Station.

NASA's FY 2020 Volume of Integrated Performance 61

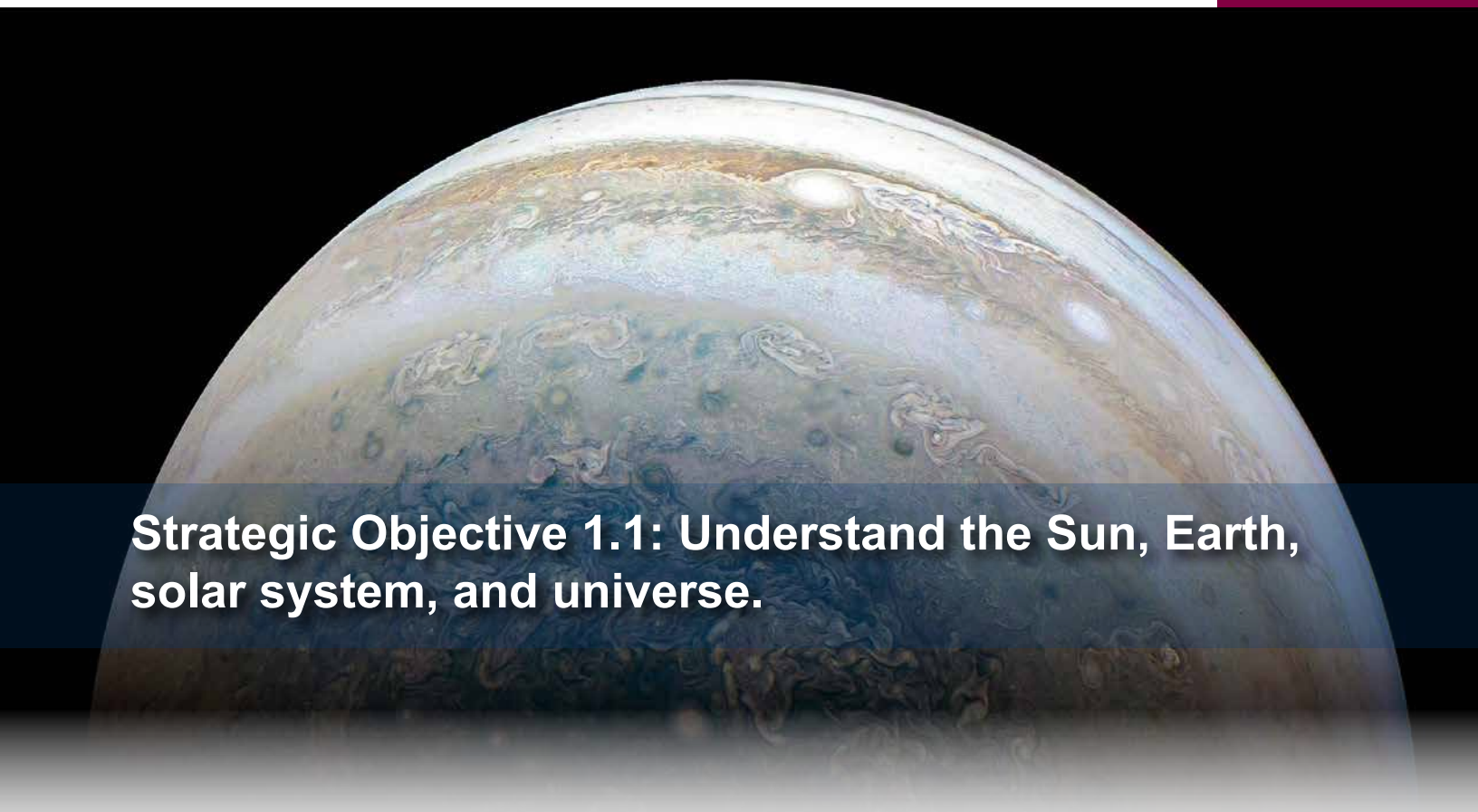
Two years of planned PGs and APIs are provided. The table will state “No PG this fiscal year” if a PG is not scheduled for renewal.

Discover

Strategic Goal 1

Expand human knowledge through new scientific discoveries.

Operation IceBridge is an airborne survey of Arctic and Antarctic ice sheets, ice shelves, and sea ice. It has helped fill the data collection between ICESat, which de-orbited in 2010, and ICESat-2, which launched in September 2018. This photo of the Larsen C ice shelf in Antarctica was taken by an IceBridge flight on October 31, 2017. Image credit: NASA/Nathan Kurtz



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

Lead Office
Science Mission Directorate (SMD), with support from the Human Exploration and Operations Mission Directorate (HEOMD)

Goal Leader
Thomas Zurbuchen, Associate Administrator, SMD

Budget

	FY	$M
Actual	2018	6,211.5
Enacted	2019	6,291.9
Requested	2020	6,303.7
Outyear	2021	6,319.0
	2022	6,319.0
	2023	5,846.5
	2024	5,815.0

NASA is conducting scientific studies of the Earth and Sun from space, return data and samples from other bodies in the solar system, peer out into the vast reaches of the universe, and play a catalyzing role in lunar robotic exploration by supporting innovative approaches to advancing science. These efforts are guided by national priorities and recommendations from the National Academies' decadal surveys and implemented through a balanced portfolio of programs.

2018 Strategic Review Summary of Progress

The **Science Mission Directorate** 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. Near-term efforts that supported the assessment included:

- *Discovering Secrets of the Universe:* Parker Solar Probe launched on August 12, 2018, will fly though the Sun's coronal atmosphere, revealing the fundamental science of what drives solar wind. SMD also continues the integration and testing of the James Webb .

Above: The Juno spacecraft's JunoCam took this color-enhanced image of Jupiter on May 23, 2018. Image credit: NASA/JPL-Caltech/SwRI/MSSS/Kevin Gill

Space Telescope (Webb), which will be the premier observatory of the next decade, studying every phase in the history of the universe, ranging from the first luminous glows after the Big Bang, to the formation of solar systems capable of supporting life on planets like Earth, to the evolution of Earth's solar system.

- *Searching for Life Elsewhere:* The Transiting Exoplanet Survey Satellite (TESS) mission, launched on April 18, 2018, is poised to increase the number of candidate life-hosting planets. SMD also continues development of the Mars 2020 mission, which will search for evidence of possible past or present life on Mars.
- *Safeguarding and Improving Life:* SMD launched the Gravity Recovery and Climate Experiment Follow-on (GRACE-FO) on May 22, 2018 to track water movement across the planet. SMD has also solicited proposals applying Earth observations for disaster risk reduction and resilience. Additionally, SMD maintains a watch for near-Earth objects, asteroids and comets that pass within Earth's neighborhood, as part of an ongoing effort to discover, catalog, and characterize these bodies.

Performance Measures for Strategic Objective 1.1

The following pages provide the performance goals and annual performance indicators supporting Strategic Objective 1.1. They include the final performance results for FY 2018, the FY 2019 Performance Plan Update, which NASA considers final for FY 2019, and the initial FY 2020 Performance Plan. Below are charts summarizing the FY 2018 performance ratings for the performance goals and annual performance indicators supporting Strategic Objective 1.1.

As NASA conducts its 2019 Strategic Review, to be completed in spring 2019, it will conduct a retrospective and prospective analyses to determine if the programs supporting this strategic objective are healthy and can address potential or realized risks. Part of the retrospective analyses will take into consideration the FY 2018 performance results found on the following pages. Looking forward, NASA will assess whether it is on track to achieve the FY 2019 annual performance indicators. The results of this early assessment will inform planning for the FY 2021 Performance Plan, which will begin in spring 2019.

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

Performance Goal

Span two to five years, and measure the performance of investments towards strategic objectives and strategic goals. The total number of performance goals is reflected in each rating box and there is no one-to-one correlation to annual performance indicator ratings. .

Annual Performance Indicator

Describe the smaller, achievable measurements that serve as NASA's basic unit of performance. They show progress achieved during the budget year, and NASA uses them to assess progress made towards achieving the performance goals and the strategic objectives. The total number of annual performance indicators is reflected in each rating box and there is no one-to-one correlation to performance goal ratings.

Performance Goal 1.1.1: Demonstrate progress in exploring the physical processes in the space environment from the Sun to Earth and throughout the solar system.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.1: Demonstrate progress in exploring the physical processes in the space environment from the Sun to Earth and throughout the solar system.

See page 55 for a list of FY 2020 performance measures.

The **Heliophysics Division**, part of SMD, conducts research on the sun, its extended solar-system environment (the heliosphere), and planetary environments as a single connected system. The scope of Heliophysics ranges from the sun's interior to Earth's upper atmosphere and beyond, through interplanetary space, to the end of the region of the sun's influence, far beyond the outer planets.

The Heliophysics Advisory Committee determined in October 2018 that NASA remained on track in its annual performance towards achieving this performance goal. Below are examples of the scientific progress reported in FY 2018.

NASA missions led to significant advances in understanding of how plasmas are heated and accelerated. Observations of the sun by the Solar Dynamics Observatory (SDO) and the Focusing Optics X-ray Solar Imager (FOXSI) showed that finger-like jets called spicules and small bursts of magnetic fields called nanoflares both contribute to heating the outer atmosphere of the sun. At the boundary of Earth's magnetosphere, which slows and deflects the solar wind, a new type of small-scale magnetic reconnection was discovered using data from the Magnetospheric Multiscale (MMS) mission.

NASA satellite missions have also made significant progress in understanding the chemistry and composition of the middle atmosphere. For instance, NASA's Aeronomy of Ice in the Mesophere (AIM) mission made the first observations of meteoric smoke composition, revealing how extraterrestrial debris affects the chemistry of the upper atmosphere.

HE-18-1: As determined by the Heliophysics Advisory Committee (HPAC), demonstrate planned progress in exploring the physical processes in the space environment from the Sun to Earth and throughout the solar system.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

HE-19-1: As determined by the Heliophysics Advisory Committee (HPAC), demonstrate planned progress in exploring the physical processes in the space environment from the Sun to Earth and throughout the solar system.

See page 55 for a list of FY 2020 performance measures.

Performance Goal 1.1.2: Demonstrate progress in advancing understanding of the connections that link the Sun, Earth, and planetary space environments, and the outer reaches of the solar system.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.2: Demonstrate progress in advancing understanding of the connections that link the Sun, Earth, and planetary space environments, and the outer reaches of the solar system.

See page 55 for a list of FY 2020 performance measures.

The **Heliophysics Division**, part of SMD, conducts research on the sun, its extended solar-system environment (the heliosphere), and planetary environments as a single connected system. The scope of Heliophysics ranges from the sun's interior to Earth's upper atmosphere and beyond, through interplanetary space, to the end of the region of the sun's influence, far beyond the outer planets.

The Heliophysics Advisory Committee determined in October 2018 that NASA remained on track in its annual performance towards achieving this performance goal. Below are examples of the scientific progress reported in FY 2018.

NASA's Interstellar Boundary Explorer (IBEX) has provided new insight into how the solar wind affects the entire heliosphere, expanding the boundaries. Additionally, simultaneous imaging of auroras in both hemispheres by NASA instruments, such as the Global Ultraviolet Imager on the Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) spacecraft, has confirmed that circulation in the ionosphere is highly controlled by the solar wind magnetic field direction.

NASA-supported investigations are improving understanding of the connections between atmospheric and space phenomena. Using data from AIM, analyses of gravity waves in the middle and upper atmosphere have shown how gravity waves transfer momentum and energy from Earth's surface throughout the atmosphere. NASA-funded research has also shown, using data from instruments on TIMED and AIM, that winds in the upper atmosphere are substantially affected by space weather. These studies demonstrate how weather events originating at Earth's surface and in space can impact the entire globe.

HE-18-2: As determined by the Heliophysics Advisory Committee (HPAC), demonstrate planned progress in advancing understanding of the connections that link the Sun, Earth, and planetary space environments, and the outer reaches of the solar system.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

HE-19-2: As determined by the Heliophysics Advisory Committee (HPAC), demonstrate planned progress in advancing understanding of the connections that link the Sun, Earth, and planetary space environments, and the outer reaches of the solar system.

See page 55 for a list of FY 2020 performance measures.

Performance Goal 1.1.3: Demonstrate progress in developing the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.3: Demonstrate progress in developing the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

See page 55 for a list of FY 2020 performance measures.

The **Heliophysics Division**, part of SMD, conducts research on the sun, its extended solar-system environment (the heliosphere), and planetary environments as a single connected system. The scope of Heliophysics ranges from the sun's interior to Earth's upper atmosphere and beyond, through interplanetary space, to the end of the region of the sun's influence, far beyond the outer planets.

The Heliophysics Advisory Committee determined in October 2018 that NASA remained on track in its annual performance towards achieving this performance goal. Below are examples of the scientific progress reported in FY 2018.

Data from NASA missions, across all heliophysics disciplines, were used to advance understanding of space weather phenomena capable of negatively affecting life on Earth as well as human and robotic explorers beyond Earth. Observations of the thermosphere by the Sounding of the Atmosphere Using Broadband Emission Radiometry (SABER) instrument on TIMED were critical to significantly improving the predictive capabilities of upper atmosphere forecast models, which reduces the risk of losing satellites to collisions or communication failures. Using data from NASA's Van Allen Probes, new understanding of radiation belt variability will help researchers assess and mitigate the hazardous effects of elevated radiation on spacecraft and crew.

HE-18-3: As determined by the Heliophysics Advisory Committee (HPAC), demonstrate planned progress in developing the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

HE-19-3: As determined by the Heliophysics Advisory Committee (HPAC), demonstrate planned progress in developing the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

See page 55 for a list of FY 2020 performance measures.

Performance Goal 1.1.4: By December 2019, launch one mission in support of Heliophysics.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Yellow	Green

Planned Performance Goals

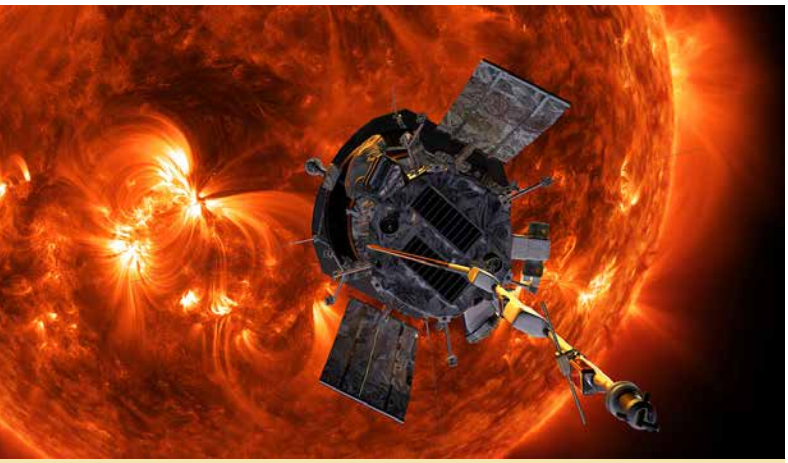
2019 - 1.1.4: By December 2019, launch one mission in support of Heliophysics.

See page 55 for the FY 2020 launch performance goal.

The **Heliophysics Division**, part of SMD, conducts research on the sun, its extended solar-system environment (the heliosphere), and planetary environments as a single connected system. The scope of Heliophysics ranges from the sun's interior to Earth's upper atmosphere and beyond, through interplanetary space, to the end of the region of the sun's influence, far beyond the outer planets.

NASA achieved this performance goal by launching the Parker Solar Probe on August 12, 2018. When the spacecraft transmitted its first science observations in December, it began to advance scientific understanding of the star that makes life on Earth possible. The mission's findings will help researchers improve their forecasts of space weather events, which have the potential to damage satellites and harm astronauts on orbit, disrupt radio communications and, at their most severe, overwhelm power grids.

Throughout its seven-year mission, the Parker Solar Probe will make 24 passes by the sun, journeying steadily closer until it makes its closest approach at 3.8 million miles, inside the sun's atmosphere. At this point, the probe will be moving at 430,000 miles per hour, setting the record for the fastest-moving object made by humankind.



NASA's Parker Solar Probe is heading to the sun. Thermal Protection System Engineer Betsy Congdon (Johns Hopkins APL) outlines why the Parker Solar Probe can take the heat in Why Won't it Melt? How NASA's Solar Probe will Survive the Sun. Image Credit: NASA

HE-18-4: Launch Parker Solar Probe (PSP).

2013	2014	2015	2016	2017	2018
No API	Green	Green	Green	Yellow	Green

Planned Annual Performance Indicators

No APIs after FY 2018

HE-18-5: Release the 2018 Heliophysics Medium Explorer (MIDEX) Announcement of Opportunity.

2013	2014	2015	2016	2017	2018
No API	Green	Green	Green	Yellow	Yellow

Explanation of Performance

NASA delayed the release of the 2018 MIDEX Announcement of Opportunity to early FY 2019 in order to eliminate overlap between the proposal evaluation effort and the evaluation/site visits for the Small Explorer (SMEX) 2016 concept study reports. The 2012 Decadal Survey for Solar and Space Physics strongly recommended a robust principal investigator-led Explorers program for Heliophysics. As a result, NASA selected five SMEX mission proposals for a Phase A study, with the intent to select two of those missions to progress to Phase B.

Planned Annual Performance Indicators

No APIs after FY 2018

HE-18-7: Complete the selection for the Interstellar Mapping and Acceleration Probe (IMAP) Announcement of Opportunity.

2013	2014	2015	2016	2017	2018
No APIs before FY 2017				Green	Green

Planned Annual Performance Indicators
HE-19-9: Complete Interstellar Mapping and Acceleration Probe (IMAP) concept studies.
See page 55 for the FY 2020 IMAP annual performance indicator.

HE-18-8: Launch the Ionospheric Connection Explorer (ICON).

2013	2014	2015	2016	2017	2018
No API	No API	Green	Green	Green	Yellow

Explanation of Performance

NASA and Northrop Grumman delayed the October 2018 ICON launch when they detected anomalous data from the Pegasus XL rocket, which contained ICON. The Pegasus XL rocket was transported back to Vandenberg Air Force Base in California for further analysis. A new launch date has not yet been set. The ICON spacecraft remains healthy.

Planned Performance Goals
See page 55 for a list of FY 2020 performance measures.

HE-19-6 [Begins in FY 2019]

Planned Annual Performance Indicators
HE-19-6: Complete the 2016 Heliophysics Small Explorer (SMEX) Announcement of Opportunity down-select.
No API after FY 2020

HE-19-7 [Begins in FY 2019]

Planned Annual Performance Indicators
HE-19-7: Deliver Science and Technology Definition Team (STDT) report.
No API for FY 2020

Performance Goal 1.1.5: Conduct on-orbit commissioning of the James Webb Space Telescope after launch. (Agency Priority Goal)

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Yellow	Red

Planned Performance Goals

2019 - 1.1.5: Conduct on-orbit commissioning of the James Webb Space Telescope after launch. (Agency Priority Goal)

See page 55 for a list of FY 2020 performance measures.

The James Webb Space Telescope, or Webb, will be a large infrared space observatory capable of studying every phase in the history of the universe, from the first glows after the Big Bang to the evolution of planets. The Webb program is part of the Science Mission Directorate.

Although NASA completed some major milestones as planned for FY 2018, Webb will not achieve this agency priority goal, which assumed that Webb would launch no later than September 30, 2019.

After successful completion of the cryovacuum testing at Johnson Space Center in October 2017, Webb's Optical Telescope Element plus Integrated Science Instrument Module, together known as OTIS, was shipped to the Northrop Grumman Aerospace System Space Park facility in Redondo Beach, California, in February 2018. Subsequent successful functional testing of OTIS was performed at Space Park in May and June 2018.

During FY 2018, NASA completed testing of the sunshield, which was integrated to the spacecraft bus in FY 2017. The testing included initial folding of the sunshield membrane, full deployment of the sunshield structure and membrane, tensioning of the membrane and re-folding and stowing into the launch configuration. During this initial testing, snags with the membrane tensioning system occurred during deployment, as well as several small tears in the membrane. The membrane tensioning system was redesigned, tested, and re-installed on the sunshield. The cause of the membrane tears is fully understood, the majority have been repaired, and corrective action has taken place so that tears are minimized during subsequent test deployments.

In early 2017, it was discovered that several dual thruster valves of the propulsion system leaked due to erosion of the seals. The replacement of the spacecraft propulsion system thruster valves was completed in March 2018.

Environmental testing of the spacecraft was initiated in April 2018. After completion of the acoustics test, which was the first of the testing series, loose screws, washers, and nuts were discovered and traced to the sunshield membrane cover battens. The root cause was identified as an insufficient installation procedure of the hardware, and all of the hardware was removed and replaced. NASA started the spacecraft/sunshield environmental testing again, with a re-run of the acoustics test in October 2018.

NASA established an Independent Review Board to assess the schedule, work to go, and underlying causes of schedule erosion. Based on the board's findings and recommendations, NASA is now planning to launch Webb in March 2021. This new launch date takes into account the lessons learned from the initial fold, deployment, and stow of the sunshield, as well as the corrective action required for the recent loosened hardware discovered after the acoustics test. In June, NASA alerted Congress of the new launch date and an increase in development cost of $800 million over the $8 billion cost cap.

JWST-18-1: Integrate the James Webb Space Telescope Optical Telescope Element (OTE) plus Integrated Science Instrument Module (ISIM), known as OTIS, with the spacecraft and sunshield.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Yellow	Red

Performance Explanation

Integration of OTIS with the spacecraft and sunshield has been delayed until October 2019 due to the discovery of loosened hardware after an acoustics test (see Performance Goal 1.1.5 for more information). Actions are being taken by the project and program to minimize procedural and human errors, as recommended by the Independent Review Board.

Planned Annual Performance Indicators
JWST-19-1: Complete spacecraft element thermal vacuum testing.

See page 55 for a list of FY 2020 performance measures.

Webb's two halves, the spacecraft and telescope, were connected together using temporary ground wiring that enabled them to "speak" to each other like they will in flight in September 2018 This was an optional "risk reduction" test that took advantage of an opportunity to connect the two halves of the observatory together electrically months earlier than planned. If any issues had been found, it would have given engineers more time to fix them and without causing further delays. As a bonus, it also provided a jumpstart for the separate spacecraft and telescope test teams to begin working jointly as they will when the whole observatory is reassembled into one spacecraft in 2019. Image credit: Northrop Grumman

Performance Goal 1.1.6: Demonstrate progress in probing the origin and destiny of the universe, including the nature of black holes, dark energy, dark matter, and gravity.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.6: Demonstrate progress in probing the origin and destiny of the universe, including the nature of black holes, dark energy, dark matter, and gravity.

See page 55 for a list of FY 2020 performance measures.

The Astrophysics Advisory Committee determined in July 2018 that NASA remained on track in its annual performance toward the achievement of this performance goal. Below are examples of the scientific progress reported in FY 2018.

Numerous new discoveries and fruitful measurements propelled progress in understanding the workings of the universe. Moments after the Laser Interferometer Gravitational-wave Observatory (LIGO) detected gravitational waves, the Fermi Gamma-ray Space Telescope picked up a pulse of high-energy light. The coincidental detections provided the first powerful evidence of a pair of stars smashing together and exploding. The Swift, Hubble, Chandra, and Spitzer missions, along with ground-based observatories including the NASA-funded Panoramic Survey Telescope And Rapid Response System (Pan-STARRS) survey, later captured the glow of the blast's debris. The detection of a gravitational-wave source's light has revealed that the event was caused by the merger of two neutron stars.

Progress has taken place in finding and understanding black holes, as well as into probing the fate of the Universe and its dark energy content by measuring the Hubble constant with higher precision. Nuclear Spectroscopic Telescope Array (NuSTAR) data has provided insight into the origin of jets around black holes. Archival observations by the Chandra X-Ray Observatory revealed the presence of a dozen black holes gathered around the supermassive black hole in the center of the Milky Way Galaxy.

The **Astrophysics Division**, part of SMD, studies the origin and evolution of the universe, including planets circling stars outside the solar system, distant galaxies and groups of galaxies, and compact objects and black holes.

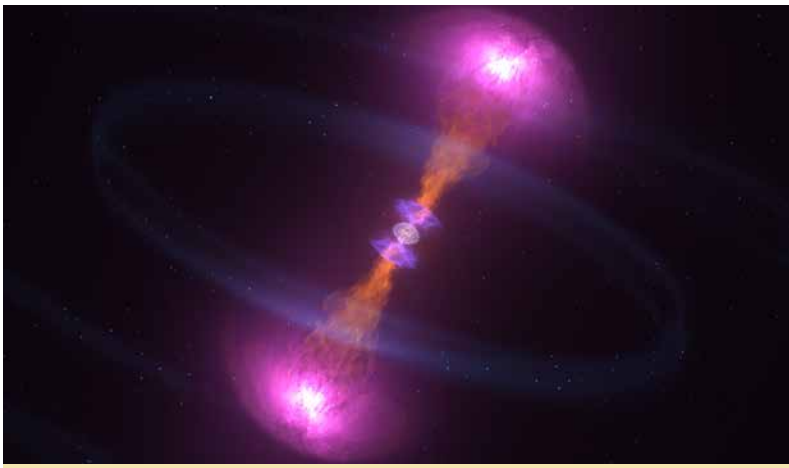
AS-18-1: As determined by the Astrophysics Advisory Committee (APAC), demonstrate planned progress in probing the origin and destiny of the universe, including the nature of black holes, dark energy, dark matter, and gravity.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

AS-19-1: As determined by the Astrophysics Advisory Committee (APAC), demonstrate planned progress in probing the origin and destiny of the universe, including the nature of black holes, dark energy, dark matter, and gravity.

See page 55 for a list of FY 2020 performance measures.



For the first time, NASA scientists have detected light tied to a gravitational-wave event, thanks to two merging neutron stars in the galaxy NGC 4993, located about 130 million light-years from Earth in the constellation Hydra. Image credit: Credits: NASA's Goddard Space Flight Center/CI Lab

Performance Goal 1.1.7: Demonstrate progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.7: Demonstrate progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe.

See page 55 for a list of FY 2020 performance measures.

The **Astrophysics Division**, part of SMD, studies the origin and evolution of the universe, including planets circling stars outside the solar system, distant galaxies and groups of galaxies, and compact objects and black holes.

The Astrophysics Advisory Committee determined in July 2018 that NASA remained on track in its annual performance toward the achievement of this performance goal. Below are examples of the scientific progress reported in FY 2018 in understanding the origin and evolution of the galaxies, stars, and planets that make up the universe.

The Kepler Space Telescope solved a previously unsolved problem related to energetic stellar explosions. Exploding stars known as supernovas sometimes include brief flashes called fast-evolving luminous transients, or FELTs. Observations by the Kepler Space Telescope helped astronomers to conclude that these brief flashes come from a vast shell of material around a supernova that abruptly lights up when the supernova blast wave crashes into it.

NASA's airborne Stratospheric Observatory for Infrared Astronomy (SOFIA) have helped astronomers to understand how massive stars form. Using data collected with SOFIA, astronomers confirmed that high-mass stars can form like their less massive siblings (like the sun), through collapsing interstellar gas and dust clouds that are collected in an "accretion disk" surrounding the young star.

AS-18-2: As determined by the Astrophysics Advisory Committee (APAC), demonstrate planned progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

AS-19-2: As determined by the Astrophysics Advisory Committee (APAC), demonstrate planned progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe.

See page 55 for a list of FY 2020 performance measures.

Performance Goal 1.1.8: Demonstrate progress in discovering and studying planets around other stars and exploring whether they could harbor life.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.8: Demonstrate progress in discovering and studying planets around other stars and exploring whether they could harbor life.

See page 55 for a list of FY 2020 performance measures.

The Astrophysics Advisory Committee determined in July 2018 that NASA remained on track in its annual performance toward the achievement of this performance goal. Below are examples of the scientific progress reported in FY 2018.

The discovery and study of planets around other stars ("exoplanets") continues to be a rapidly growing field. NASA's Kepler mission has completed a census of a field of sky in the Cygnus constellation, revealing a divide between smaller Earth-like planets and larger mini-Neptunes with significant gaseous atmospheres.

Using the Hubble and Spitzer space telescopes, scientists detected water vapor in two gas giant exoplanets, WASP-39b and WASP-121b, that orbit close to their host stars. A surprising amount of water was found in WASP-39b, suggesting that the exoplanet developed far away from its star, where it was bombarded by icy material.

Observations by the Hubble and Spitzer telescopes of the seven Earth-sized TRAPPIST-1 planets demonstrate that two of these rocky worlds have compact atmospheres like Earth's and may be good candidates as habitable worlds.

The **Astrophysics Division**, part of SMD, studies the origin and evolution of the universe, including planets circling stars outside the solar system, distant galaxies and groups of galaxies, and compact objects and black holes.

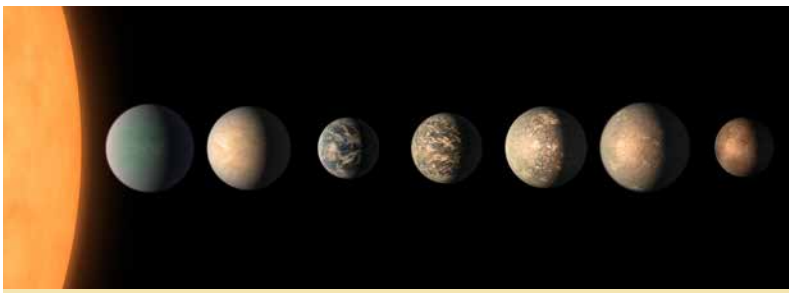
AS-18-4: As determined by the Astrophysics Advisory Committee (APAC), demonstrate planned progress in discovering and studying planets around other stars and exploring whether they could harbor life.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

AS-19-4: As determined by the Astrophysics Advisory Committee (APAC), demonstrate planned progress in discovering and studying planets around other stars and exploring whether they could harbor life.

See page 55 for a list of FY 2020 performance measures.



Analysis conducted in 2018 concluded that the seven planets of the TRAPPIST-1 system are all rocky, and some could contain significant amounts of water. This artist's concept, the relative sizes of the planets and their host star, an ultracool dwarf, are all shown to scale. Image credit: NASA/JPL-Caltech

Performance Goal 1.1.9: By December 2018, launch at least one mission in support of Astrophysics.

2013	2014	2015	2016	2017	2018
No PG	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.9: By December 2021, launch one mission in support of Astrophysics.

See page 55 for the FY 2020 launch performance goal.

NASA achieved this performance goal in April 2018 when it launched the Transiting Exoplanet Survey Satellite (TESS) on the first-of-its-kind mission to find worlds beyond the solar system, including some that could support life. TESS has started its search for planets around nearby stars, officially beginning science operations on July 25 and transmitting science data back to Earth every 13.5 days, once per orbit, as the spacecraft makes it closest approach to Earth.

Over the next two years, the spacecraft will use its array of telescopes to perform the first-ever space-borne all-sky exoplanet transit survey, looking for exoplanets ranging from Earth-sized to gas giants in orbit around the nearest and brightest stars in the sky. The project's goal is to identify terrestrial planets in the habitable zones of nearby stars. TESS will monitor the brightness of half a million stars, looking for momentary changes in brightness caused when a planet passes, or transits, in front of the star as viewed from Earth.

NASA also completed the Key Decision Point-B review for the Wide-Field Infrared Survey Telescope (WFIRST), allowing the project to explore options for fulfilling the mission, advance required technologies, and take other steps to prepare for future mission development.

The **Astrophysics Division**, part of SMD, studies the origin and evolution of the universe, including planets circling stars outside the solar system, distant galaxies and groups of galaxies, and compact objects and black holes.

AS-18-5: Complete Wide-Field Infrared Survey Telescope (WFIRST) Key Decision Point (KDP)-B.

2013	2014	2015	2016	2017	2018
No APIs before FY 2016			Green	Yellow	Green

Planned Annual Performance Indicators

No APIs after FY 2018

AS-18-6: Complete concept studies for the 2016 Astrophysics Medium Explorer (MIDEX) Announcement of Opportunity.

2013	2014	2015	2016	2017	2018
No APIs before FY 2017				Green	Green

Planned Annual Performance Indicators

AS-19-6: Complete the 2016 Astrophysics Medium Explorer (MIDEX) Announcement of Opportunity down-select.

See page 56 for the FY 2020 MIDEX annual performance indicator.

AS-18-7: Launch the Transiting Exoplanet Survey Satellite (TESS).

2013	2014	2015	2016	2017	2018
No API	Green	Green	Yellow	Green	Green

Planned Annual Performance Indicators

No APIs after FY 2018

Performance Goal 1.1.10: Demonstrate progress in advancing the understanding of how the chemical and physical processes in the solar system operate, interact, and evolve.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.10: Demonstrate progress in advancing the understanding of how the chemical and physical processes in the solar system operate, interact, and evolve.

See page 55 for a list of FY 2020 performance measures.

The Planetary Science Advisory Committee determined in September 2018 that NASA has remained on track toward achievement of this performance goal. Below are examples of the scientific progress reported in FY 2018.

The Lunar Reconnaissance Orbiter (LRO) made unprecedented measurements of the Moon's radiation environment, showing that the Moon receives an increase in radiation from galactic cosmic rays, which would be more harmful to future deep-space explorers. Scientists suggest that particles in Venus' lower clouds may contain sufficient mass balance to harbor microorganisms, water, solutes, and a potentially sufficient biomass to be detected by optical methods. The Juno mission has made new observations of cyclonic activity in Jupiter's polar regions. Cassini observed storms on Saturn that can disturb atmospheric patterns at the planet's equator. The Dawn mission discovered sites rich with organic molecules on the asteroid Ceres. Scientists discovered methane ice formations, some reaching hundreds of feet high, near Pluto's equator through data from the New Horizons mission.

The **Planetary Science Division**, part of SMD, develops and operates robotic spacecraft to advance the scientific understanding of planetary bodies. The division is improving understanding of the origin and evolution of life on Earth and guiding the search for life elsewhere. In addition, the division identifies and characterizes objects in the solar system that pose threats to Earth or offer resources for human exploration.

PS-18-1: As determined by the Planetary Science Advisory Committee (PAC), demonstrate planned progress in advancing the understanding of how the chemical and physical processes in the solar system operate, interact, and evolve.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

PS-19-1: As determined by the Planetary Science Advisory Committee (PAC), demonstrate planned progress in advancing the understanding of how the chemical and physical processes in the solar system operate, interact, and evolve.

See page 55 for a list of FY 2020 performance measures.

Using data collected during New Horizons' flyby of Pluto in July 2015, researchers have discovered blade-like spires that rise hundreds of feet. Known as "penitentes," the features were formed by erosion caused by evaporating ices. Image credit: NASA/JHUAPL/SwRI

Performance Goal 1.1.11: Demonstrate progress in exploring and observing the objects in the solar system to understand how they formed and evolve.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.11: Demonstrate progress in exploring and observing the objects in the solar system to understand how they formed and evolve.

See page 55 for a list of FY 2020 performance measures.

The **Planetary Science Division**, part of SMD, develops and operates robotic spacecraft to advance the scientific understanding of planetary bodies. The division is improving understanding of the origin and evolution of life on Earth and guiding the search for life elsewhere. In addition, the division identifies and characterizes objects in the solar system that pose threats to Earth or offer resources for human exploration.

The Planetary Science Advisory Committee determined in September 2018 that NASA has remained on track toward achievement of this performance goal. Below are examples of the scientific progress reported in FY 2018.

LRO evaluated the shapes of 930 small craters (40 meters to 10 kilometers in diameter) to highlight changes to the sizes of ubiquitous impact craters across the Moon.

Data from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM), aboard the Mars Reconnaissance Orbiter (MRO), demonstrated that clays on Mars belong to three different chemical families, based on their crystal structure. Laboratory experiments demonstrated that the thicknesses of surface clay minerals observed on Mars could have formed in a few million years or less, depending on the temperature. The less crystalline minerals above the clay layers are a record of a colder, dryer Mars.

The Juno mission created a detailed model of Jupiter's global magnetic field. Jupiter's magnetic field is shown to be different from all other known planetary magnetic fields. Cassini's final images will allow scientists to better characterize atmospheric conditions on Saturn, while the New Horizons mission enabled scientists to create global and topographic maps of Pluto and its largest moon, Charon.

PS-18-2: As determined by the Planetary Science Advisory Committee (PAC), demonstrate planned progress in exploring and observing the objects in the solar system to understand how they formed and evolve.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

PS-19-2: As determined by the Planetary Science Advisory Committee (PAC), demonstrate planned progress in exploring and observing the objects in the solar system to understand how they formed and evolve.

See page 55 for a list of FY 2020 performance measures.

PS-18-11: Complete Juno mission success criteria.

2013	2014	2015	2016	2017	2018
No API	No API	No API	Green	No API	Green

Planned Annual Performance Indicators

No APIs after FY 2018

PS-18-12: Complete Origins, Spectral Interpretation, Resource Identification, and Security-Regolith Explorer (OSIRIS-REx) arrival at the Bennu asteroid.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators
See 1.1.16 for planned APIs

PS-19-3 [Begins in FY 2019]

Planned Annual Performance Indicators
PS-19-3: Complete New Horizons' first-ever flyby of a Kuiper Belt Object (2014MU69).
No API for FY 2020

This "super-resolution" view of asteroid Bennu was created using eight images taken by OSIRIS-REx's PolyCam camera on October 29, 2018. OSIRIS-REx was about 205 miles away from Bennu, executing its third asteroid approach maneuver to slow the spacecraft and guide it toward the asteroid. Image credit: NASA/Goddard/Univ. of Arizona

Performance Goal 1.1.12: Demonstrate progress in exploring and finding locations where life could have existed or could exist today.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.12: Demonstrate progress in exploring and finding locations where life could have existed or could exist today.

See page 55 for a list of FY 2020 performance measures.

The **Planetary Science Division**, part of SMD, develops and operates robotic spacecraft to advance the scientific understanding of planetary bodies. The division is improving understanding of the origin and evolution of life on Earth and guiding the search for life elsewhere. In addition, the division identifies and characterizes objects in the solar system that pose threats to Earth or offer resources for human exploration.

The Planetary Science Advisory Committee determined in September 2018 that NASA has remained on track toward achievement of this performance goal. Below are examples of the scientific progress reported in FY 2018.

The Mars 2020 mission will analyze samples in situ and identify those that could have preserved biosignatures in ancient habitable environments. Samples will be cached for later return to Earth where detailed biosignature analyses will take place. The payload suite will include a first-time mission instrument for biosignature detection and contextual environment characterization, the Scanning Habitable Environments and Luminescence for Organics and Chemicals (SHERLOC).

Data from NASA's Cassini spacecraft revealed complex organic molecules originating from Saturn's icy moon Enceladus, strengthening the idea that this ocean world hosts conditions suitable for life. Additional data implied the presence of a global ocean underneath the icy surface of Enceladus, with a huge amount of internal heating to avoid freezing.

PS-18-3: As determined by the Planetary Science Advisory Committee (PAC), demonstrate planned progress in exploring and finding locations where life could have existed or could exist today.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

PS-19-4: As determined by the Planetary Science Advisory Committee (PAC), demonstrate planned progress in exploring and finding locations where life could have existed or could exist today.

See page 55 for a list of FY 2020 performance measures.

In December 2018, NASA announced that it had used images from the Mars Reconnaissance Orbiter's (MRO's) High Resolution Imaging Science Experiment (HiRISE) to assess several candidate landing sites for the Mars 2020 rover, looking for potential erosion by studying wind-caused ripples and dunes. Jazero Crater, shown here in an image taken by HiRISE in March 2015, and Northeast Syrtis were selected as candidate sites because they showed the most evidence for ongoing sand transport and erosion potential. The Mars 2020 rover will explore signs of habitable conditions and microbial life on ancient Mars. Image credit: NASA/JPL-Caltech

Performance Goal 1.1.13: Demonstrate progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.13: Demonstrate progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere.

See page 55 for a list of FY 2020 performance measures.

The **Planetary Science Division**, part of SMD, develops and operates robotic spacecraft to advance the scientific understanding of planetary bodies. The division is improving understanding of the origin and evolution of life on Earth and guiding the search for life elsewhere. In addition, the division identifies and characterizes objects in the solar system that pose threats to Earth or offer resources for human exploration.

The Planetary Science Advisory Committee determined in September 2018 that NASA has remained on track toward achievement of this performance goal, leading to new discoveries about the history of life on Earth. Below are examples of the scientific progress reported in FY 2018.

A team funded by the NASA Astrobiology Institute analyzed jasper rock samples from the Nuvvuagittuq belt in Canada and found microfossils of filaments and tubes filled with hematite, similar to the remains of modern-day microbes living around hydrothermal vents. The findings provide evidence for biological activity in submarine-hydrothermal environments dated to be at least 3.77 billion years old and perhaps as old as 4.28 billion years. The minimum age of these fossils would make them the oldest indication of life on Earth found to date.

Scientists with the NASA Astrobiology Institute combined several global data sets (sediment thickness, bathymetry, heat flow, bottom water temperatures) with modeling efforts to calculate the three-dimensional distribution of temperature in marine sediments. The temperature in about 25 percent of global sediment is less than 20 degrees Celsius, conditions most preferred by cold-loving psychrophiles, a type of microorganism that grows and reproduces in places that are at 15 degrees Celsius or lower. However, about 75 percent of global sediment is less than 80 degrees Celsius, a temperature range suitable for extensive biological activity, including that of mesophiles (which prefer moderate temperatures) and thermophiles (which prefer temperatures between 41 and 122 degrees Celsius).

PS-18-4: As determined by the Planetary Science Advisory Committee (PAC), demonstrate planned progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

PS-19-5: As determined by the Planetary Science Advisory Committee (PAC), demonstrate planned progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere.

See page 55 for a list of FY 2020 performance measures.

Performance Goal 1.1.14: Demonstrate progress in identifying and characterizing objects in the solar system that pose threats to Earth or offer resources for human exploration.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.14: Demonstrate progress in identifying and characterizing objects in the solar system that pose threats to Earth or offer resources for human exploration.

See page 55 for a list of FY 2020 performance measures.

The **Planetary Science Division**, part of SMD, develops and operates robotic spacecraft to advance the scientific understanding of planetary bodies. The division is improving understanding of the origin and evolution of life on Earth and guiding the search for life elsewhere. In addition, the division identifies and characterizes objects in the solar system that pose threats to Earth or offer resources for human exploration.

The Planetary Science Advisory Committee determined in September 2018 that NASA has remained on track toward achievement of this performance goal.

In FY 2018, asteroid search teams funded by NASA's Near-Earth Object Observations Program found another seven asteroids larger than one kilometer in size with orbits that can come within Earth's vicinity. Asteroid search teams also found 1,927 smaller asteroids. As of the end of FY 2018, the total known population of near-Earth asteroids was 18,637. The high-precision orbit predictions computed by the Center for Near-Earth Object Studies at NASA's Jet Propulsion Laboratory show that none of these objects is likely to strike the Earth in the next century. However, 1,927 small bodies (of which 155 are larger than one kilometer in diameter), with 107 near-Earth comets, are in orbits that could become a hazard in the more distant future and warrant continued monitoring.

The multi-agency Detecting and Mitigating the Impact of Earth-bound Near-Earth Objects (DAMIEN) Interagency Working Group released the *National Near-Earth Object Preparedness Strategy and Action Plan* on June 20, 2018. The 10-year plan identifies actions to improve the U.S. government's preparedness for a possible asteroid impact threat.

The Double Asteroid Redirection Test (DART) mission, which includes U.S. interagency and international participation on the investigation team, completed its Preliminary Design Review and was confirmed for full-scale development on August 17, 2018.

PS-18-5: Conduct research, involving both U.S. interagency and international cooperation and partnerships, into mitigation techniques and technologies to address the anticipated threat of small body impacts to life on Earth.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

PS-19-12: Conduct research, involving both U.S. interagency and international cooperation and partnerships, into mitigation techniques and technologies to address the anticipated threat of small body impacts to life on Earth.

See page 55 for a list of FY 2020 performance measures.

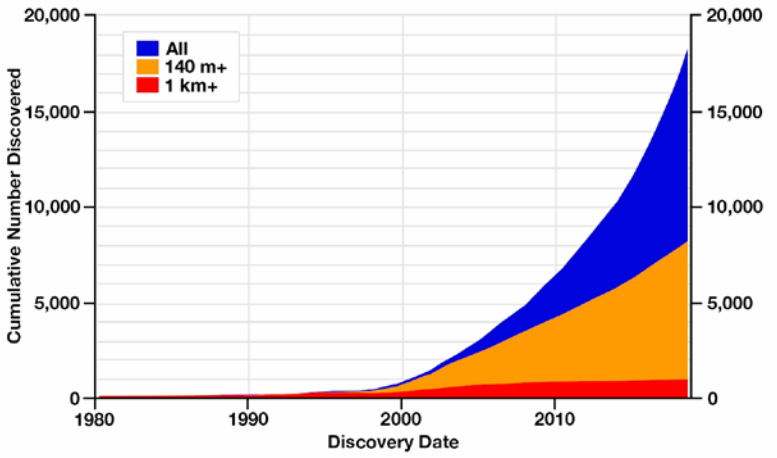
PS-18-6: As determined by the Planetary Science Advisory Committee (PAC), demonstrate planned progress in identifying and characterizing objects in the solar system that pose threats to Earth or offer resources for human exploration.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

PS-19-6: As determined by the Planetary Science Advisory Committee (PAC), demonstrate planned progress in identifying and characterizing objects in the solar system that pose threats to Earth or offer resources for human exploration.

See page 55 for a list of FY 2020 performance measures.



The chart depicts the cumulative number of NEAs identified over time, from the start of the Near Earth Observations in July 1998 through the end of May 2018. The area in orange depicts the quantity of known NEAs larger than 460 feet (140 meters). The area in blue depicts the number of known NEAs in all sizes. Image credit: NASA/JPL-Caltech

PS-18-13: Identify and catalog a cumulative 8,400 of the estimated 25,000 near-Earth asteroids (NEAs) 140 meters or larger.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Yellow

Explanation of Performance

NASA rated this annual performance indicator yellow because NASA identified and catalogued 8,307 NEAs by the end of FY 2018, missing the target by 93 NEAs. The discovery rate was impacted by extremely poor weather in spring and summer 2018 over Hawaii, which is the location for two primary NEO survey systems: the Panoramic Survey Telescope And Rapid Response System (Pan-STARRS) and the Asteroid Terrestrial-impact Last Alert System (ATLAS). The start of operations for Pan-STARRS 2 also was delayed by two hurricanes.

Planned Annual Performance Indicators

PS-19-13: Identify and catalog a cumulative 8,900 of the estimated 25,000 near-Earth asteroids (NEAs) 140 meters or larger.

See page 55 for the FY 2020 NEA catalog annual performance indicator.

Performance Goal 1.1.15: Deliver the Mars 2020 instrument payload for spacecraft integration. (Agency Priority Goal)

2013	2014	2015	2016	2017	2018
No PGs before 2018					Green

Planned Performance Goals

2019 - 1.1.15: Deliver the Mars 2020 instrument payload for spacecraft integration. (Agency Priority Goal)

See page 55 for a list of FY 2020 performance measures.

This agency priority goal is on track and is rated green for FY 2018. The Mars 2020 System Integration Review (SIR) was completed successfully on February 28, 2018. The SIR ensures that the various components and subsystems are on schedule to be physically integrated into the overall mission system. The instrument payload for the Mars 2020 rover will include instruments that will analyze the minerals on and below Mars' surface, measure the Martian wind, and look for signs of organic material.

PS-18-7: Complete Mars 2020 System Integration Review (SIR).

2013	2014	2015	2016	2017	2018
No API	No API	Yellow	Green	Green	Green

Planned Annual Performance Indicators

PS-19-7: Deliver Mars 2020 instrument payload to Assembly, Test, and Launch Operations (ATLO).

See page 56 for the Mars 2020 annual performance indicator.

The **Planetary Science Division**, part of SMD, develops and operates robotic spacecraft to advance the scientific understanding of planetary bodies. The division is improving understanding of the origin and evolution of life on Earth and guiding the search for life elsewhere. In addition, the division identifies and characterizes objects in the solar system that pose threats to Earth or offer resources for human exploration.

In this image, the second stage of the Black Brant IX sounding rocket separates from the Advanced Supersonic Parachute Inflation Research Experiment (ASPIRE) payload, which tested a parachute that will help land the Mars 2020 rover on Mars. The third and final flight test of the ASPIRE payload was launched from NASA's Wallops Flight Facility on September 7, 2018. Image credit: NASA/JPL-Caltech.

Performance Goal 1.1.16: By December 2017, launch at least two missions in support of Planetary Science.

2013	2014	2015	2016	2017	2018
No PG	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.16: By December 2021, launch one mission in support of Planetary Science.

See page 55 for the FY 2020 launch performance goal.

The **Planetary Science Division**, part of SMD, develops and operates robotic spacecraft to advance the scientific understanding of planetary bodies. The division is improving understanding of the origin and evolution of life on Earth and guiding the search for life elsewhere. In addition, the division identifies and characterizes objects in the solar system that pose threats to Earth or offer resources for human exploration.

NASA successfully completed this performance goal with the launches of the Mars Atmosphere and Volatile Evolution (MAVEN) mission in November 2013 and the Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer (OSIRIS-REx) in September 2016.

MAVEN is investigating Mars's upper atmosphere, ionosphere, and interactions with the Sun and solar wind. Scientists are using the data to determine how the loss of volatiles (substances that evaporate quickly) to space has affected the Martian atmosphere through time. MAVEN is exploring how the Sun may have stripped Mars of most of its atmosphere, turning a once possibly habitable planet into a cold and barren desert world.

OSIRIS-REx is investigating Bennu, a carbonaceous asteroid whose surface may record the earliest history of our solar system. Asteroids like Bennu also contain natural resources such as water, organics, and precious metals. In the future, these asteroids may one day fuel the exploration of the solar system by robotic and manned spacecraft.

PS-18-8: Complete New Frontiers 4 Step One Selection.

2013	2014	2015	2016	2017	2018
No APIs before 2017				Green	Green

Planned Annual Performance Indicators

PS-19-9: Complete New Frontiers 4 down-select.

FY 2020 TBD

PS-18-10: Complete Europa Instrument Preliminary Design Reviews (PDRs).

2013	2014	2015	2016	2017	2018
No APIs before 2017				Green	Green

Planned Annual Performance Indicators

PS-19-8: Complete Europa Clipper Key Decision Point (KDP)-C.

See page 56 for the FY 2020 Europa annual performance indicator.

PS-18-14: Complete the Double Asteroid Redirection Test (DART) Preliminary Design Review (PDR).

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicators

PS-19-14: Complete the Double Asteroid Redirection Test (DART) Preliminary Design Review (PDR).

See page 56 for the FY 2020 DART annual performance indicator.

PS-18-15: Launch the Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) mission.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Red	Green

Planned Annual Performance Indicators
No APIs after FY 2018

PS-19-10 [Begins in FY 2019]

Planned Annual Performance Indicators
PS-19-10: Complete the Lucy mission Key Decision Point (KDP)-C.
See page 56 for the FY 2020 Lucy mission annual performance indicator.

PS-19-11 [Begins in FY 2019]

Planned Annual Performance Indicators
PS-19-11: Complete the Psyche mission Preliminary Design Review (PDR).
See page 56 for the FY 2020 Psyche mission annual performance indicator.

The mobile service tower at Space Launch Complex-3 is rolled back to reveal the rocket with NASA's InSight spacecraft onboard, May 4, 2018, at Vandenberg Air Force Base in California. Image credit: NASA/Bill Ingalls

Performance Goal 1.1.17: Demonstrate progress in advancing the understanding of changes in Earth's radiation balance, air quality, and the ozone layer that result from changes in atmospheric composition.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.17: Demonstrate progress in advancing the understanding of changes in Earth's radiation balance, air quality, and the ozone layer that result from changes in atmospheric composition.

See page 55 for a list of FY 2020 performance measures.

The **Earth Science Division**, part of SMD, develops a scientific understanding of Earth and its response to natural or human-induced changes. Understanding Earth's atmosphere, crust, water, ice, and life as a single, connected system is necessary to improve predictions of climate, weather, and natural hazards.

The Earth Science Advisory Committee determined in October 2018 that NASA remained on track to achieve this performance goal. Below are examples of the scientific progress reported in FY 2018.

A recent study found correlations between biogenically enhanced cloud condensation nuclei concentrations and cloud droplet concentrations derived from passive satellite data. The findings suggest that marine biological activity influences cloud properties and, thus, albedo, supporting the hypothesis that biogenic activity within the ocean can influence cloud and precipitation properties.

Observations from the NASA Micro-Pulse Lidar Network site in Fairbanks, Alaska, reported unusually deep wintertime cirrus clouds, exceeding 13 kilometers above mean sea level. Such occurrences are quite rare, according to a 2006–2015 climatology developed from Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) mission measurements. The data indicate that polar meteorology is undergoing significant change and that cloud characteristics are important for predicting changes in the polar climate.

Volatile organic compounds derived from transportation, including automobiles, rail, and marine transport, have decreased due to stricter controls on air pollution. Researchers have shown that volatile chemical products, such as pesticides, coatings, printing inks, adhesives, cleaning agents, and personal care products, contribute one-half of emitted volatile organic compounds in 33 industrialized cities, thus emerging as the largest petrochemical source of urban organic emissions.

ES-18-1: As determined by the Earth Science Advisory Committee (ESAC), demonstrate planned progress in advancing the understanding of changes in Earth's radiation balance, air quality, and the ozone layer that result from changes in atmospheric composition.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

ES-19-1: As determined by the Earth Science Advisory Committee (ESAC), demonstrate planned progress in advancing the understanding of changes in Earth's radiation balance, air quality, and the ozone layer that result from changes in atmospheric composition.

See page 55 for a list of FY 2020 performance measures.

Performance Goal 1.1.18: Demonstrate progress in improving the capability to predict weather and extreme weather events.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.18: Demonstrate progress in improving the capability to predict weather and extreme weather events.

See page 55 for a list of FY 2020 performance measures.

The Earth Science Advisory Committee determined in October 2018 that NASA remained on track to achieve this performance goal. Below are examples of the scientific progress reported in FY 2018.

Over the past year, NASA researchers developed a Landslide Hazard Assessment for Situational Awareness (LHASA) model to indicate potential landslide activity in near-real time. The researchers combined satellite-based precipitation estimates (based on Tropical Rainfall Measuring Mission and Global Precipitation Measurement mission data) with a landslide susceptibility map derived from information on slope, geology, road networks, fault zones, and forest loss. When rainfall was considered to be extreme and susceptibility values were moderate to very high, the model issued a "nowcast" to indicate the times and places where landslides were more probable. LHASA nowcasts agrees with NASA's Global Landslide Catalog, with probability of detection between 8 and 60 percent, depending on the evaluation period, precipitation product used, and the size of the spatial and temporal window considered around each landslide point.

Researchers conducted intensive calibration and validation activities for the Cyclone Global Navigation Satellite System (CYGNSS) mission during the active 2017 Atlantic hurricane season using "ground truth" wind speed measurements taken with the NOAA P-3 hurricane hunter aircraft. Results indicate improvements in hurricane forecast skill and in temporal and spatial sampling of tropical convective systems with CYGNSS, and most notably, the ability to measure soil moisture and image flood inundation over land.

The **Earth Science Division**, part of SMD, develops a scientific understanding of Earth and its response to natural or human-induced changes. Understanding Earth's atmosphere, crust, water, ice, and life as a single, connected system is necessary to improve predictions of climate, weather, and natural hazards.

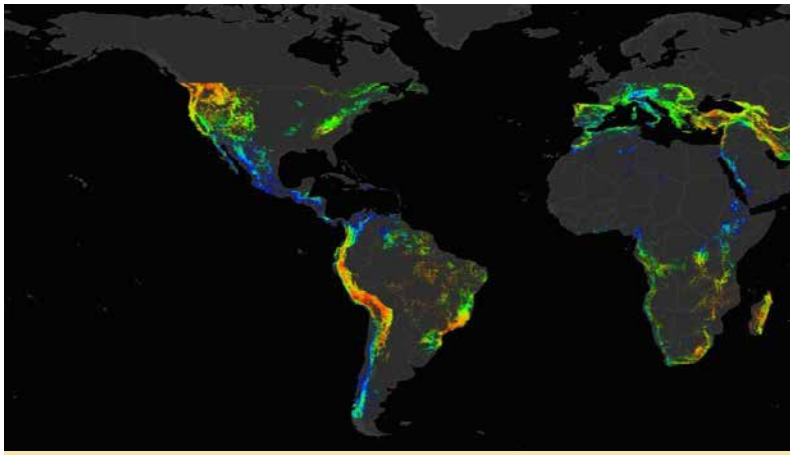
ES-18-2: As determined by the Earth Science Advisory Committee (ESAC), demonstrate planned progress in improving the capability to predict weather and extreme weather events.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

ES-19-2: As determined by the Earth Science Advisory Committee (ESAC), demonstrate planned progress in improving the capability to predict weather and extreme weather events.

See page 55 for a list of FY 2020 performance measures.



This map, focused on the Americas, shows 15 years of nowcasts of potential landslide activity generated by the LHASA model. The compilation of nowcasts highlight landslide hotspots, such as along the coast of Peru. Black and blue indicate the lowest risk of landslide and orange a red the highest risk. Image credit: NASA Scientific Visualization Studio

Performance Goal 1.1.19: Demonstrate progress in detecting and predicting changes in Earth's ecosystems and biogeochemical cycles, including land cover, biodiversity, and the global carbon cycle.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.19: Demonstrate progress in detecting and predicting changes in Earth's ecosystems and biogeochemical cycles, including land cover, biodiversity, and the global carbon cycle.

See page 55 for a list of FY 2020 performance measures.

The **Earth Science Division**, part of SMD, develops a scientific understanding of Earth and its response to natural or human-induced changes. Understanding Earth's atmosphere, crust, water, ice, and life as a single, connected system is necessary to improve predictions of climate, weather, and natural hazards.

The Earth Science Advisory Committee determined in October 2018 that NASA remained on track to achieve this performance goal. Below are examples of the scientific progress reported in FY 2018.

Researchers used satellite remote sensing and climate reanalysis data to fingerprint the sensitivity of Alaska's ecosystems to changing environmental conditions and disturbances. Approximately 13 percent of Alaska has experienced change over the last 32 years, with the majority of change processes (e.g., wildfire, glacial retreat, shrub expansion) occurring in coastal, riverine, and boreal ecozones. Increasing air temperatures have promoted vegetation growth, while increases in evaporation have resulted in drought stress predisposing vegetation to mortality from other stressors.

A study analyzing observations over the course of six El Niño events found that reductions in precipitation and terrestrial water storage increased fire emissions in pan-tropical forests by 133 percent during and following El Niño as compared with La Niña. Fires peaked in equatorial Asia early in the El Niño–Southern Oscillation cycle, when El Niño was strengthening (August-October), before moving to southeast Asia and northern South America (January-April), Central America (March-May) and the southern Amazon (July-October) during the following year.

ES-18-3: As determined by the Earth Science Advisory Committee (ESAC), demonstrate planned progress in detecting and predicting changes in Earth's ecosystems and biogeochemical cycles, including land cover, biodiversity, and the global carbon cycle.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

ES-19-3: As determined by the Earth Science Advisory Committee (ESAC), demonstrate planned progress in detecting and predicting changes in Earth's ecosystems and biogeochemical cycles, including land cover, biodiversity, and the global carbon cycle.

See page 55 for a list of FY 2020 performance measures.

Performance Goal 1.1.20: Demonstrate progress in enabling better assessment and management of water quality and quantity to accurately predict how the global water cycle evolves in response to climate change.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.20: Demonstrate progress in enabling better assessment and management of water quality and quantity to accurately predict how the global water cycle evolves in response to climate change.

See page 55 for a list of FY 2020 performance measures.

The Earth Science Advisory Committee determined in October 2018 that NASA remained on track to achieve this performance goal. Below are examples of the scientific progress reported in FY 2018.

A seminal study analyzed 14 years (2002–2016) of Gravity Recovery and Climate Experiment (GRACE) data to quantify 34 trends in terrestrial water storage and categorize their drivers as natural interannual variability, unsustainable groundwater consumption, or climate change. The study showed that the largest terrestrial water storage trends occurred in Antarctica, Greenland, the gulf coast of Alaska, and the Canadian archipelago, where the warming climate continues to drive rapid ice sheet and glacier ablation. Excluding those four ice-covered regions, freshwater was found to be accumulating in northern North America and Eurasia and in the wet tropics, while the greatest non-frozen freshwater losses have occurred at mid-latitudes. Researchers found that several of these trends had been lacking thorough investigation and attribution, including massive changes in northwestern China and the Okavango delta. Other trends were found to be consistent with climate model predictions. The researcher's observation-based assessment of how the world's water landscape is responding to climate variations provides a blueprint for evaluating and predicting emerging threats to water and food security.

NASA researchers developed a quantitative framework for characterizing the water cycle intensity over land by using a spatially distributed water-balance model of the contiguous United States. They found that water cycle intensity increase over most of the lower United States between the 1945–1974 and 1985–2014 periods was driven primarily by increases in precipitation.

The **Earth Science Division**, part of SMD, develops a scientific understanding of Earth and its response to natural or human-induced changes. Understanding Earth's atmosphere, crust, water, ice, and life as a single, connected system is necessary to improve predictions of climate, weather, and natural hazards.

ES-18-4: As determined by the Earth Science Advisory Committee (ESAC), demonstrate planned progress in enabling better assessment and management of water quality and quantity to accurately predict how the global water cycle evolves in response to climate change.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

ES-19-4: As determined by the Earth Science Advisory Committee (ESAC), demonstrate planned progress in enabling better assessment and management of water quality and quantity to accurately predict how the global water cycle evolves in response to climate change.

See page 55 for a list of FY 2020 performance measures.

Performance Goal 1.1.21: Demonstrate progress in improving the ability to predict climate changes by better understanding the roles and interactions of the ocean, atmosphere, land, and ice in the climate system.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.21: Demonstrate progress in improving the ability to predict climate changes by better understanding the roles and interactions of the ocean, atmosphere, land, and ice in the climate system.

See page 55 for a list of FY 2020 performance measures.

The **Earth Science Division**, part of SMD, develops a scientific understanding of Earth and its response to natural or human-induced changes. Understanding Earth's atmosphere, crust, water, ice, and life as a single, connected system is necessary to improve predictions of climate, weather, and natural hazards.

The Earth Science Advisory Committee determined in October 2018 that NASA remained on track to achieve this performance goal. Below are examples of the scientific progress reported in FY 2018.

The 2017 Arctic sea-ice minimum extent was recorded on September 13, 2017, at approximately 1.79 million square miles, the eighth-lowest in the 38-year satellite record. The winter maximum for 2018 was similarly low at an extent of 5.59 million square miles. This value, recorded on March 17, 2018, is the second lowest in the 39-year satellite record, falling just behind 2017.

An assessment from the joint NASA–European Space Agency Ice Sheet Mass Balance Intercomparison Project (IMBIE) demonstrated that Antarctica is losing mass overall and that East Antarctica is in balance to within measurement uncertainties. The East Antarctic result is particularly important, because previous assessments had yielded contrasting estimates. Landsat data also showed increased West Antarctic and unchanged East Antarctic ice discharge over the last seven years.

Another study demonstrated how the use of sea surface salinity improves predictive skill for the extreme precipitation over the continental United States. Owing to its sensitivity to freshwater flux, salinity serves as an indicator of the ocean water cycle in the subtropical Atlantic, which plays the dominant role in sustaining the moisture supply over the mid- and southwestern United States.

ES-18-5: As determined by the Earth Science Advisory Committee (ESAC), demonstrate planned progress in improving the ability to predict climate changes by better understanding the roles and interactions of the ocean, atmosphere, land, and ice in the climate system.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

ES-19-5: As determined by the Earth Science Advisory Committee (ESAC), demonstrate planned progress in improving the ability to predict climate changes by better understanding the roles and interactions of the ocean, atmosphere, land, and ice in the climate system.

See page 55 for a list of FY 2020 performance measures.

Performance Goal 1.1.22: Demonstrate progress in characterizing the dynamics of Earth's surface and interior, improving the capability to assess and respond to natural hazards and extreme events.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.22: Demonstrate progress in characterizing the dynamics of Earth's surface and interior, improving the capability to assess and respond to natural hazards and extreme events.

See page 55 for a list of FY 2020 performance measures.

The **Earth Science Division**, part of SMD, develops a scientific understanding of Earth and its response to natural or human-induced changes. Understanding Earth's atmosphere, crust, water, ice, and life as a single, connected system is necessary to improve predictions of climate, weather, and natural hazards.

The Earth Science Advisory Committee determined in October 2018 that NASA remained on track to achieve this performance goal. Below are examples of the scientific progress reported in FY 2018.

Modernization of NASA's Global Navigation Satellite System (GNSS) Network, initiated in 2016, was completed in FY 2018, providing access to measurements from all major GNSS constellations.

Researchers found that of the 24 millimeters of uplift of the Sierra Nevada from 2011 to 2015, just 5 millimeters were caused by Central Valley groundwater loss, less than 2 millimeters was due to tectonic uplift, and 17 millimeters was caused by solid Earth's elastic response to water loss in the Sierra Nevada.

Fast-moving, highly destructive debris flows triggered by intense rainfall are one of the most dangerous post-fire hazards, but assessing debris flows with remote sensing has been challenging. A recent study used unmanned autonomous vehicle (UAV) synthetic aperture radar (SAR) data spanning the 2017 Thomas fire in southern California to develop an innovative approach for analyzing high-resolution L-band UAVSAR data (both polarimetric and interferometric imagery) to map the fire extent and then characterize debris flow paths. This study shows the potential to track debris flows with UAVSAR.

ES-18-6: As determined by the Earth Science Advisory Committee (ESAC), demonstrate planned progress in characterizing the dynamics of Earth's surface and interior, improving the capability to assess and respond to natural hazards and extreme events.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

ES-19-6: As determined by the Earth Science Advisory Committee (ESAC), demonstrate planned progress in characterizing the dynamics of Earth's surface and interior, improving the capability to assess and respond to natural hazards and extreme events.

See page 55 for a list of FY 2020 performance measures.

Performance Goal 1.1.23: Further the use of Earth system science research to inform decisions and provide benefits to society.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goals

2019 - 1.1.23: Further the use of Earth system science research to inform decisions and provide benefits to society.

See page 55 for a list of FY 2020 performance measures.

The **Earth Science Division**, part of SMD, develops a scientific understanding of Earth and its response to natural or human-induced changes. Understanding Earth's atmosphere, crust, water, ice, and life as a single, connected system is necessary to improve predictions of climate, weather, and natural hazards.

NASA has made substantial progress in furthering the use of Earth science to inform decisions. Below are examples from FY 2018:

- The New York State Department of Health lowered the Heat Advisory threshold for alerting the public of an upcoming heat wave from 100 to 95 degrees to help prevent heat-related illnesses. This decision stemmed from a project with the Department of Health using heat metrics from the North American Land Data Assimilation System.
- The Delaware Division of Fish and Wildlife used ocean color and sea surface temperature data from the Aqua and Suomi National Polar-orbiting Partnership (NPP) satellites to assess sturgeon occurrence risk and make decisions on permits and commercial fishing to avoid unwanted sturgeon encounters.
- NASA enabled the use of data from multiple Earth observing satellites to measure surface deformation, support sulfur dioxide monitoring for air quality issues, and track lava flow from fissures during the 2018 Kilauea eruption in Hawaii.
- Bureau of Land Management and Forest Service employed the NASA-sponsored Rehabilitation Capability Convergence for Ecosystem Recovery (RECOVER) system on over 40 wildfire events in 2018, using NASA satellite data to shorten response and recovery time.
- Department of Agriculture's Crop Explorer made NASA soil moisture data available operationally, and it now integrates soil moisture into its monthly global crop production estimates.

ES-18-7: Advance at least 40 percent of Earth science applications projects one Applications Readiness Level.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

ES-19-7: Advance at least 40 percent of Earth science applications projects one Applications Readiness Level.

See page 55 for the FY 2020 Earth science applications annual performance indicator.

ES-18-8: Maintain high level of customer satisfaction, as measured by exceeding the most recently available Federal Government average rating of the American Customer Satisfaction Index.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

ES-19-8: Maintain high level of customer satisfaction, as measured by exceeding the most recently available Federal Government average rating of the American Customer Satisfaction Index.

See page 55 for the FY 2020 customer satisfaction annual performance indicator.

Performance Goal 1.1.24: By December 2021, launch three missions in support of Earth Science.

2013	2014	2015	2016	2017	2018
No PG	Green	Green	Yellow	Yellow	Green

Planned Performance Goals

2019 - 1.1.24: By December 2021, launch three missions in support of Earth Science.

See page 55 for the FY 2020 launch performance goal.

The **Earth Science Division**, part of SMD, develops a scientific understanding of Earth and its response to natural or human-induced changes. Understanding Earth's atmosphere, crust, water, ice, and life as a single, connected system is necessary to improve predictions of climate, weather, and natural hazards.

During FY 2018, NASA remained on track to achieve this performance goal by launching two Earth Science missions.

The Gravity Recovery and Climate Experiment Follow On (GRACE-FO) mission launched from Vandenberg Air Force Base, California, on May 22. The twin spacecraft, a joint project of NASA and the German Research Centre for Geoscience, will measure how mass is redistributed within and among Earth's atmosphere, oceans, land and ice sheets, as well as within Earth itself.

The Ice, Cloud, and Land Elevation Satellite (ICESat)-2 launched on September 15 from Vandenberg Air Force Base. The satellite will study changes to Earth's polar ice caps. It will study the shrinking or growth of sea ice, measure how much melting ice sheets contribute to sea level changes, and measure the height of forests to calculate the amount of vegetation in a region.

Future scheduled launches include Landsat 9 and Sentinel-6A, both with planned November 2021 launch readiness dates.

The NASA/German Research Centre for Geosciences GRACE Follow-On spacecraft launch onboard a SpaceX Falcon 9 rocket, Tuesday, May 22, 2018, from Space Launch Complex 4E at Vandenberg Air Force Base in California. The mission will measure changes in how mass is redistributed within and among Earth's atmosphere, oceans, land and ice sheets, as well as within Earth itself. GRACE-FO is sharing its ride to orbit with five Iridium NEXT communications satellites as part of a commercial rideshare agreement. Photo Credit: (NASA/Bill Ingalls)GRACE-FO launched on May 22, 2018, sharing its ride to orbit with a communications satellite as part of a commercial rideshare agreement. Image credit: NASA/Bill Ingalls

ES-18-9: Complete the Landsat 9 Critical Design Review (CDR).

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

ES-19-12: Complete Landsat 9 Thermal Infrared Sensor (TIRS)-2 instrument Pre-Ship Review (PSR).

See page 56 for the FY 2020 Landsat 9 annual performance indicator.

ES-18-10: Complete NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR) L-Band SAR Instrument Critical Design Review (CDR).

2013	2014	2015	2016	2017	2018
No APIs before FY 2016			Green	Yellow	Green

Planned Annual Performance Indicators

ES-19-10: Complete NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR) Critical Design Review (CDR).

See page 56 for the FY 2020 NISAR annual performance indicator.

ES-18-11: Complete the Surface Water and Ocean Topography (SWOT) mission Critical Design Review (CDR).

2013	2014	2015	2016	2017	2018
No API	No API	Green	Green	Green	Green

Planned Annual Performance Indicators

ES-19-9: Complete Surface Water and Ocean Topography (SWOT) Ka-band Radar Interferometer (KaRIn) Integration and Test (I&T) Readiness Review.

See page 56 for the FY 2020 SWOT annual performance indicator.

ES-18-12: Launch the Gravity Recovery and Climate Experiment Follow-On (GRACE-FO) mission.

2013	2014	2015	2016	2017	2018
No API	Green	Green	Green	Yellow	Green

Planned Annual Performance Indicators

No APIs after FY 2018

ES-18-13: Launch the Ice, Cloud, and Land Elevation Satellite (ICESat)-2.

2013	2014	2015	2016	2017	2018
Yellow	Yellow	Green	Green	Yellow	Green

Planned Annual Performance Indicators

No APIs after FY 2018

ES-18-14: Release the Earth Venture Instrument (EVI)-5 Announcement of Opportunity.

2013	2014	2015	2016	2017	2018
No APIs before FY 2016			Green	Yellow	Green

Planned Annual Performance Indicators

ES-19-11: Complete Earth Venture Instrument (EVI)-5 evaluation panel.

No API in FY 2020

ES-18-15: Complete the Earth Venture Suborbital (EVS)-3 selection.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicators

No APIs after FY 2018

ES-19-13 [Begins in FY 2019]

Planned Annual Performance Indicators

ES-19-13: Complete Sentinel-6 Pre-Ship Review (PSR)-A.

See page 56 for the FY 2020 Sentinel-6 annual performance indicator.

Science Mission Directorate's FY 2020 Performance Plan

Performance Goal: Demonstrate progress in exploring and understanding of the physical processes and connections of the Sun, space and planetary enviroments throughout the solar system.

Annual Performance Indicator: As determined by external expert review, demonstrate progress in exploring and advancing understanding of the physical processes and connections of the Sun, space, and planetary environments throughout the solar system.

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

Annual Performance Indicator: As determined by external expert review, demonstrate progress in exploring and probing the origin, evolution, and destiny of the galaxies, stars, and planets that make up the universe.

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

Annual Performance Indicator: As determined by external expert review, demonstrate progress in exploring, observing, and understanding objects in the solar system in order to understand how they formed, operate, interact, and evolve.

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

Annual Performance Indicator: As determined by external expert review, demonstrate progress in discovering and studying planets around other stars.

Performance Goal: 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.

Annual Performance Indicator: As determined by external expert review, 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.

Performance Goal: 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.

Annual Performance Indicator: As determined by external expert review, 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.

Annual Performance Indicator: As determined by external expert review, demonstrate progress in 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.

Annual Performance Indicator: Complete the Ionospheric Connection Explorer (ICON) mission success criteria.

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

Annual Performance Indicator: As determined by external expert review, demonstrate progress in identifying, characterizing, and predicting objects in the solar system that pose threats to Earth or offer resources for human exploration.

Annual Performance Indicator: Identify and catalog a cumulative 9,500 of the estimated 25,000 near-Earth asteroids (NEAs) 140 meters or larger.

Performance Goal: 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.

Annual Performance Indicator: As determined by external expert review, 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.

Annual Performance Indicator: Advance at least 40 percent of Earth science applications projects one Applications Readiness Level, ensuring that a robust portfolio continually matures Earth science products for sustained use.

Annual Performance Indicator: Maintain high level of customer satisfaction, as measured by exceeding the most recently available Federal Government average rating of the American Customer Satisfaction Index.

Performance Goal: 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.

Annual Performance Indicator: As determined by external expert review, 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.

Annual Performance Indicator: Complete Ice, Cloud and land Elevation Satellite (ICESat)-2 mission success criteria.

Performance Goal: Launch at least five major missions in support of this objective by December 2021.

Annual Performance Indicator: Complete Interstellar Mapping and Acceleration Probe (IMAP) Key Decision Point (KDP)-B review.

Annual Performance Indicator: Complete the 2016 Medium Explorer (MIDEX) Announcement of Opportunity Key Decision Point (KDP)-C review.

Annual Performance Indicator: Complete the Europa Clipper mission Critical Design Review (CDR).

Annual Performance Indicator: Complete the Lucy mission Critical Design Review (CDR).

Annual Performance Indicator: Complete the Psyche mission Critical Design Review (CDR).

Annual Performance Indicator: Complete the Double Asteroid Redirection Test (DART) mission Key Decision Point (KDP)-D review.

Annual Performance Indicator: Award the second the Commercial Lunar Payload Services (CLPS) mission task order.

Annual Performance Indicator: Complete the Landsat 9 Key Decision Point (KDP)-D review.

Annual Performance Indicator: Complete the Sentinel-6A satellite Flight Acceptance Review.

Annual Performance Indicator: Complete the Surface Water and Ocean Topography (SWOT) System Integration Review (SIR).

Annual Performance Indicator: Complete the NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR) System Integration Review (SIR).

Performance Goal: Webb APG - Placeholder for FY 2020-2021 cycle.

Annual Performance Indicator: Placeholder for FY 2020.

Performance Goal: Mars 2020 APG - Placeholder for FY 2020-2021 cycle.

Annual Performance Indicator: Launch the Mars 2020 mission.

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 Mumford, Deputy Associate Administrator, HEOMD

Budget

	FY	$M
Actual	2018	375.4
Enacted	2019	360.8
Requested	2020	352.7
Outyear	2021	368.7
	2022	360.7
	2023	345.1
	2024	332.6

NASA is conducting a robust program of space-based research to advance technologies that enable space exploration, and to pioneer uses of the space environment to benefit life on Earth.

2018 Strategic Review Summary of Progress

The **Human Exploration and Operations Mission Directorate** leads and manages NASA space operations related to human exploration in and beyond low Earth orbit. HEOMD oversees requirements development, policy, and programmatic oversight across its numerous programs. HEOMD's activities include the International Space Station (ISS), commercial space transportation, low Earth orbit spaceflight operations, deep space exploration systems, launch services, and space communications. Efforts that supported the assessment included:

- The Human Research Program has developed an original and innovative approach to integrate basic research into human space flight technology development and mission architecture design.
- NASA will establish agreements for delivery of research products that enable exploration technologies.
- The actual crew hours and research hours for the recent ISS Expeditions greatly exceeded plans.

Above: NASA astronaut Joe Acaba conducts operations on the ACME investigation. ACME aims to improve fuel efficiency and reduce pollutant production in practical combustion on Earth, while improving fire prevention efforts aboard spacecraft. Image credit: NASA

Performance Measures for Strategic Objective 1.2

The following pages provide the performance goals and annual performance indicators supporting Strategic Objective 1.2. They include the final performance results for FY 2018, the FY 2019 Performance Plan Update, which NASA considers final for FY 2019, and the initial FY 2020 Performance Plan. Below are charts summarizing the FY 2018 performance ratings for the performance goals and annual performance indicators supporting Strategic Objective 1.2.

As NASA conducts its 2019 Strategic Review, to be completed in spring 2019, it will conduct a retrospective and prospective analyses to determine if the programs supporting this strategic objective are healthy and can address potential or realized risks. Part of the retrospective analyses will take into consideration the FY 2018 performance results found on the following pages. Looking forward, NASA will assess whether it is on track to achieve the FY 2019 annual performance indicators. The results of this early assessment will inform planning for the FY 2021 Performance Plan, which will begin in spring 2019.

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

Performance Goal 1

Span two to five years, and measure the performance of investments towards strategic objectives and strategic goals. The total number of performance goals is reflected in each rating box and there is no one-to-one correlation to annual performance indicator ratings.

Annual Performance Indicator 5

Describe the smaller, achievable measurements that serve as NASA's basic unit of performance. They show progress achieved during the budget year, and NASA uses them to assess progress made towards achieving the performance goals and the strategic objectives. The total number of annual performance indicators is reflected in each rating box and there is no one-to-one correlation to performance goal ratings.

Performance Goal 1.2.1: Conduct basic and applied biological and physical research to advance and sustain U.S. scientific expertise.

2013	2014	2015	2016	2017	2018
Green	Green	Yellow	Red	Yellow	Green

Planned Performance Goal for FY 2019-2020
1.2.1: Conduct basic and applied biological and physical research to advance and sustain U.S. scientific expertise.

The **International Space Station Program** manages the unique low Earth orbit platform that enables research in a microgravity environment. Several research facilities are on the ISS to support science investigations in biology, biotechnology, human physiology, material science, physical sciences, and technology development. The ISS program is part of HEOMD.

NASA achieved its biological and physical research planned goals for the ISS Program in FY 2018. In June, NASA installed the Cold Atom Laboratory, which will produce ultra-cooled atoms called Bose-Einstein condensates. The laboratory will help NASA conduct research related to the physics and applications of quantum gasses identified by the National Research Council decadal survey, Recapturing a Future for Space Exploration, Life and Physical Sciences Research for a New Era, as a priority.

In September, the Life Sciences Glovebox, a fully enclosed workspace with two glove ports, was delivered to the ISS. The Japan Aerospace Exploration Agency built the new facility in partnership with the Dutch commercial firm Bradford Engineering several years ago. They updated the glovebox and prepared it for the ISS in response to increased demand for research glovebox space. Two additional EXPRESS racks, which can hold everything from small facilities to equipment, also were delivered.

NASA completed the five experiments for the Advanced Combustion via Microgravity Experiments (ACME) research series, which began aboard the ISS in January. ACME is focused on advanced combustion technology. The Advanced Plant Habitat completed its first science operations in November 2018, when Astronaut Serena Auñón-Chancellor completed the final harvest after six-weeks of plant growth. Additionally, two Vegetable Production System units are now installed and operational on the ISS.

NASA also returned some research facilities to Earth. The Bioculture System, a cell biology research platform that was delivered to the ISS in 2016, was returned to Earth in January. After 10 weeks of operation, the Zero Boil-off Tank, which studied storage of very cold cryogenic fluids, was returned to Earth in December 2017.

ISS-18-3: Enhance the research capabilities on the International Space Station (ISS) by installing and operating the Cold Atom Laboratory, Life Sciences Glove Box, additional Express Racks, and Bioculture System; and complete operations for Zero Boil Off Tank.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicators
No APIs after FY 2018

Above: NASA astronaut Ricky Arnold performs maintenance on the ACEM on April 16, 2018. Image credit: NASA

ISS-18-4: Through the Center for the Advancement of Science in Space (CASIS) cooperative agreement, meet the goals identified in the annual performance plan to completely use the 50 percent National Laboratory allocation; and develop and execute the sponsored research.

2013	2014	2015	2016	2017	2018
No API	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

ISS-19-1: Through the Center for the Advancement of Science in Space (CASIS) cooperative agreement, meet the goals identified in the annual performance plan to completely use the 50 percent National Laboratory allocation and establish a robust innovation cycle to develop and execute the sponsored research.

ISS-20-1: Through the Center for the Advancement of Science in Space (CASIS) cooperative agreement, meet the goals identified in the annual performance plan to completely use the 50 percent National Laboratory allocation and establish a robust innovation cycle to develop and execute the sponsored research.

ISS-18-5: Enable the production of 500 peer-reviewed publications from spaceflight and ground projects in human research, space biology, and physical sciences.

2013	2014	2015	2016	2017	2018
No API	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

ISS-19-4: Enable the production of 500 peer-reviewed publications from spaceflight and ground projects in human research, space biology, and physical sciences.

ISS-20-4: Enable the production of 500 peer-reviewed publications from spaceflight and ground projects in human research, space biology, and physical sciences.

ISS-18-6: Install and conduct the first scientific investigation in the new Plant Habitat facility, and operate two Vegetable Production System (Veggie) units aboard the International Space Station (ISS) to conduct research with the Human Research Program on the nutritional and behavioral aspects of growing plants for food in space.

2013	2014	2015	2016	2017	2018
Green	Green	Red	Red	Green	Green

Planned Annual Performance Indicators

ISS-19-2: Conduct experiments across the range of space biology, including research on rodents, an investigation using the Advanced Plant Habitat, an investigation in cell biology, and an investigation on the microbiome of the International Space Station (ISS), to sustain progress in a balanced research portfolio.

ISS-20-2: Successfully conduct four research investigations aboard the International Space Station (ISS) on the highest-priority recommendations for plant and microbial science from the 2011 Space Life and Physical Sciences Decadal Survey in the areas of responses and adaptations to spaceflight and long-term life support.

Above: Astronaut Alexander Gerst, of the European Space Agency, checks a culture bag for the Space Algae experiment, which is exploring the potential of cultivating algae for recycling carbon dioxide and providing food for crew members on long space voyages. The culture bags are placed in the ISS VEGGIE facility to promote growth over a few weeks, with the samples returned to Earth for analysis. Image credit: NASA

ISS-18-14: Accomplish new research in the Combustion Integrated Rack through installation and operation of Advanced Combustion via Microgravity Experiments research series; and complete three investigations in colloidal and self-assembling systems in the Fluids Integrated Rack.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Red	Red	Green

Planned Annual Performance Indicators

ISS-19-3: Complete the temperature-controlled series of investigations on self-assembling and self-organizing particles in the Advanced Colloids Experiment (ACE) facility, hold successful Pre-Ship Reviews (PSRs) for the Solid Fuel Ignition and Extinction (SoFIE) facility and the Flow Boiling and Condensation Experiment instrument, and enter experiment operations with the Cold Atom Laboratory facility.

ISS-20-3: Complete research in the Advanced Combustion via Microgravity Experiments (ACME) and Light Microscopy Module (LMM) facilities, and initiate research in the Solid Fuel Ignition and Extinction (SoFIE) and Flow Boiling and Condensation Experiment (FBCE) facilities, in order to implement Decadal recommendations for research supporting exploration technologies.

Explore

Strategic Goal 2

Extend human presence deeper into space and to the Moon for sustainable long-term exploration and utilization.

A structural test version of the intertank for NASA's new deep-space rocket, the Space Launch System, arrives at NASA's Marshall Space Flight Center on March 4, 2018, aboard the barge Pegasus. Image credit: NASA/MSFC/Tyler Martin

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 Mumford, Deputy Associate Administrator, HEOMD

Budget

	FY	$M
Actual	2018	2,027.9
Enacted	2019	2,155.0
Requested	2020	2,104.4
Outyear	2021	2,146.7
	2022	2,194.4
	2023	2,144.3
	2024	2,122.6

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, technology development, and to extend human presence in space.

2018 Strategic Review Summary of Progress

The **Human Exploration and Operations Mission Directorate** leads and manages NASA space operations related to human exploration in and beyond low Earth orbit. HEOMD oversees requirements development, policy, and programmatic oversight across its numerous programs. HEOMD's activities include the ISS, commercial space transportation, low Earth orbit spaceflight operations, deep space exploration systems, launch services, and space communications. Efforts that supported the assessment included:

- The ISS has been continually crewed with six crew members, and only for 16 days with three crew members during Soyuz vehicle exchange. The ISS also accommodated commercial resupply missions OA-8 and SpX-13 during the first quarter of FY 2018, bringing supplies and research to the crew.

Above: At Johnson Space Center, engineers help Canadian Space Agency astronaut Jeremey Hansen train for future spacewalks. Image credit: NASA/Josh Valcarcel

- NASA completed the ISS Transition Report, which was delivered to Congress and posted online in March 2018. ISS has begun communicating with international partners regarding the transition.
- At the time of the Strategic Review, which was completed in spring 2018, the ISS program was on track to achieve all of its annual performance indicators.

Performance Measures for Strategic Objective 2.1

The following pages provide the performance goals and annual performance indicators supporting Strategic Objective 2.1. They include the final performance results for FY 2018, the FY 2019 Performance Plan Update, which NASA considers final for FY 2019, and the initial FY 2020 Performance Plan. Below are charts summarizing the FY 2018 performance ratings for the performance goals and annual performance indicators supporting Strategic Objective 2.1.

As NASA conducts its 2019 Strategic Review, to be completed in spring 2019, it will conduct a retrospective and prospective analyses to determine if the programs supporting this strategic objective are healthy and can address potential or realized risks. Part of the retrospective analyses will take into consideration the FY 2018 performance results found on the following pages. Looking forward, NASA will assess whether it is on track to achieve the FY 2019 annual performance indicators. The results of this early assessment will inform planning for the FY 2021 Performance Plan, which will begin in spring 2019.

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

Performance Goal 3

Span two to five years, and measure the performance of investments towards strategic objectives and strategic goals. The total number of performance goals is reflected in each rating box and there is no one-to-one correlation to annual performance indicator ratings.

Annual Performance Indicator 7 1

Describe the smaller, achievable measurements that serve as NASA's basic unit of performance. They show progress achieved during the budget year, and NASA uses them to assess progress made towards achieving the performance goals and the strategic objectives. The total number of annual performance indicators is reflected in each rating box and there is no one-to-one correlation to performance goal ratings.

Performance Goal 2.1.1: Increase the crew time for research and development beyond the three U.S. Orbital Segment crew baseline.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goal for FY 2019-2020

2.1.1: Increase the crew time for research and development beyond the three U.S. Orbital Segment crew baseline.

The **International Space Station Program** manages the unique low Earth orbit platform that enables research in a microgravity environment. Several research facilities are on the ISS to support science investigations in biology, biotechnology, human physiology, material science, physical sciences, and technology development. The ISS program is part of HEOMD.

NASA's three ISS crew members exceeded the baseline of 35 hours per week for research and development in the U.S. Orbital Segment by logging approximately 57 hours per week.

Crew Rotations

Expedition	Launch Date	Land Date
54-55	9/12/2017	2/27/2018
55-56	3/23/2018	10/4/2018

ISS-18-1: In concert with international partners, maintain a continuous five- or six-crew capability on the International Space Station (ISS) by coordinating and managing resources, logistics, systems, and operational procedures.

2013	2014	2015	2016	2017	2018
Green	Green	Yellow	Green	Green	Green

Planned Annual Performance Indicators

ISS-19-5: In concert with international partners, maintain a continuous five- or six-crew capability on the International Space Station (ISS) by coordinating and managing resources, logistics, systems, and operational procedures.

ISS-20-5: In concert with international partners, maintain a continuous five- or six-crew capability on the International Space Station (ISS) by coordinating and managing resources, logistics, systems, and operational procedures.

ISS-18-2: Maintain the capability to perform at least 40 hours of research per week by coordinating and managing resources, logistics, and research and development procedures.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicators

ISS-19-6: Maintain the capability to perform at least 40 hours of research per week by coordinating and managing resources, logistics, and research and development procedures.

ISS-20-6: Maintain the capability to perform at least 40 hours of research per week by coordinating and managing resources, logistics, and research and development procedures.

Performance Goal 2.1.2: Ensure vital assets are ready, available, and appropriately sized to conduct NASA's Mission.

2013	2014	2015	2016	2017	2018
No PG	Green	Green	Green	Green	Green

Performance Goal Planned for FY 2019-2020
2.1.2: Ensure vital assets are ready, available, and appropriately sized to conduct NASA's Mission.

In FY 2018, the astronaut corps was sized appropriately and met all mission needs and all health and training standards during the fourth quarter performance reporting period.

The **Human Space Flight Operations Program** supports the training, readiness, and health of crew members before, during, and after each mission to the ISS. The Human Space Flight Operations Program provides astronaut selection and training, and it manages all aspects of crew health. The program also provides expert medical input to program boards, flight rule recommendations, annual physicals post retirement from government service, and medical care guideline requirements for space health care systems.

SFS-18-1: Ensure the astronaut corps meets all mission-related training requirements and mission-related health standards.

2013	2014	2015	2016	2017	2018
No API	Green	Green	Green	Green	Green

Planned Annual Performance Indicators
SFS-19-1: Ensure the astronaut corps meets all mission-related training requirements and mission-related health standards.
SFS-20-1: Ensure the astronaut corps meets all mission-related training requirements and mission-related health standards.

Performance Goal 2.1.3: Facilitate the commercial development of low Earth orbit (LEO) to transition to a commercial LEO human spaceflight enterprise where NASA is one of many customers.

2013	2014	2015	2016	2017	2018
No API before FY 2018					Green

Planned Performance Goal for FY 2019-2020
2.1.3: Facilitate the commercial development of low Earth orbit (LEO) to transition to a commercial LEO human spaceflight enterprise where NASA is one of many customers.

The **International Space Station Program** manages the unique low Earth orbit platform that enables research in a microgravity environment. Several research facilities are on the ISS to support science investigations in biology, biotechnology, human physiology, material science, physical sciences, and technology development. The ISS program is part of HEOMD.

NASA met this performance goal by achieving all but one of the supporting annual performance indicators.

The Materials ISS Experiment Flight Facility (MISSE-FF) arrived on the ISS in April 2018. MISSE-FF is a continuation of the successful flight payloads that provides the ability for NASA, the private sector, and others to test materials, coatings, and components in the harsh space environment. Unlike previous MISSE units, the MISSE-FF does not have to be mounted on the exterior of the ISS by an astronaut. The unit's base structure and avionics stay inside the ISS and the sample carriers are mounted outside the ISS using the robotically operated Canadarm-2. Also delivered in April 2018 was the commercially developed and operated Multi-use Variable-g Platform (MVP), which has two carousels that can produce up to 2*g* of artificial gravity.

During FY 2018, the Center for the Advancement of Science in Space (CASIS), which runs the ISS National Laboratory, met all of its targets by signing agreements with 23 new and 27 return customers.

ISS-18-9: Issue an Announcement for Proposals (AFP) for the commercial use of low Earth orbit (LEO) for ongoing human spaceflight activities.

2013	2014	2015	2016	2017	2018
No API before FY 2018					Green

Planned Annual Performance Indicators
ISS-19-10: Award one or more proposals for the commercial use of low Earth orbit (LEO) for ongoing human spaceflight activities.
No API after 2019

Above: The blue MISSE-FF and the Japanese Experiment Module (JEM) Exposed Facility exit the ISS through the JEM airlock. The experiment is comprised of a structural platform that holds multiple MISSE sample carriers. Image credit: NASA

ISS-18-10: Add at least two new in-orbit commercial International Space Station (ISS) facilities and/or facility managers during FY 2018.

2013	2014	2015	2016	2017	2018
No API before FY 2018					Green

Planned Annual Performance Indicators
ISS-19-12: Add at least two new in-orbit commercial International Space Station (ISS) facilities and/or facility managers during FY 2019.
ISS-20-9: Add at least two new in-orbit commercial International Space Station (ISS) facilities and/or facility managers during FY 2020.

ISS-18-11: Sign agreements with at least 20 new National Laboratory customers during FY 2018.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicators
ISS-19-11: Sign agreements with at least 20 new National Laboratory customers during FY 2019.
ISS-20-8: Sign agreements with at least 20 new National Laboratory customers during FY 2020.

ISS-18-12: Sign agreements with at least 15 repeat National Laboratory customers during FY 2018.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicators
ISS-19-13: Sign agreements with at least 15 repeat National Laboratory customers during FY 2019.
ISS-20-10: Sign agreements with at least 15 repeat National Laboratory customers during FY 2020.

ISS-18-13: Release a policy document on the commercial use of the International Space Station (ISS).

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Yellow

Explanation of Performance

NASA produced a draft in FY 2018, but work to complete the policy document continues to require extensive coordination. NASA expects to complete the policy document by mid-FY 2019.

Planned Annual Performance Indicators
No APIs after FY 2018

ISS-19-8 [Begins in FY 2019]

Planned Annual Performance Indicators
ISS-19-8: Deliver the commercial airlock for launch integration on the International Space Station (ISS).
ISS-20-7: PLACEHOLDER. NASA will set its FY 2020 annual performance indicator at the end of fiscal year 2019, after it has the results from the NASA Research Announcement (NRA) Study for Commercialization of Low Earth Orbit (Solicitation Number 80JSC018LEOCOM) released in May 2018.

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 Mumford, Deputy Associate Administrator, HEOMD

NASA is extending human presence into cis-lunar space and the lunar surface, with capabilities that allow for sustained operations in deep space and the lunar surface.

Budget

	FY	$M
Actual	2018	4,790.0
Enacted	2019	4,698.8
Requested	2020	5,021.7
Outyear	2021	5,295.5
	2022	5,481.4
	2023	6,639.0
	2024	7,042.3

2018 Strategic Review Summary of Progress

The **Human Exploration and Operations Mission Directorate** leads and manages NASA space operations related to human exploration in and beyond low Earth orbit. HEOMD oversees requirements development, policy, and programmatic oversight across its numerous programs. HEOMD's activities include the International Space Station, commercial space transportation, low Earth orbit spaceflight operations, deep space exploration systems, launch services, and space communications. Efforts that supported the assessment included:

- NASA continues to plan for an Exploration Mission (EM)-1 launch in December 2019, with six months of schedule reserve to June 2020 to address possible first-time manufacturing and production risks.
- NASA preparations underway for EM-2 include production of the Orion EM-2 crew module pressure vessel at the Michoud Assembly Center and the active launch abort system.

Above: The propulsion system that will give the Orion spacecraft the "in-space push" needed to travel thousands of miles beyond the moon and back has completed its major assembly at United Launch Alliance in Decatur, Alabama. Image credit: ULA

- NASA preparations underway for EM-2 include design reviews for the Space Launch System Block 1B exploration upper stage and early manufacturing for the RL-10 engines for the exploration upper stage.

Performance Measures for Strategic Objective 2.2

The following pages provide the performance goals and annual performance indicators supporting Strategic Objective 2.2. They include the final performance results for FY 2018, the FY 2019 Performance Plan Update, which NASA considers final for FY 2019, and the initial FY 2020 Performance Plan. Below are charts summarizing the FY 2018 performance ratings for the performance goals and annual performance indicators supporting Strategic Objective 2.2.

As NASA conducts its 2019 Strategic Review, to be completed in spring 2019, it will conduct a retrospective and prospective analyses to determine if the programs supporting this strategic objective are healthy and can address potential or realized risks. Part of the retrospective analyses will take into consideration the FY 2018 performance results found on the following pages. Looking forward, NASA will assess whether it is on track to achieve the FY 2019 annual performance indicators. The results of this early assessment will inform planning for the FY 2021 Performance Plan, which will begin in spring 2019.

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

Performance Goal 2 2

Span two to five years, and measure the performance of investments towards strategic objectives and strategic goals. The total number of performance goals is reflected in each rating box and there is no one-to-one correlation to annual performance indicator ratings.

Annual Performance Indicator 2 5 1

Describe the smaller, achievable measurements that serve as NASA's basic unit of performance. They show progress achieved during the budget year, and NASA uses them to assess progress made towards achieving the performance goals and the strategic objectives. The total number of annual performance indicators is reflected in each rating box and there is no one-to-one correlation to performance goal ratings.

Performance Goal 2.2.1: Achieve critical milestones in development of new systems for the human exploration of deep space. (Agency Priority Goal)

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Yellow

Planned Performance Goals

FY 2019 - 2.2.1: Achieve critical milestones in development of new systems for the human exploration of deep space. (Agency Priority Goal)

FY 2020 - 2.2.1: Achieve critical milestones in development of new systems for the human exploration of deep space, including the first test flight of the integrated Space Launch System (SLS), Orion, and Exploration Ground System (EGS) capability on Exploration Mission (EM)-1.

NASA's **Exploration Systems Development programs**, part of HEOMD, are working together to build the spaceflight system made up of the **Orion crew vehicle**, the **Space Launch System (SLS) rocket**, and the **Exploration Ground Systems (EGS)**. These system will enable the Agency's new missions to extend human presence beyond low Earth orbit.

NASA experienced delays in completing the SLS core stage liquid oxygen tank (Annual Performance Indicator ESD-18-1) and the Orion EM-1 crew module (Annual Performance Indicator ESD-18-2). However, neither delay currently does not disrupt the overall schedule for (EM)-1, which will be the first time NASA launches SLS and Orion together on an uncrewed test flight.

NASA met its goals for the EGS program for FY 2018 by completing the integrated verification and validation testing of the mobile launcher and the Vehicle Assembly building.

Above: Technicians lower the crew module for Ascent Abort-2 onto a stand at the Johnson Space Center on March 2, 2018. Image credit: NASA/Robert Markowitz

ESD-18-1: Complete production of the Exploration Mission-1 Core Stage liquid oxygen tank.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Yellow

Performance Explanation

The completion of the liquid oxygen tank for the SLS core stage, which will be used for EM-1, experienced a delay beyond the end of FY 2018 due to first-time production challenges. NASA does not expect the delay to affect the overall schedule for the core stage. NASA has completed application of thermal protection system foam on the barrel section and is currently proceeding with the application of the thermal protection foam on the domes.

Planned Annual Performance Indicators

ESD-19-1: Perform the green run hot-fire test of the Space Launch System's Core Stage at the Stennis Space Center.

ESD-20-1: Complete all ten Exploration Mission (EM)-2 booster segments.

ESD-18-2: Complete work to have the Exploration Mission-1 Crew Module ready for stacking in the Armstrong Operations and Checkout Building at the Kennedy Space Center.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Yellow

Performance Explanation

Delays in the readiness of the crew module are attributed to the need to remove and rework avionics hardware, to the delayed delivery of the crew module side hatch components, and to some qualification testing failures. NASA completed the integration and rework of the side hatch and avionics hardware, and the Orion EM-1 crew module cabin was delivered to the Kennedy Space Center in November for stacking.

Planned Annual Performance Indicators
ESD-19-2: Conduct the Ascent Abort-2 test of the Orion Launch Abort System.
ESD-20-2: Complete testing of the Orion Structural Test Article (STA) to validate the Orion structural design in preparation for the first crewed flight on Exploration Mission (EM)-2.

ESD-18-3: Complete integrated verification and validation testing of the Mobile Launcher and the Vehicle Assembly Building.

2013	2014	2015	2016	2017	2018
No API	Green	Yellow	Yellow	Yellow	Green

Planned Annual Performance Indicators
ESD-19-3: Roll the Mobile Launcher to the Vehicle Assembly Building to support the start of Exploration Mission-1 stacking operations.
ESD-20-3: Complete integration of the Space Launch System (SLS) and Orion stack in the Vehicle Assembly Building (VAB) at the Kennedy Space Center (KSC) in preparation for Exploration Mission (EM)-1.

Left: A team prepares an RS-25 engine No. 0525 for installation on the A-1 Test Stand at Stennis Space Center on July 23, 2018, in preparation for SLS hotfire tests. Four RS-25 engines, working in conjunction with a pair of solid rocket boosters, will help power the SLS rocket at launch. Image credit: NASA

Performance Goal 2.2.2 [Begins in FY 2019]

Performance Goal Planned for FY 2019-2020
2.2.2: Demonstrate deep space habitat concepts using prototypes developed in partnership with Next Space Technologies for Exploration Partnerships (NextSTEP) Phase 2 industry partners.

Advanced Exploration Systems (AES), part of HEOMD, develops innovative approaches and public-private partnerships to rapidly develop prototype systems, advance key capabilities, and validate operational concepts for future human missions beyond Earth orbit. AES activities are related to crew mobility, habitation, vehicle systems, robotic precursors, and foundational systems for deep space.

ERD-19-1 [Begins in FY 2019]

Planned Annual Performance Indicators
ERD-19-1: Complete ground testing of Next Space Technologies for Exploration Partnerships (NextSTEP) Phase 2 prototype habitat concepts to evaluate human factors, develop and verify interoperability standards and common interfaces for cislunar habitats with industry and international partner participation, and develop the final reference configuration for the acquisition phase.
ERD-20-1: Deliver the Spacecraft Fire Experiment (Saffire)-IV fire safety flight experiment for launch on Cygnus.

Above: NASA performed tests the week of June 25, 2018, at the Johnson Space Center to help engineers refine NASA's requirements for the design of a deep space habitat, one of several elements comprising the Gateway. In this photo, an engineer, Astronaut Shannon Walker, Astronaut Candidates Raja Chari and Robb Kulin, and Japan Aerospace Exploration Agency Astronaut Aki Hoshide, evaluate spacewalk-related procedures. Image credit: NASA/Robert Markowitz

Performance Goal 2.2.3: Use the International Space Station (ISS) as a testbed to demonstrate the critical systems necessary for long-duration missions. Between October 1, 2017, and September 30, 2019, NASA will initiate at least eight in-space demonstrations of technology critical to enable human exploration in deep space. (Agency Priority Goal)

2013	2014	2015	2016	2017	2018
Green	Green	Yellow	Green	Green	Green

Planned Performance Goals for FY 2019-2020
FY 2019 - 2.2.3: Use the International Space Station (ISS) as a testbed to demonstrate the critical systems necessary for long-duration missions. Between October 1, 2017, and September 30, 2019, NASA will initiate at least eight in-space demonstrations of technology critical to enable human exploration in deep space. (Agency Priority Goal)
FY 2020 - 2.2.3: Use the International Space Station (ISS) as a testbed to demonstrate key capabilities necessary for long-duration missions. Between October 1, 2019, and September 30, 2021, NASA will initiate at least ten in-space demonstrations of technology critical to enable human exploration in deep space.

NASA continues to be on track to achieve this agency priority goal. In spring 2018, researchers conducted the first-ever experiments on long-term exposure to galactic cosmic ray-like radiation at the National Space Radiation Laboratory, at the Brookhaven National Laboratory. These experiments will enable better assessments of space radiation health risks involved in human space exploration.

The **International Space Station** is a unique scientific platform in low Earth orbit that enables research in a microgravity environment. The **Human Research Program** focuses on discovering the best methods and technologies to support safe and productive human space travel. **Advanced Exploration Systems (AES)** develops innovative approaches and public-private partnerships to rapidly develop prototype systems, advance key capabilities, and validate operational concepts for future human missions beyond Earth orbit. All three programs are part of HEOMD.

ERD-18-2: Deliver both the Spacecraft Atmosphere Monitor and Brine Water Processor to the International Space Station (ISS) for technology demonstrations.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Red

Explanation of Performance

Neither the Spacecraft Atmosphere Monitor (SAM) nor the Brine Water Processor were delivered to the ISS by the end of the first quarter of FY 2019. SAM, which continuously measures gases in the air on the ISS and transmits that data to researchers on Earth, will be delivered in March 2019 to the Jet Propulsion Laboratory due to the late delivery of ion pumps and other components. The Brine Water Processor, also known as the Brine Processor Assembly, will demonstrate the recovery of water from urine brine produced by the ISS Urine Processor Assembly. The delivery of the Brine Water Processor for flight integration will be delayed to early September 2019 due to design issues with its bladder and logic control board.

Planned Annual Performance Indicators
ERD-19-2: Deliver the Universal Waste Management System (UWMS) for flight on the International Space Station (ISS).
ERD-20-2: Deliver the Brine Processor Assembly for launch to the International Space Station.

ISS-18-8: Initiate in-space demonstration of three new technologies for Environmental Control and Life Support or Environmental Monitoring, including thermal amine for carbon dioxide removal.

2013	2014	2015	2016	2017	2018
No API before FY 2018					Yellow

Explanation of Performance

NASA rated this annual performance indicator yellow because two new technologies were delivered to the ISS and initiated in FY 2018: the Aerosol Samplers in July and the Acoustic Monitor in August. Two other technologies being developed for potential delivery to ISS in FY 2018 were delayed.

The Thermal Amine System, which will demonstrate the removal of carbon dioxide from the ISS cabin atmosphere, was delayed due to a component failure during a ground test. NASA has completed both the rework and re-testing of the system, and it is manifested to fly to ISS in April 2019.

The Brine Processor Assembly was delayed due to several technical issues encountered during assembly and test. The new expected delivery date to ISS is during the second quarter of FY 2020.

Planned Annual Performance Indicators
ISS-19-7: Initiate in-space demonstration of three new technologies for Environmental Control and Life Support or Environmental Monitoring, including the Spacecraft Atmosphere Monitor (SAM).
ISS-20-11: Initiate in-space demonstration of five new technologies for Environmental Control and Life Support or Environmental Monitoring.

ERD-18-5: Perform mixed-field, low-dose rate galactic cosmic ray simulation investigations at the NASA Space Radiation Laboratory to enable better assessment of space radiation health risks for exploration.

2013	2014	2015	2016	2017	2018
No API before FY 2018					Green

Planned Annual Performance Indicators

ERD-19-3: Complete and deliver the Advanced Twin Lifting and Aerobic System (ATLAS) deep space exercise device for testing and validation; implement a human health and performance study with the National Science Foundation on the effects of remote location, extreme isolation, and confinement; and implement a bedrest study with the European Space Agency to assess the use of artificial gravity as a human physiology countermeasure.

ISS-20-2: Implement a microbial risk assessment study to ensure crew safety and allow increased dependence on bioregenerative food systems; develop space habitat standards and evaluation tools for use in designing and evaluating vehicle volume and layout to optimize crew performance and health; and complete a study to determine optimal methods for detecting individual performance susceptibilities to sleep loss and circadian desynchronization to inform individualized countermeasures during spaceflight.

Performance Goal 2.2.4: Develop planetary In-Situ Resource Utilization technologies.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Yellow	Green	Yellow

Planned Performance Goal for FY 2019-2020
No PGs after FY 2018

This performance goal is rated yellow because delivery of the Mars Oxygen In Situ Resource Utilization (ISRU) Experiment (MOXIE) was delayed until early calendar year 2019. Its delivery slipped due to troubleshooting of electrical shorts. MOXIE's delay will not effect the schedule for integrating the mission payload suite with Mars 2020, and its progress is being continuously monitored.

MOXIE is intended to demonstrate technology for producing oxygen from the Martian atmosphere for use in propellant or life support systems.

Advanced Exploration Systems, part of HEOMD, develops innovative approaches and public-private partnerships to rapidly develop prototype systems, advance key capabilities, and validate operational concepts for future human missions beyond Earth orbit. AES activities are related to crew mobility, habitation, vehicle systems, robotic precursors, and foundational systems for deep space.

ERD-18-1: Deliver the Mars Oxygen ISRU [In-Situ Resource Utilization] Experiment (MOXIE) flight article to the Mars 2020 rover for assembly, test, and launch operations.

2013	2014	2015	2016	2017	2018
No API	Green	Green	Yellow	Green	Yellow

Explanation of Performance

See the performance goal explanation for more information.

Planned Annual Performance Indicators
No APIs after FY 2018

Performance Goal 2.2.5: Engage industry in developing concepts to satisfy both NASA and commercial goals for a Power and Propulsion Element for deep space transportation.

2013	2014	2015	2016	2017	2018
No PG before FY 2018					Green

Planned Performance Goal for FY 2019-2020
2.2.5: Achieve milestones in the design and development of a Power and Propulsion Element in partnership with industry.

Advanced Exploration Systems, part of HEOMD, develops innovative approaches and public-private partnerships to rapidly develop prototype systems, advance key capabilities, and validate operational concepts for future human missions beyond Earth orbit. AES activities are related to crew mobility, habitation, vehicle systems, robotic precursors, and foundational systems for deep space.

In March 2018, NASA completed industry studies on potential synergies for NASA–industry partnership to build and flight demonstrate a spacecraft that uses advanced solar electric propulsion. This power and propulsion element would support NASA's plans for exploration operations in deep space. Based on the studies, NASA completed the first major milestone to solicit proposals from industry to build and demonstrate a Power and Propulsion Element.

Power and Propulsion Element Moves Ahead

- June 21, 2018 - Released draft solicitation for spaceflight demonstration of a Power and Propulsion Element seeking industry comments
- July 10, 2018 – Held Industry Day at Glenn Research Center
- July 20, 2018 – Received industry comments on the draft solicitation
- September 6, 2018 – Released final broad agency announcement for the Spaceflight Demonstration of a Power and Propulsion Element

ERD-18-6: Complete industry studies on potential synergies for a NASA-industry partnership to demonstrate a Power and Propulsion Element using advanced solar electric propulsion.

2013	2014	2015	2016	2017	2018
No API before FY 2018					Green

Planned Annual Performance Indicators
ERD-19-4: In partnership with industry, conduct one or more Preliminary Design Reviews for the Power and Propulsion Element.
AES-20-1: Achieve milestones in the design and development of a Power and Propulsion Element (PPE) in partnership with industry. (NASA will identify a specific milestone to track for this annual performance indicator in 3rd quarter FY 2019, following PPE partner selection and contract award.)

Develop

Strategic Goal 3

Address national challenges and catalyze economic growth.

NASA's autonomous testbed called Prototype Technology-Evaluation Research Aircraft, or PTERA, takes off on a flight to test the ability of shape memory alloy to fold wings in-flight. NASA, in this flight, observed the successful folding of PTERA's wings 70 degrees upward. Image credit: NASA/Ken Ulbrich

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) [Note: STMD will be reorganized moving forward as mentioned on page iv.

Goal Leader
Prasun Desai, Deputy Associate Administrator for Management, STMD

Budget

	FY	$M
Actual	2018	760.0
Enacted	2019	760.0
Requested	2020	1,014.3
Outyear	2021	976.1
	2022	995.4
	2023	964.4
	2024	943.1

NASA is advancing revolutionary technologies for NASA and the Nation, involving commercial space products, specifically for utilization of near-Earth space; efficient transportation through space; access to planetary surfaces; enabling human space exploration; next generation science missions; and growth and utilization of the U.S. industrial and academic base.

2018 Strategic Review Summary of Progress

The **Space Technology Mission Directorate** has been responsible for developing the crosscutting, pioneering, new technologies and capabilities that NASA needs to achieve its current and future missions. STMD has sought to mature these technologies for NASA's science and exploration missions while proving the capabilities and lowering the cost for other government agencies and commercial space activities. Efforts that supported the assessment included:

- The Deep Space Atomic Clock, Green Propellant Infusion Mission, and CubeSat Proximity Operations Demonstration have completed development and are currently in storage, and are ready for launch.
- The Laser Communications Relay Demonstration flight demonstration has successfully entered the implementation phase. Other demonstrations remain on track, including: Mars Oxygen ISRU Experiment (MOXIE), Terrain Relative Navigation, and Mars

Above: Blue Origin's New Shepard booster rocket returns to its launch pad on December 12 after completing a flight that tested the Evolved Medical Microgravity Suction Device technology. NASA funded the microgravity service on the flight. Image credit: Blue Origin

Entry, Descent and Landing Instrumentation 2 (MEDLI2) for the Mars 2020 lander mission; Deep Space Optical Communication (DSOC); and Solar Electric Propulsion.

Performance Measures for Strategic Objective 3.1

The following pages provide the performance goals and annual performance indicators supporting Strategic Objective 3.1. They include the final performance results for FY 2018, the FY 2019 Performance Plan Update, which NASA considers final for FY 2019, and the initial FY 2020 Performance Plan. Below are charts summarizing the FY 2018 performance ratings for the performance goals and annual performance indicators supporting Strategic Objective 3.1.

As NASA conducts its 2019 Strategic Review, to be completed in spring 2019, it will conduct retrospective and prospective analyses to determine if the programs supporting this strategic objective are healthy and can address potential or realized risks. Part of the retrospective analyses will take into consideration the FY 2018 performance results found on the following pages. Looking forward, NASA will assess whether it is on track to achieve the FY 2019 annual performance indicators. The results of this early assessment will inform planning for the FY 2021 Performance Plan, which will begin in spring 2019. In addition, as parts of these analyses, NASA will factor in any relevant updates and/or changes that arise from the reorganization of STMD as part of the FY 2019-2021 planning.

Summary of Strategic Objective 3.1: Develop and transfer revolutionary technologies to enable exploration capabilities for NASA and the Nation.

Performance Goal 4

Span two to five years, and measure the performance of investments towards strategic objectives and strategic goals. The total number of performance goals is reflected in each rating box and there is no one-to-one correlation to annual performance indicator ratings.

Annual Performance Indicator 7

Describe the smaller, achievable measurements that serve as NASA's basic unit of performance. They show progress achieved during the budget year, and NASA uses them to assess progress made towards achieving the performance goals and the strategic objectives. The total number of annual performance indicators is reflected in each rating box and there is no one-to-one correlation to performance goal ratings.

Performance Goal 3.1.1: Explore and advance promising early stage solutions to space technology challenges through investment across the U.S. innovation community.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goal for FY 2019-2020

3.1.1: Invest across the U.S. innovation community to explore and advance promising early stage solutions to space technology challenges.

Early Stage Innovation and Partnerships (formerly **Space Technology Research Grants**, **NASA Innovative Advanced Concepts**, and the **Center Innovation Fund** programs) nurture visionary ideas, stimulate innovation, and examine the feasibility of new ideas and approaches to address the technology needs of NASA and the Nation.

NASA has met this multi-year performance goal as the Agency continues to advance early stage innovation. In FY 2018, NASA selected 56 NASA Space Technology Research Fellowships, 12 Early Stage Innovations awards, and 11 Early Career Faculty awards.

NASA selected 25 new concept studies in FY 2018, comprising 16 Phase I projects and 9 Phase II projects, through NIAC, a program that helps innovators and entrepreneurs develop innovative, technically credible, advanced concepts to "change the possible" in aerospace. The Agency also encouraged creativity and innovation within the NASA centers by supporting emerging technologies and creative initiatives, selecting 125 Center Innovation Fund projects in FY 2018.

ST-18-1: Conduct at least 185 new activities, with appropriate contribution from each underlying early stage program, to research, study, or develop concepts for new technologies.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

ET-19-1: Invest in at least 185 promising new early stage technologies and concepts, with potential for transformative impact.

ET-20-1: Invest in at least 185 promising new early stage technologies and concepts, with potential for transformative impact.

Performance Goal 3.1.2: Advance technologies that offer significant improvement to existing solutions or enable new space science and exploration capabilities.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Yellow	Green

Performance Goal Planned for FY 2019-2020

3.1.2: Mature technologies that offer significant improvement to existing solutions or enable space exploration capabilities.

Technology Maturation (formerly the **Game Changing Development (GCD)** Program) advances space technologies that may lead to entirely new approaches for the Agency's future space missions and provide solutions to significant national needs. The program generally focuses efforts in taking technologies from proof of concept through component testing in a relevant environment. GCD employs a balanced approach to technology development efforts, competitively selecting efforts from across academia, industry, and government agencies.

In FY 2018, GCD continued advancement of many promising technology solutions. NASA and the National Nuclear Security Administration demonstrated a new nuclear fission reactor power system, called Kilopower, that could enable long-duration crewed missions to the Moon, Mars, and destinations beyond. The experiment was conducted at the National Nuclear Security Administration's Nevada National Security Site from November 2017 through March 2018.

A team of NASA engineers demonstrated fully autonomous X-ray navigation in space during the demonstration that occurred in November 2017. The Space Exploration for X-ray Timing and Navigation Technology (SEXTANT) demonstration showed that millisecond pulsars could be used to accurately determine the location of an object moving in space.

NASA is breaking ground in the world of additive manufacturing with the Low Cost Upper Stage-Class Propulsion project. The Agency successfully hot-fire tested a combustion chamber at NASA's Marshall Space Flight Center made using a new combination of 3-D printing techniques. This project aims to further improve production time and costs for thrust chamber assemblies.

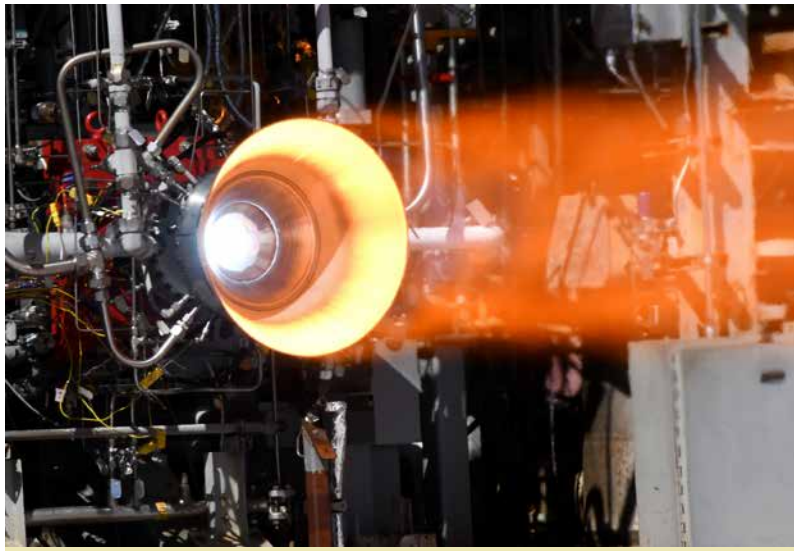
ST-18-2: Complete at least 70 percent of Game Changing Development program milestones, as established at the beginning of the fiscal year.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Red	Green

Planned Annual Performance Indicators

ET-19-2: Mature state of the art technologies by completing at least 70 percent of Technology Maturation program milestones.

ET-20-2: Mature state of the art technologies by completing at least 60 percent of key performance parameters of Technology Maturation projects.



Above: Combustion chambers must withstand both extreme hot and cold temperatures inside a rocket engine as extremely cold propellants are heated up and burned for propulsion. In 2018, NASA successfully hot-fire tested a combustion chamber made from a 3-D printed copper liner and a nickel-alloy jacket. The final hot-fire test went the full planned 25 seconds at 100 percent power. Image credit: NASA/David Olive

Performance Goal 3.1.3: Mature new crosscutting space technology capabilities for demonstration.

2013	2014	2015	2016	2017	2018
No PG	Green	Green	Green	Green	Green

Planned Performance Goal for FY 2019-2020
3.1.3: Demonstrate new technologies and capabilities for space exploration.

The **Small Spacecraft Technology Program** develops and demonstrates new small spacecraft technologies and capabilities for NASA's missions in science, exploration, and space operations. The **Technology Demonstration Program** bridges the gap between scientific and engineering challenges and the technological innovations needed to overcome them, enabling robust new space missions.

NASA achieved this multi-year performance goal as it continues to foster and mature new crosscutting space technology capabilities for demonstration. In FY 2018, the Small Spacecraft Technology program made progress on several projects, including completing eight major milestones:

- Level-1 Requirements Completion Review for the Integrated Solar And Reflectarray Antenna mission, which will demonstrate a CubeSat communications capability
- Preliminary Design Review (PDR) and Critical Design Review in December 2017 for the Pathfinder Technology Demonstrator (PTD), which will test CubeSat technologies in low Earth orbit
- Qualification Test Readiness Review for the Tethers Unlimited, Inc., HYDROS-C thruster payload, which uses water as propellant, for PTD-1
- Qualification TRR for the Blue Canyon Technologies HyperXACT Attitude Determination and Control payload for PTD-2
- System Readiness Review and payload PDR for CubeSat Lasercom Infrared Crosslink, which will demonstrate intersatellite communications for small spacecraft
- Flight Readiness Review for CubeSat Handling Of Multisystem Precision Time Transfer, which will demonstrate high-precision time transfer from Earth to low Earth orbiting CubeSat

NASA also completed five major milestones for Technology Demonstration Missions projects:

- SRR/Mission Definition Review, and Key Decision Point (KDP)-B for Deep Space Optical Communications
- PDR for Restore-L satellite servicing project
- SRR and KDP-B for Low Earth Orbit-based Flight Test demonstration of Inflatable Decelerator (LOFTID)
- A continuation review for eCryo cryogenic fluid management technologies project
- Close-out reviews for In-space Robotic Manufacturing and Assembly (IRMA)

ST-18-3: Reach at least eight major milestones, including delivery of small spacecraft for flight demonstration or other milestones, for development and demonstration of transformative technologies for more affordable science and exploration missions.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators
ET-19-3: Advance development, demonstration, and mission implementation of new exploration technologies by reaching a key milestone in at least six small spacecraft projects.
ET-20-3: Advance development, demonstration, and mission implementation of new exploration technologies by reaching a key milestone in at least four small spacecraft projects.

ST-18-4: Complete five major milestones for Technology Demonstration Mission (TDM) technology development projects.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators
ET-19-4: Advance Technology Demonstration capabilities by completing at least six key decision points towards technology demonstration.
ET-20-4: Advance Technology Demonstration capabilities by completing at least six key decision points towards technology demonstration.

Above: Engineers Lok Wong and Kyle Doyle assemble pieces of a truss segment for the Commercial Infrastructure for Robotic Assembly and Services (CIRAS) project at the Structures and Materials Test Laboratory at Langley Research Center in March 2018. CIRAS is part of the IRMA project portfolio, managed by STMD's Technology Demonstration Missions program. Image credit: NASA/David C. Bowman

Performance Goal 3.1.4: Engage the established commercial sector, emerging aerospace markets, and economic regions to leverage common interests and grow the national economy.

2013	2014	2015	2016	2017	2018
No PG before 2017				Green	Green

Planned Performance Goal for FY 2019-2020
3.1.4: Engage and partner with the commercial aerospace sector, to leverage technology advancements and grow the national economy.

NASA achieved this multi-year performance goal through its engagements with small businesses and research institutions. NASA provided cash prize incentives to non-traditional sources for innovations of interest and value to the Agency and the Nation. The Prizes and Challenges Program supported three centennial challenges in the areas of 3D Printed Habitat Challenge, the Vascular Tissue Challenge, and the CO2 Conversion Challenge.

NASA provided opportunities for small, highly innovative companies and research institutions, through its SBIR/STTR programs. In FY 2018, NASA created 97 post-Phase II SBIR/STTR opportunities.

The Flight Opportunities program strives to advance the operational readiness of space technologies while also stimulating the development and utilization of the U.S. commercial spaceflight industry. During FY 2018, Flight Opportunities competitively selected 36 payloads. In addition, NASA made progress in the entry, descent, and landing focus area through a successful flight test of a Navigation Doppler Lidar and Lander Vision System for future robotic and crewed missions.

Partnerships and Technology Transfer (formerly **Prizes and Challenges**) recognizes the value of incentivizing new technology advancement and problem solving through "open innovation" approaches including the use of prize competitions and challenges open to the public. **Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR)** provides an opportunity for small, high-tech companies and research institutions to participate in government-sponsored R&D efforts in key technology areas. **Technology Demonstration** (formerly **Flight Opportunities**) develops and provides opportunities for space technologies to be demonstrated and validated in relevant environments. It fosters the development of the commercial reusable suborbital transportation industry.

ST-18-5: Conduct at least three prize competitions.

2013	2014	2015	2016	2017	2018
No API before FY 2017				Green	Green

Planned Annual Performance Indicators
ET-19-5: Conduct at least four prize competitions to encourage innovation and address technology challenges through engaging non-traditional NASA partners.
ET-20-5: Conduct at least four prize competitions to encourage innovation and address technology challenges through engaging non-traditional NASA partners.

ST-18-6: Create 10 opportunities for advancement beyond Phase II SBIR/ STTR.

2013	2014	2015	2016	2017	2018
No API before FY 2017				Green	Green

Planned Annual Performance Indicators
ET-19-6: Create 10 opportunities for advancement of SBIR/ STTR technologies beyond Phase II, leveraging non-SBIR/ STTR NASA investment or external investment.
ET-20-6: Create 10 opportunities for advancement of SBIR/ STTR technologies beyond Phase II, leveraging non-SBIR/ STTR NASA investment or external investment.

Above: Team SEArch+/Apis Cor of New York won first place in Phase 3: Level 2 of NASA's 3D-Printed Habitat Challenge. For this level, they printed a foundation and subjected it to various tests, including dropping a shotput on it to simulate a meteor strike. Watch the full video of their entry and testing. Image credit: SEArch+/Apis Corstrike. Watch the full video of their entry and testing. Image credit: SEArch+/Apis Cor

ST-18-7: Competitively select at least 12 payloads from NASA, other government agencies, industry, and academia for flight on commercial flight vehicles that meet Agency priorities.

2013	2014	2015	2016	2017	2018
No APIs before FY 2017				Green	Green

Planned Annual Performance Indicators
ET-19-7: Competitively select at least 14 payloads from NASA centers, other government agencies, industry, or academia for flight on commercial flight vehicles to achieve Agency priorities.
ET-20-7: Competitively select at least 16 payloads from NASA centers, other government agencies, industry, or academia for flight on commercial vehicles to advance lunar exploration and commercial development in Earth orbit.

Strategic Objective 3.2: Transform aviation through revolutionary technology research, development, and transfer.

Lead Office
Aeronautics Research Mission Directorate (ARMD)

Goal Leader
Robert A. Pearce, Deputy Associate Administrator for Strategy, ARMD

Budget

	FY	$M
Actual	2018	690.0
Enacted	2019	685.0
Requested	2020	666.9
Outyear	2021	673.6
	2022	680.3
	2023	587.1
	2024	587.0

NASA is maintaining and advancing U.S. global leadership in aviation through application of new concepts and technologies pioneered by NASA and developed in partnership with U.S. industry, leading to transformative improvements in mobility, efficiency, and safety.

2018 Strategic Review Summary of Progress

The **Aeronautics Research Mission Directorate** designs, develops, and tests advanced technologies that will make aviation much more environmentally friendly, maintain safety in more crowded skies, and ultimately transform the way the United States and the world flies. Research conducted by ARMD directly benefits today's air transportation system, the aviation industry, and the passengers and businesses who rely on aviation every day. Efforts that supported the assessment included:

- The Low-Boom Flight Demonstration contract was awarded April 2, 2018. The Strategic Review was completed in spring 2018, and the LBFD project team completed the Key Decision Point (KDP)-C in the first quarter of FY 2019.
- ARMD was on track to complete the Airspace Technology Demonstration (ATD)-1 and ATD-2 and deliver the results to the Federal Aviation Administration according to the Research Transition Team plan by FY 2020 (i.e., ARMD's Thrust #1 Critical Commitment).

Above: NASA test pilots Jim Less and Wayne Ringelberg conduct pre-flight safety checks for a F/A-18 before going out on a supersonic QSF18 flight, part of NASA's Low-Boom Flight Demonstration. Image credit: NASA/Josh Valcarcel

- ARMD was on track to deliver its first flight validated community response database to the International Civil Aviation Organization by end of FY 2024.

Performance Measures for Strategic Objective 3.2

The following pages provide the performance goals and annual performance indicators supporting Strategic Objective 3.2. They include the final performance results for FY 2018, the FY 2019 Performance Plan Update, which NASA considers final for FY 2019, and the initial FY 2020 Performance Plan. Below are charts summarizing the FY 2018 performance ratings for the performance goals and annual performance indicators supporting Strategic Objective 3.2.

As NASA conducts its 2019 Strategic Review, to be completed in spring 2019, it will conduct a retrospective and prospective analyses to determine if the programs supporting this strategic objective are healthy and can address potential or realized risks. Part of the retrospective analyses will take into consideration the FY 2018 performance results found on the following pages. Looking forward, NASA will assess whether it is on track to achieve the FY 2019 annual performance indicators. The results of this early assessment will inform planning for the FY 2021 Performance Plan, which will begin in spring 2019.

Summary of Strategic Objective 3.2: Transform aviation through revolutionary technology research, development and transfer.

Performance Goal 5 1

Span two to five years, and measure the performance of investments towards strategic objectives and strategic goals. The total number of performance goals is reflected in each rating box and there is no one-to-one correlation to annual performance indicator ratings.

Annual Performance Indicator 9 1

Describe the smaller, achievable measurements that serve as NASA's basic unit of performance. They show progress achieved during the budget year, and NASA uses them to assess progress made towards achieving the performance goals and the strategic objectives. The total number of annual performance indicators is reflected in each rating box and there is no one-to-one correlation to performance goal ratings.

Performance Goal 3.2.1: Develop solutions that will advance decision-making ability for improving air traffic management to accommodate future growth in air travel, and for increasing aviation safety under hazardous conditions.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goal for FY 2019-2020

3.2.1: Develop solutions that will advance decision-making ability for improving air traffic management to accommodate future growth in air travel, and for increasing aviation safety under hazardous conditions.

The **Airspace Operations and Safety Program** part of ARMD, works with the Federal Aviation Administration, industry, and academic partners to conceive and develop Next Generation Air Transportation System (NextGen) technologies to further improve the safety of current and future aircraft. NextGen methods and means will provide advanced automated support to air navigation service providers and aircraft operators to reduce air-travel times and delays, and to ensure greater safety in all weather conditions.

The Airspace Technology Demonstration (ATD)-2 effort provides solutions to air transportation system inefficiency through an integrated arrival, departure, and surface system (IADS). During FY 2018, Phase 1 of the ATD-2 demonstrated benefits by reducing the amount of fuel used by aircraft, the amount of time aircraft are delayed on the surface, and the amount of carbon dioxide emitted by the aircraft.

The Phase 2 version of the IADS system was deployed in mid-September 2018. This version features five new capabilities, which will be evaluated in FY 2019. Phase 2 will complete ATD-2's single-airport IADS research. The Phase 3 multi-airport field demonstration will formally begin in FY 2020, but an initial concept evaluation with the North Texas Field Demonstration Partners is planned for spring or summer in 2019.

Phase 1 Benefits

As of September 17, 2018

638,068 pounds of fuel saved

89.1 hours of surface delay avoided

22,857 trees-worth of carbon dioxide emission offsets

912 hours of reduced engine runtime

Above: NASA Administrator Jim Bridenstine (right) participates in a FutureFlight Central demonstration of ATD-2 at Ames Research Center on August 30, 2018. He is looking at the Ramp Traffic Console, a new technology tested through human-in-the-loop simulation and currently deployed to the field at Charlotte Douglas International Airport. The Ramp Traffic Control is one of many new air traffic tools NASA is working on to improve arrival, departure, and surface activity at airports. Image credit: NASA

AR-18-1: Demonstrate the Integrated Demand Management (IDM) concept to coordinate management of traffic demand and flight trajectories across multiple constraints, resulting in improved arrival operations in the New York City metroplex airspace.

2013	2014	2015	2016	2017	2018
No API	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

AR-19-1: Assess and document capacity of future air traffic services that increase Urban Air Mobility (UAM) capacity over current-day operations.

AR-20-1: Evaluate a service-oriented architecture, intended to improve safety and efficiency, for traditional operations in a relevant airspace.

AR-19-6 [Begins in FY 2019]

2013	2014	2015	2016	2017	2018
No APIs until FY 2019					

Planned Annual Performance Indicators

AR-19-6: Conduct Shadow Mode assessment of Integrated Arrival/Departure/Surface (IADS) metroplex departure metering prototypes.

AR-20-2: Conduct an operational assessment of the Integrated Arrival/Departure/Surface (IADS) metroplex departure management prototype.

Performance Goal 3.2.2: Demonstrate the ability to reduce sonic booms, enabling future industry innovation in commercial supersonic aircraft.

2013	2014	2015	2016	2017	2018
No API	Green	Green	Green	Yellow	Green

Performance Goal Planned for FY 2019-2020

3.2.2: Demonstrate the ability to reduce sonic booms, enabling future industry innovation in commercial supersonic aircraft.

The **Integrated Aviation Systems Program (IASP)** part of ARMD, conducts flight-oriented, system-level research and technology development to mature and transition advanced aeronautic technologies into future air vehicles and systems, supporting all phases of NASA's aeronautics research. For relatively new technologies, IASP aims to accelerate their development and determine their feasibility. For more mature technologies, IASP aims to reduce risk and transition the technologies to industry.

NASA is on track to complete the Low Boom Flight Demonstration (LBFD), which will demonstrate a sonic boom with greatly reduced noise in order to pave the way for commercial supersonic flight over land. NASA awarded the contract for construction of the X-59 Quiet Supersonic Technology (QueSST) experimental aircraft to Lockheed Martin in Palmdale, CA, in April 2018. The LBFD project passed Key Decision Point (KDP)-C in the first quarter of FY 2019, receiving Agency-level approval for its project plan, cost, and schedule baseline and to begin implementation.

NASA is responsible for managing the construction of the aircraft, and proving its ability to create a sonic "thump" instead of an annoying sonic boom. The LBFD project's technical goals are to design, build and test the X-59 QueSST with low-noise sonic boom signature characteristics acceptable to communities and traceable to future civil supersonic airliners.

Above: The X-59 QueSST experimental aircraft, shown here in an artist's concept, is shaped so that supersonic shockwaves do not coalesce together to create sonic booms. The noise nuisance associated with sonic booms prompted the government to ban supersonic flight over land years ago. Data from the X-59 QueSST project could be the path for new commercial markets in supersonic flight in the United States and internationally. Image credit: NASA

AR-18-2: Award the Low-Boom Flight Demonstration (LBFD) Aircraft Design, Build, and Initial Test contract.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

AR-19-2: Complete the Low-Boom Flight Demonstration (LBFD) Critical Design Review (CDR).

AR-20-3: Complete final assembly of the Low Boom Flight Demonstrator aircraft.

Performance Goal 3.2.3: Advance airframe and engine technologies to enable the development of future generations of ultra-efficient air vehicles that minimize environmental impact.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Yellow

Planned Performance Goal for FY 2019-2020

3.2.3: Advance airframe and engine technologies to enable the development of future generations of ultra-efficient air vehicles that minimize environmental impact.

Aeronautics Research Mission Directorate encompasses multiple research programs that develop advanced technologies to reduce aviation's environmental impact and to transform how the world flies, including the Advanced Air Vehicles Program, the Airspace Operations and Safety Program, the Integrated Aviation Systems Program, and the Transformative Aeronautics Concepts Program.

The majority of work within this performance goal is on track for successful, on-time completion. The demonstration of novel landing gear technologies in order to reduce noise is complete. The third and final landing gear noise flight test was completed in May 2018 and data analysis is ongoing. The full extent of noise reduction benefits from main landing gear fairings and cavity treatments was documented to be between three and four decibels.

Two initial tests of the wing-body juncture flow experiment were completed, leading to the successful development of a validation-quality dataset in a subsonic tunnel facility at the Langley Research Center. The measurements and dataset produced by these tests will be used to enable better computational tools for the prediction of future air vehicle designs.

A multidisciplinary design analysis and optimization process for the conceptual design of vertical lift vehicles was successfully demonstrated. The development and demonstration metrics cover five factors: fidelity, metric scope, objective function, tool efficiency, and design goals. The combined metrics show multi-faceted improvements made to discipline tools integrated in a design optimization framework. The final DDM score was rated at 15, exceeding the success criteria DDM score of 12.

This performance goal is rated yellow because early fabrication issues caused delivery of the passive aeroelastic tailored (PAT) wing test article to slip into FY 2019. The composite wing, designed and built by Aurora Flight Sciences, was delivered to the Armstrong Flight Research Center on April 9, 2018. Ground vibration testing of the PAT wing test article was completed in July 2018, and assessments were completed in September 2018. Static load testing and data analysis began at the end of FY 2018, but were completed during the first quarter of FY 2019.

AR-18-3: Design, fabricate, and test a high aspect ratio wing box employing tow-steered composites and demonstrate vehicle-level fuel-burn benefit through aeroelastic-tailored structural design.

2013	2014	2015	2016	2017	2018
Green	Green	No API	Green	Green	Yellow

Explanation of Performance

See Performance Goal 3.2.3.

Planned Annual Performance Indicators

AR-19-3: Design, fabricate, and conduct high-speed wind tunnel performance test on an advanced Transonic Truss Braced Wing (TTBW) configuration at a cruise Mach number near 0.8 and quantify its overall fuel-burn benefits.

No API in FY 2020

AR-18-6: Demonstrate novel landing gear porous fairing and wheel cavity treatments that reduce the airframe component of aircraft noise by at least 1.5 decibels (dB).

2013	2014	2015	2016	2017	2018
No APIs before FY 2017				Green	Green

Planned Annual Performance Indicators
No APIs after FY 2018

AR-18-7: Complete detailed experimental measurements in the wing-body junction region of an aircraft to enable better computational tools for prediction of future air vehicle designs.

2013	2014	2015	2016	2017	2018
No APIs before 2017				Yellow	Green

Planned Annual Performance Indicators
AR-19-7: Develop multidisciplinary design optimization capability that will enable assessment of On-Demand Mobility (ODM) vehicle designs with tightly integrated propulsion-airframe systems that optimally account for competing requirements for performance, noise, and energy usage.
No API in FY 2020

AR-18-8: Demonstration of a multidisciplinary design analysis and optimization (MDAO) process for the conceptual design of vertical lift vehicles.

2013	2014	2015	2016	2017	2018
No APIs before 2017				Green	Green

Planned Annual Performance Indicators
No APIs after FY 2018

AR-19-8 [Begins in FY 2019]

Planned Annual Performance Indicators
AR-19-8: Demonstrate tools and methodologies able to reduce the timeline to develop and certify composite structures and demonstrate timeline benefit through systems analysis.
No API in FY 2020

AR-19-11 [Begins in FY 2019]

Planned Annual Performance Indicators
AR-19-11: Achieve noise reduction of at least five decibels (dB) on approach to landing during flight test operations designed for low noise.
No API in FY 2020

AR-20-4 [Begins in FY 2020]

Planned Annual Performance Indicators
No APIs before FY 2020
AR-20-4: Design, fabricate, assemble, and test components and sub-systems for a small core, high-pressure compressor concept engine, intended to improve operational efficiency.

AR-20-5 [Begins in FY 2020]

Planned Annual Performance Indicators
No APIs before FY 2020
AR-20-5: Develop and flight test a flexible, deployable vortex generator (VG) system for cost-effective fuel reduction on transport aircraft using passive-shape, low-temperature shape memory alloys.

AR-20-6 [Begins in FY 2020]

Planned Annual Performance Indicators
No APIs before FY 2020
AR-20-6: Complete detailed analysis of turbulent heat flux data obtained from NASA's Turbulent Heat Flux (THX) experiment to enable better computational tools for prediction and design of future air vehicle propulsion systems.

Performance Goal 3.2.4: Facilitate significant environmental and efficiency improvements through research on alternative jet fuel use, and on hybrid gas-electric propulsion system concepts.

2013	2014	2015	2016	2017	2018
No PG	Green	Green	Green	Yellow	Green

Planned Performance Goal for FY 2019-2020

3.2.4: Facilitate significant environmental and efficiency improvements through research on alternative jet fuel use, and on hybrid gas-electric propulsion system concepts.

Aeronautics Research Mission Directorate encompasses multiple research programs that develop advanced technologies to reduce aviation's environmental impact and to transform how the world flies, including the Advanced Air Vehicles Program, the Airspace Operations and Safety Program, the Integrated Aviation Systems Program, and the Transformative Aeronautics Concepts Program.

Progress continues in the area of alternative jet fuel research with the development and testing of a small-core fuel-flexible combustor in conjunction with a United Technologies Research Center. Testing in that area will be completed in the first quarter of FY 2019. The X-57 Maxwell Scaled Convergent Electric Propulsion Technology Operations Research (SCEPTOR) sub-project successfully completed a re-plan effort to ensure a viable path to successful completion of the flight demonstration.

Progress also continues in the area of hybrid gas-electric propulsion by moving forward in designing a full-scale, 1-megawatt (MW) power inverter and electric motor. General Electric's Silicon-Carbide Lightweight Inverter for Megawatt-Power inverter and the University of Illinois high-speed, high-frequency air core machine have shown full-scale, 1-MW designs that meet the requirements of the associated annual performance indicator, AR-18-5. Going even further than the requirements of the annual performance indicator, full-scale builds and sub-scale tests to establish the feasibility of the designs are planned for the first quarter of FY 2019.

AR-18-5: Design, build, and test key ambient-temperature electric aircraft powertrain components that achieve specific performance parameters necessary for large commercial applications.

2013	2014	2015	2016	2017	2018
No API	Green	Green	Green	Red	Green

Planned Annual Performance Indicators

AR-19-5: Design, assemble, and initiate testing of a megawatt (MW)-scale electrified aircraft powertrain.

AR-20-7: Complete Preliminary Design Review (PDR) of a full-scale powertrain for hybrid gas-electric aircraft.

AR-19-12 [Begins in FY 2019]

Planned Annual Performance Indicators

AR-19-12: Demonstrate integrated electrical system functionality of the X-57 aircraft through assembling components with a power delivery system and conducting an Integrated Electrical End-to-End Test.

No API in FY 2020

Performance Goal 3.2.5: Significantly increase the ability to anticipate and resolve potential safety issues, and to predict the health and robustness of aviation systems.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goal for FY 2019-2020
3.2.5: Significantly increase the ability to anticipate and resolve potential safety issues, and to predict the health and robustness of aviation systems.

The **Airspace Operations and Safety Program** part of ARMD, works with the Federal Aviation Administration, industry and academic partners to conceive and develop Next Generation Air Transportation System (NextGen) technologies to further improve the safety of current and future aircraft. NextGen methods and means will provide advanced automated support to air navigation service providers and aircraft operators to reduce air-travel times and delays, and to ensure greater safety in all weather conditions.

As the National Airspace System expands and becomes more complex, it has become more challenging to maintain the current high level of safety. NASA is developing tools for real-time safety monitoring and prediction to improve safety in the NAS and support envisioned operational growth.

NASA completed a real-time safety monitoring framework with a set of safety monitoring metrics and information about current potentially adverse conditions, which are automatically monitored in real-time. The real-time safety monitoring framework supports a variety of users, from those who need a broad overview of a day's flight operations to those who need to decide on a control tactic to employ within the next few minutes. Using an intelligent interface, the real-time safety monitoring framework predicts conditions within a specified prediction horizon. The real-time safety monitoring framework gives users access to information about adverse conditions in time to make efficient preemptive decisions without sacrificing safety. The real-time safety monitoring framework was integrated with the NASA test-bed and demonstrated using live data from the National Airspace System.

NASA, in collaboration with the MITRE Corporation, demonstrated progress in identifying operationally significant anomalies in flight operations quality assurance data. NASA developed an anomaly detection algorithm, Multiple Kernel Anomaly Detection. For this project, it identifies anomalies in Flight Operations Quality Assurance data, which are data collected onboard commercial aircraft. Like most anomaly detection methods, Multiple Kernel Anomaly Detection identifies data points that are statistically anomalous, some of which may be safety issues, but the remaining of which are false alarms. NASA has developed an active learning method that learns from domain expert feedback on whether the statistical anomalies are safety issues or false alarms, with the goal of reducing the false alarm rate on future data.

NASA has significantly sped up data pre-processing to improve data usability. Additionally, NASA will begin work with MITRE on identifying additional work needed to make its data-driven methods more useful to safety analysts. NASA, in collaboration with the Federal Aviation Administration, has demonstrated success in identifying operationally significant anomalies in Threaded Track data, a compilation of surveillance sources into a representation of an aircraft's optimal end-to-end trajectory. Threaded Track data also allows a wide range of safety, efficiency, and security analyses. NASA is working with Booz Allen Hamilton on extracting data from Aviation Safety Reporting System reports and will also explore the possible use of additional data sources with the goal of identifying leading and lagging indicators of safety issues.

AR-18-4: Develop initial tools for identifying, measuring, and monitoring safety margins with initial components for evolution of real-time system-wide capability.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicators
AR-19-4: Identify data architecture requirements (i.e., content and quality) for real-time monitoring of selected operational risks for small Unmanned Aircraft Systems (UAS).
AR-20-9: Validate a human fatigue monitoring tool, and publish a report relating human performance metrics to aircraft performance.

AR-20-8 [Begins in FY 2020]

Planned Annual Performance Indicators
No APIs until FY 2020
AR-20-8: Demonstrate the use of formalizable requirements in order to reduce errors, improve traceability to verification and validation data, and mitigate safety risks.

Performance Goal 3.2.6: Support transformation of civil aircraft operations and air traffic management through the development, application, and validation of advanced autonomy and automation technologies, including addressing critical barriers to enabling urban on-demand air mobility and Unmanned Aircraft Systems (UAS) operations in low-altitude airspace.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goal for FY 2019-2020

3.2.6: Support transformation of civil aircraft operations and air traffic management through the development, application, and validation of advanced autonomy and automation technologies, including addressing critical barriers to enabling urban on-demand air mobility and unmanned aircraft systems (UAS) operations in low-altitude airspace.

Aeronautics Research Mission Directorate encompasses multiple research programs that develop advanced technologies to reduce aviation's environmental impact and to transform how the world flies, including the Advanced Air Vehicles Program, the Airspace Operations and Safety Program, the Integrated Aviation Systems Program, and the Transformative Aeronautics Concepts Program.

Safe integration of UAS, commonly called drones, into the NAS requires research in multiple areas, including communications, human–machine interfaces, sense-and-avoid, and separation assurance. NASA completed all of its planned milestones for FY 2018, continuing progress towards developing a UAS Traffic Management (UTM) concept and transforming civil aircraft operations.

Between March and May 2018, NASA completed Technology Capability Level (TCL) 3 flight tests at six Federal Aviation Administration (FAA) UAS test sites around the country (Nevada, Alaska, North Dakota, New York, Virginia, and Texas). The testing investigated several aspects of UTM system operation and UAS technologies, including communication and navigation in degraded environments, sensing and avoiding aircraft, data exchange for nominal and off-nominal conditions, and a concept of operations for contingencies and priority operations, such as public safety. Selective, focused test flights of vehicle technologies that are needed for TCL-3 performance in sensing and avoiding and in communication and navigation were performed and documented.

The UTM ground automation system was further developed to the TCL 3 level by addition of capabilities and services that enable a federated network of industry-provided UAS Service Supplier systems. The Flight Information System was also enhanced and the technology was transferred to the FAA for further testing and evaluation. NASA has provided its results to date online.

AR-18-9: Deliver the third Unmanned Aircraft System Traffic Management (UTM) Technology Capability Level (TCL) demonstration to enable beyond visual line-of-sight operations in suburban settings in a live, virtual constructive environment.

2013	2014	2015	2016	2017	2018
No APIs before FY 2016			Green	Green	Green

Planned Annual Performance Indicators

AR-19-9: Demonstrate the fourth Unmanned Aircraft System (UAS) Traffic Management (UTM) Technology Capability Level (TCL) to enable management of beyond visual line of sight UAS operations in a populated urban setting in a live virtual constructive environment.

No API in FY 2020

AR-18-10: Complete the data collection, analysis, and reporting for the Detect and Avoid (DAA) well clear / alerting requirements, foundational terminal operations, human-in-the-loop (HITL) simulation; and complete the initial test asset for the Command and Control (C2) version six (V6) terrestrial communication system test.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicators
AR-19-10: Complete the data collection, analysis, and reporting for the Detect and Avoid (DAA) flight test five (FT5) and for the Command and Control (C2) version six (v6) terrestrial communication system flight test.
No API in FY 2020

AR-20-10 [Begins in FY 2020]

Planned Annual Performance Indicators
No APIs until FY 2020
AR-20-10: Develop, conduct, and validate through simulation increasingly autonomous and automated technologies to support transformation of civil aircraft operations and air traffic management and address critical barriers to enabling on-demand urban air mobility operations in low-altitude airspace.

Above: NASA's Ikhana aircraft, based at Armstrong Flight Research Center in Edwards, California, takes off on June 12, 2018, for the Agency's first large-scale, remotely-piloted aircraft flight in the national airspace without a safety chase aircraft. The successful flight moved the United States closer to normalizing unmanned aircraft operations in the airspace used by commercial and private pilots. Flying these large remotely-piloted aircraft over the United States opens the doors to all types of services, from monitoring and fighting forest fires, to providing new emergency search and rescue operations. Image credit: NASA/Ken Ulbrich

Strategic Objective 3.3: Inspire and engage the public in aeronautics, space, and science.

Lead Offices
Missions Support Directorate (MSD) and Office of Communications (OCOM)

Goal Leader
Bettina Inclãn, Associate Administrator, OCOM

Budget

	FY	$M
Actual	2018	108.4
Enacted	2019	118.1
Requested	2020	8.3
Outyear	2021	8.3
	2022	8.3
	2023	8.3
	2024	8.3

NASA is inspiring, engaging, educating, and employing the next generation of explorers through NASA-unique science, technology, engineering and mathematics (STEM) learning opportunities

2018 Strategic Review Summary of Progress

The **Mission Support Directorate** enables the Agency's missions by managing institutional services and capabilities. 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. The **Office of Communications** develops and implements outreach strategies to communicate NASA's activities to a wide audience. OCOM ensures that NASA uses consistent messaging across the Agency and that communications activities are consistent with the priorities identified in the *NASA 2018 Strategic Plan*. Efforts that supported the assessment included:

- OCOM was on track to realign the communication campaigns to reflect NASA's current policy direction.

Above: Students run the robot they designed and built through an obstacle course at the NASA Community College Aerospace Scholars Program (NCAS) Robotics competition in June 2018. Image credit: NASA

- NASA's **Office of Diversity and Equal Opportunity (ODEO)** continued to conduct more than the required number of compliance reviews of grantee institutions annually.
- Significant progress had been made to define and establish the Agency's STEM engagement function, guiding policies, and governance model for operations.

Performance Measures for Strategic Objective 3.3

The following pages provide the performance goals and annual performance indicators supporting Strategic Objective 3.3. They include the final performance results for FY 2018, the FY 2019 Performance Plan Update, which NASA considers final for FY 2019, and the initial FY 2020 Performance Plan. Below are charts summarizing the FY 2018 performance ratings for the performance goals and annual performance indicators supporting Strategic Objective 3.3.

The FY 2020 Budget proposes the termination of NASA's traditional education portfolio of domestic assistance awards (grants and cooperative agreements) that are fully funded in the year of the award or annually funded with a performance period of three to five years. Therefore, the Office of STEM [science, technology, engineering, and mathematics] Engagement performance areas presented in the following pages do not include a performance plan for FY 2020.

As NASA conducts its 2019 Strategic Review, to be completed in spring 2019, it will conduct a retrospective and prospective analyses to determine if the programs supporting this strategic objective are healthy and can address potential or realized risks. Part of the retrospective analyses will take into consideration the FY 2018 performance results found on the following pages. Looking forward, NASA will assess whether it is on track to achieve the FY 2019 annual performance indicators. The results of this early assessment will inform planning for the FY 2021 Performance Plan, which will begin in spring 2019.

Summary of Strategic Objective 3.3: Inspire and engage the public in aeronautics, space, and science.

Performance Goal 5

Span two to five years, and measure the performance of investments towards strategic objectives and strategic goals. The total number of performance goals is reflected in each rating box and there is no one-to-one correlation to annual performance indicator ratings.

Annual Performance Indicator 10

Describe the smaller, achievable measurements that serve as NASA's basic unit of performance. They show progress achieved during the budget year, and NASA uses them to assess progress made towards achieving the performance goals and the strategic objectives. The total number of annual performance indicators is reflected in each rating box and there is no one-to-one correlation to performance goal ratings.

Performance Goal 3.3.1: Enhance reach and effectiveness of programs and projects that engage the public.

2013	2014	2015	2016	2017	2018
Green	Green	Yellow	Green	Green	Green

Planned Performance Goal for FY 2019-2020

No PGs after FY 2018

The **Office of Communications** develops and implements outreach strategies to communicate NASA's activities to a wide audience. OCOM ensures that NASA uses consistent messaging across the Agency and that communications activities are consistent with the priorities identified in the *NASA 2018 Strategic Plan*.

During FY 2018, NASA launched its official presence on Reddit, allowing their large and diverse audience to directly engage NASA subject matter experts. NASA also distributed regularly scheduled video series through the Facebook Watch feature.

NASA partnered with American Girl on the 2018 Girl of the Year, Luciana Vega, an ambitious 11-year-old girl who aspires to be an astronaut and the first girl to put footprints on Mars. The partnership resulted in a three-book series and NASA-inspired products, including an extravehicular activity spacesuit, space habitat, robotics workbench, and other features. NASA also continued its collaboration with LEGO, including merchandise approvals for the following LEGO sets: NASA Apollo Saturn V and Women of NASA.

The Office of Communications (OCOM) conducted an analysis of stories on NASA's Snapchat and Instagram accounts and determined that each story should be less than 10 slides in length. By slightly tweaking how much content is added to Instagram, Snapchat, or Facebook stories on any given day, the social media team has decreased user drop-off as more followers are watching the entire story. For example, a four-slide story posted during the Mars Close Approach on July 30, 2018, had a 62 percent completion rate, as compared with previously published 10-slide stories that garner anywhere between a 40 percent and 50 percent completion rate.

AMO-18-14: Add at least one new communications technology, platform, or tool to facilitate and improve cross-Agency communications collaboration and to reach increasingly broad and diverse audiences.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

AMO-19-1: Add at least one new communications technology, platform, tool, or method to make more effective operations and use of resources in alignment with the communications priorities.

AMO-20-1: Add at least one new communications technology, platform, tool, or method to make more effective operations and use of resources in alignment with the communications priorities.

AMO-18-15: Increase cross-Agency participation in a program of metrics by which to assess the reach and effectiveness, and articulate the value, of activities in the Agency's communications portfolio.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

AMO-19-2: Add at least one new communications technology, platform, tool or method to achieve more systematic measurement and evaluation of reach, outcomes, and value of agency communications investments.

AMO-20-2: Add at least one new communications technology, platform, tool or method to achieve more systematic measurement and evaluation of reach, outcomes, and value of Agency communications investments.

AMO 18-16: Maintain, grow, and promote a toolkit (clearinghouse) of NASA communications products to share with NASA's communications professionals and employees to help ensure that consistent and current content is utilized in communicating the Agency's results to the public.

2013	2014	2015	2016	2017	2018
No APIs before 2016			Green	Green	Green

Planned Annual Performance Indicators

AMO-19-3: Add at least one new communications technology, platform, tool or method to help prepare NASA employees to engage in telling the NASA story.

AMO-20-3: Add at least one new communications technology, platform, tool or method to help prepare NASA employees to engage in telling the NASA story.

AMO 18-17: Strengthen strategic communications planning by improving alignment of Agency-wide communications activities with both Office of Communications and NASA strategic goals and objectives, including established processes of communications activities prioritization and campaign teams for execution.

2013	2014	2015	2016	2017	2018
No APIs before 2018					Green

Planned Annual Performance Indicators

No APIs after FY 2018

SMD-19-1 [Begins in FY 2019]

Planned Annual Performance Indicators

SMD-19-1: Expand Science Mission Directorate unique assets to support learners in all 50 states.

SMD-20-29: Ensure every Science Activation agreement includes at least one NASA-funded subject matter expert and validate the process by which experts are identified and utilized.

Explore NASA

Aligning communications with the Strategic Plan

NASA's Communications Coordinating Council unveiled six communications themes to align with the *NASA 2018 Strategic Plan* and policy directive. For each theme, OCOM provides communications products for use throughout the Agency, including key messages and talking points, graphics and videos, and a website for theme-related NASA stories. Image credit: NASA

Explore NASA

Your home. Our mission.

Explore Flight

NASA's with you when you fly.

Explore Humans in Space

Leading discovery, improving life on Earth.

Explore Moon to Mars

Moon lights the way.

Explore Solar System & Beyond

Discovering the secrets of the universe.

Explore Space Tech

Technology drives exploration.

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

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Performance Goal Planned for FY 2019-2020

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

The **Office of Diversity and Equal Opportunity's** external civil rights compliance programs encompass policy, technical assistance, and compliance components, and have long been recognized as "best in class" by the Department of Justice's Federal Coordination and Compliance Section, which has oversight over all grant-related civil rights law administration and enforcement.

NASA launched and began conducting equal opportunity reviews on three recipients of NASA financial assistance in FY 2018, including two university science, technology, engineering, and mathematics (STEM) programs and one science museum/center. In all, NASA has conducted over 70 compliance reviews since 2006 to better ensure equal opportunities and promote diversity and inclusion in both formal and informal STEM education.

The MissionSTEM website is the Agency's centerpiece for technical assistance on diversity and equal opportunity for its grant recipient institutions and their participants. NASA has established a vigorous civil rights compliance review program for its grantee institutions and a robust technical assistance effort centered on its MissionSTEM website. These efforts are designed to better ensure equal opportunity in programs receiving NASA grants and cooperative or Space Act Agreement funding. Analytics show that the site had at least 4,200 new visitors every month in 2018.

Equal Opportunity in Programs Receiving NASA Cooperative and Space Act Agreement Funds

ODEO ensures programs and activities have a broad impact on the larger STEM community.

750 science centers, museums, and research institutes

$1 billion total awards

AMO-18-4: Continue to conduct civil rights compliance assessments at a minimum of two STEM or STEM-related programs that receive NASA funding; and broaden the scope of civil rights technical assistance to NASA grantees through the MissionSTEM website, focused on grantee civil rights requirements and promising practices for grantee compliance and diversity and inclusion.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

AMO-19-4: Continue to conduct civil rights compliance assessments at a minimum of two STEM or STEM-related programs that receive NASA funding; and broaden the scope of civil rights technical assistance to NASA grantees through the MissionSTEM website, focused on grantee civil rights requirements and promising practices for grantee compliance and diversity and inclusion.

AMO-20-4: Conduct civil rights compliance assessments at a minimum of two NASA-funded STEM or STEM-related programs, and broaden the scope of civil rights technical assistance to NASA grantees through the MissionSTEM website, focusing on grantee civil rights requirements and promising practices for grantee compliance and diversity and inclusion.

Performance Goal 3.3.3: Provide opportunities for students to engage with NASA's aeronautics, space, and science people, content, and facilities in support of a diverse future NASA and aerospace industry workforce.

2013	2014	2015	2016	2017	2018
White	Green	Green	Green	Green	Green

Performance Goal Planned for FY 2019-2020

3.3.3: Provide opportunities for students to engage with NASA's aeronautics, space, and science people, content, and facilities in support of a diverse future NASA and aerospace industry workforce.

NASA continues to support the Administration's STEM priorities by creating unique opportunities that: engage students in authentic learning experiences with NASA's people, content, and facilities; build a diverse future workforce; and contribute to exploration missions. The FY 2020 budget proposes that STEM activities, such as internships and fellowships, will be fully-integrated into work across the Agency, and does not fund NASA's traditional education portfolio of domestic assistance awards (e.g., grants and cooperative agreements). Activities will be coordinated by a small functional office at NASA Headquarters, funded out of **Agency Management and Operations**.

Moving forward, NASA will reassess annual performance indicators used for this goal, to better reflect agency-wide efforts to support a diverse aerospace workforce. NASA will also review its existing STEM efforts to ensure alignment with the Federal STEM strategic plan, *Charting a Course for Success: America's Strategy for STEM Education*, which seeks to increase diversity, equity, and inclusion in STEM.

The Office of STEM Engagement exceeded the national average of participation of STEM higher education students self-reporting as being of underrepresented race or ethnicity. NASA's performance in diversity is examined across ethnicity, race, gender, and disability status of higher education students who received significant awards. In FY 2017,* OSTEM provided 7,409 higher education significant awards (e.g., internships, fellowships, scholarships, and other significant engagement opportunities such as engineering design challenges with greater than 160 hours of participation) to higher education students across all institutional categories and levels.

Higher Education Significant Awards

Percentage That Meet or Exceed National Average

Category	NASA Actual	National Average**
Racially or ethnically underrepresented student participants	30.7	24.5
Higher education interns and fellows identified as Hispanic or Latino	15.9	14.4
Racial categories traditionally underrepresented in STEM fields	17.6	9.6
Women	36.4	40.6
Persons with disabilities	2.12	10.5

** National averages were obtained from the U.S. Department of Education's National Center for Education Statistics Integrated Postsecondary Education Database

*Note: NASA assesses annual performance using data reported for academic years. FY 2018 performance is based on work in the 2016-2017 academic year.

Above: NASA's summer 2018 Headquarters interns pose for a photo with NASA Administrator Jim Bridenstine. Image credit: NASA/Aubrey Gemignani

STEM-18-1: Provide significant, direct student awards in higher education to (1) students across all institutional categories and levels (as defined by the U.S. Department of Education); (2) racially or ethnically underrepresented students, (3) women, and (4) persons with disabilities at percentages that meet or exceed the national percentages for these populations, as determined by the most recent, publicly available data from the U.S. Department of Education's National Center for Education Statistics for a minimum of two of the four categories.

2013	2014	2015	2016	2017	2018
White	Green	Green	Green	Green	Green

Planned Annual Performance Indicator
STEM-19-1: Provide significant, direct student awards in higher education to (1) students across all institutional categories and levels (as defined by the U.S. Department of Education), (2) racially or ethnically underrepresented students (Hispanics and Latinos, African Americans, American Indians, Alaska Native, Native Hawaiians and Pacific Islanders), (3) women, and (4) persons with disabilities, at percentages that meet or exceeded at the national percentages for the science and engineering graduates, as determined by the most recent, publicly available data from the U.S. Department of Education's National Center for Education Statistics for a minimum of two of the four categories.
NASA is developing FY 2020 annual performance indicators to reflect Agency-wide STEM efforts.

Performance Goal 3.3.4: Enhance the effectiveness of education investments using performance assessment and evaluation-driven processes.

2013	2014	2015	2016	2017	2018
No PGs before FY 2018					Green

Performance Goal Planned for FY 2019-2020
FY 2019 - 3.3.4: Enhance the effectiveness of education investments using performance assessment and evaluation-driven processes.
No PG in FY 2020

NASA continues to support the Administration's STEM priorities by creating unique opportunities that: engage students in authentic learning experiences with NASA's people, content, and facilities; build a diverse future workforce; and contribute to exploration missions. The FY 2020 budget proposes that STEM activities, such as internships and fellowships, will be fully-integrated into work across the Agency, and does not fund NASA's traditional education portfolio of domestic assistance awards (e.g., grants and cooperative agreements). Activities will be coordinated by a small functional office at NASA Headquarters, funded out of **Agency Management and Operations**.

In FY 2018, NASA defined STEM engagement, guiding policies, and a governance model for operations. The new approach encompasses all of NASA's efforts to attract, engage, and educate students, and support educators and institutions. NASA is using a rigorous approach to planning and implementing activities through the use of evidence-based effective practices for STEM education, performance measurement, and evaluation.

Completed Action Items and Milestones

- Established the STEM Engagement Council to provide strategic direction, planning, operational integration and oversight, assessment, and stakeholder management of NASA's comprehensive set of STEM engagement functions and activities.
- Completed an assessment of infrastructure, tools, and systems.
- Created a new performance measurement and assessment strategy, framework, and learning agenda.
- Refined evaluation business processes.
- Developed an Agency wide STEM engagement strategy.

STEM-18-2: Establish NASA's science, technology, engineering, and mathematics (STEM) engagement function, guiding policies, and governance model for operations that will transform the Agency's portfolio of STEM engagement opportunities.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicator
STEM-19-2: Design a comprehensive data management system aligned to performance assessment and evaluation strategy to collect, analyze, and report data for STEM engagement investments.
No API in FY 2020

STEM-18-3: Develop a comprehensive performance assessment and evaluation strategy, including business processes, measures, processes, and tools that will be used as the foundation for evidence-based decision making.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicator
STEM-19-3: Conduct a multiple case study focused on NASA STEM engagement higher education challenges, competitions, and internships to build knowledge about how these activities: a) contribute to NASA's aeronautics, space, and science missions; b) align to evidence-based effective practices for STEM learning; and c) recruit and retain participants from groups historically underrepresented and/or underserved in STEM fields. No API in FY 2020

STEM-18-4: Release solicitations for all NASA Office of Education-funded programs that are in alignment with the science, technology, engineering, and mathematics (STEM) engagement model and mission directorate priorities.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicator
STEM-19-4: Contribute to American technical capability by supporting the release of at least 1,300 paper presentations and peer-reviewed research publications through STEM engagement investments. No API in FY 2020

Performance Goal 3.3.5: Provide opportunities for students to contribute to NASA's aeronautics, space, and science missions and work in exploration and discovery.

2013	2014	2015	2016	2017	2018
No PGs before FY 2018					Green

Performance Goal Planned for FY 2019-2020
3.3.5: Provide opportunities for students to contribute to NASA's aeronautics, space, and science missions and work in exploration and discovery.

Moving forward, NASA will reassess annual performance indicators used for this goal, to better reflect agency-wide efforts to support a diverse aerospace workforce. NASA will also review its existing STEM efforts to ensure alignment with the Federal STEM strategic plan, *Charting a Course for Success: America's Strategy for STEM Education*, which seeks to increase diversity, equity, and inclusion in STEM.

In FY 2018, NASA provided funding support for three large networks. Space Grant is a network of colleges and universities that fund fellowships and scholarships. EPSCoR helps states and regions develop academic research capability and competitiveness. MUREP awards multiyear grants to assist minority institution faculty and students in NASA related research.

The Agency assesses the contributions of learners to NASA's missions by counting peer-reviewed publications and technical presentations that result from grants and awards to these institutions. In FY 2018, Space Grant, EPSCoR, and MUREP grantee and awardee institutions reported 1,797 peer-reviewed publications and technical paper presentations in FY 2017.* Fifty-two percent of the Space Grant and MUREP peer-reviewed publications were authored or coauthored by students.

The 2020 Budget proposes to terminate funding for the Office of STEM Engagement, including Space Grant, EPSCoR, and MUREP. The Budget continues to support other STEM-related activities, such as internships funded outside of OSTEM, in support of Performance Goal 3.3.5.

*Note: NASA assesses annual performance using data reported for academic years. FY 2018 performance is based on work in the 2016-2017 academic year.

NASA continues to support the Administration's STEM priorities by creating unique opportunities that: engage students in authentic learning experiences with NASA's people, content, and facilities; build a diverse future workforce; and contribute to exploration missions. The FY 2020 budget proposes that STEM activities, such as internships and fellowships, will be fully-integrated into work across the Agency, and does not fund NASA's traditional education portfolio of domestic assistance awards (e.g., grants and cooperative agreements). Activities will be coordinated by a small functional office at NASA Headquarters, funded out of Agency Management and Operations.

STEM-18-5: Contribute to American technical capability by supporting the release of at least 1,200 paper presentations and peer-reviewed research publications through National Space Grant College and Fellowship Program (Space Grant), Established Program to Stimulate Competitive Research (EPSCoR), and Minority University Research and Education Project (MUREP) investments.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicator
STEM-19-3: Conduct a multiple case study focused on NASA STEM engagement higher education challenges, competitions, and internships to build knowledge about how these activities: a) contribute to NASA's aeronautics, space, and science missions; b) align to evidence-based effective practices for STEM learning; and c) recruit and retain participants from groups historically underrepresented and/or underserved in STEM fields.
NASA is developing FY 2020 annual performance indicators to reflect Agency-wide in support of STEM efforts.

STEM-19-4 [Begins in FY 2019]

Planned Annual Performance Indicator
STEM-19-4: Contribute to American technical capability by supporting the release of at least 1,300 paper presentations and peer-reviewed research publications through STEM engagement investments.
NASA is developing FY 2020 annual performance indicators to reflect Agency-wide in support of STEM efforts.

Enable

Strategic Goal 4

Optimize capabilities and operations.

On May 3, 2018, a crane lifts the InSight mission, which is enclosed in the payload fairing shown here, onto an Atlas-V rocket at Space Launch Complex-3 at Vandenberg Air Force Base, California. The InSight mission was delivered by flatbed trailer to Vandenberg on April 23, and teams worked to mate the fairing to rocket for the May 5 mission launch. Image credit: NASA/Bill Ingalls

Strategic Objective 4.1: Engage in partnership strategies.

Lead Office
Mission Support Directorate (MSD)

Goal Leader
Daniel Tenney, Associate Administrator, MSD

NASA is supporting cooperative, reimbursable, and funded initiatives through domestic and international partnerships.

Budget

	FY	$M
Actual	2018	69.8
Enacted	2019	84.2
Requested	2020	86.7
Outyear	2021	86.0
	2022	85.4
	2023	84.8
	2024	84.3

2018 Strategic Review Summary of Progress

The **Mission Support Directorate** enables the Agency's missions by managing institutional services and capabilities. 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. Efforts that supported the assessment included:

- NASA identified methods to increase utilization of new and existing strategic sourcing initiatives for FY 2018 and beyond. NASA reduced the number of new contracts across the Agency.
- The **Office of International and Interagency Relations (OIIR)** supports mission directorate and center work related to NASA mission directorates and centers for international and interagency agreements for issues of interest to the Agency. OIIR is negotiating and concluding over 80 new international and interagency agreements each year.

Above: NASA astronauts Peggy Whitson and Jack Fischer move a payload on to the NanoRacks External Platform (NREP) to prepare them for deployment via an airlock in the Japanese Experiment Module on the International Space Station. NREP is a commercial platform that gives customers access to the extreme space environment. Image credit: NASA

- NASA will continue to evaluate utilization and benefits of the best-in-class, strategic sourcing solution(s), Agency-level managed contracts (Tier 1), and increased competition through open market purchase for the best value for the Government.

Performance Measures for Strategic Objective 4.1

The following pages provide the performance goals and annual performance indicators supporting Strategic Objective 4.1. They include the final performance results for FY 2018, the FY 2019 Performance Plan Update, which NASA considers final for FY 2019, and the initial FY 2020 Performance Plan. Below are charts summarizing the FY 2018 performance ratings for the performance goals and annual performance indicators supporting Strategic Objective 4.1.

As NASA conducts its 2019 Strategic Review, to be completed in spring 2019, it will conduct a retrospective and prospective analyses to determine if the programs supporting this strategic objective are healthy and can address potential or realized risks. Part of the retrospective analyses will take into consideration the FY 2018 performance results found on the following pages. Looking forward, NASA will assess whether it is on track to achieve the FY 2019 annual performance indicators. The results of this early assessment will inform planning for the FY 2021 Performance Plan, which will begin in spring 2019.

Summary of Strategic Objective 4.1: Engage in partnership strategies.

Performance Goal 3

Span two to five years, and measure the performance of investments towards strategic objectives and strategic goals. The total number of performance goals is reflected in each rating box and there is no one-to-one correlation to annual performance indicator ratings.

Annual Performance Indicator 6

Describe the smaller, achievable measurements that serve as NASA's basic unit of performance. They show progress achieved during the budget year, and NASA uses them to assess progress made towards achieving the performance goals and the strategic objectives. The total number of annual performance indicators is reflected in each rating box and there is no one-to-one correlation to performance goal ratings.

Performance Goal 4.1.1: Efficiently manage the coordination of NASA's domestic, interagency, and international partnership agreements to ensure that the partnerships continue to provide value to the Agency, including through the advancement of one or more Agency institutional or programmatic objectives.

2013	2014	2015	2016	2017	2018
No PGs before 2018					Green

Planned Performance Goal for FY 2019-2020
No PGs after FY 2018

NASA's Partnership Office and OIIR both met their targets for partnership agreements in FY 2018.

NASA's partnership offices negotiated and signed 661 new partnership agreements with domestic, non-governmental entities. In an effort to continue engaging new and existing partners, NASA personnel from all centers conducted numerous outreach meetings and participated in external forums and conferences throughout the year to identify and engage with potential partners. A few of the most visible forums NASA participated in this year included the 34th Space Symposium held April 16-19 in Colorado Springs, Colorado; the Offshore Technology Conference, held April 30-May 3 in Houston, Texas; and the Small Satellite Conference held August 4-9 in Logan, Utah. Every year, Center Partnership Offices and the Space Technology Mission Directorate Regional Economic Development Program engage with leaders and clients of small business incubators, startup hubs, accelerators, and other economic development organizations. All these outreach activities, which occur in different regions of the country, initiate contact between NASA and future potential partners to identify strategic partnerships of mutual benefit to NASA, U.S. industry, academia, non-profits, and other government agencies.

Throughout the fiscal year, OIIR managed 775 active international agreements with 131 countries and 950 interagency agreements with 50 agencies. In addition, OIIR serves as the principal Agency liaison with the National Security Council, the Office of Science and Technology Policy, the Department of State, and the Department of Defense. OIIR provides management oversight and staff support to NASA's advisory committees, commissions, and panels, and manages the NASA Export Control Program and foreign travel.

NASA engages in partnerships with international, intergovernmental, academic, industrial, and entrepreneurial communities, recognizing them as important contributors of skill and creativity to NASA missions and for the propagation of its results. The **Partnership Office**, within MSD, provides Agency-level strategic policy and procedural guidance for all domestic, unclassified partnerships matters. The **Office of International and Interagency Relations (OIIR)** provides executive leadership and coordination for NASA's international activities and partnerships and for policy interactions between NASA and other U.S. Executive Branch offices and agencies. The Partnership Office and OIIR work closely together to ensure consistency regarding the Agency's partnerships related activities.

OIIR conducted:

- 85 New agreements
- 28 Countries and international organizations
- 83 Additional agreements in development

AMO-18-11: Negotiate and conclude international and interagency agreements with foreign and domestic partners in support of NASA missions.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators
No APIs after FY 2018

AMO-18-30: Negotiate and sign at least 300 new partnership agreements with domestic, non-governmental parties.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicators
No APIs after FY 2018

Left: A technician inspects one of the two satellites for NASA's Gravity Recovery and Climate Experiment Follow-On (GRACE-FO) mission at the Airbus Defence and Space manufacturing facility in Friedrichshafen, Germany. GRACE-FO is a partnership between NASA and the German Research Center for Geosciences. Image credit: Airbus DS GmbH-A. Ruttloff

Performance Goal 4.1.2: Achieve savings for the Agency through acquisition reforms.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goal for FY 2019-2020

FY 2019 - 4.1.2: Achieve savings for the Agency through acquisition reforms.

FY 2020 - TBD

NASA's **Office of Procurement**, part of MSD, explores and executes innovative, effective, and efficient acquisition business solutions to optimize capabilities and operations that enable NASA's missions.

Overall NASA has achieved savings for both the Agency and Federal strategic sourcing initiatives through increased contract efficiencies and reduced transaction cost in procurement. These initiatives and the cost savings/avoidance have generated efficiencies and savings across the Agency and are expected to continue and, in some cases, increase in coming years.

The Office of Procurement has achieved cost savings/avoidance for NASA by reducing the cost of getting the contract work done (i.e., transaction costs). Of the eight contract efficiencies initiatives NASA identified for FY 2018, six (or 75 percent) were effective, with a slight increase in the total dollars awarded of non-competed actions compared with FY 2017. The Office of Procurement is focusing on the following areas to achieve efficiencies and savings across the Agency: reduce contract lead times, use of less complex evaluation procedures when appropriate, reduce the number of task orders, consolidate software licenses, reduce the use of award fee contracts and reduce the number of incremental funding/de-obligation actions. Some significant examples are below:

- Reducing and Managing High Risk Contract Actions. NASA continues to make significant progress in the reduction and the management of high-risk contract actions.
  - » Cost-plus-award fee (CPAF) contracts pay a fee based on the contractor's work performance, determined subjectively by a fee determination official. A cost-plus contract is often used when the work to be performed is such that it is neither feasible nor effective to devise predetermined objective incentive targets applicable to cost, schedule, and technical performance; and the likelihood of meeting acquisition objectives will be enhanced by using a contract that effectively motivates the contractor toward exceptional performance and provides the Government with the flexibility to evaluate both actual performance and the conditions under which it was achieved. For FY 2018, the dollar value of CPAF contracts remain consistent compared to FY 2017 ($6.8 billion in FY 2018 versus $6.8 billion in FY 2017).
  - » For FY 2018, the number of new delivery and task orders issued steadily decreased, with a decrease of about 6 percent compared to FY 2017 (2,891 in FY 2018 versus 2,986 in FY 2017).
- NASA Shared Services Center (NSSC) Next Generation. The NSSC contract's primary objective is to enable the NSSC to continue to provide over 50 business, technical, and administrative services to customers across the Agency, utilizing a shared services business model. The NSSC Transactional savings resulting from the consolidations achieved an approximate cost avoidance in FY 2018 of $6.55 million.

NASA also continues to make strides and achieve savings for the Agency through effective use of strategic sourcing strategies, both at the Federal and Agency level. Of the 10 strategic sourcing initiatives NASA identified for FY 2018, 10 (or 100 percent) achieved cost avoidance. Significant examples of efforts resulting in savings and usage of strategic sourcing efforts are summarized below:

- Solutions for Enterprise-Wide Procurement (SEWP) V is a multi-award, government-wide acquisition contract that negotiates cost avoidance/savings through leveraged purchases, reduced fees for utilization (fee avoidance), and decreased price per unit compared to current higher market prices (cost avoidance). For FY 2018, the total SEWP V fee cost avoidance and the total negotiated cost avoidance/saving combined was approximately $6.7 million, an

amount that reflects an adjustment to account for the administrative cost of running the program.

- Enterprise License Management Team (ELMT) is an Agency-based, strategic sourcing effort to consolidate software license across the Agency. ELMT continues to identify and add additional software to its inventory. This increases NASA's buying power by lowering the price per unit, resulting in increased savings. The ELMT program has achieved an estimated $64.9 million in savings (cost avoidance) in FY 2018.
- Synergy Achieving Consolidated Operations and Maintenance (SACOM) contract consolidates base operations support for the Michoud Assembly Facility and the Stennis Space Center. The SACOM procurement achieved an estimated $27.3 million in cost avoidance in FY 2018 by providing business at a reduced cost, based on previous prices paid.
- Continuation of NASA's Infrastructure Technology (IT) Infrastructure Integration Program (I3P) Activities have achieved an estimated $15.49 million in savings in FY 2018. These Agency-based strategic sourcing efforts represent negotiated cost avoidance/savings and fee avoidance.

IT Infrastructure Integration Program Contracts FY 2018 Cost Avoidance

Millions of Dollars

I3P Contract	Cost Avoidance
EAST2	$2.37
ACES	$3.29
NICS	$8.46
Networx	$1.37
Total	**$15.49**

AMO-18-9: Achieve savings in at least 70 percent of identified procurement initiatives through effective use of both Federal-level and Agency-level strategic sourcing approaches.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

AMO-19-10: Achieve savings in at least 70 percent of identified procurement initiatives through effective use of both Federal-level and Agency-level strategic sourcing approaches.

TBD

AMO-18-10: Achieve savings in at least 70 percent of identified procurement initiatives through increased contract efficiencies and reduced transaction costs in NASA procurements.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

AMO-19-9: Achieve savings in at least 70 percent of identified procurement initiatives through increased contract efficiencies and reduced transaction costs in NASA procurements.

TBD

Performance Goal 4.1.3: Develop and implement the multiyear NASA Small Business Strategic Plan, which will promote and increase small business programs and outreach through strategic collaborative efforts with internal and external partners and stakeholders.

2013	2014	2015	2016	2017	2018
No PGs before FY 2018					Green

Performance Goals Planned for FY 2019-2020

FY 2019 - 4.1.3: Develop and implement the multiyear NASA Small Business Strategic Plan, which will promote and increase small business programs and outreach through strategic collaborative efforts with internal and external partners and stakeholders.

FY 2020 - TBD

The **Office of Small Business Programs (OSBP)** works to promote and integrate small businesses into the competitive base of contractors that pioneer the future of space exploration, scientific discovery, and aeronautics research.

During FY 2018, The Office of Small Business Programs (OSBP) achieved results that were a first in NASA's small business history by transforming NASA's outreach to the small business community. Through fostered relationships with numerous internal and external stakeholders, OSBP hosted regional outreach events in partnership with local procurement technical assistance centers in nontraditional, geographically-targeted areas, where the Agency does not have a traditional footprint, to enhance all categories of small business.

At the Midwest Aerospace Small Business Industry Day "The Future Is Now" event, held May 9, 2018, 90 percent of the survey respondents stated that the event increased their level of knowledge about NASA and what NASA procures. More than 93 percent of the survey respondents said they would be agreeable with NASA following up to see what acquisition opportunities resulted from the event, enabling OSBP to have a more targeted and streamlined approach to outreach.

Every year, the Small Business Administration's Procurement Scorecard assesses how federal agencies perform on negotiated small business, socio-economic prime contracting and subcontracting goals. For the FY 2017 Procurement Scorecard, released in May 2018, the Small Business Administration awarded NASA an "A". NASA exceeded its small business engagement goals in both prime and subcontracting awards for the first time since FY 2013, awarding approximately $2.8 billion directly to small businesses—about $100 million more than FY 2016 prime awards.

AMO-18-32: Strengthen and promote small business awareness and participation by utilizing innovative techniques to benefit the Agency's small business program, including through the consolidation of Agency-level small business activities in specific, pre-determined geographical areas.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicators

AMO-19-11: Strengthen and promote small business awareness and participation by utilizing innovative techniques to benefit the Agency's small business program, including through the consolidation of Agency-level small business activities in specific, pre-determined geographical areas.

TBD

AMO-18-33: Implement a strategic training plan to promote the NASA Small Business Program.

2013	2014	2015	2016	2017	2018
No APIs before 2018					Green

Planned Annual Performance Indicators
No APIs after FY 2018

AMO-19-12 [Begins in FY 2019]

Planned Annual Performance Indicators
AMO-19-12: Implement a set of pre-award procurement activities designed to increase opportunities for small businesses.
No APIs after 2019

Glenn Delgado, Associate Administrator for OSBP, provides insight to small businesses at the Reaching High Aerospace Matchmaker Event in Athens, Ohio, on July 17, 2018. Associate Administrator Delgado talked about the event on Spectrum, a show broadcast on Athens public radio station WOUB. The interview was aired in 58 counties in Ohio, West Virginia, Pennsylvania and eastern Kentucky. The full interview is available through WOUB Digital's Spectrum site (NASA is Reaching Out to Promote and Increase Contracts with Small Businesses). Image credit: NASA

Strategic Objective 4.2: Enable space access and services.

Lead Office
Human Exploration and Operations Mission Directorate (HEOMD)

Goal Leader
Altonell Mumford, Deputy Associate Administrator, HEOMD

Budget

	FY	$M
Actual	2018	2,345.8
Enacted	2019	2,108.7
Requested	2020	1,828.6
Outyear	2021	1,854.1
	2022	1,814.5
	2023	1,746.2
	2024	1,727.2

NASA is supporting the communication, launch service, rocket propulsion testing, and strategic capabilities needs of NASA's programs.

2018 Strategic Review Summary of Progress

The **Human Exploration and Operations Mission Directorate** leads and manages NASA space operations related to human exploration in and beyond low Earth orbit. HEOMD oversees requirements development, policy, and programmatic oversight across its numerous programs. HEOMD's activities include the International Space Station, commercial space transportation, low Earth orbit spaceflight operations, deep space exploration systems, launch services, and space communications. Efforts that supported the assessment included:

- NASA and its Commercial Crew Program partners continued to work their transportation system production and certification activities and subsequent post certification missions.
- NASA was on track in meeting a minimum of 90 percent overall availability of Space Environments Testing Management Office (SETMO) portfolio of assets, which are necessary to meet the long-term needs and requirements of the Agency.

Above: SpaceX's Dragon spacecraft lifts off on a Falcon 9 rocket from Cape Canaveral Air Force Station in Florida on June 29, 2018, on its way to the International Space Station. Image credit: SpaceX

- On February 8, 2018, Space Communications and Navigation (SCaN) successfully transferred the Tracking and Data Relay Satellite (TDRS)-13 to the Space Network Project for operations.
- The Rocket Propulsion Test Program (RPT) achieved a 99.1 percent facility availability, far exceeding its target of 90 percent facility readiness.
- The Launch Support Program (LSP) completed the Falcon 9 Full Thrust Category-2 Certification in January 2018.

Performance Measures for Strategic Objective 4.2

The following pages provide the performance goals and annual performance indicators supporting Strategic Objective 4.2. They include the final performance results for FY 2018, the FY 2019 Performance Plan Update, which NASA considers final for FY 2019, and the initial FY 2020 Performance Plan. Below are charts summarizing the FY 2018 performance ratings for the performance goals and annual performance indicators supporting Strategic Objective 4.2.

As NASA conducts its 2019 Strategic Review, to be completed in spring 2019, it will conduct a retrospective and prospective analyses to determine if the programs supporting this strategic objective are healthy and can address potential or realized risks. Part of the retrospective analyses will take into consideration the FY 2018 performance results found on the following pages. Looking forward, NASA will assess whether it is on track to achieve the FY 2019 annual performance indicators. The results of this early assessment will inform planning for the FY 2021 Performance Plan, which will begin in spring 2019.

Summary of Strategic Objective 4.2: Enable space access and services.

Performance Goal 7 1

Span two to five years, and measure the performance of investments towards strategic objectives and strategic goals. The total number of performance goals is reflected in each rating box and there is no one-to-one correlation to annual performance indicator ratings.

Annual Performance Indicator 8 1

Describe the smaller, achievable measurements that serve as NASA's basic unit of performance. They show progress achieved during the budget year, and NASA uses them to assess progress made towards achieving the performance goals and the strategic objectives. The total number of annual performance indicators is reflected in each rating box and there is no one-to-one correlation to performance goal ratings.

Performance Goal 4.2.1: Provide cargo transportation to support on-orbit crew members and utilization.

2013	2014	2015	2016	2017	2018
Green	Green	Yellow	Green	Green	Green

Planned Performance Goal for FY 2019-2020

4.2.1: Provide cargo transportation to support on-orbit crew members and utilization.

The **International Space Station** is a unique scientific platform in low Earth orbit that enables research in a microgravity environment. Several research facilities are on the ISS to support science investigations in biology, biotechnology, human physiology, material science, physical sciences, and technology development. The ISS program is part of HEOMD.

U.S. commercial providers exceeded the target of three commercial cargo launches for this performance goal to be rated green. There were five commercial cargo launches by U.S. providers in FY 2018, delivering research and logistics hardware to the International Space Station. Two deliveries, in November 2017 and May 2018, were provided by Orbital ATK.[1] Three deliveries, in December 2017, April 2018, and July 2018, were provided by Space Explorations Technologies Corporation (SpaceX).

ISS-18-7: Complete at least three flights, delivering research and logistics hardware to the International Space Station (ISS), by U.S.-developed cargo delivery systems.

2013	2014	2015	2016	2017	2018
Green	Green	Yellow	Green	Green	Green

Planned Annual Performance Indicators

ISS-19-9: Complete at least three flights, delivering research and logistics hardware to the International Space Station (ISS), by U.S.-developed cargo delivery systems.

ISS-20-13: Complete at least three flights, delivering research and logistics hardware to the International Space Station (ISS), by U.S.-developed cargo delivery systems.

1In June 2018, Orbital ATK became Northrop Grumman Innovation Systems.

Performance Goal 4.2.2: Facilitate the development of and certify U.S. industry-based crew transportation systems while maintaining competition, returning International Space Station (ISS) crew transportation to the United States. (Agency Priority Goal)

2013	2014	2015	2016	2017	2018
No PG	Green	Green	Green	Yellow	Yellow

Planned Performance Goals

2019 - 4.2.2: Facilitate the development of and certify U.S. industry-based crew transportation systems while maintaining competition, returning International Space Station (ISS) crew transportation to the United States. (Agency Priority Goal)

2020 - 4.2.2: Facilitate the development, certification, and operation of U.S. industry-based crew transportation systems while maintaining competition. Return crew transportation to and from the International Space Station (ISS) and other space destinations to the United States.

The **Commercial Crew Program**, part of HEOMD, is working with the American aerospace industry as companies develop and operate a new generation of spacecraft and launch systems capable of carrying crews to low Earth orbit and the ISS.

The Commercial Crew Program and its industry partners, the Boeing Company (Boeing) and SpaceX, continue to make measurable technical and programmatic progress toward the certification of commercial crew transportation systems. However, in late June 2018, Boeing experienced an anomaly while conducting a hot fire test of its test service module's abort engines. As a result of the anomaly, Boeing was unable to complete the pad abort test during the fiscal year.

During the static pad abort test, conducted at NASA's White Sands Test Facility, Boeing tested engines that would propel the service module away from its launch vehicle if an emergency is detected on the pad or during ascent. The test is an important step in certifying the spacecraft for flight. Boeing is analyzing the test data to identify the root causes, and will provide NASA an updated schedule for this milestone.

SpaceX completed its milestones, including completion of the qualification testing program of its Merlin 1D engine for use in the Falcon 9 rocket, which will carry the SpaceX crew module.

CS-18-1: Continue monitoring partner milestone progress toward identifying and closing certification products, in alignment with negotiated contract milestones, including the completion by the Boeing Company of its planned Service Module hot fire, launch abort test.

2013	2014	2015	2016	2017	2018
No PG	Green	Green	Green	Yellow	Yellow

Planned Annual Performance Indicators

CS-19-1: Continue monitoring partner milestone progress toward identifying and closing certification products, in alignment with negotiated contract milestones, including the completion by at least one of NASA's industry partners of its Certification Review.

CS-20-1: Continue monitoring partner progress toward negotiated contract milestones, to include at least one industry partner having a certified crew transportation system and making demonstrable progress toward its post-certification missions.

Above: The upper and lower domes of the Boeing CST-100 Starliner Spacecraft 2 Crew Flight Test Vehicle were mated June 19, 2018, inside the Commercial Crew and Cargo Processing Facility (C3PF) at Kennedy Space Center in Florida. The Starliner will launch astronauts on a United Launch Alliance Atlas V rocket to the International Space Station enabled by NASA's Commercial Crew Program. Image credit: Boeing

Above: The SpaceX Crew Dragon spacecraft that will be used for the company's uncrewed flight test, known as Demonstration Mission 1, arrived at Cape Canaveral Air Force Station in Florida on Tuesday, July 10, 2018. The spacecraft recently underwent thermal vacuum and acoustic testing at NASA's Plum Brook Station in Ohio. The Demonstration Mission 1 flight test is part of NASA's Commercial Crew Transportation Capability contract with the goal of returning human spaceflight launch capabilities to the United States. Image credit: SpaceX

Performance Goal 4.2.3: Invest financial and technical resources to stimulate efforts within the private sector to develop and demonstrate safe, reliable, and cost-effective space capabilities.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goal

2019 - 4.2.3: Invest financial and technical resources to stimulate efforts within the private sector to develop and demonstrate safe, reliable, and cost-effective space capabilities.

No PG in FY 2020

The Commercial Crew Program, part of HEOMD, is working with the American aerospace industry as companies develop and operate a new generation of spacecraft and launch systems capable of carrying crews to low Earth orbit and the ISS.

NASA is working with the American aerospace industry to develop commercial spaceflight capabilities for low Earth orbit and beyond. In FY 2018, NASA's industry partners completed planned milestones for designing and developing space transportation capabilities.

In December 2017, Final Frontier Design completed microgravity tests of their intravehicular activity (IVA) spacesuit aboard a Boeing 727. The successful tests, which were conducted through a grant from NASA's Flight Opportunities Program, were an important milestone in qualifying the IVA spacesuit for use.

Blue Origin made progress in building its Orbital Launch Site at Kennedy Space Center's multi-user spaceport. At the end of FY 2018, the launch vehicle manufacturing and operations building was nearly complete and work was progressing to build new launch infrastructure at the two historic Launch Center (LC)-36 pads. Blue Origin will eventually use LC-36 to launch its New Glenn rocket.

In March 2018, Orbital ATK subsidiary SpaceLogistics announced that it is developing a second-generation Mission Extension Vehicle (MEV), capable of docking with a satellite and managing that satellite's guidance, navigation, and control. The MEV would be able to extend the life of a satellite for up to five years, as well as help relocate the satellite to a graveyard orbit at the end of operations. SpaceLogistics is developing the MEV in partnership with NASA's Science Technology Mission Directorate.

CS-18-2: Continue monitoring partner milestone progress based on agreement content, including the first microgravity test of Final Frontier Design's commercially developed pressurized intravehicular activity (IVA) spacesuit in a microgravity environment.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

CS-19-2: Continue monitoring partner milestone progress based on agreement content, including the launch of Orbital ATK's first Mission Extension Vehicle (MEV).

No APIs after 2019

Performance Goal 4.2.4: Review the current state of the NASA test capabilities, known test requirements, and test requests, and ensure their availability to meet the Nation's needs.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goal for FY 2019-2020
4.2.4: Review the current state of the NASA test capabilities, known test requirements, and test requests, and ensure their availability to meet the Nation's needs.

NASA's **Rocket Propulsion Test (RPT) Program**, part of HEOMD, is responsible for managing and sustaining the Agency's facilities for ground testing rocket engines. It works both to advance new test technologies and to reduce propulsion test costs. The RPT program is also NASA's representative on the National Rocket Propulsion Test Alliance, represents NASA on the National Rocket. The alliance works with other Federal Government agencies to shape national rocket propulsion test capabilities.

The RPT Program continually monitors the state of NASA's test capabilities, known test requirements, and test requests. NASA uses weekly Rocket Propulsion Test Management Board teleconferences and semi-annual Program Manager Reviews to monitor the condition and operational state of all facilities and to work solutions as needed. The board tracks current test activities, requirements for upcoming tests, and requests for future testing.

During FY 2018, RPT centers performed 1,056 tests, with 12,762 seconds of hot-fire testing and 1,173,600 seconds of thermal vacuum testing, for a total of 1,186,365 seconds of time spent in testing. During the same period, there were seven facility-caused delays at RPT facilities. As a result, the RPT program a facility readiness rating of 99.3 percent facility readiness rating, which exceeded the RPT program's 90 percent target for the fiscal year.

SFS-18-2: Sustain 90 percent availability of test facilities to support NASA and other customers' planned test requirements.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators
SFS-19-2: Sustain 90 percent availability of test facilities to support NASA and other customers' planned test requirements.
SFS-20-2: Sustain 90 percent availability of test facilities to support NASA and other customers' planned test requirements.

Right: Technicians ready a developmental RS-25 engine number 0525 for installation on the A-1 test stand at Stennis Space Center on July 23 in preparation for a series of hot-fire tests. Once unloaded from the delivery platform, the engine will be lifted by crane into its test position. NASA conducted the series of hot-fire tests in mid-August. Image credit: NASA

Performance Goal 4.2.5: Complete Launch Services Program (LSP) objectives for all NASA-managed expendable launches.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goal for FY 2019-2020
4.2.5: Complete Launch Services Program (LSP) objectives for all NASA-managed expendable launches.

NASA's **Launch Services Program (LSP)** is responsible for the acquisition and management of commercial, expendable launch vehicle missions for NASA and NASA-sponsored payloads. LSP oversees all aspects of launch services, including launch vehicle engineering and manufacturing, launch operations and countdown management, and quality and mission assurance.

LSP sustained a 100 percent success rate for FY 2018, with the successful launch of seven missions aboard seven different launch vehicle configurations supporting missions from both the east coast and west coast launch bases. LSP also successfully completed all acquisitions scheduled for award in FY 2018. Each acquisition was awarded on-time, and met customer requirements. In October 2017, launch service task orders were awarded for both the Sentinel-6A and Landsat 9 missions. Launch services task order acquisitions are in work for the GOES-T, Imaging X-ray Polarimetry Explorer (IXPE), Lucy, and the Double Asteroid Redirection Test (DART) missions.

FY 2018 Launches

- November 18, 2017 - Joint Polar Satellite System (JPSS)-1
- March 1, 2018 - Geostationary Operational Environmental Satellite (GOES)-S
- May 22, 2018 - Gravity Recovery and Climate Experiment Follow-on (GRACE-FO)
- April 18, 2018 - Transiting Exoplanet Survey Satellite (TESS)
- May 5, 2018 - Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight)
- August 12, 2018 - Parker Solar Probe (PSP)
- September 15, 2018 - Ice, Cloud, and land Elevation Satellite (ICESat)-2

SFS-18-3: Sustain a 100 percent success rate with the successful launch of NASA-managed expendable launches as identified each fiscal year on the Launch Services Flight Planning Board manifest.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators
SFS-19-3: Sustain a 100 percent success rate with the successful launch of NASA-managed expendable launches as identified each fiscal year on the Launch Services Flight Planning Board manifest.
SFS-20-3: Sustain a 100 percent success rate with the successful launch of NASA-managed expendable launches as identified each fiscal year on the Launch Services Flight Planning Board Manifest.

SFS-18-4: Complete acquisitions on time for NASA-managed expendable launches.

2013	2014	2015	2016	2017	2018
No API	Green	Green	Green	Green	Green

Planned Annual Performance Indicators
SFS-19-4: Complete acquisitions on time for NASA-managed expendable launches.
SFS-20-4: Complete acquisitions on time for NASA-managed expendable launches.

Performance Goal 4.2.6: Maintain a minimum of 95 percent delivery of the Space Communications network services that support NASA and other customers' mission success.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goal for FY 2019-2020
4.2.6: Maintain a minimum of 95 percent delivery of the Space Communications network services that support NASA and other customers' mission success.

The **Space Communications and Navigation (SCaN) program**, part of the HEOMD, is responsible for the NASA-wide operation, management, and development of all NASA space communications and navigation capabilities and enabling technologies. The SCaN program manages and directs the ground-based facilities and services of three networks, including the Near Earth Network, Space Network, and Deep Space Network, which span the globe and support over 70 missions.

During FY 2018, SCaN exceeded its annual performance target of 99 percent delivery of space communications to NASA and other customers. The Space Network maintained near-continuous communications (more than 99.9 percent) for the International Space Station, Hubble Space Telescope, and other satellites below geosynchronous orbit.

On January 31, 2018, NASA completed the Initial Operational Capability milestone to transition the Tracking and Data Relay Satellite (TDRS)-M (since renamed TDRS-13) into operation as part of the Space Network. TDRS-13 has been in operation since February 2019. It transmits data to and from ground stations on Earth for NASA space missions and expendable rockets.

SFS-18-5: Demonstrate Initial Operating Capability of the Tracking and Data Relay Satellite (TDRS)-M spacecraft.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators
SFS-19-5: Maintain a minimum of 95 percent delivery of the Space Communications network services that support NASA and other customers' mission success.
SFS-20-5: Maintain a minimum of 95 percent delivery of the Space Communications network services that support NASA and other customers' mission success.

Above: The White Sands Ground Terminal in Las Cruces, New Mexico, comprises several antennas that provide communications to spacecraft as part of NASA's Space Network. Image credit: NASA/Amber Jacobson

Performance Goal 4.2.7: Replace the aging Deep Space Network (DSN) infrastructure.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goal for FY 2019-2020
4.2.7: Replace the aging Deep Space Network (DSN) infrastructure.

The **Space Communications and Navigation (SCaN) program**, part of the HEOMD, is responsible for the NASA-wide operation, management, and development of all NASA space communications and navigation capabilities and enabling technologies. The SCaN program manages and directs the ground-based facilities and services of three networks, including the Near Earth Network, Space Network, and Deep Space Network, which span the globe and support over 70 missions.

In FY 2018, SCaN continued construction of its two new antennas, Deep Space Station (DSS)-53 and DSS-56 at the Madrid Deep Space Communications Complex in FY 2018. SCaN completed construction on the dishes' pedestals, which support the 34-meter antenna structures and house the electronic and radio frequency equipment critical to their operation. The antenna structures are being erected on top of the pedestals, and the electronics work is on schedule.

The Madrid Deep Space Communications Complex, located in Spain, is part of NASA's Deep Space Network and provides communications to and from interplanetary spacecraft.

SFS-18-6: Continue the Deep Space Network Aperture Enhancement Project (DAEP) at the Madrid Deep Space Communications Complex (MDSCC) by completing the pedestal construction of both Deep Space Station (DSS)-56 and DSS-53 by the end of FY 2018.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators
SFS-19-6: Continue the Deep Space Network Aperture Enhancement Project (DAEP) at the Madrid Deep Space Communications Complex (MDSCC) by completing the construction milestones to lift the antenna reflector for Deep Space Station (DSS)-56 and to deliver the 20-kilowatt transmitter for DSS-53 by the end of FY 2019.
SFS-20-6: Continue the Deep Space Network Aperture Enhancement Project (DAEP) at the Madrid Deep Space Communications Complex (MDSCC) by completing subsystem acceptance testing for Deep Space Station (DSS)-53 by the end of FY 2020.

Performance Goal 4.2.8: Ensure the strategic availability and maintenance of facilities that are necessary to meet the long-term needs and requirements of the Agency.

2013	2014	2015	2016	2017	2018
No PG	Green	Green	Green	Green	Green

Planned Performance Goal for FY 2019-2020

4.2.8: Ensure the strategic availability and maintenance of facilities that are necessary to meet the long-term needs and requirements of the Agency.

The **Strategic Environments Testing Management Office (SETMO)**, part of the Office of Strategic Infrastructure, maintains the skilled workforce and performs essential preventive maintenance to ensure that NASA's key capabilities and critical assets will continue to be available in the future to support the missions that require them. Core capabilities supported within SETMO include thermal vacuum chambers, simulators, and the Arc Jet Complex at Ames Research Center.

Overall availability of the SETMO portfolio of capability components was 97.2 percent in FY 2018, exceeding the target performance of 90 percent availability. Availability did not reach 100 percent due to two events. Ames Research Center Arc Jet Complex had a fire in one of its power transformers. After completing repairs, the Arc Jet Complex, which provides the facilities to test thermal protection system concepts and materials, anticipates resuming operation after January 1, 2019. At the Ames Research Center's Vertical Motion Simulator, a flight simulation complex, an operational amplifier on a circuit board failed. While both events reduced overall availability, neither delayed nor had major impacts on critical project milestones.

SC-18-1: Achieve a minimum of 90 percent overall availability of Space Environment Testing Management Office (SETMO) portfolio of assets, which are necessary to meet the long-term needs and requirements of the Agency.

2013	2014	2015	2016	2017	2018
No API	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

SC-19-1: Achieve a minimum of 90 percent overall availability of Space Environment Testing Management Office (SETMO) portfolio of assets, which are necessary to meet the long-term needs and requirements of the Agency.

SC-20-1: Achieve a minimum of 90 percent overall availability of Space Environment Testing Management Office (SETMO) portfolio of assets, which are necessary to meet the long-term needs and requirements of the Agency.

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
Harold Bell, Deputy Chief, OSMA

Budget

	FY	$M
Actual	2018	175.7
Enacted	2019	175.1
Requested	2020	192.0
Outyear	2021	192.0
	2022	194.2
	2023	186.2
	2024	186.2

NASA is assuring effective management of NASA programs and operations to complete the mission safely and successfully.

2018 Strategic Review Summary of Progress

NASA's Safety and Mission Success programs incorporate the work of multiple offices and facilities to protect the health and safety of the NASA workforce and improve the likelihood that the Agency's programs, projects, and operations will be completed safely and successfully. These offices and facilities include the **Office of the Chief Engineer**, **Office of the Chief Health and Medical Officer**, **Office of Safety and Mission Assurance**, the **NASA Safety Center,** and **NASA's Independent Verification and Validation Facility**. Efforts that supported the assessment included:

- Zero fatalities or permanent disabling injuries to the public resulting from NASA activities.
- Active engagement with NASA programs and institutions in order to advise, advocate, and ensure safety and mission success.
- Robust knowledge management and communities of practice that capture and integrate lessons learned into future missions.

Above: Engineers use fake smoke to imitate a scenario in which astronauts must exit the Orion capsule when their vision is obscured. The simulation was part of safety evaluations conducted in late October 2017. Image credit: NASA/Rad Sinyak

Performance Measures for Strategic Objective 4.3

The following pages provide the performance goals and annual performance indicators supporting Strategic Objective 4.3. They include the final performance results for FY 2018, the FY 2019 Performance Plan Update, which NASA considers final for FY 2019, and the initial FY 2020 Performance Plan. Below are charts summarizing the FY 2018 performance ratings for the performance goals and annual performance indicators supporting Strategic Objective 4.3.

As NASA conducts its 2019 Strategic Review, to be completed in spring 2019, it will conduct a retrospective and prospective analyses to determine if the programs supporting this strategic objective are healthy and can address potential or realized risks. Part of the retrospective analyses will take into consideration the FY 2018 performance results found on the following pages. Looking forward, NASA will assess whether it is on track to achieve the FY 2019 annual performance indicators. The results of this early assessment will inform planning for the FY 2021 Performance Plan, which will begin in spring 2019.

Summary of Strategic Objective 4.3: Assure safety and mission success.

Performance Goal 2

Span two to five years, and measure the performance of investments towards strategic objectives and strategic goals. The total number of performance goals is reflected in each rating box and there is no one-to-one correlation to annual performance indicator ratings.

Annual Performance Indicator 8

Describe the smaller, achievable measurements that serve as NASA's basic unit of performance. They show progress achieved during the budget year, and NASA uses them to assess progress made towards achieving the performance goals and the strategic objectives. The total number of annual performance indicators is reflected in each rating box and there is no one-to-one correlation to performance goal ratings.

Performance Goal 4.3.1: Assure the safety and health of NASA's activities and reduce damage to assets through the development, implementation, and oversight of Agency-wide safety, reliability, maintainability, quality assurance, and health and medical policies and procedures.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goal for FY 2019-2020
4.3.1: Assure the safety and health of NASA's activities and reduce damage to assets through the development, implementation, and oversight of Agency-wide safety, reliability, maintainability, quality assurance, and health and medical policies and procedures.

NASA's Safety and Mission Success programs incorporate the work of multiple offices and facilities to protect the health and safety of the NASA workforce and improve the likelihood that the Agency's programs, projects, and operations will be completed safely and successfully. These offices and facilities include the **Office of Safety and Mission Assurance**, the **Office of the Chief Health and Medical Officer**, the **Office of the Chief Engineer**, the **NASA Safety Center**, and **NASA's Independent Verification and Validation Facility**.

In FY 2018, NASA continued to ensure the safety and health of its activities and minimized the damage to its assets. There were no fatalities or permanent disabling injuries to the public from NASA activities in FY 2018. Health issues that have impacted an astronaut's medical certification have been reviewed and dispositioned within one month of the time of diagnosis. Employees filing workers' compensation claims have been contacted within three days of receiving a request for assistance with documentation, and these requests have been dispositioned within 30 days.

NASA has achieved a Total Case Rate and Lost Time Case Rate beyond the injury and illness goals of the Administration. Specifically, an agency must have total and lost time injury rates at least one percent below its prior year rates. If an agency has a rate of one injury or illness per 100 employees per year or less, no further reductions are required. NASA's Total Case Rate is currently significantly under one injury or illness per 100 employees per year; at the end of FY 2018, NASA's FY 2018 Total Case Rate is 0.19 and NASA's Lost Time Case Rate is only 0.03.

AMO-18-25: Achieve zero fatalities or permanent disabling injuries to the public resulting from NASA activities during FY 2018.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators
AMO-19-13: Achieve zero fatalities or permanent disabling injuries to the public resulting from NASA activities during FY 2019.
AMO-20-8: Achieve zero fatalities or permanent disabling injuries to the public resulting from NASA activities during FY 2020.

AMO-18-26: Maintain a Total Case Rate and Lost Time Case Rate below 1.0 cases per 100 employees.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators
AMO-19-14: Maintain a Total Case Rate and Lost Time Case Rate below 1.0 cases per 100 employees.
AMO-20-9: Maintain a Total Case Rate and Lost Time Case Rate below 1.0 cases per 100 employees.

AMO-18-27: Reduce damage to NASA assets (excluding launched flight hardware) by two percent per year through FY 2018, compared to an FY 2010 baseline (in real dollars).

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

AMO-19-15: Reduce damage to NASA assets (excluding launched flight hardware) by two percent per year through FY 2019, compared to an FY 2010 baseline (in real dollars).

AMO-20-10: Reduce damage to NASA assets (excluding launched flight hardware) in FY 2020 to a level less than the historical annual average.

AMO-18-34: During FY 2018, make sure that the medical certifications of NASA's active astronauts are reviewed and dispositioned within one month of diagnosis, and that employees who file Workers' Compensation claims are contacted within three days of receiving a request for assistance and that these requests are dispositioned within 30 days.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicators

AMO-19-16: During FY 2019, make sure that the medical certifications of NASA's active astronauts are reviewed and dispositioned within one month of diagnosis, and that employees who file Workers' Compensation claims are contacted within three days of receiving a request for assistance and that these requests are dispositioned within 30 days.

AMO-20-11: During FY 2020, make sure that the medical certifications of NASA's active astronauts are reviewed and dispositioned within one month of diagnosis, and that employees who file Workers' Compensation claims are contacted within three days of receiving a request for assistance and that these requests are dispositioned within 30 days.

FY 2018 Costs Associated with Non-Mission Failure Damage

$3.8 million of non-mission (i.e., excluding launched flight hardware) was significantly below the target of $6.5 million. The five-year running average was $4.2 million.

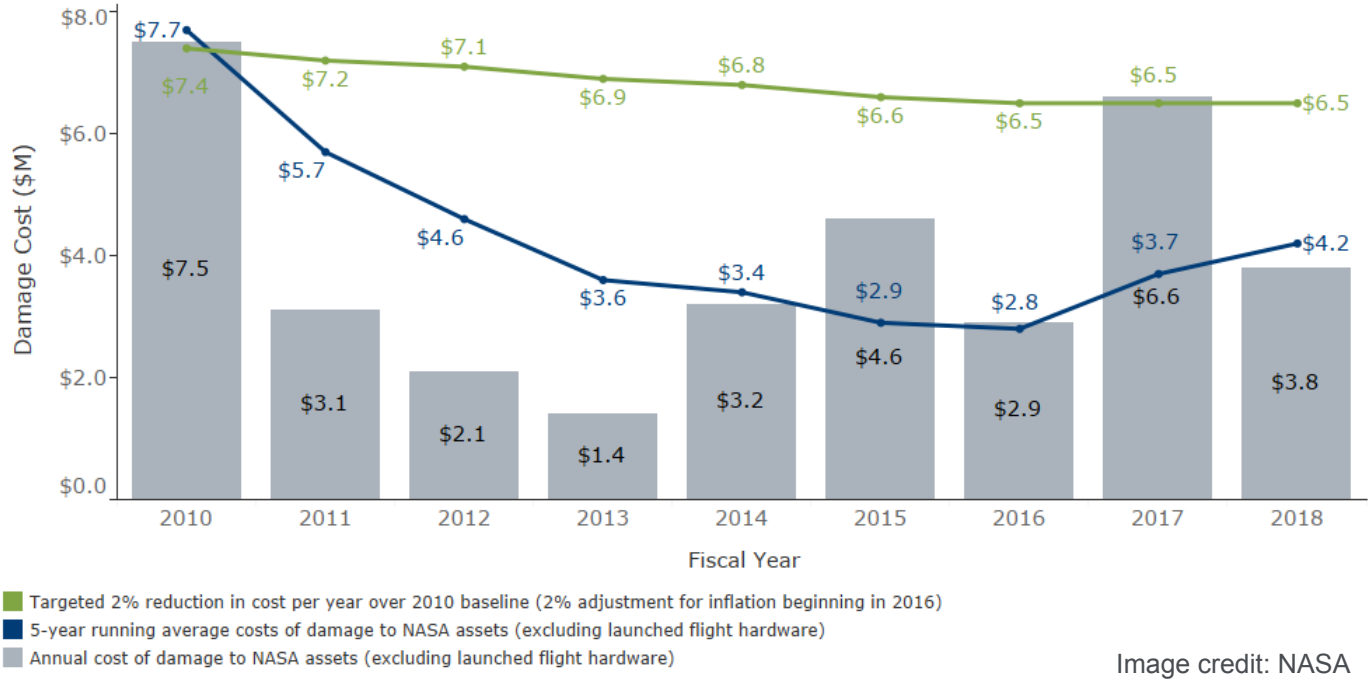


Image credit: NASA

Performance Goal 4.3.2: Implement the policies, procedures, and oversight to continuously improve the probability of technical and programmatic mission success.

2013	2014	2015	2016	2017	2018
No API	Green	Green	Green	Green	Green

Performance Goal Planned for FY 2019-2020
No PGs after FY 2018

NASA's Safety and Mission Success programs incorporate the work of multiple offices and facilities to protect the health and safety of the NASA workforce and improve the likelihood that the Agency's programs, projects, and operations will be completed safely and successfully. These offices and facilities include the **Office of Safety and Mission Assurance**, the **Office of the Chief Health and Medical Officer**, the **Office of the Chief Engineer**, the **NASA Safety Center**, and **NASA's Independent Verification and Validation Facility**.

NASA continued implementing policies, procedures, and oversight necessary to improve the probability of technical and programmatic mission success. NASA assigns projects to category 1,2, or 3 based on the estimated lifecycle costs and priority level. During FY 2018, 100 percent of the category 1 and 2 projects complied with Safety and Mission success policies and procedures. All projects that conducted lifecycle reviews had independent reviews scheduled. All category 1 and 2 projects were executing to an approved plan or were in an approved re-baseline planning cycle. The NASA Engineering and Safety Center supported all requested assessments for category 1 and 2 projects meeting the NASA Engineering and Safety Center's established acceptance criteria.

In addition, the entire engineering and programmatic workforce had access to the standards and knowledge base necessary to maintain and build their skills.

The Academy of Program/Project and Engineering Leadership (APPEL) maintains and funds remote database and reference material access capabilities to allow 100 percent of the program and project management community access to the materials needed to achieve or maintain their certification requirements. The materials required by the workforce are maintained on an Agency-accessible community of practice knowledge website. During FY 2018, the website did not experience non-scheduled outages. Furthermore, the NASA Engineering Network availability was 99.7 percent, exceeding the requirement of greater than 98 percent. The NASA Engineering Network provides an online forum for engineering and programmatic workforce to share lessons learned, interact with subject matter experts, find useful tools and resources, and keep up with current events.

AMO-18-28: Assure 100 percent of Category 1 and 2 projects use Agency Safety and Mission Success policy, procedures and independent assessments focused on both technical and programmatic mission success.

2013	2014	2015	2016	2017	2018
No API	Green	Green	Green	Green	Green

Planned Annual Performance Indicators
No APIs after FY 2018

AMO-18-29: Assure that 100 percent of the engineering and programmatic workforce has access to the standards and knowledge base needed to maintain and build their skills.

2013	2014	2015	2016	2017	2018
No API	Green	Green	Green	Green	Green

Planned Annual Performance Indicators
No APIs after FY 2018

AMO-18-35: During FY 2018, keep the number of variances made in any single human spaceflight program to below five percent of the total number of program requirements derived from Office of the Chief Health and Medical Officer (OCHMO) standards and policies.

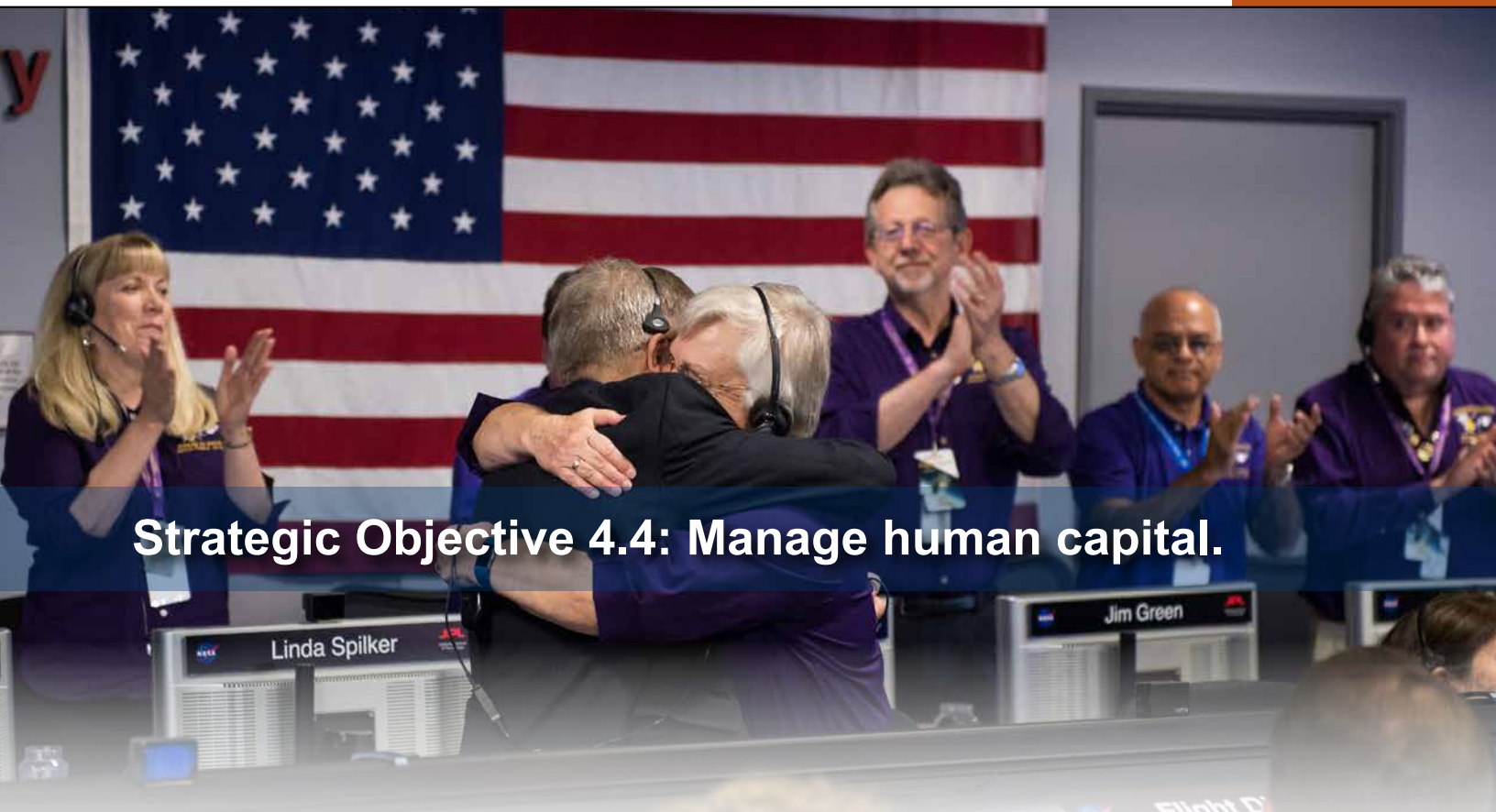
2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicators
No APIs after FY 2018

AMO-18-40: Achieving Agency strategic goals depends on adhering to aggressive schedules and avoiding resource expenditures and risk incurrence associated with delayed implementation. During FY 2018, support the success of the human spaceflight program by responding to all program variance requests relating to Office of the Chief Health and Medical Officer (OCHMO) standards for crew health and performance within one month from the time of the initial program request.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicators
No APIs after FY 2018



Strategic Objective 4.4: Manage human capital.

Lead Office
Mission Support Directorate (MSD) and Office of the Chief Human Capital Officer (OCHCO)

Goal Leader
Daniel Tenney, Associate Administrator, MSD

Budget

	FY	$M
Actual	2018	38.4
Enacted	2019	68.5
Requested	2020	69.2
Outyear	2021	68.6
	2022	68.8
	2023	67.8
	2024	67.4

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 Agency's Mission.

2018 Strategic Review Summary of Progress

The **Mission Support Directorate** enables the Agency's missions by managing institutional services and capabilities. 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. The **Office of the Chief Human Capital Officer**, part of MSD, helps NASA maintain an adaptable and skilled workforce. OCHCO is responsible for building and maintaining an integrated talent management model that addresses the entire employee lifecycle. It also provides workforce analytics that deliver strategic insight and measures success through integrated human capital systems. Efforts that supported the rating included:

- NASA will fully implement human capital at NASA as a line of business focused on people, process, operations, and technology with established leadership, budget, full-time equivalent authority, and delegations of authority in place.

Above: Program team members cheered the end of a successful mission after operators deliberately plunged the Cassini spacecraft into Saturn on September 15, 2017. Image credit: NASA/Joel Kowsky

- NASA will fully develop effectiveness and accountability metrics and tracking mechanisms to monitor progress towards performance goals.
- NASA will continue to attract and sustain a diverse workforce that is flexible and agile, with the skills and competencies needed for the Agency's Mission.

Performance Measures for Strategic Objective 4.4

The following pages provide the performance goals and annual performance indicators supporting Strategic Objective 4.4. They include the final performance results for FY 2018, the FY 2019 Performance Plan Update, which NASA considers final for FY 2019, and the initial FY 2020 Performance Plan. Below are charts summarizing the FY 2018 performance ratings for the performance goals and annual performance indicators supporting Strategic Objective 4.4.

As NASA conducts its 2019 Strategic Review, to be completed in spring 2019, it will conduct a retrospective and prospective analyses to determine if the programs supporting this strategic objective are healthy and can address potential or realized risks. Part of the retrospective analyses will take into consideration the FY 2018 performance results found on the following pages. Looking forward, NASA will assess whether it is on track to achieve the FY 2019 annual performance indicators. The results of this early assessment will inform planning for the FY 2021 Performance Plan, which will begin in spring 2019.

Summary of Strategic Objective 4.4: Manage human capital.

Performance Goal 2

Span two to five years, and measure the performance of investments towards strategic objectives and strategic goals. The total number of performance goals is reflected in each rating box and there is no one-to-one correlation to annual performance indicator ratings.

Annual Performance Indicator 5

Describe the smaller, achievable measurements that serve as NASA's basic unit of performance. They show progress achieved during the budget year, and NASA uses them to assess progress made towards achieving the performance goals and the strategic objectives. The total number of annual performance indicators is reflected in each rating box and there is no one-to-one correlation to performance goal ratings.

Performance Goal 4.4.1: Define and build diverse workforce skills and competencies needed for the Agency's Mission.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goal for FY 2019-2020
4.4.1: Define and build diverse workforce skills and competencies needed for the Agency's Mission.

The **Office of the Chief Human Capital Officer**, part of MSD, helps NASA maintain an adaptable and skilled workforce. OCHCO provides an integrated talent management model that addresses the entire employee lifecycle. It also provides workforce analytics that deliver strategic insight and measures success through integrated human capital systems.

The Office of Personnel Management's annual Federal Employee Viewpoint Survey (FEVS) measures employees' perceptions of whether, and to what extent, conditions characteristic of successful organizations are present in their agencies. This includes perceptions about opportunities to contribute to the agency's success. In the 2018 FEVS, NASA employees rated their satisfaction with the Agency, based on the innovation index (three questions below) as 83 percent favorable on the Innovation Index, which is based on employee responses to three questions:

Question 3: I feel encouraged to come up with new and better ways of doing things.

Question 8: I am constantly looking for ways to do my job better.

Question 32: Creativity and innovation are rewarded.

This rating exceeds NASA's 2016 baseline of achieving employee satisfaction scores of a minimum of 81 percent.

AMO-19-34 [Begins in FY 2019]

Planned Annual Performance Indicators
AMO-19-34: Ensure that NASA's workforce has an appropriately-balanced skill and grade mix to meet current and future workforce needs by achieving an Agency hiring goal of 50 percent hires or intern conversions to be at entry and mid-level positions on the General Schedule (GS) pay scale (i.e., the GS-11 level or below or GS-12 level with a Ph.D.).
AMO-20-13: Ensure that NASA's workforce has an appropriately-balanced skill and grade mix to meet current and future workforce needs by achieving an Agency hiring goal of 50 percent hires or intern conversions to be at entry and mid-level positions on the General Schedule (GS) pay scale (i.e., the GS-11 level or below or GS-12 level with a Ph.D.).

AMO-18-1: Sustain NASA's Innovation Score, as measured by the Innovation-related questions of the Federal Employee Viewpoint Survey (FEVS), by taking actions such as refining and updating human capital policies, programs, and systems to support and encourage innovation to meet NASA's missions.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators
AMO-19-20: Sustain NASA's Innovation Score, as measured by the Innovation-related questions of the Federal Employee Viewpoint Survey (EVS), by taking actions such as refining and updating human capital policies, programs, and systems to support and encourage innovation to meet NASA's missions.
AMO-20-12: Sustain NASA's Innovation Score, as measured by the Innovation-related questions of the Federal Employee Viewpoint Survey (FEVS), by taking actions such as refining and updating human capital policies, programs, and systems to support and encourage innovation to meet NASA's missions.

Performance Goal 4.4.2: Sustain equal opportunity (EO) and diversity and inclusion (D&I) programs and processes that help to proactively prevent discrimination, achieve more equitable and inclusive work environments, and more efficiently address EO concerns.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Performance Goal Planned for FY 2019-2020
4.4.2: Sustain equal opportunity (EO) and diversity and inclusion (D&I) programs and processes that help to proactively prevent discrimination, achieve more equitable and inclusive work environments, and more efficiently address EO concerns.

The **Office of Diversity and Equal Opportunity**, part of MSD, implements equal employment opportunity programs and processes to proactively prevent discrimination and resolve issues and concerns as promptly and efficiently as possible. The Office of Diversity and Equal Opportunity provides leadership to make NASA a model agency for diversity, inclusion, and equal opportunity, through evidence-based policies and innovations, to optimize mission success.

NASA's equal employment opportunity (EEO) programs, including alternative dispute resolution in the EEO complaints process, reasonable accommodations for individuals with disabilities, and the Anti-Harassment Program. For example, the NASA-wide FY 2018 Anti-Harassment Campaign encompassed outreach and education at every level of the Agency, from top senior leadership to non-supervisory employees. The campaign is based on the singularly important message that harassment prevention is about ensuring the safety and success of individual NASA employees, as well as the Agency's missions.

As an indicator of the Agency's continuing successful efforts in diversity and inclusion, NASA's scores on the Office of Personnel Management's New Inclusion Quotient of the Federal Employee Viewpoint Survey (FEVS), which consists of 20 questions related to an inclusive work environment, rose from 77.6 percent in the 2017 FEVS results to 78.2 percent in the 2018 results.

Employment Diversity

Change in underrepresented EEO group participation between 2014 baseline and 2018

EEO Group	Change from Baseline
Individuals with disabilities within workforce	+14.7%
Representation in senior-level positions: women	+4.6%
Representation in senior-level positions: African Americans	+8.6%
Representation in senior-level positions: Asian Americans and Pacific Islanders	+3.6%
Representation in senior-level positions: Hispanics	+18.5%

AMO-18-2: Continue implementation of the NASA Diversity and Inclusion Strategic Implementation Plan FY 2016 to FY 2019.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators
No API after FY 2018

AMO-18-3: Improve employee perceptions relating to fairness and career advancement as measured by the Federal Employee Viewpoint Survey (FEVS) Inclusion Index percentages.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

AMO-19-21: Sustain employee perceptions of the workplace as measured by the Federal Employee Viewpoint Survey (FEVS) Inclusion Index percentages.

AMO-20-14: Sustain employee perceptions of the workplace as measured by the Federal Employee Viewpoint Survey (FEVS) Inclusion Index percentages.

AMO-18-23: Increase efficiency in equal employment opportunity (EEO) programs (for example, EEO complaints processing and anti-harassment), as demonstrated through increased utilization of alternative dispute resolution (ADR) in EEO cases and decreased case processing times across-the-board.

2013	2014	2015	2016	2017	2018
No API before FY 2018					Green

Planned Annual Performance Indicators

AMO-19-35: Increase efficiency in equal employment opportunity (EEO) programs (such as EEO complaints processing, anti-harassment, and reasonable accommodations), demonstrated by achieving at least 85 percent timely processing of matters raised in FY 2019.

AMO-20-15: Increase efficiency in equal employment opportunity (EEO) programs (such as EEO complaints processing, anti-harassment, and reasonable accommodations), demonstrated by achieving at least 85 percent timely processing of matters raised in FY 2020.

AMO-18-24: Identify any barriers to equal employment opportunity, including statistical disparities in workforce representation, and implement strategies to eliminate identified barriers within two to three years.

2013	2014	2015	2016	2017	2018
No API before 2018					Green

Planned Annual Performance Indicators

AMO-19-36: Identify any existing barriers to equal employment opportunity, as reflected in statistical disparities in workforce representation, and implement strategies to eliminate identified barriers within two to three years.

AMO-20-16: Identify any existing barriers to equal employment opportunity, as reflected in statistical disparities in workforce representation, and implement strategies to eliminate identified barriers within two to three years.

AMO-19-34 [Begins in FY 2019]

Planned Annual Performance Indicators

AMO-19-34: Ensure that NASA's workforce has an appropriately-balanced skill and grade mix to meet current and future workforce needs by achieving an Agency hiring goal of 50 percent hires or intern conversions to be at entry and mid-level positions on the General Schedule (GS) pay scale (i.e., the GS-11 level or below or GS-12 level with a Ph.D.).

AMO-20-13: Ensure that NASA's workforce has an appropriately-balanced skill and grade mix to meet current and future workforce needs by achieving an Agency hiring goal of 50 percent hires or intern conversions to be at entry and mid-level positions on the General Schedule (GS) pay scale (i.e., the GS-11 level or below or GS-12 level with a Ph.D.).

Strategic Objective 4.5: Ensure enterprise protection.

Lead Office
Office of the Chief Information Officer (OCIO) and Office of Protective Services (OPS)

Goal Leader
Renee Wynn, Chief Information Officer, and Ray Taylor, Principal Advisor for Enterprise Protection

Budget

	FY	$M
Actual	2018	390.2
Enacted	2019	350.2
Requested	2020	388.1
Outyear	2021	385.9
	2022	370.6
	2023	374.5
	2024	362.1

NASA is increasing the resiliency of NASA's enterprise systems by assessing risks and implementing comprehensive, economical, and actionable solutions.

2018 Strategic Review Summary of Progress

NASA's Enterprise Protection Program provides coordination on critical Agency-wide infrastructure protection. As part of this function, the program guides NASA's decision-making and communications for cyber security, national security and protection of space and aeronautical systems, ground systems, technology, and infrastructure. The **Office of the Chief Information Officer** delivers data and IT systems easily, efficiently, and securely to NASA's federal and contractor employees to enable NASA's Mission. OCIO focuses on partnering with customers to deliver excellence, capitalizing on data and innovation, safeguarding NASA's data and assets, maximizing business value through optimization, and enabling the Agency's workforce to safely and securely use the Agency's IT assets. Their 2018 assessment included the following efforts:

- NASA established and chartered the Enterprise Protection Board (EPB) which held three meetings in FY 2018. The EPB drive integrated cross-agency enterprise protection efforts.

Above: Charles Spern, project manager on the Engineering Services Contract, uplinks Veggie System instructions to astronaut Joe Acaba on the ISS. Image credit: NASA/Amanda Griffin

- NASA is developing and implementing policies and strategies to strengthen NASA's cybersecurity capabilities across its mission, corporate, and physical domains.
- NASA is actively working on protecting its critical space systems and supporting infrastructure. The Agency needs to implement risk management for system protection of its aeronautics and science capabilities.
- NASA is enhancing its Center Protective Services operations by maintaining existing and pursuing new federal law enforcement training accreditations.

Performance Measures for Strategic Objective 4.5

The following pages provide the performance goals and annual performance indicators supporting Strategic Objective 4.5. They include the final performance results for FY 2018, the FY 2019 Performance Plan Update, which NASA considers final for FY 2019, and the initial FY 2020 Performance Plan. Below are charts summarizing the FY 2018 performance ratings for the performance goals and annual performance indicators supporting Strategic Objective 4.5.

As NASA conducts its 2019 Strategic Review, to be completed in spring 2019, it will conduct a retrospective and prospective analyses to determine if the programs supporting this strategic objective are healthy and can address potential or realized risks. Part of the retrospective analyses will take into consideration the FY 2018 performance results found on the following pages. Looking forward, NASA will assess whether it is on track to achieve the FY 2019 annual performance indicators. The results of this early assessment will inform planning for the FY 2021 Performance Plan, which will begin in spring 2019.

Summary of Strategic Objective 4.5: Ensure enterprise protection.

Performance Goal 1 2

Span two to five years, and measure the performance of investments towards strategic objectives and strategic goals. The total number of performance goals is reflected in each rating box and there is no one-to-one correlation to annual performance indicator ratings.

Annual Performance Indicator 3 2

Describe the smaller, achievable measurements that serve as NASA's basic unit of performance. They show progress achieved during the budget year, and NASA uses them to assess progress made towards achieving the performance goals and the strategic objectives. The total number of annual performance indicators is reflected in each rating box and there is no one-to-one correlation to performance goal ratings.

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

2013	2014	2015	2016	2017	2018
No PG	Yellow	Green	Red	Yellow	Yellow

Planned Performance Goal for FY 2019-2020
4.5.1: Safeguard NASA's data and IT assets by implementing cybersecurity and privacy capabilities.

The **Office of the Chief Information Officer** delivers data and IT systems easily, efficiently, and securely to NASA's federal and contractor employees to enable NASA's Mission. OCIO focuses on partnering with customers to deliver excellence, capitalizing on data and innovation, safeguarding NASA's data and assets, maximizing business value through optimization, and caring for the Agency workforce and preparing them to securely unleash the power of NASA's data.

OCIO is making progress toward achieving this cybersecurity performance goal in alignment with the President's Management Agenda and related cross-agency priority goal ("Modernize IT to Increase Productivity and Security"). NASA achieved an overall rating of "Managing Risk" in the Office of Management and Budget's Cybersecurity Risk Management Assessment. This rating indicates that the Agency has established cybersecurity policies, procedures, and tools and actively manages risks. While NASA achieved an overall rating of "Managing Risk," OCIO determined that some underlying capabilities are not yet operating at this level and plans to have all cybersecurity domains rated as "Managing Risk" by the end of FY 2020, in alignment with the Office of Management and Budget's targets.

In April 2018, OCIO released its *NASA Information Technology Strategic Plan* for FY 2018 through 2021, which specifies the strategic goals and objectives that communicate the target state for NASA's cybersecurity capabilities. OCIO also collaborated with the Office of Management and Budget and the Department of Homeland Security to perform a CyberStat activity to strengthen NASA's cybersecurity capabilities across its mission, corporate, and physical domains.

Mitigation of NASA's cybersecurity risks remains a multi-layered effort due to the Agency's complex IT ecosystem. OCIO has made significant progress identifying, mitigating, and monitoring cybersecurity risks across its domains. NASA increased its Agency-wide personal identity verification (PIV) authentication for unprivileged access to 87 percent by the end of FY 2018, exceeding the cross-agency target of 85 percent. NASA maintains 100 percent PIV authentication of privileged user accounts to its network. OCIO also made substantial cybersecurity capability improvements by deploying available Continuous Diagnostics and Mitigation (CDM) tools to improve NASA's hardware and software asset inventory and by enhancing anti-phishing defenses.

AMO-18-18: Attain 85 percent multi-factor authentication for non-privileged access to hardware.

2013	2014	2015	2016	2017	2018
No API	No API	Green	Red	Yellow	Green

Planned Annual Performance Indicators
No APIs after FY 2018

AMO-18-19: Attain Hardware and Software Asset Management of 95 percent for the corporate environment.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Yellow

NASA attained 100 percent for hardware asset management and 87 percent for software asset management in FY 2018. The Agency's substantial progress was driven by an increase in CDM Phase 1 deployment in the corporate and mission environments in accordance with Federal Information Security Modernization Act (FISMA) requirements and OMB's CyberStat effort.

NASA has not obtained the complete system inventory for the mission and physical environments required to fully enable the deployment of CDM tools into these environments. NASA will improve its software asset management capabilities as CDM Phase 1 tools continue to deploy in FY 2019. NASA's timeline for implementing hardware and software asset management in the mission and physical environments depends on the award and implementation of the next phase of the Department of Homeland Security's CDM capabilities. The Agency will closely monitor the contract status for the next phase of CDM, which will drive availability of the required capabilities.

This annual performance indicator supports the cross-agency priority goal "Modernize IT to Increase Productivity and Security."

Planned Annual Performance Indicators
No APIs after FY 2018

AMO-19-23 [Begins in FY 2019]

Planned Annual Performance Indicators
AMO-19-23: Enforce a 30-minute inactivity time-out for remote access security.
No API in FY 2020

AMO-20-17 [Begins in FY 2020]

Planned Annual Performance Indicators
No API in FY 2019
AMO-20-17: Ensure at least 95 percent of hardware assets are covered by a capability to detect and alert upon the connection of an unauthorized hardware asset per the IT Modernization cross-agency priority goals on Performance.gov for NASA.

AMO-20-18 [Begins in FY 2020]

Planned Annual Performance Indicators
No API in FY 2019
AMO-20-18: Ensure at least 95 percent of software assets are covered by a whitelisting capability per the IT Modernization cross-agency priority Goals on Performance.gov for NASA.

AMO-20-19 [Begins in FY 2020]

Planned Annual Performance Indicators
No API in FY 2019
AMO-20-19: At least 4 of 6 Intrusion Detection and Prevention metrics (from FISMA) have met an implementation target of at least 90 percent and 100 percent of email traffic is analyzed using DMARC email authentication protocols (DHS BOD 18-01) per the IT Modernization cross-agency priority goals on Performance.gov for NASA.

AMO-20-20 [Begins in FY 2020]

Planned Annual Performance Indicators
No API in FY 2019
AMO-20-20: Ensure at least 90 percent of high value assets (HVA) require all users to authenticate using a personal identity verification (PIV) card or Authenticator Assurance Level (AAL) 3 multifactor authentication method per the IT Modernization cross-agency priority goals on Performance.gov for NASA.

Performance Goal 4.5.2 [Begins in FY 2019]

Planned Performance Goal for FY 2019-2020
Improve the security and resiliency of NASA's operational technology (OT) systems to ensure safe and secure operation of NASA's critical infrastructure in a manner consistent with guidance from the National Institute of Standards and Technology (NIST).

AMO-19-24 [Begins in FY 2019]

Planned Annual Performance Indicators
AMO-19-24: Identify at least 95 percent of the operational technology (OT) systems that are part of the assets on the NASA Critical Infrastructure (NCI) list. FY 2020 API TBD

Performance Goal 4.5.3: Achieve improvements in overall Office of Protective Services physical security operations, standardization, efficiencies, and economies of scale.

2013	2014	2015	2016	2017	2018
No PGs before FY 2018					Yellow

Performance Goal Planned for FY 2019-2020
4.5.3: Achieve improvements in overall Office of Protective Services physical security operations, standardization, efficiencies, and economies of scale.

NASA is making progress toward achieving this performance goal through improvements to its Center Protective Services operations by maintaining existing and pursuing new Federal Law Enforcement Training Accreditations (FLETA). The Agency successfully achieved accreditation in April 2018 for its Protective Services Training Academy from the FLETA Board of Directors, and NASA is effectively monitoring and maintaining its Federal Arrest Authority programmatic accreditation.

The Office of Protective Services (OPS) deployed the NASA Visitor Management System (NVMS) for foreign national access in July 2018. It delayed the NVMS release for U.S. citizens until December 2018 due to issues encountered with the vendor's software package. OPS is working with its vendor and holding weekly meetings to address issues and complete system testing.

The **Office of Protective Services** provides NASA's security management. This includes Agency-wide personnel, physical, and information security policy, intelligence analysis, counterintelligence and counterterrorism services, national security systems, handling of sensitive and classified information, identity, credential, and systems access management, emergency management, and continuity of operations functions.

AMO-18-37: Deploy NASA's Visitor Management System for U.S. citizens, then enhance system to include visitor management for foreign nationals.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Yellow

Explanation of Performance

Deployment of NVMS for U.S. citizens is scheduled for December 2018, pending successful system testing. NASA is working with its vendor to correct issues with the NVMS software package release for U.S. citizens and is holding weekly meetings to address issues.

Planned Annual Performance Indicators
No APIs after FY 2018

AMO-18-38: Achieve initial Federal Law Enforcement Training Accreditation (FLETA) Academy accreditation for NASA Protective Services Training Academy and maintain FLETA programmatic accreditation for NASA's Federal Arrest Authority (FAA) Program.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicators
AMO-19-25: Maintain Federal Law Enforcement Training Accreditation (FLETA) Federal Arrest Authority (FAA) programmatic accreditation and Academy accreditation.
No API in FY 2020

Performance Goal 4.5.4: Formalize NASA's enterprise protection structure and execution across the Agency and its Federal, commercial, and international partners to increase enterprise protection effectiveness.

2013	2014	2015	2016	2017	2018
No PGs before FY 2018					Green

Planned Performance Goal for FY 2019-2020
No PGs after FY 2018

The **Enterprise Protection Program** provides coordination on critical Agency-wide infrastructure protection. As part of this function, the program guides NASA's decision-making and communications for cybersecurity, national security, as well as protection of space and aeronautical systems, ground systems, technology, and infrastructure.

During FY 2018, the Enterprise Protection Program made progress in establishing an enterprise protections structure across NASA and its partners. NASA established the Enterprise Protection Board and finalized board's charter. The Enterprise Protection Board held five meetings in FY 2018 to collaboratively address cross-Agency protection issues. NASA incorporated the new Enterprise Protection Program, the Enterprise Protection Board, and the Principal Advisor for Enterprise Protection into NASA Policy Directive (NPD) 1000.3, which defines and establishes NASA's organization.

NASA made significant progress toward cross-Agency enterprise protection. NASA has been consolidating threat information into a classified, user-friendly web-based portal, which depends on information sharing across NASA organizations. NASA's Enterprise Protection Program established an Enterprise Protection Community Forum of cross-Agency participants and held its first meeting to discuss and resolve issues at a working level.

AMO-18-36: Establish the Enterprise Protection Board to drive integrated enterprise protection risk management and Agency-level direction regarding protection risk.

2013	2014	2015	2016	2017	2018
No APIs before FY 2018					Green

Planned Annual Performance Indicators
No APIs after FY 2018

AMO-19-23 [Begins in FY 2019]

Planned Annual Performance Indicators
AMO-19-23: Enforce a 30-minute inactivity time-out for remote access security.
No API in FY 2020

Strategic Objective 4.6: Sustain infrastructure capabilities and operations.

Lead Office
Mission Support Directorate (MSD)

Goal Leader
Daniel Tenney, Associate Administrator, MSD

Budget

	FY	$M
Actual	2018	2,714.1
Enacted	2019	2,452.0
Requested	2020	2,940.7
Outyear	2021	2,812.6
	2022	2,826.1
	2023	2,618.8
	2024	2,551.1

NASA is enabling its mission by providing the facilities, tools, and services required to efficiently manage, operate and sustain the infrastructure necessary to meet mission objectives.

2018 Strategic Review Summary of Progress

The **Mission Support Directorate** enables the Agency's missions by managing institutional services and capabilities. 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. Efforts that supported the assessment included:

- Six of NASA's 10 centers reduced unscheduled maintenance this past year, and the Agency reduced overall unscheduled maintenance by three percent over the last two years. All of NASA's new buildings are constructed to Leadership in Energy and Environmental Design (LEED) sustainable standards.
- As of January 2018, NASA constructed 3.2 million square feet of sustainable buildings.

Above: Nithin Abraham, a coatings engineer at NASA's Goddard Space Flight Center, adds a protective coating to the support area beneath the Johnson Space Center's Chamber A. She was part of a team that ensured that the chamber was as clean as possible before cryogenic testing began on the James Webb Space Telescope. Image credit: NASA/Chris Gunn

- NASA reduced energy intensity, utilized renewable energy, increased clean energy, and decreased water intensity. The re-commissioning program will have the goals of short return on investment, improving the sustainability of the facilities, and reducing out-year maintenance costs by integrating technology to improve maintenance efficiency.

Performance Measures for Strategic Objective 4.6

The following pages provide the performance goals and annual performance indicators supporting Strategic Objective 4.6. They include the final performance results for FY 2018, the FY 2019 Performance Plan Update, which NASA considers final for FY 2019, and the initial FY 2020 Performance Plan. Below are charts summarizing the FY 2018 performance ratings for the performance goals and annual performance indicators supporting Strategic Objective 4.6.

As NASA conducts its 2019 Strategic Review, to be completed in May, it will conduct a retrospective and prospective analyses to determine if the programs supporting this strategic objective are healthy and can address potential or realized risks. Part of the retrospective analyses will take into consideration the FY 2018 performance results found on the following pages. Looking forward, NASA will assess whether it is on track to achieve the FY 2019 annual performance indicators. The results of this early assessment will inform planning for the FY 2021 Performance Plan, which will begin in spring 2019.

Summary of Strategic Objective 4.6: Sustain Infrastructure capabilities and operations.

Performance Goal 3

Span two to five years, and measure the performance of investments towards strategic objectives and strategic goals. The total number of performance goals is reflected in each rating box and there is no one-to-one correlation to annual performance indicator ratings.

Annual Performance Indicator 5

Describe the smaller, achievable measurements that serve as NASA's basic unit of performance. They show progress achieved during the budget year, and NASA uses them to assess progress made towards achieving the performance goals and the strategic objectives. The total number of annual performance indicators is reflected in each rating box and there is no one-to-one correlation to performance goal ratings.

Performance Goal 4.6.1: Between 2012 and 2018, support the demolition and elimination of obsolete and unneeded facilities.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Performance Goal for FY 2019-2020
4.6.1: Between 2018 and 2022, support the demolition and elimination of obsolete and unneeded facilities.

The **Office of Strategic Infrastructure** ensures that the right infrastructure is available to meet NASA's mission requirements. OSI identifies and prioritizes NASA's essential assets and implements strategic investment decisions to sustain, enhance, replace, modify, or dispose of them based on NASA and national needs.

NASA demolishes obsolete, unneeded infrastructure in order to improve efficiency and mitigate safety and environmental risks. The program is an important part of NASA's efforts to reduce its infrastructure and operating costs. The Office of Strategic Infastructure (OSI) evaluates unused and unneeded facilities on a regular basis and has made progress toward reducing NASA's overall footprint through demolition.

During FY 2018, NASA achieved the target of initiating demolition actions for five facilities:

- Johnson Space Center Environmental Hygiene Laboratory (B228)
- Jet Propulsion Laboratory B89
- Glenn Research Center B35 Research Combustion Laboratory Complex
- Stennis Space Center B9100
- Wallops Flight Facility E-005 and J-17 (managed by Goddard Space Flight Center)

OSI has achieved all of its planned demolition actions set through FY 2018, successfully completing this performance goal. Beginning in FY 2019, OSI will begin work on new demolition and elimination targets.

COF-18-1: Initiate the demolition or disposal of five facilities or structures during 2018 to reduce the Agency's footprint.

2013	2014	2015	2016	2017	2018
Green	Green	Green	Green	Green	Green

Planned Annual Performance Indicators
COF-19-1: Dispose of 20 facilities or structures during 2019 to reduce the Agency's footprint.
COF-20-1: Dispose of 20 facilities/structures or 100,000 square feet in FY 2020.

Performance Goal 4.6.2: Ensure that NASA continues progress towards implementing the targets and goals reflected in its annual Sustainability Plan.

2013	2014	2015	2016	2017	2018
No PG	Green	Yellow	Yellow	Green	Green

Performance Goal Planned for FY 2019-2020
4.6.2: Ensure that NASA continues progress towards implementing the targets and goals reflected in its annual Sustainability Plan.

NASA's sustainability policy is to execute the mission without compromising the planet's resources so that resources are conserved for future generations. The **Office of Strategic Infrastructure** targets and tracks the best opportunities for NASA to meet a range of energy, water, pollution, and waste reduction targets reflected in this policy.

NASA achieved all three Sustainability Plan targets in FY 2018. OSI chose the three targets to track—energy intensity, sustainable buildings, and facility efficiency—from the Office of Management and Budget's Scorecard for Efficient Federal Operations/Management. The data reflects NASA's actual performance from FY 2017 and is available from the Office of Federal Sustainability.

NASA continued to reduce the amount of energy consumed by its buildings and facilities, measured per gross square foot. The federal target was to reduce consumption 30 percent from the FY 2003 baseline, and NASA achieved 40 percent reduction. Twenty one percent of NASA-owned gross square footage met the guiding principles for sustainable buildings, exceeding the federal target of 15 percent. NASA's renewable electricity use reached 13 percent, greatly exceeding the federal target of 7.5 percent and NASA's FY 2008 baseline of 3.6 percent.

AMO-18-5: Reduce energy intensity (energy consumption per gross square feet, or Btu/gsf) to meet the target set by the Office of Management and Budget for FY 2018 in the Sustainability and Energy Scorecard.

2013	2014	2015	2016	2017	2018
No API	Yellow	Yellow	Yellow	Green	Green

Planned Annual Performance Indicators
AMO-19-27: Reduce energy intensity (energy consumption per gross square feet, or Btu/gsf) to meet the target set by the Office of Management and Budget (OMB) for FY 2019 in the OMB Scorecard for Efficient Federal Operations/Management.
AMO-20-25: Reduce energy intensity (energy consumption per gross square feet, or Btu/gsf) to meet the target set by the Office of Management and Budget (OMB) for FY 2020 in the OMB Scorecard for Efficient Federal Operations/Management.

AMO-18-6: Meet sustainable building inventory target (percentage of gross square footage of inventory meeting guiding principles) set by the Office of Management and Budget for FY 2018 in the Sustainability and Energy Scorecard.

2013	2014	2015	2016	2017	2018
No API	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

AMO-19-28: Meet sustainable building inventory target (percentage of gross square footage of inventory meeting guiding principles) set by the Office of Management and Budget (OMB) for FY 2019 in the OMB Scorecard for Efficient Federal Operations/Management.

AMO-20-26: Meet sustainable building inventory target (percentage of gross square footage of inventory meeting guiding principles) set by the Office of Management and Budget (OMB) for FY 2020 in the OMB Scorecard for Efficient Federal Operations/Management.

AMO-18-7: Ensure that a percentage of electricity consumed is generated from renewable energy sources, to meet the target set by the Office of Management and Budget for FY 2018 in the Sustainability and Energy Scorecard.

2013	2014	2015	2016	2017	2018
No API	Green	Green	Green	Green	Green

Planned Annual Performance Indicators

AMO-19-29: Ensure that a percentage of electricity consumed is generated from renewable energy sources, to meet the target set by the Office of Management and Budget (OMB) for FY 2019 in the OMB Scorecard for Efficient Federal Operations/Management.

AMO-20-27: Ensure that a percentage of electricity consumed is generated from renewable energy sources, to meet the target set by the Office of Management and Budget (OMB) for FY 2020 in the OMB Scorecard for Efficient Federal Operations/Management.

Performance Goal 4.6.3: Between 2018 and 2019, demonstrate increased facility reliability by reducing spending on unscheduled maintenance by one percent annually.

2013	2014	2015	2016	2017	2018
No PG before FY 2016			Red	Red	Green

Planned Performance Goal for FY 2019-2020

4.6.3: Between 2018 and 2019, demonstrate increased facility reliability by reducing spending on unscheduled maintenance by one percent annually.

The **Office of Strategic Infrastructure** ensures that the right infrastructure is available to meet NASA's mission requirements. OSI implements risk mitigation and sustainability practices across the Agency's infrastructure to prevent adverse mission impacts, protect mission resources, and enable the NASA missions to the fullest extent possible.

NASA performs scheduled maintenance on its equipment to keep it in good operating condition. When equipment fails, NASA 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. In FY 2018, the ratio of unscheduled maintenance to total maintenance was 31.5 percent, which exceeded the targeted 1 percent reduction from FY 2017 to FY 2018.

Ratio of Unscheduled Maintenance to Total Maintenance, From Baseline Through FY 2018

NASA's target is to reduce unscheduled maintenance by one percent from the previous fiscal year's percentage of unscheduled maintenance to total maintenance.

Fiscal Year	Target Ratio of Unscheduled Maintenance to Total Maintenance	Actual Ratio of Unscheduled Maintenance to Total Maintenance
2015 (Baseline)	31.6%	31.6%
2016	30.6%	37.1%
2017	36.1%	32.9%
2018	31.9%	31.5%*

*The FY 2019 target will be to reduce unscheduled maintenance 1 percent below 31.5 percent of total maintenance.

AMO-18-8: Reduce spending on unscheduled maintenance (out of total maintenance spending) by at least one percentage point.

2013	2014	2015	2016	2017	2018
No APIs before FY 2016			Red	Red	Green

Planned Annual Performance Indicators

AMO-19-30: Reduce spending on unscheduled maintenance (out of total maintenance spending) by at least one percentage point.

AMO-20-28: Reduce spending on unscheduled maintenance (out of total maintenance spending) by at least one percentage point.

Appendices

NASA's 380-foot-tall mobile launcher, atop crawler-transporter 2, approaches Launch Pad 39B on August 31, 2018, at Kennedy Space Center. NASA's Exploration Ground Systems is preparing the ground systems necessary to launch the Space Launch System and Orion on Exploration Mission-1. Image credit: NASA/Cory Huston

Appendix A
Changes to the FY 2019 Performance Plan

Each fiscal year, NASA's budget request to Congress contains an annual performance plan (APP) that aligns with the funds requested. However, all of the program and project plans described in the President's budget request and annual performance plan may not be realized as anticipated. When this happens, the Agency revises its performance measures and provides it as an APP update accompanying the budget request for the upcoming fiscal year. NASA revises its performance measures when the final appropriation differs from the amount requested, or if congressional or executive direction places a different emphasis on programs relative to what was initially requested. Additionally, the dynamic nature of research and development can lead to shifting priorities. This may result in NASA no longer pursuing activities originally identified in the annual performance plan or placing greater emphasis on other activities.

NASA's policy has been to allow one of the following actions if programs are impacted by congressional budget action via an appropriations or authorization law or executive direction places a different emphasis on programs:

- Add new performance measures;
- Remove old performance measure (do not rate the performance measure);
- Update the targeted performance (rate at the new target);
- Renumber the performance measure; or
- Move the performance measure to the following year's annual performance plan (do not rate until the following year).

Once the APP update is released, the performance measures are considered final. If a final performance measure cannot be achieved due the reasons described above, NASA generally will retain the measure and the target, but rate it white, indicating that the measure is canceled or postponed.

Above: At NASA Earth Day 2018, a visitor uses virtual reality to explore the solar system. Image credit: NASA/Aubrey Gemignani

FY 2019 Performance Plan Update

NASA released the FY 2019 Performance Plan in May 2018, concurrent with its FY 2019 President's budget request in May 2018. NASA has since reviewed and updated the FY 2019 measures to align with the FY 2020 budget request and administration priorities. All revisions have been reviewed and approved by the Office of Management and Budget. The following list shows the performance measures that have been added, updated, or removed for FY 2019. Only measures with substantive changes are shown.

1.1.2: Demonstrate progress in advancing understanding of the connections that link the Sun, Earth and planetary space environments, and the outer reaches of the solar system.

Moved to FY 2020: HE-19-5: Achieve the Ionospheric Connection Explorer (ICON) mission success criteria.

1.1.4: By December 2019, launch one mission in support of Heliophysics.

Removed: HE-19-4: Complete the 2018 Heliophysics Medium Explorer (MIDEX) Announcement of Opportunity step-one selection.

1.1.5: Conduct on-orbit commissioning of the James Webb Space Telescope after launch. (Agency Priority Goal)

Revised: JWST-19-1: Complete spacecraft element thermal vacuum testing.

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

Revised: PS-19-13: Identify and catalog a cumulative 8,900 of the estimated 25,000 near-Earth asteroids (NEAs) 140 meters or larger.

1.1.16: By December 2017, launch at least two missions in support of Planetary Science.

Added: PS-19-15: Conduct close-orbit global mapping for sample site identification and evaluation for the Origins, Spectral Interpretation, Resource Identification, and Security-Regolith Explorer (OSIRIS-REx) mission asteroid sample collection.

1.1.24: By December 2021, launch three missions in support of Earth Science.

Revised: ES-19-9: Complete Surface Water and Ocean Topography Ka-band Radar Interferometer Integration and Test Readiness Review.

***Added:* 3.1.1: Invest across the U.S. innovation community to explore and advance promising early stage solutions to space technology challenges.**

Added: ET-19-1: Invest in at least 185 promising new early stage technologies and concepts, with potential for transformative impact.

***Added:* 3.1.2: Mature technologies that offer significant improvement to existing solutions or enable space exploration capabilities.**

Added: ET-19-2: Mature state of the art technologies by completing at least 70 percent of Technology Maturation program milestones.

***Added:* 3.1.3: Demonstrate new technologies and capabilities for space exploration.**

Added: ET-19-3: Advance development, demonstration, and mission implementation of new exploration technologies by reaching a key milestone in at least six small spacecraft projects.

Added: ET-19-4: Advance Technology Demonstration Mission (TDM) capabilities by completing at least six key decision points towards technology demonstration.

***Added:* 3.1.4: Engage and partner with the commercial aerospace sector, to leverage technology advancements and grow the national economy.**

Added: ET-19-5: Conduct at least four prize competitions to encourage innovation and address technology challenges through engaging non-traditional NASA partners.

Added: ET-19-6: Create 10 opportunities for advancement of SBIR/STTR technologies beyond Phase II, leveraging non-SBIR/STTR NASA investment or external investment.

Added: ET-19-7: Competitively select at least 16 payloads from NASA centers, other government agencies, industry, or academia for flight on commercial vehicles to advance lunar exploration and commercial development in Earth orbit.

3.2.1: Develop solutions that will advance decision-making ability for improving air traffic management to accommodate future growth in air travel, and for increasing aviation safety under hazardous conditions.

Revised: AR-19-1: Assess and document capacity of future air traffic services that increase Urban Air Mobility (UAM) capacity over current-day operations.

3.2.4: Facilitate significant environmental and efficiency improvements through research on alternative jet fuel use, and on hybrid gas-electric propulsion system concepts.

Revised: AR-19-12: Demonstrate integrated electrical system functionality of the X-57 aircraft through assembling components with a power delivery system and conducting an Integrated Electrical End-to-End Test.

3.2.5: Significantly increase the ability to anticipate and resolve potential safety issues, and to predict the health and robustness of aviation systems.

Revised: AR-19-4: Identify data architecture and information requirements (i.e., content and quality) for in-time monitoring of selected operational risks for small Unmanned Aircraft Systems.

3.2.6: Support transformation of civil aircraft operations and air traffic management through the development, application, and validation of advanced autonomy and automation technologies, including addressing critical barriers to enabling urban on-demand air mobility and Unmanned Aircraft Systems (UAS) operations in low-altitude airspace.

Revised: AR-19-10: Complete the data collection, analysis, and reporting for the Detect and Avoid and Integrated Test and Evaluation (IT&E) flight test five (FT5) and for the Command and Control version six (v6) terrestrial communication system flight test.

***Added:* 3.3.3: Provide opportunities for students to engage with NASA's aeronautics, space, and science people, content, and facilities in support of a diverse future NASA and aerospace industry workforce.**

Added: STEM-19-1: Provide significant, direct student awards in higher education to (1) students across all institutional categories and levels (as defined by the U.S. Department of Education), (2) racially or ethnically underrepresented students (Hispanics and Latinos, African Americans, American Indians, Alaska Native, Native Hawaiians and Pacific Islanders), (3) women, and (4) persons with disabilities, at percentages that meet or exceeded at the national percentages for the science and engineering graduates, as determined by the most recent, publicly available data from the U.S. Department of Education's National Center for Education Statistics for a minimum of two of the four categories.

***Added:* 3.3.4: Enhance the effectiveness of education investments using performance assessment and evaluation-driven processes.**

Added: STEM-19-2: Design a comprehensive data management system aligned to performance assessment and evaluation strategy to collect, analyze, and report data for STEM engagement investments.

***Added:* 3.3.5: Provide opportunities for students to contribute to NASA's aeronautics, space, and science missions and work in exploration and discovery.**

Added: STEM-19-3: Conduct a multiple case study focused on NASA STEM engagement higher education challenges, competitions, and internships to build knowledge about how these activities: a) contribute to NASA's aeronautics, space, and science missions; b) align to evidence-based effective practices for STEM learning; and c) recruit and retain participants from groups historically underrepresented and/or underserved in STEM fields.

Added: STEM-19-4: Contribute to American technical capability by supporting the release of at least TBD* paper presentations and peer-reviewed research publications through STEM engagement investments.

***Removed:* 4.1.1: Efficiently manage the coordination of NASA's domestic, interagency, and international partnership agreements to ensure that the partnerships continue to provide value to the Agency, including through the advancement of one or more Agency institutional or programmatic objectives.**

Removed: AMO-19-5: Negotiate and sign at least 300 new partnership agreements with domestic, non-governmental parties.

Removed: AMO-19-6: Negotiate and conclude at least 80 international and interagency agreements with foreign and domestic partners in support of NASA missions.

4.1.3: Develop and implement the multiyear NASA Small Business Strategic Plan, which will promote and increase small business programs and outreach through strategic collaborative efforts with internal and external partners and stakeholders.

Revised: AMO-19-11: Strengthen and promote small business awareness and participation by utilizing innovative techniques to benefit the Agency's small business program, including through the consolidation of Agency-level small business activities in specific, pre-determined geographical areas

4.3.1: Assure the safety and health of NASA's activities and reduce damage to assets through the development, implementation, and oversight of Agency-wide safety, reliability, maintainability, quality assurance, and health and medical policies and procedures.

Revised: AMO-19-19: During FY 2019, keep the number of variances made in any single human spaceflight program to below five percent of the total number of program requirements derived from Office of the Chief Health and Medical Officer standards and policies.

***Removed:* 4.3.2: Implement the policies, procedures, and oversight to continuously improve the probability of technical and programmatic mission success.**

Removed: AMO-19-17: Assure 100 percent of Category 1 and 2 projects use Agency Safety and Mission Success policy, procedures and independent assessments focused on both technical and programmatic mission success.

Removed: AMO-19-18: Assure that 100 percent of the engineering and programmatic workforce has access to the standards and knowledge base needed to maintain and build their skills.

Moved to 4.3.1: AMO-19-19: During FY 2019, keep the number of variances made in any single human spaceflight program to below five percent of the total number of program requirements derived from Office of the Chief Health and Medical Officer (OCHMO) standards and policies.

4.4.2: Sustain equal opportunity (EO) and diversity and inclusion (D&I) programs and processes that help to proactively prevent discrimination, achieve more equitable and inclusive work environments, and more efficiently address EO concerns.

Revised: AMO-19-21: Sustain employee perceptions of the workplace as measured by the Federal Employee Viewpoint Survey Inclusion Index percentages.

Revised: AMO-19-35: Increase efficiency in equal employment opportunity (EEO) programs (such as EEO complaints processing, anti-harassment, and reasonable accommodations), demonstrated by achieving at least 85 percent timely processing of matters raised in FY 2020.

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

Removed: AMO-19-22: At least 45 percent of NASA's applicable high-value assets (HVAs) require all users to authenticate through the machine-based or user-based enforcement of a two-factor Personal Identity Verification (PIV) credential or other Identity Assurance Level 3/Authenticator Assurance Level 3 credential, as applicable based on an HVA assessment of system architecture.

***Updated:* 4.5.2: Improve the security and resiliency of NASA's operational technology (OT) systems to ensure safe and secure operation of NASA's critical infrastructure in a manner consistent with guidance from the National Institute of Standards and Technology (NIST).**

Revised: AMO-19-24: Identify at least 95 percent of the operational technology systems that are part of the assets on the NASA Critical Infrastructure list.

***Removed:* 4.5.3: Achieve improvements in overall Office of Protective Services physical security operations, standardization, efficiencies, and economies of scale.**

Removed: AMO-19-25: Maintain Federal Law Enforcement Training Accreditation Federal Arrest Authority programmatic accreditation and Academy accreditation.

Appendix B
Data Quality Elements

Data quality elements describe how NASA ensures the accuracy and reliability of the data used to measure progress towards each performance goal for the FY 2018 Annual Performance Report. These elements include the sources of the data, the means used to verify and validate the results, and any limitations to the data at the required level of accuracy. If any significant data limitations exist that could impede accurate reporting, this section will include a discussion of how the Agency compensates for those limitations.

Strategic Goal 1: Expand human knowledge through new scientific discoveries.

Performance Goal 1.1.1: Demonstrate progress in exploring the physical processes in the space environment from the Sun to Earth and throughout the solar system.

Data Source: Review of the ratings and supporting material from the external expert review panel, along with a written explanation of any other significant factors considered in arriving at the rating, if applicable.

Verification & Validation: On an annual basis, an independent, external expert review panel from the Heliophysics Advisory Committee (HPAC) evaluates scientific progress relative to the current science plan and assigns a rating to the annual performance indicator (API) that supports this performance goal (PG). Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/. The Heliophysics Division Director recommends a rating for the performance goal based on the findings of the review panel and other significant factors, if applicable. Ratings are reviewed by the Deputy Associate Administrator for Research within NASA's Science Mission Directorate (SMD), with any issues being resolved by the Associate Administrator for SMD.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.2: Demonstrate progress in advancing understanding of the connections that link the Sun, Earth, and planetary space environments, and the outer reaches of the solar system.

Data Source: Review of the ratings and supporting material from the external expert review panel, along with a written explanation of any other significant factors considered in arriving at the rating, if applicable.

Verification & Validation: On an annual basis, an independent, external expert review panel from HPAC evaluates scientific progress relative to the current science plan and assigns a rating to the API that supports this PG. Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/. The Heliophysics Division Director recommends a rating for the performance goal based on the findings of the review panel and other significant factors, if applicable. Ratings are reviewed by the Deputy Associate Administrator for Research within NASA SMD, with any issues being resolved by the Associate Administrator for SMD.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Above: Lockheed Martin engineers assemble Orion's crew module at NASA Kennedy Space Center Operations and Checkout building. Image credit: NASA/Rad Sinyak

Performance Goal 1.1.3: Demonstrate progress in developing the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

Data Source: Review of the ratings and supporting material from the external expert review panel, along with a written explanation of any other significant factors considered in arriving at the rating, if applicable.

Verification & Validation: On an annual basis, an independent, external expert review panel from HPAC evaluates scientific progress relative to the current science plan and assigns a rating to the API that supports this PG. Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/. The Heliophysics Division Director recommends a rating for the performance goal based on the findings of the review panel and other significant factors, if applicable. Ratings are reviewed by the Deputy Associate Administrator for Research within NASA SMD, with any issues being resolved by the Associate Administrator for SMD.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.4: By December 2019, launch one mission in support of Heliophysics.

Data Source: Written explanation of the rating and supporting material from the SMD's Flight Program Review archives. The Deputy Associate Administrator for SMD recommends a rating based on whether the underlying missions are on track to launch during the goal period.

Verification & Validation: Review of the documentation listed under Data Sources.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.5: Conduct on-orbit commissioning of the James Webb Space Telescope after launch. (Agency Priority Goal)

Data Source: Emails, press releases, and program-internal documents indicating progress NASA's industry partners make toward the James Webb Space Telescope integration, test and launch.

Verification & Validation: NASA monitors and tracks its progress towards this goal using various Agency documents and reports, including Directorate Program Management Council (DPMC) materials, monthly reports from the project and industry partners, and other program-internal documents.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.6: Demonstrate progress in probing the origin and destiny of the universe, including the nature of black holes, dark energy, dark matter, and gravity.

Data Source: On an annual basis, an independent, external expert review panel from the Astrophysics Advisory Committee (AAC) evaluates scientific progress relative to the current science plan and assigns a rating to the API that supports this PG. Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/apac#meetingdocs. The Astrophysics Division Director recommends a rating for the performance goal based on the findings of the review panel and other significant factors, if applicable. Ratings are reviewed by the Deputy Associate Administrator for Research within NASA SMD, with any issues being resolved by the Associate Administrator for SMD.

Verification & Validation: Review of the ratings and supporting material from the external expert review panel, along with a written explanation of any other significant factors considered in arriving at the rating, if applicable.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.7: Demonstrate progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe.

Data Source: On an annual basis, an independent, external expert review panel from AAC evaluates scientific progress relative to the current science plan and assigns a rating to the API that supports this PG. Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/apac#meetingdocs. The Astrophysics Division Director recommends a rating for the performance goal based on the findings of the review panel and other significant factors, if applicable. Ratings are reviewed by the Deputy Associate Administrator for Research within NASA SMD, with any issues being resolved by the Associate Administrator for SMD.

Verification & Validation: Review of the ratings and supporting material from the external expert review panel, along with a written explanation of any other significant factors considered in arriving at the rating, if applicable.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.8: Demonstrate progress in discovering and studying planets around other stars and exploring whether they could harbor life.

Data Source: On an annual basis, an independent, external expert review panel from the AAC evaluates scientific progress relative to the current science plan and assigns a rating to the API that supports this PG. Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/apac#meetingdocs. The Astrophysics Division Director recommends a rating for the performance goal based on the findings of the review panel and other significant factors, if applicable. Ratings are reviewed by the Deputy Associate Administrator for Research within NASA SMD, with any issues being resolved by the Associate Administrator for SMD.

Verification & Validation: Review of the ratings and supporting material from the external expert review panel, along with a written explanation of any other significant factors considered in arriving at the rating, if applicable.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.9: By December 2021, launch one mission in support of Astrophysics.

Data Source: Written explanation of the rating and supporting material from SMD's Flight Program Review archives. The Deputy Associate Administrator for SMD recommends a rating based on whether the underlying mission is on track to launch during the goal period.

Verification & Validation: Review of the documentation listed under Data Sources.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.10: Demonstrate progress in advancing the understanding of how the chemical and physical processes in the solar system operate, interact, and evolve.

Data Source: On an annual basis, an independent, external expert review panel from the Planetary Science Advisory Committee (PAC) evaluates scientific progress relative to the current science plan and assigns a rating to the API that supports this PG. Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/. The Planetary Science Division Director recommends a rating for the performance goal based on the findings of the review panel and other significant factors, if applicable. Ratings are reviewed by the Deputy Associate Administrator for Research within NASA SMD, with any issues being resolved by the Associate Administrator for SMD.

Verification & Validation: Review of the ratings and supporting material from the external expert review panel, along with a written explanation of any other significant factors considered in arriving at the rating, if applicable.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.11: Demonstrate progress in exploring and observing the objects in the solar system to understand how they formed and evolve.

Data Source: On an annual basis, an independent, external expert review panel from the PAC evaluates scientific progress relative to the current science plan and assigns a rating to the API that supports this PG. Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/. The Planetary Science Division Director recommends a rating for the performance goal based on the findings of the review panel and other significant factors, if applicable. Ratings are reviewed by the Deputy Associate Administrator for Research within NASA SMD, with any issues being resolved by the Associate Administrator for SMD.

Verification & Validation: Review of the ratings and supporting material from the external expert review panel, along with a written explanation of any other significant factors considered in arriving at the rating, if applicable.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.12: Demonstrate progress in exploring and finding locations where life could have existed or could exist today.

Data Source: On an annual basis, an independent, external expert review panel from PAC evaluates scientific progress relative to the current science plan and assigns a rating to the API that supports this PG. Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/. The Planetary Science Division Director recommends a rating for the performance goal based on the findings of the review panel and other significant factors, if applicable. Ratings are reviewed by the Deputy Associate Administrator for Research within NASA SMD, with any issues being resolved by the Associate Administrator for SMD.

Verification & Validation: Review of the ratings and supporting material from the external expert review panel, along with a written explanation of any other significant factors considered in arriving at the rating, if applicable.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.13: Demonstrate progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere.

Data Source: On an annual basis, an independent, external expert review panel from PAC evaluates scientific progress relative to the current science plan and assigns a rating to the API that supports this PG. Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/. The Planetary Science Division Director recommends a rating for the performance goal based on the findings of the review panel and other significant factors, if applicable. Ratings are reviewed by the Deputy Associate Administrator for Research within NASA SMD, with any issues being resolved by the Associate Administrator for SMD.

Verification & Validation: Review of the ratings and supporting material from the external expert review panel, along with a written explanation of any other significant factors considered in arriving at the rating, if applicable.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.14: Demonstrate progress in identifying and characterizing objects in the solar system that pose threats to Earth or offer resources for human exploration.

Data Source: On an annual basis, an independent, external expert review panel from PAC evaluates scientific progress relative to the current science plan and assigns a rating to the API that supports this PG. Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/. The Planetary Science Division Director recommends a rating for the performance goal based on the findings of the review panel and other significant factors, if applicable. Ratings are reviewed by the Deputy Associate Administrator for Research within NASA SMD, with any issues being resolved by the Associate Administrator for SMD.

Verification & Validation: Review of the ratings and supporting material from the external expert review panel, along with a written explanation of any other significant factors considered in arriving at the rating, if applicable.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.15: Deliver the Mars 2020 instrument payload for spacecraft integration. (Agency Priority Goal)

Data Source: Emails, press releases, and program-internal documents indicating progress toward integration, test, and launch.

Verification & Validation: NASA monitors and tracks its progress towards this goal using various Agency documents and reports, including DPMC materials, monthly reports from the project and contributing partners, and other program-internal documents.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.16: By December 2017, launch at least two mission in support of Planetary Science.

Data Source: Written explanation of the rating and supporting material from SMD's Flight Program Review archives. The Deputy Associate Administrator for SMD recommends a rating based on whether the underlying missions are on track to launch during the goal period.

Verification & Validation: Review of the documentation listed under Data Sources.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.17: Demonstrate progress in advancing the understanding of changes in Earth's radiation balance, air quality, and the ozone layer that result from changes in atmospheric composition.

Data Source: On an annual basis, an independent, external expert review panel from the Earth Science Advisory Committee (ESAC) evaluates scientific progress relative to the current science plan and assigns a rating to the API that supports this PG. Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/. The Earth Science Division Director recommends a rating for the performance goal based on the findings of the review panel and other significant factors, if applicable. Ratings are reviewed by the Deputy Associate Administrator for Research within NASA SMD, with any issues being resolved by the Associate Administrator for SMD.

Verification & Validation: Review of the ratings and supporting material from the external expert review panel, along with a written explanation of any other significant factors considered in arriving at the rating, if applicable.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.18: Demonstrate progress in improving the capability to predict weather and extreme weather events.

Data Source: On an annual basis, an independent, external expert review panel from the ESAC evaluates scientific progress relative to the current science plan and assigns a rating to the API that supports this PG. Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/. The Earth Science Division Director recommends a rating for the performance goal based on the findings of the review panel and other significant factors, if applicable. Ratings are reviewed by the Deputy Associate Administrator for Research within NASA SMD, with any issues being resolved by the Associate Administrator for SMD.

Verification & Validation: Review of the ratings and supporting material from the external expert review panel, along with a written explanation of any other significant factors considered in arriving at the rating, if applicable.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.19: Demonstrate progress in detecting and predicting changes in Earth's ecosystems and biogeochemical cycles, including land cover, biodiversity, and the global carbon cycle.

Data Source: On an annual basis, an independent, external expert review panel from the ESAC evaluates scientific progress relative to the current science plan and assigns a rating to the API that supports this PG. Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/. The Earth Science Division Director recommends a rating for the performance goal based on the findings of the review panel and other significant factors, if applicable. Ratings are reviewed by the Deputy Associate Administrator for Research within NASA SMD, with any issues being resolved by the Associate Administrator for SMD.

Verification & Validation: Review of the ratings and supporting material from the external expert review panel, along with a written explanation of any other significant factors considered in arriving at the rating, if applicable.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.20: Demonstrate progress in enabling better assessment and management of water quality and quantity to accurately predict how the global water cycle evolves in response to climate change.

Data Source: On an annual basis, an independent, external expert review panel from the ESAC evaluates scientific progress relative to the current science plan and assigns a rating to the API that supports this PG. Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/. The Earth Science Division Director recommends a rating for the performance goal based on the findings of the review panel and other significant factors, if applicable. Ratings are reviewed by the Deputy Associate Administrator for Research within NASA SMD, with any issues being resolved by the Associate Administrator for SMD.

Verification & Validation: Review of the ratings and supporting material from the external expert review panel, along with a written explanation of any other significant factors considered in arriving at the rating, if applicable.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.21: Demonstrate progress in improving the ability to predict climate changes by better understanding the roles and interactions of the ocean, atmosphere, land, and ice in the climate system.

Data Source: On an annual basis, an independent, external expert review panel from the ESAC evaluates scientific progress relative to the current science plan and assigns a rating to the API that supports this PG. Their findings are available online at https://science.

nasa.gov/researchers/nac/science-advisory-committees/. The Earth Science Division Director recommends a rating for the performance goal based on the findings of the review panel and other significant factors, if applicable. Ratings are reviewed by the Deputy Associate Administrator for Research within NASA SMD, with any issues being resolved by the Associate Administrator for SMD.

Verification & Validation: Review of the ratings and supporting material from the external expert review panel, along with a written explanation of any other significant factors considered in arriving at the rating, if applicable.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.22: Demonstrate progress in characterizing the dynamics of Earth's surface and interior, improving the capability to assess and respond to natural hazards and extreme events.

Data Source: On an annual basis, an independent, external expert review panel from the ESAC evaluates scientific progress relative to the current science plan and assigns a rating to the API that supports this PG. Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/. The Earth Science Division Director recommends a rating for the performance goal based on the findings of the review panel and other significant factors, if applicable. Ratings are reviewed by the Deputy Associate Administrator for Research within NASA SMD, with any issues being resolved by the Associate Administrator for SMD.

Verification & Validation: Review of the ratings and supporting material from the external expert review panel, along with a written explanation of any other significant factors considered in arriving at the rating, if applicable.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.23: Further the use of Earth system science research to inform decisions and provide benefits to society.

Data Source: NASA Applied Sciences Program's Annual Report, CFI Group report, and other documentation, as appropriate. The Director of the NASA Applied Sciences Program recommends a rating after reviewing progress toward the performance goal.

Verification & Validation: Review of the documentation listed under Data Sources.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.24: By December 2021, launch three missions in support of Earth Science.

Data Source: Written explanation of the rating and supporting material from SMD's Flight Program Review archives. The Deputy Associate Administrator for SMD recommends a rating based on whether the underlying missions are on track to launch during the goal period.

Verification & Validation: Review of the documentation listed under Data Sources.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.2.1: Conduct basic and applied biological and physical research to advance and sustain U.S. scientific expertise.

Data Source: Documentation for payloads delivered to the International Space Station (ISS) Program; ISS flight manifests; Standing Review Board program reports; Center for the Advancement of Science in Space press releases and award documents; project and investigator internal reporting; and the NASA Task Book bibliographic data, available at https://taskbook.nasaprs.com/Publication/index.cfm?action=bib_search.

Verification & Validation: Review of the documentation listed under Data Sources.

Data Limitation: Potential lag time. For peer-reviewed publications, data are gathered throughout the year, but tend to concentrate at the end of the year. Intermediate data are of limited significance. Data are sufficiently accurate for their intended use.

Strategic Goal 2: Extend human presence deeper into space and to the Moon for sustainable long-term exploration and utilization.

Performance Goal 2.1.1: Increase the crew time for research and development beyond the three U.S. Orbital Segment crew baseline.

Data Source: Human Exploration and Operations Mission Directorate (HEOMD) DPMC and the ISS Program Quarterly Reviews.

Verification & Validation: Review of the documentation listed under Data Sources.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 2.1.2: Ensure vital assets are ready, available, and appropriately sized to conduct NASA's Mission.

Data Source: Center level analysis and schedules.

Verification & Validation: The DPMC is the governing body for review of this performance goal.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 2.1.3: Facilitate the commercial development of low Earth orbit (LEO) to transition to a commercial LEO human spaceflight enterprise where NASA is one of many customers.

Data Source: HEOMD DPMC and the ISS Program Quarterly Reviews.

Verification & Validation: Review of the documentation listed under Data Sources.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 2.2.1: Achieve critical milestones in development of new systems for the human exploration of deep space. (Agency Priority Goal)

Data Source: Schedules and Quarterly Program Status Report packages.

Verification & Validation: Review by the HEOMD DPMC.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 2.2.2: Demonstrate deep space habitat concepts using prototypes developed in partnership with Next Space Technologies for Exploration Partnerships Phase 2 industry partners.

Data Source: Industry partner-provided data to verify accomplishment of milestones.

Verification & Validation: Review of contractually-binding technical milestones.

Data Limitation: None identified. Data are sufficiently accurate for their intended use. Some of the data developed by NASA's commercial partners may be protected under Intellectual Property Statutes.

Performance Goal 2.2.3: Use the International Space Station (ISS) as a testbed to demonstrate the critical systems necessary for long-duration missions. Between October 1, 2017, and September 30, 2019, NASA will initiate at least eight in-space demonstrations of technology critical to enable human exploration in deep space. (Agency Priority Goal)

Data Source: Press releases and program-internal documents indicating whether or not NASA has initiated its planned inspace technology demonstrations.

Verification & Validation: NASA monitors and tracks its progress towards this goal using various Agency documents and reports, including materials from the Advanced Exploration Systems, and ISS program reviews, project schedules, and other program-internal documents. NASA also issues press releases for its major technology demonstration experiments.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 2.2.4: Develop planetary In-Situ Resource Utilization technologies.

Data Source: Link(s) to press releases and design review board documents

Verification & Validation: HEOMD DPMC and NASA Policy Directive 7120.8 or tailored 7120.5 for the In-Situ Resource Utilization payload.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 2.2.5: Engage industry in developing concepts to satisfy both NASA and commercial goals for a Power and Propulsion Element for deep space transportation.

Data Source: Link(s) to press releases and Design Review Board documents. See also https://www.nasa.gov/feature/nasa-seeks-industry-studies-for-deep-space-power-propulsion and https://www.fbo.gov/spg/NASA/GRC/OPDC20220/80GRC018R0005/listing.html.

Verification & Validation: Review by HEOMD DPMC.

Data Limitation: Materials provided by NASA's industry partners may include company-proprietary information. Data are sufficiently accurate for their intended use.

Strategic Goal 3: Address national challenges and catalyze economic growth.

Performance Goal 3.1.1: Explore and advance promising early stage solutions to space technology challenges through investment across the U.S. innovation community.

Data Source: Space Technology Research Grants, NASA Innovative Advanced Concepts, and Center Innovation Fund program documentation and press releases.

Verification & Validation: Within Space Technology Mission Directorate (STMD), Strategic Planning and Integration (SPI) coordinates and integrates performance goal and PG/API review and evaluation, working closely with portfolio executives, program executives, and program managers responsible for individual PGs/APIs. For this PG, this process includes review of program documentation and press releases for Space Technology Research Grants, NASA Innovative Advanced Concepts, and Center Innovation Fund. Final ratings and justifications are approved by the SPI Director. During annual program performance status reviews, each program reports applicable PG/API ratings and justification to the STMD Program Management Council (PMC).

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.1.2: Advance technologies that offer significant improvement to existing solutions or enable new space science and exploration capabilities.

Data Source: Evidence will include the list of planned fiscal year milestones, along with completion status.

Verification & Validation: Within STMD, SPI coordinates and integrates PG/API review and evaluation, working closely with portfolio executives, program executives and program managers responsible for individual PGs/APIs. For this PG, this process includes monthly assessment of milestone progress by Game Changing Development, including presentation of status to STMD leadership. Final ratings and justifications are approved by the SPI Director. During annual program performance status reviews, each program reports applicable PG/API ratings and justification to the STMD PMC.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.1.3: Mature new crosscutting space technology capabilities for demonstration.

Data Source: Review reports, Key Decision Points (KDP) decision memoranda, or other relevant milestone documentation.

Verification & Validation: Within STMD, SPI coordinates and integrates PG/API review and evaluation, working closely with portfolio executives, program executives, and program managers responsible for individual PGs/APIs. For this PG, this process includes quarterly verification of completion of project KDPs or key associated reviews (e.g., Preliminary Design Reviews, Critical Design Reviews), as defined in governing NASA Procedural Requirements; launches; and significant ground tests or flight operations. Final ratings and justifications are approved by the SPI Director. During annual program performance status reviews, each program reports applicable PG/API ratings and justification to the STMD PMC.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.1.4: Engage the established commercial sector, emerging aerospace markets, and economic regions to leverage common interests and grow the national economy.

Data Source: Web articles, NASA news releases, program spreadsheets, and other relevant documentation stored on a document and records management system.

Verification & Validation: Within STMD, SPI coordinates and integrates PG/API review and evaluation, working closely with portfolio executives, program executives and program managers responsible for individual PGs/APIs. For this PG, this process includes review of NASA news releases, Web articles, and other relevant internal and external program documentation for the Small Business Innovation Research/Small Business Technology Transfer, Centennial Challenges, Prizes and Challenges, Flight Opportunities, and NASA Technology Transfer activities. During annual program performance status reviews, each program reports applicable PG/API ratings and justification to the STMD PMC.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.2.1: Develop solutions that will advance decision-making ability for improving air traffic management to accommodate future growth in air travel, and for increasing aviation safety under hazardous conditions.

Data Source: Execution of a series of demonstrations of NASA-developed concepts and technologies; demonstration data, including available aircraft and system performance metrics, and controller and pilot workload and acceptance data; and demonstration reports and technical publications that include data analyses, conclusions, and any recommendations from the demonstration participants.

Verification & Validation: Measure rating reviewed and approved quarterly by the Program Director and Aeronautics Research Mission Directorate (ARMD) Associate Administrator.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.2.2: Demonstrate the ability to reduce sonic booms, enabling future industry innovation in commercial supersonic aircraft.

Data Source: Successful completion and reports for Project key decision points and lifecycle reviews. Plans and approvals for Initial Community Response.

Verification & Validation: Measure rating reviewed and approved semi-annually and annual reviews by the Program Director and ARMD Associate Administrator.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.2.3: Advance airframe and engine technologies to enable the development of future generations of ultra-efficient air vehicles that minimize environmental impact.

Data Source: NASA publications (e.g., technical memoranda, contractor reports) and/or presentations and test reports.

Verification & Validation: Measure rating reviewed and approved semi-annually and annual reviews by the Program Director and ARMD Associate Administrator.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.2.4: Facilitate significant environmental and efficiency improvements through research on alternative jet fuel use, and on hybrid gas-electric propulsion system concepts.

Data Source: NASA publications (e.g., technical memoranda, contractor reports) and/or presentations and test reports.

Verification & Validation: Measure rating reviewed and approved semi-annually and annual reviews by the Program Director and ARMD Associate Administrator.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.2.5: Significantly increase the ability to anticipate and resolve potential safety issues, and to predict the health and robustness of aviation systems.

Data Source: Assured tools that improve the accuracy of real-time detection, diagnosis, and prediction of hazardous states and the impact of these states on system safety. Demonstration, benefits analysis, and transition of new real-time system-wide safety technologies.

Verification & Validation: Measure rating reviewed and approved semi-annually and annual reviews by the Program Director and ARMD Associate Administrator.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.2.6: Support transformation of civil aircraft operations and air traffic management through the development, application, and validation of advanced autonomy and automation technologies, including addressing critical barriers to enabling urban on-demand air mobility and unmanned aircraft systems (UAS) operations in low-altitude airspace.

Data Source: UAS Traffic Management Technology Capability Level research assessment and related documentation.

Verification & Validation: Measure rating reviewed and approved semi-annually and annual reviews by the Program Director and ARMD Associate Administrator.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.3.1: Enhance reach and effectiveness of programs and projects that engage the public.

Data Source: Specific to each platform or communications tool, with contributions from programs, mission directorates, functional offices, and field centers. Includes after-event reports, lessons-learned documentation, media monitoring, and/or media metrics.

Verification & Validation: Measure rating reviewed and approved semi-annually and annual reviews by the Program Director and ARMD Associate Administrator.

Data Limitation: Constrained by legal limitations on collecting information on the public. Data are sufficiently accurate for their intended use.

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

Data Source: Office of Diversity and Equal Opportunity (ODEO) Compliance Tracking System; MissionSTEM Analytics.

Verification & Validation: Review compliance with NASA Policy Directive 2081.1A and NASA Procedural Requirements 2081.1A. Ensure signature by grant recipient institutions of NASA Form 1206 (i.e., the Assurance of Compliance form).

Data Limitation: Quantifying compliance actions in percentages is subject to some level or interpretation. In addition, there can be a lag time in reporting, because the purpose of the program is to assess grantee institution compliance with federal civil rights requirements, and if there is non-compliance, it can take months or years to achieve compliance.

Performance Goal 3.3.3: Provide opportunities for students to engage with NASA's aeronautics, space, and science people, content, and facilities in support of a diverse future NASA and aerospace industry workforce.

Data Source: Project activity data from the Office of Education Performance Measurement (OEPM) System.

Verification & Validation: NASA's Office of STEM Engagement reviews the data collected using the OEPM System to determine whether goals have been met. The measure is reviewed and approved by the Associate Administrator for the NASA Office of STEM Engagement.

Data Limitation: There is a data lag. Academic calendars do not coincide with the federal fiscal year calendar. In order to ensure accurate data collection and reporting, NASA's Office of STEM Engagement uses prior year data (e.g., in FY 2019, NASA's Office of STEM Engagement reports on 2017-2018 academic calendar year data) to meet performance reporting requirements. Data are sufficiently accurate for their intended use.

Performance Goal 3.3.4: Enhance the effectiveness of education investments using performance assessment and evaluation-driven processes.

Data Source: STEM Engagement Council working group's deliverables and grant/cooperative agreement solicitations released by the Office of Education.

Verification & Validation: Documents serving as the deliverables for each milestone will be obtained and reviewed by the Office of STEM Engagement Performance Assessment, Evaluation and Information Management Team to assess achievements of each milestone. A written assessment will be reviewed by the Deputy Associate Administrator for STEM Engagement to verify and validate findings.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.3.5: Provide opportunities for students to contribute to NASA's aeronautics, space, and science missions and work in exploration and discovery.

Data Source: Project activity data from the OEPM System.

Verification & Validation: NASA's Office STEM Engagement staff review the data collected using the OEPM System to determine whether goals have been met. The measure rating is reviewed and approved by the Associate Administrator for NASA's Office of STEM Engagement.

Data Limitation: There is a data lag. Academic calendars do not coincide with the federal fiscal year calendar. In order to ensure accurate data collection and reporting, NASA's Office of STEM Engagement uses prior year data (e.g., in FY 2018, NASA education reports on FY 2017 data) to meet performance reporting requirements. Data are sufficiently accurate for their intended use.

Strategic Goal 4: Optimize capabilities and operations.

Performance Goal 4.1.1: Efficiently manage the coordination of NASA's domestic, interagency, and international partnership agreements to ensure that the partnerships continue to provide value to the Agency, including through the advancement of one or more Agency institutional or programmatic objectives.

Data Source: NASA Headquarters Mission Directorate Reviews; Information from the Partnerships Agreement Maker Database; and Partnership Council meetings and briefings.

Verification & Validation: Review of documentation listed under Data Sources. Partnership Council review of significant partnership activities; and compliance with NASA Policy Directive 1050.11 and NASA Advisory Implementing Instructions 1050-1, 1050-2, 1050-3.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.1.2: Achieve savings for the Agency through acquisition reforms.

Data Source: NASA Strategic Sourcing Plan, Master Buy Plan Database, and Federal Procurement Data System.

Verification & Validation: Review compliance with the Office of Management and Budget (OMB) Strategic Sourcing Policy, NASA Policy Directive 1000.5B, Federal Acquisition Regulation (FAR), and the NASA FAR Supplement.

Data Limitation: Contract data availability from the Federal Procurement Data System and Federal Strategic Sourcing Initiative data collection system lags in the reporting cycle. Data are sufficiently accurate for their intended use.

Performance Goal 4.1.3: Develop and implement the multiyear NASA Small Business Strategic Plan, which will promote and increase small business programs and outreach through strategic collaborative efforts with internal and external partners and stakeholders.

Data Source: NASA's Office of Small Business Programs website, NASA Vendor Database, press releases, and NASA-internal documentation.

Verification & Validation: Review of the documentation listed under Data Sources. Final rating is determined by the Associate Administrator of OSBP.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.2.1: Provide cargo transportation to support on-orbit crew members and utilization.

Data Source: HEOMD DPMC and the ISS Program Quarterly Reviews.

Verification & Validation: Review of the documentation listed under Data Sources.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.2.2: Facilitate the development of and certify U.S. industry-based crew transportation systems while maintaining competition, returning International Space Station (ISS) crew transportation to the United States. (Agency Priority Goal)

Data Source: Email(s) and press releases indicating industry partners continue to make progress maturing their transportation system technical and certification/verification efforts.

Verification & Validation: Review by NASA's PMC and HEOMD DPMC.

Data Limitation: Materials provided by NASA's industry partners may include company-proprietary information. Data are sufficiently accurate for their intended use.

Performance Goal 4.2.3: Invest financial and technical resources to stimulate efforts within the private sector to develop and demonstrate safe, reliable, and cost-effective space capabilities.

Data Source: Email(s) and press releases indicating industry partners continue to make progress maturing their transportation system technical and certification/verification efforts.

Verification & Validation: Review by NASA's PMC and the HEOMD DPMC.

Data Limitation: Materials provided by NASA's industry partners may include company-proprietary information. Data are sufficiently accurate for their intended use.

Performance Goal 4.2.4: Review the current state of the NASA test capabilities, known test requirements, and test requests, and ensure their availability to meet the Nation's needs.

Data Source: Rocket Propulsion Test staff presentations at quarterly DPMC and program management review meetings.

Verification & Validation: Review of the documentation listed under Data Sources.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.2.5: Complete Launch Services Program (LSP) objectives for all NASA-managed expendable launches.

Data Source: LSP Mission Success Metric 0773, which is updated at the end of each fiscal year; and link(s) to mission press release(s).

Verification & Validation: Review of the documentation listed under Data Sources by the HEOMD Launch Services Office Director, and Launch Services Program Program Planning Office.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.2.6: Maintain a minimum of 95 percent delivery of the Space Communications network services that support NASA and other customers' mission success.

Data Source: NASA-internal presentation charts and link(s) to external press releases.

Verification & Validation: Review of the documentation listed under Data Sources by the HEOMD DPMC and at the Baseline Performance Review.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.2.7: Replace the aging Deep Space Network infrastructure.

Data Source: NASA-internal presentation charts and link(s) to external press releases.

Verfication & Validation: Review of the documentation listed under Data Sources by the HEOMD DPMC and at the Baseline Performance Review.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.2.8: Ensure the strategic availability and maintenance of facilities that are necessary to meet the long-term needs and requirements of the Agency.

Data Source: Quarterly program reviews by the Space Environments Testing Management Office (SETMO).

Verification & Validation: Assessment SETMO by staff at the quarterly program reviews.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.3.1: Assure the safety and health of NASA's activities and reduce damage to assets through the development, implementation, and oversight of Agency-wide safety, reliability, maintainability, quality assurance, and health and medical policies and procedures.

Data Source: NASA Mishap Information System.

Verification & Validation: Quarterly review of the data listed under Data Sources.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.3.2: Implement the policies, procedure and oversight to continuously improve the probability of technical and programmatic mission success.

Data Source: Baseline Performance Review.

Verfication & Validation: Quarterly reviews noted under Data Source.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.4.1: Define and build diverse workforce skills and competencies needed for the Agency's Mission.

Data Source: Federal Employee Viewpoint Survey (FEVS) Innovation Index. Publicly available from the Office of Personnel Management (OPM) and Partnership for Public Service.

Verification & Validation: Review trends from the 2011 baseline. Monitor focus areas that drive innovation, including recognizing/rewarding innovative performance, engaging/connecting the workforce, and building model supervisors and leaders, through additional indices in the FEVS.

Data Limitation: None identified. Data are sufficiently accurate for their intended use and are generally available late in the 4th quarter of the fiscal year.

Performance Goal 4.4.2: Sustain equal opportunity (EO) and diversity and inclusion programs and processes that help to proactively prevent discrimination, achieve more equitable and inclusive work environments, and more efficiently address EO concerns.

Data Source: NASA Model Equal Employment Opportunity Agency Plan, Strategic Management Council, Diversity and Inclusion Strategic Partnership meetings, and Baseline Performance Review reporting.

Verification & Validation: Assessment of the NASA Model Equal Employment Opportunity Agency Plan and NASA Diversity and Inclusion Strategic Implementation Plan.

Data Limitation: Some lag time in reporting of data, particularly at the end of the fiscal year. The OPM, which administers the FEVS, releases an FEVS technical report to accompany the survey each year. The FEVS technical report includes detailed information on FEVS sample design and selection; the survey instrument; and data collection, cleaning, weighting and analysis. OPM posts the survey results and FEVS technical reports to its http://www.fedview.opm.gov/ website.

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

Data Source: Quarterly President's Management Council cybersecurity assessments for the maturity of specific cybersecurity capabilities.

Verification & Validation: Review of quarterly President's Management Council's cybersecurity assessments.

Data Limitation: Data regarding specific protections may be sensitive. Data are sufficiently accurate for their intended use.

Performance Goal 4.5.3: Achieve improvements in overall Office of Protective Services physical security operations, standardization, efficiencies, and economies of scale.

Data Source: Integrated Security Functional Review functional review report(s), formal Federal Law Enforcement Training Accreditation certificates, and NASA-internal reports.

Verification & Validation: Review of the documentation listed under Data Sources.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.6.1: Between 2012 and 2018, support the demolition and elimination of obsolete and unneeded facilities.

Data Source: Quarterly budget and excess property reports.

Verification & Validation: Review of the documentation listed under Data Source.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.6.2: Ensure that NASA continues progress towards implementing the targets and goals reflected in its annual Sustainability Plan

Data Source: Annual external reporting to the Department of Energy, OMB, and Council on Environmental Quality via the Energy-Greenhouse Gas Workbook; OMB Scorecard on Sustainability/Energy; and Strategic Sustainability Performance Plan.

Verification & Validation: Review of the documentation listed under Data Source.

Data Limitation: Lag time. Preliminary data are available in October or November after the end of each fiscal year, but final data typically are not available until January. Data are sufficiently accurate for their intended use.

Performance Goal 4.6.3: Between 2018 and 2019, demonstrate increased facility reliability by reducing spending on unscheduled maintenance by one percent annually.

Data Source: Systems application products and NASA center work plans.

Verification & Validation: Review of the documentation listed under Data Source.

Data Limitation: None identified. Data are sufficiently accurate for their intended use.